Biodiversity Action Plan

for

SUSTAINABLE AQUACULTURE IN MANGROVE ECOSYSTEM (SAIME)

In Bangladesh

By: Bangladesh Environment & Development Society

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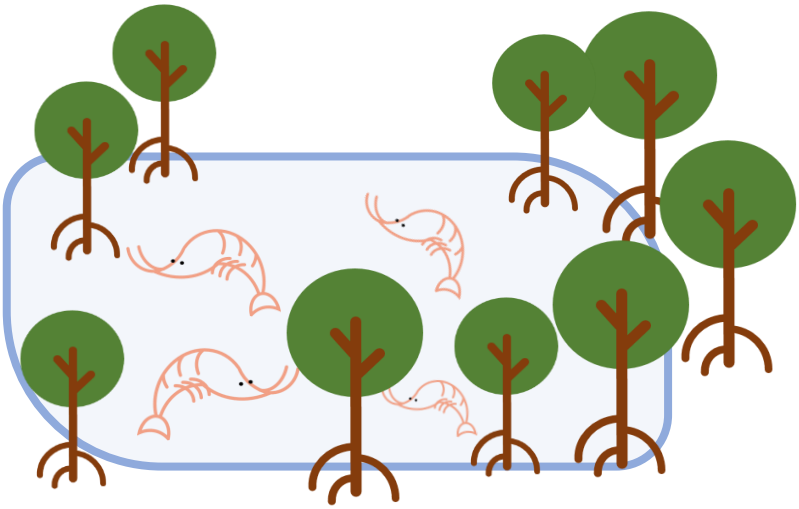

1. Initial situation and objective

Sundarbans region teems with life and biodiversity, making it a global hotspot for wildlife. It is home to a wide range of species, many of which are rare, endangered, or even endemic. The expansion of shrimp farming poses a significant threat to its environment. The Biodiversity Action Plan (BAP) seeks to mitigate this impact by harmonizing shrimp farming with mangrove conservation and biodiversity enhancement. Key elements of the plan include mangrove rehabilitation efforts, engaging the local community, protecting water quality are essential components and also focusing on previously disturbed lands for restoration. Habitat enhancement and community involvement are crucial. Regular data collection, audits, and transparent reporting ensure we can adapt our strategies effectively. Collaboration with academic institutions, NGOs, and government agencies strengthens our commitment to biodiversity conservation.

This plan represents our dedication to protecting the Sundarbans, fostering a sustainable future for both nature and communities. The objectives of this initiative are multifaceted and central to its mission. It strives to promote environmentally friendly practices within the shrimp aquaculture sector. This entails encouraging and implementing strategies that minimize the industry's environmental footprint while ensuring the sustainability of its operations. A critical goal is to conserve and rejuvenate the vulnerable mangrove ecosystem. Recognizing the ecological significance of these mangroves, the project is committed to preserving and restoring them, thus fortifying the region's natural defenses and biodiversity. Additionally, the project seeks to enhance biodiversity, not only within the aquaculture settings but also in the surrounding areas. This involves the creation of environments that support a rich tapestry of plant and animal species, fostering thriving ecosystems. Finally, there's a concerted effort to diversify habitats for the local fauna and flora. By introducing a variety of habitats within and around the shrimp farms, the project aims to accommodate the unique requirements of different species, ensuring their long-term survival and the overall health of the ecosystem. These objectives collectively form the backbone of the initiative, steering it towards a future where sustainable shrimp aquaculture and vibrant, resilient ecosystems coexist harmoniously.

2. Introduction to mangrove forests

Mangrove forests are a unique and diverse environment that support a dynamic and diversified flora and fauna that are frequently unique (Khan et al., 2020). For numerous terrestrial and aquatic creatures, they offer food, resting, and breeding habitats in addition to shelter (Mahmood et al., 2021). Food, fresh water, fuel (dung, wood, twigs, and leaves), fiber (grasses, timber, wool, and silk), biochemicals and pharmaceuticals (medicines and food additives) are some of the many benefits of the mangrove forest ecosystem. There are also genetic resources (genes and genetic information that are utilized for plant breeding and biotechnology), ornamental resources (skins, sell, and flowers), social and cultural functions (spiritual fulfillment and recreational opportunities), and biological diversity (Iqbal, 2020). Bangladesh is widely recognized for possessing the largest mangrove environment globally (Mahmood et al., 2021). One of the hotspots for biodiversity in the world, the Sundarbans mangrove forest is home to numerous unique biomes. The biome is home to more than 1186 species of known living things, including both plants and animals (Rahman and Begum, 2011). Globally, one of the industries with the quickest rates of job growth and supply of animal protein is aquaculture (FAO, 2020). According to the FRS Survey (2021), Bangladesh ranks fifth among the countries that produce shrimp. Bangladesh is a deltaic nation with large coastal and riverine areas devoted to aquaculture, making it a vital industry. Export-oriented prawn (*Macrobrachium rosenbergii*) and shrimp (*Penaeus monodon*) production dominates aquaculture in Bangladesh's coastal zones (Ahmed et al., 2023).

Shrimp farming has drawn harsh criticism despite its financial advantages due to its numerous detrimental effects on ecosystems, biodiversity, and society (Naylor et al., 2021). On the other hand, many nations have recently begun looking for strategies to stop or even reverse the loss of mangroves due to new discoveries. Fostering co-management between mangroves and shrimp can help reduce the loss of mangroves and restore portions of the mangrove ecosystem while also increasing the sustainability of shrimp aquaculture (Bosma et al., 2020; Bosma et al., 2016). In addition to being concerning from an ecological point of view, the extensive loss of mangroves is concerning for Bangladesh's economy and people's well-being because the nation is prone to flooding (World Bank, 2018). Consequently, taking into account the significance of mangrove-shrimp-pond ecosystems for biodiversity, coastal protection, nature preservation, food production, and local residents' means of subsistence (Ahammad et al., 2014), reintroducing mangroves into the current aquaculture landscape that is centered on shrimp monoculture is essential (Debrot et al., 2020).

