Regional Flyway Initiative · Site Study

January 2026

RFI Priority Site · Khlong Yai

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Asian Development Bank

General Site Information

Country	Thailand			
RFI Site Name	Khlong Yai			ID133
City/ Municipality, Province, Region	Khlong Yai town and district, Trat Province			
Geographical coordinates	11.78ºN, 102.88ºE		Area (has)	30,146 ha
Key species	Spotted Greenshank (EN)			
Key habitats (biomes)	Mangroves and intertidal mudflats.			
Key ecosystem services	Provisioning services			
Key drivers of change	Port activities and aquaculture			
Conservation status (mark all that applies)	☐	Protected Area	☐	Flyway Network Site
	☐	Ramsar Site	☐	Others _____
IBA/ KBA name (and number) and other designations	NA			
Management Stakeholders	Khlong Yai town and *tambon* government. DMCR, DWR, ONEP and fishery cooperatives.			
With management plan?				
Project concept themes	Sustainable fisheries, coastal wetland management.			
Length of project	6 years			
Sector/s	Fisheries			
No. of potential beneficiaries				
Indigenous Peoples	☒	No	☐	Yes _____
Anticipated Implementation Risks	Potential impacts on migratory species with poorly planned restoration works.			
Estimated Project Budget (US$)	8,350,000			
Potential Source/s of Financing	☒	Loan (to be identified)	☐	Private Sector
	☒	Grant (to be identified)	☐	Public-Private Partnership

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Acronyms

ADB	Asian Development Bank
AWC	Asian Waterbird Census
BCST	Bird Conservation Society of Thailand
CREL	Climate Resilient Ecosystems and Livelihoods
CSR	Conservation Status Review
DOF	Department of Fisheries
DMC	Developing Member Country
DMCR	Department of Marine and Coastal Resources
DWR	Department of Water Resources
EAAFP	East Asian-Australasian Flyway Partnership
ECA	Ecologically Critical Area
IBA	Important Bird and Biodiversity Area
IUCN	International Union for the Conservation of Nature
NGO	Non-governmental Organisation
ONEP	Office of Natural Resources and Environmental Policy
RFI	Regional Flyway Initiative
TAO	*Tambon* Administrative Organisation
TESSA	Toolkit for Ecosystem Services Assessment
USAID	United States Agency for International Development
USD	United States Dollars

Executive summary

The Khlong Yai (30,146 ha) coastline spans the eastern Inner Gulf of Thailand and is situated on the seaward side of Trat province along the international border with Cambodia. Khlong Yai comprises extensive areas of intertidal flats, mangrove forests and inshore waters around the town (*mueang*) and district (*amphoe*) of Khlong Yai and has been recently identified to provide feeding and roosting habitat for migrant waterbirds. The site has recently been found to support significant numbers of Spotted Greenshank (*Tringa guttifer*) EN and Tibetan Sandplover (*Anarynchus atrifrons*) LC, while a further eight species are globally Near Threatened or globally threatened. At present, there are no management structures or formal protection in place for Khlong Yai at either the local or national level although scoping work under the RFI project has identified important sections of the coast for its mangrove cover and key areas of intertidal flats used by migratory species.

Khlong Yai's coastal ecosystems offer important provisioning services through its coastal (fish) and crab fisheries and which benefit communities living along the Trat coastline, including significant numbers of migrant workers. Khlong Yai also provides key regulating services in the form of coastal protection – its contribution to reducing coastal risk as a percentage of the maximum potential exposure is modelled to be consistently above average (7.27% vs. 5.44% for RFI coastal sites and 3.92% for all other coastal areas in Thailand). The main source of economic activity for communities in Khlong Yai includes port and fishery work at a container port and more than 100 small fishing ports (for both fish and crabs).

Drivers of change for Khlong Yai arises from port activities, pollution, and habitat degradation. Stakeholders noted that its ports with large-scale loading and unloading of goods contributes to habitat disturbance and pollution while shipping infrastructure further modify the site's water flow and connectivity. Over time, the site is also vulnerable to sea level rise. RFI interventions at this site should aim to strengthen community and habitat resilience to climate change impacts. This is expected to involve a multi-stakeholder approach to improving wetland management through mangrove restoration, biodiversity monitoring, and the development of a site management plan to guide long-term management interventions, alongside activities to address pollution arising from port activities and fisheries. To strengthen livelihoods and address declining coastal fisheries, initiatives are proposed to promote sustainable fishing and aquaculture practices, including capacity building/training programmes, microfinance, and the establishment of multi-stakeholder structures.

1. Background of the Regional Flyway Initiative

In July 2021, the Asian Development Bank made a commitment to develop a long-term Regional Flyway Initiative (RFI) in the East-Asian Australasian Flyway (EAAF) (Sovereign Project 55056-001) to protect and restore priority wetland ecosystems and the associated ecosystem services they provide in the EAAF, the most threatened migratory bird flyway globally. The Initiative is slated for implementation in nine ADB developing member countries (DMCs) in East, South and Southeast Asia: Mongolia, People's Republic of China (PRC), Bangladesh, Viet Nam, Cambodia, Philippines, Thailand, Malaysia and Indonesia. In 2023, the geographic scope of the RFI was further extended to two DMCs in Southeast Asia and the Pacific respectively, Lao PDR and Papua New Guinea.

The primary aim of the RFI is to enhance and expand the existing efforts in conserving and managing wetlands of the highest priority for migratory birds within the EAAF through innovative loan and grant financing, and at scale. Consultations and analyses over the development period help identify key interventions to strengthen the management of wetlands, enabling the implementation of nature-based solutions while strengthening biodiversity protection. Over time, the RFI seeks to leverage collaborative opportunities by developing partnerships among important stakeholders including national governments, civil society organizations, communities, regional organizations like the East Asian-Australasian Flyway Partnership (EAAFP), development agencies, the private sector, and other relevant entities.

Through the RFI Technical Assistance (TA) implemented over the RFI's development phase from 2021 to 2024, BirdLife International takes the lead in providing and coordinating technical support for development of the RFI. This is carried out in collaboration with the EAAFP and a consortium of international non-governmental organizations including Wetlands International and the Paulson Institute, as well as two universities, namely the University of Southampton, UK and the National University of Singapore. Over the development phase, the TA team undertook a site selection analysis to identify priority wetland sites in all 10 countries based on recent bird data benchmarked against internationally accepted criteria under the Convention on Wetlands of International Importance (or Ramsar Convention), EAAFP Flyway Network Sites and Important Bird and Biodiversity Areas (IBAs). The team further developed ecosystem services profiles for prioritised wetlands using a multi-pronged approach used the TESSA ecosystem services assessment tool, and data-driven modelling of water-based ecosystem services and stored carbon.

In Thailand, a total of 36 wetland sites, including several Asian Waterbird Census (AWC) count sites, were initially assessed through data analysis and expert consultation, of which 18 were short-listed for assessment. Of this pool of sites, twelve (12) were defined and identified to be RFI priority sites on the basis that they support more than 1% the flyway population of at least one EAAF migratory waterbird species. Nine (9) of the RFI sites identified are coastal wetlands, a consequence of the country's long coastline along the Gulf of Thailand and Peninsular Thailand, with the largest cluster of priority sites concentrated in the Inner Gulf of Thailand (four: Pak Thale-Laem Pak Bia, Khok Kham, Bang Pu, Khlong Tamru). 15 EAAF species exceeded the 1% threshold at the site level in Thailand, with species such as Spotted Greenshank exceeding 10% of the estimated population in just one site (Laem Pak Bia) on a

regular basis. Other species with important non-breeding populations in Thailand includes Spoon-billed Sandpiper, Great Knot, and Sarus Crane.

2. Site profile of Khlong Yai

Location: Khlong Yai town is the capital of Khlong Yai District, in Trat Province, eastern Thailand. It is located on the eastern coast of the Gulf of Thailand, on a narrow strip of territory belonging to Thailand. The town is very close to the border with Cambodia (eastwards from the site), which runs roughly parallel to the coast inland at a distance of about two kilometres. Khlong Yai's coastal plains rise steeply into the foothills of the Cardamom mountains, which defines and spans the international border between Thailand and Cambodia.

Area: The Khlong Yai RFI site covers an area of 30,146 ha, most of which is coastal waters.

Altitude: Sea level.

Geographical coordinates: 11.78ºN, 102.88ºE

Description of site: Khlong Yai is a coastal town, where intertidal flats and mangroves provide habitat for migratory waterbirds.

Site administration, management and land tenure: The wetlands at Khlong Yai are not formally protected and were only recently surveyed and demarcated. Since the discovery of an important population of Spotted Greenshank *Tringa guttifer* at this site (and several other key sites for the species), Bird Conservation Society of Thailand (BCST) have developed a project named *Securing the wintering grounds of the endangered Spotted Greenshank in Thailand*, which is strengthening scientific knowledge of the species, implementing nature conservation measures at its key sites, and advancing local engagement activities through education and outreach to secure the wetland habitats. The initiative has engaged the Khlong Yai fisheries group to build community participation in the conservation of migratory shorebirds and coastal wetlands at this RFI site. BCST is working with local stakeholders, ONEP and DMCR to promote wetland conservation and migratory waterbirds and has engaged local schools.