3. SAIME initiative: objectives, partners, and focused conservation sites

The collaborative venture of the Global Nature Fund (GNF), Naturland e.V., Nature Environment and Wildlife Society (NEWS), and Bangladesh Environment and Development Society (BEDS) converge in the implementation of the project named "Multi-stakeholder partnership (MSP) to strengthen transformative processes in shrimp trade as a basis for the protection of mangrove ecosystems in South Asia" with a prime focus on "Sustainable Aquaculture in Mangrove Ecosystem (SAIME)."

The Sustainable Aquaculture in Mangrove Ecosystem (SAIME) project stands as a pivotal initiative aimed at preserving the delicate mangrove ecosystems within the Sundarban region of Bangladesh through the implementation of sustainable shrimp aquaculture practices. Bringing together a diverse coalition comprising officers from the Department of Fisheries, civil society members, local government representatives, Fisheries Research Institute, and expert trainers affiliated with Khulna University, the SAIME project prioritizes the safeguarding of mangrove ecosystems while promoting responsible shrimp farming techniques.

With a primary focus on the Sundarban areas encompassing the Dacope sub-district of Khulna district, Shyamnagar sub-district of Satkhira district, Rampal sub-district, and Mongla sub-district of Bagerhat district, the project directly engages with approximately 1,250 individuals and indirectly influences the lives of 10,000 community members. The overarching objective of SAIME revolves around the establishment of robust dialogue structures, the reinforcement of sustainable livelihoods, and the development of resilient models tailored to combat the challenges posed by climate change.

SAIME places a significant emphasis on transformative practices within aquaculture, aiming to strike a harmonious balance between human activities and the preservation of the invaluable mangrove ecosystems. Through strategic partnerships, community engagement, and the implementation of sustainable aquaculture methodologies, the project endeavors to mitigate adverse impacts on the environment while

nurturing economic growth and enhancing the resilience of the region against the perils of climate change and natural disasters.

4. Benefits of Sustainable Aquaculture In Mangrove Ecosystem (SAIME) in brackish ecosystem

For Consumers

Sustainable seafood: Consumers can enjoy seafood products (such as shrimp and fish) with confidence, knowing that they are produced using environmentally responsible practices, reducing the ecological impact and ensuring a sustainable seafood source.
Health and safety: This approach emphasize reduced chemical and antibiotic use, leading to healthier and safer seafood products for consumers. Lower use of chemicals contributes to safer water quality.
Biodiversity conservation: Consumers indirectly benefit from enhanced biodiversity conservation, as this approach protect ecosystems and species diversity, contributing to a more resilient environment.
Food security: Preservation of mangrove ecosystems supports the livelihoods of local communities and their food security, which can have a broader positive impact on the region's food supply and availability.
Quality assurance: Consumers can expect higher product quality and purity standards due to reduced pollution and water contamination in sustainable aquaculture practices.
Ethical choices: Ethically conscious consumers can support businesses that adhere to responsible and sustainable aquaculture practices, making ethical choices in their product purchases.
Transparency and traceability: This approach encourage transparent supply chains and traceability, allowing consumers to verify the origin and production methods of the seafood they purchase.

For Society

Community empowerment: SAIME involves local communities in restoration efforts, empowering them as stewards of their ecological heritage. This fosters a sense of ownership and responsibility, contributing to stronger and more resilient communities.
Climate adaptation: SAIME helps mitigate the effects of climate change by enhancing the resilience of local communities through sustainable aquaculture. The system can adapt to rising sea levels and changing environmental conditions, reducing the vulnerability of communities.
Economic opportunities: This approach create economic opportunities for communities living in the Sundarbans region. Local jobs are generated, reducing dependence on unsustainable activities, like illegal logging or overfishing, and improving the livelihoods of residents.
Ecotourism: Improved biodiversity conservation and restored mangroves can attract ecotourism, boosting the local economy, creating jobs in the tourism sector, and increasing awareness of the importance of the Sundarbans forest.

Social resilience: Sustainable practices contribute to social resilience by reducing poverty, providing food security, and supporting community well-being. This enhances the stability of local societies.
Cultural preservation: The preservation of the Sundarbans and its unique ecosystem helps safeguard the cultural heritage of the communities living in the region, as their traditions and livelihoods are closely tied to these ecosystems.
Education and capacity building: This system facilitate education and capacity building within local communities, providing knowledge and skills that empower individuals and communities to actively engage in conservation and sustainable practices.

For Businesses

Sustainable reputation: Companies adopting this method can gain a reputation for environmentally responsible and sustainable practices, attracting consumers who prefer to support eco-friendly businesses.
Access to markets: Certification through programs like organic aquaculture can provide businesses with access to international markets, expanding their customer base and increasing sales opportunities.
Long-term viability: Sustainable practices ensure the long-term viability of businesses operating in the Sundarbans region, mitigating the risks associated with environmental damage and regulatory compliance.
Innovation: The development and adoption of this tactic encourage innovation in sustainable aquaculture practices and biodiversity conservation, fostering industry leadership and research opportunities.
Risk reduction: Sustainable practices minimize risks associated with environmental damage, illegal activities, and disruptions caused by climate change, thus contributing to business continuity.
Brand loyalty: Businesses that embrace sustainability and contribute to the well-being of local communities can build strong brand loyalty and a dedicated customer base.
Investment opportunities: Adopting environmentally responsible practices opens doors to investment opportunities, including impact investments and partnerships with organizations focused on sustainability and conservation.