Social and economic values: A major economic activity at Khlong Yai is fishing. A new deep-sea port was constructed in Khlong Yai District and opened in 2015, and which is designed to support the growing international trade between Thailand and Cambodia; this major development is expected to impact the wetlands at the site.

Figure 1. Map of Khlong Yai, showing its boundary (in black) and location within Thailand (in pink) (data from EAAFP Site Information Sheet).

3. Biodiversity value of Khlong Yai

3.1. Key habitats

The wetlands at Khlong Yai are not formally protected and were only recently surveyed and demarcated. Khlong Yai is a coastal town, where intertidal flats and mangroves provide habitat for migratory waterbirds.

3.2. Importance of Khlong Yai for migratory waterbird species

Count data from the Thailand Shorebird Survey (2021-2022), supplemented by data on Spotted Greenshank from Zöckler et al. (2018), was used in the RFI analysis for Khlong Yai, and then compared against the EAAFP Conservation Status Review (CSR1) 1% population estimates to estimate a score for each species. Two species, notably the Spotted Greenshank (EN) and among the most imperilled shorebirds in Asia, were found to regularly exceed the 1% population estimate during this survey (Table 1).

Table 1. List of migratory species (based on the EAAFP list of species) with globally significant congregations in the Khlong Yai coastline.

Scientific name	IUCN	Average count	CSR1	CSR1 score
Tibetan Sandplover *Anarynchus atrifrons*	LC	470	300	1.6
Spotted Greenshank *Tringa guttifer*	EN	12	10	1.2

Eight further Threatened or Near Threatened migratory bird species have been found at the site in smaller numbers comprising; Bar-tailed Godwit (*Limosa lapponica*) NT, Black-tailed Godwit (*Limosa limosa*) NT, Asian Dowitcher (*Limnodromus semipalmatus*) NT, Great Knot (*Calidris tenuirostris*) EN, Red Knot (*Calidris canutus*) NT, Broad-billed Sandpiper (*Calidris falcinellus*) VU, Curlew Sandpiper (*Calidris ferruginea*) VU, and Red-necked Stint (*Calidris ruficollis*) NT.

3.3. Other notable biodiversity

There is little information available on the site, but it is possible that the coastal waters of Khlong Yai may support small numbers of Dugong *Dugong dugon*, given known occurrence of the species just across the international border in western Cambodia in Koh Kong Province.

4. Ecosystem services

4.1. Ecosystem services provided by Khlong Yai

The coastline of Khlong Yai overlaps with diverse wetland habitats along the Outer Gulf of Thailand, providing valuable provisioning, regulating, and cultural ecosystem services (Figure 2). The results from the RFI workshop[1] highlights the top ecosystem services provided by the site, emphasising their essential and non-substitutable nature (Table 2). Provisioning services, particularly food provision, benefit communities both within and adjacent to the site. This service has seen an increase in the past but is projected to decrease in the future. Genetic resources, benefiting distant communities, have experienced a decrease and are expected to continue declining. Regulating services such as storm hazard regulation and erosion regulation are crucial, primarily benefiting communities within the site. Storm hazard

[1] Asian Development Bank. (2023, November 27-29). Thailand: Wetland Ecosystem Services Workshop [Workshop]. Thailand. https://events.development.asia/learning-events/thailand-wetland-ecosystem-services-workshop

regulation has increased in the past and is projected to continue rising, while erosion regulation has remained stable and is expected to stay unchanged in the future. Cultural services, specifically knowledge systems and education, benefit adjacent communities. This service has remained unchanged in the past but is anticipated to increase in the future, emphasizing the site's growing importance for local knowledge and learning.