For the Sundarbans Forest

Ecosystem restoration: SAIME restores mangrove ecosystems, which serve as vital habitats for various species, protect against coastal erosion, and maintain water quality, thereby supporting the Sundarbans' overall ecological health.
Climate resilience: SAIME enhances the resilience of the Sundarbans forest by mitigating climate change impacts through a combination of aquaculture and mangrove restoration. This adaptation helps maintain the integrity of the forest in the face of rising sea levels and extreme weather events.
Biodiversity conservation: This approach contributes to the conservation of biodiversity within the Sundarbans. This safeguards endangered species, keystone species, and the broader ecosystem, maintaining the forest's ecological balance

Economic and social Stability: This method reduce pressures on the Sundarbans forest by offering alternative livelihoods for local communities. This, in turn, minimizes illegal logging, land conversion, and overfishing, ensuring the forest's long-term sustainability.
Carbon sequestration: Mangroves in the Sundarbans are excellent carbon sinks, capturing and storing significant amounts of carbon dioxide. The conservation and restoration of mangroves contribute to global climate change mitigation efforts.
Habitat preservation: Mangroves and their adjacent ecosystems provide essential habitats for diverse wildlife, and the protection of these habitats is vital for the long-term survival of many species.
Water quality improvement: The approach helps in maintaining healthy water quality in the Sundarbans, which benefits not only the forest but also the surrounding aquatic ecosystems, supporting various life forms.

5. Strategies for sustainably restoring mangroves utilized by SAIME

Community-Based Ecological Mangrove Restoration (CBEMR): It is an innovative approach to the restoration and conservation of mangrove ecosystems. At its core, CBEMR places local communities at the forefront of restoration efforts, actively involving them in all stages of the process. This community engagement is pivotal in ensuring that restoration plans align with the needs and priorities of the people living in and around mangrove areas. CBEMR goes beyond simply planting mangrove trees; it emphasizes the restoration of specific ecosystem traits and the emulation of natural functions. Long-term monitoring is a key feature, allowing for continuous assessment and adaptive management to address any issues that may arise. In the face of climate change and its impacts, CBEMR also plays a role in enhancing the resilience of mangrove ecosystems. Moreover, it takes into account the socio-economic dimension, supporting the sustainable livelihoods of local communities through activities like aquaculture, which coexist with restoration efforts. Overall, CBEMR is a holistic, community-driven approach that not only conserves mangroves but also empowers communities to be stewards of their natural heritage, benefiting both the environment and the well-being of local residents.

Integrated Mangrove Aquaculture (IMA): It is an approach that combines mangrove restoration with sustainable aquaculture practices, typically implemented in coastal areas where mangrove ecosystems have been degraded or destroyed. This approach establishes a symbiotic relationship between mangrove trees and aquaculture activities, creating a mutually beneficial system. IMA emphasizes sustainable aquaculture by promoting the extensive polyculture of shrimp and finfish, reducing the need for supplementary feed and minimizing the environmental impact often associated with intensive shrimp farming. Importantly, IMA contributes to mangrove protection as these ecosystems serve as a natural buffer against coastal erosion, storm surges, and other climate-related challenges. To minimize risks and overexploitation of wild stocks, IMA often involves the use of hatchery-produced shrimp seeds, such as Penaeus monodon, as candidate species for aquaculture. This approach not only provides a sustainable livelihood for local communities but also supports broader efforts to mitigate the impacts of climate change and promote environmentally responsible practices, making it a holistic and forward-thinking strategy for both community well-being and environmental conservation.

5.1 APPROACHES AND MEASURES USED BY BAP TO PROTECT AND PROMOTE BIODIVERSITY IN SAIME

The Biodiversity Action Plan (BAP) for Sustainable Aquaculture in Mangrove Ecosystem (SAIME) employs a multifaceted approach to protect and enhance biodiversity. It encompasses site selection and assessment, responsible farming practices, mangrove conservation, rigorous monitoring and reporting, stakeholder engagement, regulatory compliance, and extensive education and outreach. These measures are designed to minimize the environmental impact of shrimp farming, conserve critical mangrove ecosystems, and promote biodiversity. BAP's collaborative and transparent efforts aim to benefit consumers, society, and businesses while safeguarding the Sundarbans Forest and its unique biodiversity

Table- 1: Requirements and criteria governing the incorporation of Sustainable Aquaculture in Mangrove Ecosystem (SAIME) practices into their execution

Criteria	Immediate Effectiveness	Long term Effective-ness	Key indicator
Site selection and preparation • Choosing suitable areas for SAIME integration • Ensuring existing mangroves are not disturbed • Selecting previously disturbed areas for farming		**Yes**	Ecological assessment reports for site selection
Mangrove rehabilitation • Actively restoring mangrove habitats • Regular maintenance of mangrove health • Engaging the local community in mangrove restoration • Establishment of mangrove nursery facilities		**Yes**	Number of mangrove trees planted annually
Water quality management • Implementation of efficient water treatment systems • Monitoring and maintaining proper water quality levels • Exploring the use of eco-friendly shrimp feed • Optimization of feeding practices to reduce overfeeding and waste • Establishment emergency response protocol for crisis moments		**Yes**	Regular water quality reports showing pollutant levels

Criteria	Immediate Effectiveness	Long term Effective-ness	Key indicator
Sustainable farming practices • Minimizing the use of antibiotics and chemicals • Responsible feed management to reduce waste • Regular monitoring and management of stocking densities • Adopt energy-efficient farming techniques • Managing farm effluents responsibly	**Yes**		Decrease in chemical and antibiotic usage.
Waste management • Development of efficient waste management systems • Recycling organic waste as feed or fertilizer to reduce waste generation • Conducting regular waste audits to improve waste handling practices • Exploring opportunities for value-added products from waste materials	**Yes**		Adoption and effectiveness of waste management practices. Record of concentration of the pesticides of chemicals used. Record of if the application is avoided on culture practice.
Biodiversity conservation • Conducting periodic biodiversity surveys to assess species health and diversity • Identification and monitoring of endangered or keystone species for protection • Assessment of genetic diversity in the farm's ecosystems to maintain robust populations • Exploring and conserving microbial diversity for ecosystem health • Monitoring indicator species for early warnings of ecological stress • Tracking phenology of key species to understand environmental changes		**Yes**	Biodiversity health and diversity indices. List of available flora and fauna at a definite location in each year. Plant and animal species that are protected or endangered found around the farm. (Yes/No) If found record of measures that are taken to protect them.

Criteria	Immediate Effectiveness	Long term Effective-ness	Key indicator
• Implementation of invasive species management to protect native biodiversity • Certation of habitat maps to guide and monitor conservation efforts • Implementation of habitat restoration and reintroduction for at-risk species • Development of climate resilience plans to adapt to changing environmental conditions • Collection of baseline data for ongoing monitoring and comparison			
Protected zones • Designation and enforcement of no-fishing or restricted access zones to safeguard sensitive areas • Creation of wildlife corridors and buffer zones to facilitate habitat connectivity • Regularly monitoring and managing the health and changes in protected zones • Application of adaptive management practices within protected zones for conservation • Implementation of visitor education to raise awareness and promote conservation efforts • Maintaining and managing zone connectivity to facilitate wildlife movement • Preservation of buffer zone vegetation to support wildlife and ecosystem functions • Use of non-intrusive barriers in buffer zones to control access without harming wildlife		**Yes**	Establishment and compliance with restricted zones

Criteria	Immediate Effectiveness	Long term Effective-ness	Key indicator
• Enhancing habitats within buffer zones to attract and support local wildlife • Regularly maintaining wildlife corridors to ensure consistent connectivity			

5.2 Determination of baseline operation and when relevant, set the baseline criteria and employ the Biodiversity Performance Tool (BPT)

The current status of shrimp farming in the Sundarbans region of Bangladesh, reflects a significant industry that has expanded over the years to meet global demand for shrimp products. While providing economic benefits, this growth has raised several environmental concerns. Shrimp farming has been associated with adverse impacts on the fragile ecosystem of the Sundarbans, such as water pollution, habitat degradation, and loss of biodiversity. The release of effluents containing chemicals, antibiotics, and excess nutrients into local water bodies threatens water quality and the health of aquatic organisms. Furthermore, the conversion of pristine mangrove areas into shrimp farms disrupts crucial ecological functions and exacerbates issues like soil erosion and loss of critical habitat for various species.

The importance of a "baseline operation" in the context of Sustainable Aquaculture in Mangrove Ecosystem (SAIME) cannot be overstated. Establishing a baseline operation involves assessing and documenting the existing state of shrimp farming in the Sundarbans, from farm practices to their environmental impacts. It provides a crucial benchmark for evaluating changes in environmental conditions, species diversity, and ecosystem health over time. These baseline data and criteria help in defining what needs to be conserved or improved to ensure the sustainability of shrimp aquaculture in the region. The Biodiversity Action Plan (BAP) can significantly benefit from this baseline operation. By having a clear understanding of the initial environmental status, the BAP can develop specific criteria and sustainability goals tailored to the unique challenges of the Sundarbans. This enables the BAP to focus on areas that require immediate attention and prioritize actions to mitigate environmental harm while promoting biodiversity conservation. The baseline operation data and criteria can serve as a reference point to assess the effectiveness of the BAP in the long term, helping to track progress and ensure that the aquaculture industry aligns with responsible environmental practices in the Sundarbans. The following indicators need to be considered during initial screening:

Table-2: Criteria and metrics for evaluating the farm and its effects on the surrounding environment

Landscape	Indicator	Comprehensive clarification
Mangrove propagation areas	Success of mangrove replanting initiatives	How do shrimp farming practices align with or support mangrove propagation efforts in the region?
Water bodies and aquatic ecosystems	Water quality parameters (salinity, pH, dissolved oxygen)	What are the impacts of shrimp farming on water quality and aquatic ecosystems, and how are these impacts managed or mitigated?
Coastal areas	Erosion rates and sediment deposition.	How does shrimp farming influence coastal erosion and sediment deposition, and what strategies are employed to mitigate these effects?
Biodiversity and wildlife habitats	Species diversity and population abundance	What is the impact of shrimp farming on local biodiversity and wildlife habitats, and how are these impacts addressed?
Farmlands and agricultural areas	Soil quality and land use patterns	How does shrimp farming influence soil quality and land use in adjacent agricultural areas, and what practices maintain soil health?
Waterways and canals	Water flow and connectivity.	How are waterways and canals affected by shrimp farming, and what measures ensure their continued functionality?
Community livelihoods	Socioeconomic benefits for local communities	What economic and social advantages does shrimp farming bring to local communities, and how are these benefits balanced with environmental concerns?
Fishing grounds	Catching fish and harvest	How does shrimp farming impact fishing grounds and the livelihoods of local fishermen, and what strategies support sustainable coexistence?
Protected areas and reserves	Presence and health of protected areas	How does shrimp farming interact with nearby protected areas and reserves, and what measures are in place to preserve their ecological integrity?
Ecosystem habitat disturbance	Changes in the health and biodiversity of local ecosystems.	To what extent does shrimp farming disturb natural ecosystems, and what mitigation measures are adopted to minimize the disturbance?
Tidal flats and marshlands	Changes in tidal flat and marshland ecosystems	What impact does shrimp farming have on tidal flats and marshlands, and how is their ecological value preserved?

Table-3: Monitoring criteria for aquaculture farms and integrated mangrove aquaculture practice

Landscape	Indicator	Comprehensive clarification
Aquaculture Farms		
Site selection	Site selection criteria	Careful site selection helps prevent environmental damage and optimizes aquaculture operations by considering factors like water quality, accessibility, and ecological sensitivity.
Species selection	Species suitability and biodiversity conservation	Choosing appropriate species for aquaculture impacts productivity, resource use, and the ecological compatibility of the operation.
Water quality	Dissolved oxygen (DO) levels (mg/L)	Maintaining optimal water quality ensures that fish have the oxygen they need for respiration, supporting overall aquatic health and productivity.
Stock health	Disease incidence rate (%)	Monitoring disease incidence is vital to safeguarding the well-being of aquaculture species, preventing outbreaks, and maintaining high production levels.
Sediment quality	Sediment organic content (%)	Sediment quality affects the benthic environment, nutrient cycling, and the overall health of aquatic ecosystems, making it crucial for sustainability.
Waste management	Effluent nutrient concentration (mg/L)	Effective waste management controls nutrient pollution, reducing the environmental impact of aquaculture operations.
Compliance with regulations	Number of regulatory violations	Adherence to regulations guarantees sustainable and responsible aquaculture practices, preventing legal issues and promoting public trust.
Monitoring and evaluation	Frequency of performance evaluations and identification of problems	Regular monitoring and evaluation provide insights for continuous improvement, ensuring the long-term sustainability and success of aquaculture farms.
Mangrove Integration		
Mangrove health	Mangrove canopy cover (%)	Healthy mangroves provide essential ecosystem services, such as shoreline protection and habitat for marine life, helping mitigate erosion and sustaining biodiversity.
Mangrove species selection	Diversity of mangrove species	Selecting diverse mangrove species enhances resilience and ecosystem functions, contributing to the overall health of the integrated system.
Mangrove management	Mangrove restoration success rate	Effective mangrove management, including restoration efforts, ensures the long-term viability of these vital coastal ecosystems.
Ecosystem services	Nutrient retention efficiency (%)	Ecosystem services, like nutrient cycling, maintain water quality and support the long-term productivity of integrated mangrove aquaculture systems

Biodiversity conservation	Presence of endangered species	Protecting endangered species within these environments helps conserve unique wildlife and ensures the integrity of local ecosystems.
Adaptive management	Number of adaptive management actions taken	Adaptive management allows for timely responses to changing conditions, ensuring the continued success and resilience of the integrated system in a dynamic environment.
Economic viability	Net profit margin (%)	Ensuring economic viability sustains livelihoods and supports economic well-being, ultimately benefiting the local economy.

5.3 ESTABLISHING THE STARTING POINT (BASELINE SCENARIO)

Mapping the farm's baseline for effective biodiversity action planning in aquaculture and customizing BAP to farm specific needs is a crucial aspect of responsible aquaculture management. The initial step of mapping the farm's baseline provides a comprehensive understanding of the existing ecosystem, allowing aquaculture practitioners to identify ecological hotspots and potential zones for Sustainable Aquaculture in Mangrove Ecosystem (SAIME). This mapping process, whether accomplished through Geographic Information System (GIS) technology or hand-drawn methods, serves not only as a tool for informative visualization but also as a catalyst for raising awareness and motivation among stakeholders. Additionally, customizing the BAP to meet the specific needs of individual aquaculture farms is essential. It ensures that the proposed conservation measures and strategies align with the farm's unique circumstances, ultimately enhancing the sustainability of aquaculture operations. By exploring these vital components, we can harness the power of tailored BAPs to promote the coexistence of aquaculture and biodiversity conservation while maintaining economic viability. The criteria for monitoring in the starting point are listed below:

Table-4: Criteria for biodiversity documentation in current practices

Criteria	**Immediate Effectiveness**	**Long term Effectiveness**	**Key indicator**
Farm information documentation Gathering information pertaining to the farm's natural and ecological landscape, including the surrounding areas, to facilitate the identification of potential water bodies suitable for Sustainable Aquaculture in Mangrove Ecosystem (SAIME) practice The parameters should include the following: • Farm layout and boundaries • Ownership and legal status	Yes		Accurate farm map and boundary demarcation for mangrove restoration and integration

Criteria	Immediate Effectiveness	Long term Effectiveness	Key indicator
• Farm size and configuration • Mangrove ecosystem • Water source and management • Infrastructure and equipment • Water quality monitoring • Community engagement			
Biodiversity conservation measures and compliance with regulations		Yes	Documentation of conservation efforts. Marking potential brackish water resources in the map including water quality parameters and areas of the farm. Assessment of the suitability of the habitat for mangrove restoration

5.4 Establishment of Biodiversity Action Plan (BAP)

The Biodiversity Action Plan (BAP) in Sundarbans, Bangladesh, encompasses several vital objectives and main targets. Its core objectives revolve around the preservation and restoration of the fragile mangrove ecosystems in the Sundarbans region, which are essential for biodiversity. The plan aims to enhance and safeguard the biodiversity of the area, with a particular focus on protecting the habitats of endangered species. Another key objective is to promote sustainable and responsible aquaculture practices along the coastal region, recognizing the importance of balancing economic activities with environmental conservation.

Biodiversity conservation, the BAP seeks to improve the livelihoods and well-being of local communities who depend on the Sundarbans ecosystem. This involves promoting community engagement and providing alternative livelihood options to reduce pressure on the environment. Furthermore, the plan addresses the pressing issue of climate change, aiming to develop strategies for resilience and adaptation to mitigate the impacts of climate change on the Sundarbans environment. By focusing on these objectives and targets, the Biodiversity Action Plan endeavors to ensure the long-term health and sustainability of the Sundarbans, its unique biodiversity, and the communities that call it home.

Table -5: Key criteria for effective biodiversity action planning

Criteria	Immediate Effectiveness	Long term Effectiveness	Key indicator
Farm area management • Establish and maintain accurate farm maps and boundary demarcations. In cases where	**Yes**		The precision and up-to-date status of farm maps and boundary demarcation are crucial indicators for effective farm area management.

Criteria	Immediate Effectiveness	Long term Effectiveness	Key indicator
mapping is time-consuming, such as when land ownership lacks clear regulation, a basic representation of the structures and areas suffices. • Regularly update proof of legal ownership and permits for the farm area. • Continuously monitor the total farm area, shape, and layout for any alterations. • Implement documentation of mangrove species present and their health status. • Maintain records on the source of water for aquaculture and its management practices. • Create and update an inventory of infrastructure and equipment in use on the farm. • Maintain comprehensive records of water quality parameters over time. • Document evidence of community interactions and partnerships related to the farm area. • Keep records of any changes in land use or expansions in the farm area. • Continuously update and maintain data on any land or soil improvements. • Monitor and record the impact of farm operations on local biodiversity. • Document any restoration or conservation efforts within the farm area			
Stakeholder engagement • Engage local communities, government agencies, NGOs, and experts for collaboration. • Document meeting minutes, participant lists, agreements,		**Yes**	Level of participation and cooperation of stakeholders in meetings and collaborative activities.

Criteria	Immediate Effectiveness	Long term Effectiveness	Key indicator
and correspondence with stakeholders. • Ensure transparent and productive stakeholder involvement			
Baseline assessment • Conduct a comprehensive baseline assessment of biodiversity. • Document biodiversity assessment reports, hotspot maps, species data, and threat reports. • Gain a clear understanding of the ecosystem's current state.	**Yes**		Completion and accuracy of baseline assessment reports, including hotspot maps, species data, and identified threats.
Resource allocation • Allocate financial and human resources effectively. • Document budgets, resource allocation decisions, and personnel involved. • Ensure transparent and accountable resource management		**Yes**	Effective allocation of financial and human resources, as reflected in budget accuracy and resource utilization
Community inclusivity • Involve local communities in decision-making processes. • Document community meeting details, agreements, and feedback. • Foster community engagement and cooperation.		**Yes**	Degree of community involvement, documented in meeting records, agreements, and feedback.
Monitoring framework • Establish a robust monitoring system. • Document monitoring plans, reports, and biodiversity data. • Assess the impact of conservation measures and track progress.		**Yes**	The functionality and efficiency of the monitoring system, as evidenced by monitoring plans and data quality.
Capacity building • Enhance the skills and knowledge of stakeholders through training. • Document training schedules, attendance, and training materials.		**Yes**	Participation and progress in training activities, improving stakeholders' knowledge and skills.

Criteria	Immediate Effectiveness	Long term Effectiveness	Key indicator
• Ensure individuals and organizations can execute the plan effectively.			
Adaptability • Be ready to adapt the BAP to changing circumstances. • Document BAP revisions, reasons for changes, and outcomes of adaptive management. • Ensure the plan remains relevant and effective over time.		**Yes**	The number of BAP revisions and the effectiveness of adaptive management.

5.5 Promotion of native species preservation and mitigating invasive alien species (IAS) in Sustainable Aquaculture in Mangrove Ecosystem (SAIME)

The preservation of native species encompasses the protection and restoration of critical habitats, particularly mangrove ecosystems, which act as nurseries for indigenous aquatic life. This strategy also includes selective breeding programs to maintain genetic diversity within these populations. Simultaneously, SAIME farms employ vigilant monitoring and control measures to detect and combat IAS. The early detection of invasive species enables swift containment efforts, including their physical removal and the introduction of natural predators. SAIME farms also adhere to government regulations and international conventions to prevent the introduction of IAS. These combined efforts work cohesively to safeguard the Sundarbans' unique biodiversity, support local communities, and ensure the long-term sustainability of SAIME practices.

Table-6: Key criteria for fostering indigenous species and safeguarding against invasives

Criteria	Immediate Effectiveness	Long term Effectiveness	Key indicator
Community Awareness: Inform fishers and community members about the decline of indigenous species population and the impact of Invasive Alien Species (IAS).		**Yes**	Percentage of community members informed about indigenous species decline and IAS impact.
Socio-economic Support: Support the socio-economic structure of SAIME farms through capacity building, training, and expert advice.	**Yes**		• Farm registration under appropriate authority. • Knowledge of farm managers on the importance of biodiversity. • Training on biodiversity management. • Aquaculture species harvested by farmers.

IAS Identification and Reporting: Identify IAS on farmland and report occurrences to the competent nature conservation authority.		**Yes**	• Presence of IAS on the farmland. • Reporting to the authority about IAS occurrences. • Inclusion of IAS control measures in the Biodiversity Action Plan (BAP).
Protection of Threatened Species: Explicitly point out that threatened, declining, and protected animal and plant species must not be collected, and protected areas must not be affected	**Yes**		Documentation of compliance with government regulations regarding protected species and areas.

5.6 Measures to minimize negative impacts on environment and sustainable shrimp farming practices

5.6.1 Site selection

1. Avoid converting pristine mangrove areas into shrimp farms:
It is crucial to resist the temptation to establish shrimp farms in untouched, pristine mangrove areas. These untouched mangroves are essential for biodiversity, serving as nurseries for various species and acting as natural barriers against coastal erosion and storm damage. By avoiding their conversion, we protect these invaluable ecosystems.
2. Select previously disturbed or degraded areas for farm establishment:
Opting for locations that have already been subjected to human activity, such as deforestation or agricultural use, helps minimize the environmental impact. Choosing these areas for shrimp farming allows for their ecological recovery, aiding in the rehabilitation of degraded lands.

5.6.2 Mangrove rehabilitation

1. Implement mangrove restoration efforts within and around the farm:
The deliberate restoration and maintenance of mangrove habitats is essential for maintaining biodiversity. By actively replanting mangrove trees within the farm and its immediate locality, not only safeguard these critical ecosystems but also enhance water quality, provide habitat for numerous species, and contribute to the stability of coastlines.
2. Monitor and maintain mangrove health through regular tree planting and protection:
To ensure the continued vitality of mangroves, it is essential to engage in ongoing care. Regular tree planting and protective measures, such as guarding against illegal logging or land conversion, are necessary to guarantee that these ecosystems remain robust and continue to fulfill their ecological roles. Logging or land conversion, are necessary to guarantee that these ecosystems remain robust and continue to fulfill their ecological roles.
3. Engage the local community in mangrove restoration:
Collaborate with the local community and provide opportunities for them to actively participate in mangrove restoration efforts. Involving the community not only promotes a sense of ownership but also strengthens the commitment to conserving these ecosystems.

4. Establish mangrove nursery facilities:
Set up mangrove nursery facilities where seedlings can be cultivated and nurtured before being transplanted into the farm and surrounding areas. This ensures a reliable source of healthy mangrove trees for restoration efforts.

5.6.3 Water quality management

1. Establish efficient water treatment systems to reduce pollution:
Implementing advanced water treatment systems within the shrimp farm is critical. These systems remove harmful substances, ensuring that discharged water is of higher quality and thus significantly reduces the negative impact on local aquatic life.
2. Monitor and maintain proper water quality levels, including salinity and dissolved oxygen:
Consistent monitoring of water quality parameters, such as salinity and dissolved oxygen, is essential to maintain a healthy aquatic environment. Proper maintenance of these levels supports the well-being of both farmed shrimp and nearby ecosystems.
3. Evaluate the use of eco-friendly feed:
Explore the use of eco-friendly shrimp feed that produces lower waste and fewer pollutants when consumed by the shrimp. These feeds can lead to improved water quality by reducing nutrient excess.
4. Optimize feeding practices:
Develop and implement feeding schedules and practices that minimize overfeeding, which can lead to waste and water quality issues. Careful management of feeding quantities contributes to a healthier aquatic environment.
5. Implement educational programs for farm workers:
Educate farm workers about the importance of water quality management and how their daily activities can impact it. Training and awareness programs empower employees to actively contribute to maintaining water quality.
6. Establish emergency response protocols:
Develop and maintain emergency response protocols for potential incidents that could affect water quality, such as disease outbreaks or extreme weather events. Having well-defined plans in place can help mitigate damage and protect the environment.

5.6.4 Sustainable farming practices

1. Implement best aquaculture practices, minimizing the use of antibiotics and chemicals:
Responsible aquaculture practices minimize the reliance on antibiotics and chemicals, reducing the risk of environmental contamination and harm to non-target species.
2. Employ responsible feed management strategies to reduce waste and nutrient pollution:
Managing shrimp feed efficiently reduces waste and nutrient pollution. This practice minimizes the release of excess nutrients into the water, which can otherwise lead to ecological imbalances.
3. Regularly monitor and manage farm stocking densities:
Monitoring and managing stocking densities helps prevent overloading the farm environment, maintaining a healthier balance between farmed shrimp and local ecosystems.
4. Adopt energy-efficient farming techniques:

Incorporate energy-efficient technologies and practices into farm operations, such as the use of solar power, efficient aeration systems, and reduced reliance on fossil fuels. This minimizes the carbon footprint of shrimp farming.
5. Manage farm effluents responsibly:
Implement strategies to manage and treat farm effluents effectively before discharge. These measures can include constructed wetlands, sedimentation ponds, and biological filters to reduce the environmental impact.

5.6.5 Waste management

1. Develop efficient waste management systems, including sedimentation ponds and waste processing:
The establishment of waste management systems, such as sedimentation ponds and waste processing facilities, ensures that waste products from shrimp farming are efficiently handled, preventing their release into the environment.
2. Recycle organic waste as feed or fertilizer:
Recycling organic waste as feed or fertilizer reduces waste accumulation and maximizes its utility within the farming system, reducing the environmental impact.
3. Implement regular waste audits:
Conduct regular waste audits to assess the composition and volume of waste generated by the shrimp farm. These audits help identify areas for waste reduction and improvement in waste handling practices.
4. Explore the potential for value-added products:
Investigate opportunities to create value-added products from waste materials, such as shrimp shell-based chitin or chitosan products. These can generate additional income and reduce waste.

5.7 Implementation and Monitoring of the Biodiversity Action Plan (BAP)

The practice of integrated mangrove aquaculture, the successful execution and oversight of Biodiversity Action Plan (BAP) in farms necessitate the establishment of a robust Monitoring & Evaluation (M&E) system. This system hinges on identifying two distinct sets of indicators: Performance Monitoring Indicators and Impact Indicators.

✓ **Performance monitoring indicators:** **Definition:** These indicators critically evaluate the performance and execution of the strategies detailed in the BAP. **Elaboration:** Performance indicators play a pivotal role in assessing the effectiveness of the steps taken to implement the BAP. They offer real-time insights into the progress of each measure, facilitating adaptive management.
✓ **Impact indicators:** **Definition:** Impact indicators are strategically crafted to assess the broader consequences of the implemented measures on biodiversity. **Elaboration:** These indicators primarily concentrate on the overall impact of the BAP on biodiversity within farms in the Sundarbans. They measure shifts in ecological well-being, alterations in species diversity, and the progress of habitat restoration efforts, offering valuable insights into the long-term achievements of the BAP.

✓ **Data collection methods:**

Identification: Following the determination of indicators, suitable methods for data collection will be identified.

Elaboration: The selection of effective data collection methods is of utmost importance for accurate monitoring. This may encompass on-site observations, interviews, surveys, and the utilization of technology to gather both quantitative and qualitative data.

✓ **Implementation and monitoring table:**

Definition: This table constitutes a comprehensive blueprint for executing and monitoring the BAP in farms. It delineates specific actions, assigns responsibility, sets timelines, and outlines expected outcomes.

Elaboration: Serving as an exhaustive guide, the table provides detailed information for every action item, specifying who is accountable for its implementation, the schedule for its completion, and the anticipated results.

5.8 RESPONSIBILITY OF ON-SITE AGENT

To ensure the effective execution of the BAP, our on-site agents will work in close cooperation with farmers, assuming designated roles and responsibilities as detailed in the table provided below:

Table- 7: Responsibility of on-site agent

Goal	Timeline	Measure	Indicator	Type of indicator	Data collection methods	Responsibilities
Implementation of Integrated Mangrove Aquaculture to mitigate adverse effects on biodiversity within the farms.	Long term	Water exchange at the farms occurs every 15 days, coinciding with the full moon and new moon phases, while ensuring a minimum water depth of 3-4 ft is maintained	Number of farms maintaining water depth	Performance Monitoring	Collection of data by agents from the farmers	Agent and farmers
		Reducing stocking density at the farms and introducing hatchery-bred shrimp seeds is undertaken to	Disease outbreak in shrimp andfish		Collection of data by agents from the farmers	Agent and farmers

		minimize the risk of disease outbreaks				
		Exclusively relying on natural food sources at the farms, utilizing Mustard Oil Cake (MOC) to promote plankton growth	Exogenous feeds are not used inhectares offarm area		Collection of data by agents from the farmers	Agent and farmers
		Completely avoiding the use of chemicals within the farms and utilizing lime to uphold water quality	Chemicals are not usedin hectares of farm area		Collection of data by agents from the farmers	Agent and farmers
		Regularly assessing water quality parameters at specific intervals to ensure the ponds' water quality is well-maintained	Number offarmers aremeasuring the pH andsalinity of their farms		Collection of data by agents from the farmers	Agent and farmers
		Conducting a study to investigate how leaf litter affects nutrient dynamics within the farms and identify plankton species that benefit the growth of shrimp and fish	Number of farms are studied the impact of leaf litter	**Impact assessment**	Collection of reports by agent and agencies	Agent and analyst
Implementing integrated mangrove aquaculture to	Long term	Land modification initiatives to extend pond	Land shaping done in hectares offarm area		Maintenance of record by the agent and the farm	Agent and farmer

facilitate the restoration of the Sundarbans' mangrove ecosystem		embankments and establish islands within the farms, designated for mangrove plantation				
		Installation of fencing around the farms to safeguard saplings from grazing	Fencing structure created in hectares offarm area		Maintenance of record by the agent and the farm	Agent and farmer
		Plantation of mangrove trees to restore the mangroves	Mangrove structure created in hectares offarm area		Collection of data by agent and implemented by farmer	Agent and farmer
		Assessment of the survival and growth of planted saplings on the farms and evaluating the potential for natural mangrove regeneration	Restoration of mangroves in hectares of mangrove area	**Performance monitoring**	Record keeping by agent	Agent
		Reduce the introduction of wild-caught shrimp seeds to safeguard ecosystem diversity and instead utilize hatchery-bred SPF organic black tiger shrimp seeds on the farms	Number ofhatchery-bred seeds stocked in the farms		Collection of data by agent and implemented by farmer	Agent and farmer
		Assess the diversity of beneficial algae in the farms for aquaculture	Abundanceof algal diversity inthe farms		Collection of reports by agents and agencies	Agent and analyst
		Evaluate the microbial diversity within	Number of microbes available inthe farms		Collection of reports by	Agent and analyst

		the farms that contribute to aquaculture benefits			agents and agencies	
		Assessing shifts in floral diversity following the BAP implementation	Number of flora increased/decreased after implementation of in the farms		Record keeping by agent	Agent
		Investigation of the increase in faunal diversity post-BAP implementation	Number of fauna increased/decreased after implementation of in the farms		Record keeping by agent	Agent
		Prevent the introduction of invasive alien fish/shrimp species into the farms	Number of invasive/alien species available in the farms	**Impact assessment**	Maintenance ofrecord by organizations	Corres-pondent
		Guard against the introduction of invasive alien fish/shrimp species into the farms	Number of species restored in and near the farms		Maintenance of record by organizations	Corres-pondent

5.9 STAKEHOLDER ENGAGEMENT

Collaborate with local communities, NGOs, and government agencies to ensure compliance and support for biodiversity conservation efforts:

Building a strong relationship with local communities involves not only sharing the farm's goals and addressing concerns but also offering opportunities for local employment and educational programs. Additionally, partnerships with environmental NGOs bring specialized expertise in biodiversity conservation and access to valuable resources. Engaging with government agencies through transparent communication and regulatory compliance demonstrates the farm's commitment to operating within environmental laws.

Seek third-party certifications, to validate responsible farming practices:

Certification, for instance, involves a thorough assessment of the farm's practices against sustainability standards, demonstrating dedication to environmental protection and ethical standards. Similarly, BAP certification evaluates environmental and social responsibility, assuring consumers and stakeholders of responsible farming practices. These certifications enhance the farm's reputation and marketability, providing independent verification of its commitment to high industry standards.

Research collaboration:

Collaborate with academic institutions and researchers to conduct studies that assess the environmental impact and effectiveness of conservation efforts. Sharing findings can contribute to broader knowledge and inform best practices.

Community feedback mechanisms:

Establish mechanisms for ongoing feedback from local communities and stakeholders. Regularly seek input and address concerns to maintain a positive relationship and demonstrate responsiveness to their needs.

6. Summary

The Biodiversity Action Plan (BAP aims to harmonize shrimp farming with mangrove conservation and enhance biodiversity, addressing the environmental challenges associated with shrimp farming expansion through Sustainable Aquaculture in Mangrove Ecosystem (SAIME) project in this unique and biodiverse area. The BAP incorporates strategies and measures such as site assessment, responsible farming practices, mangrove conservation, monitoring, stakeholder engagement, regulatory compliance, and educational outreach to protect and enhance biodiversity within SAIME. Customized BAPs for individual aquaculture farms tailor conservation measures to specific farm needs, promoting sustainability and coexistence between aquaculture and biodiversity, while addressing climate adaptation and community empowerment. This plan strives to ensure the long-term health of the biodiversity, ecosystem, and local communities while balancing economic activities with environmental conservation.

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