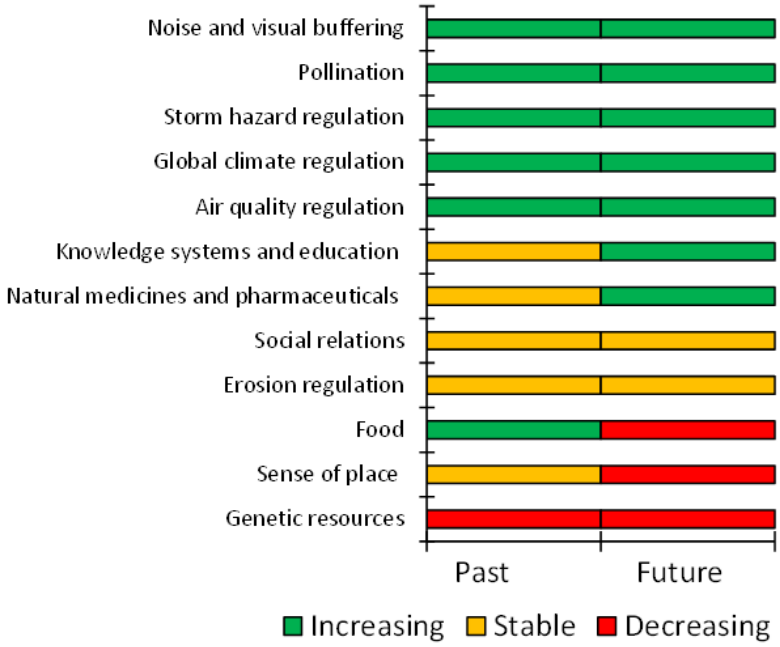

Figure 2. List of ecosystem services provided by Khlong Yai, as identified through stakeholder consultation at the Regional Flyway Initiative workshop.

Table 2. List of top ecosystem services provided by Khlong Yai's wetlands.

Ecosystem services	Essential or non-substitutable	Benefits to communities			Change	
		Within the site	Adjacent to the site	Distant to the site	Past	Future
Provision services						
Food	Yes	✓	✓		Increase	Decrease
Genetic resources	Yes			✓	Decrease	Decrease
Regulating services						
Storm hazard regulation	Yes	✓			Increase	Increase
Erosion regulation	Yes	✓			No change	No change
Cultural services						
Knowledge systems and education		✓			No change	Increase

4.2. Global climate regulating services

Based on systematic reviews (Chen and Lee, 2022; Stankovic et al., 2023), the amount of carbon stored in Khlong Yai is estimated to range from 3,330 to 17,300 tonnes, while the annual carbon sequestration rate is estimated to be between 52 and 462 tonnes per year.

4.3. Coastal protection services

The coastal protection services provided by Khlong Yai were assessed using both biophysical indices and monetary values (see Tables A1 and A2, and Annex 1 for details). When compared to both the average of the nine RFI coastal sites and the average of all other coastal areas in Thailand (Table A3 in Annex 1), Khlong Yai shows some only partly mixed results in terms of risk level:

(1) for the potential exposure to coastal hazards, Khlong Yai is consistently below average (index: 2.15 vs. 2.75 for RFI coastal sites and 2.70 for all other coastal areas);

(2) for the contribution to reducing coastal risk as a proportion of population density with 2.5 km of the coast, Khlong Yai is also below average (59 vs. 63 people/ha for RFI coastal sites and 30 people/ha for all other coastal areas); but

(3) for the contribution to reducing coastal risk as a percentage of the maximum potential exposure, Khlong Yai is consistently above average (7.27% vs. 5.44% for RFI coastal sites and 3.92% for all other coastal areas).

In monetary terms (Table A4 in Annex 1), Khlong Yai ranks well below the national RFI average (37 vs. 1,987 USD/ha) in terms of total annual benefits per ha of mangroves. Similarly, these benefits for the total area of Khlong Yai are also below average (0.3 vs. 1.8 million USD for RFI coastal sites and 0.8 million USD for all other coastal areas in Thailand).

5. Drivers of change and their potential impacts on Khlong Yai

5.1. Current drivers of change and their level of impact

Stakeholders at the RFI workshop[2] identified several drivers of change impacting Khlong Yai. Table 3 highlights these key drivers of change and their corresponding levels of impact on the wetland site. Medium-impact drivers include ports with large-scale loading and unloading of goods, which contribute to habitat disturbance and pollution. Shipping lanes and canals further modify the site's natural water flow and connectivity. Tourism and recreation infrastructure development also moderately impacts the wetland by introducing habitat fragmentation and disturbance.

Over time, sea-level rise may further impact the site. Norris *et al*. (2024) estimated that sea-level at the site will increase by 0.3m up to 2050 and 0.7m by the late century under a high emissions pathway. Under various scenarios there will be increased flooding, increased saline intrusion, changes to the extent of mangroves and changes to the available habitat for shorebirds. Temperatures are also expected to increase, exacerbating heat stress. Rainfall is likely to be more variable, with larger dry periods and increased rainfall in shorter timeframes. These effects will have impacts on both the biodiversity and on the resident population and will impact on livelihoods.

Table 3. Drivers of change and their potential impact on the integrity of Khlong Yai based on consultations with stakeholders.

Driver of change	Impact
Ports with large scale loading and unloading of goods	Medium
Shipping lanes and canals	
Tourism and recreation infrastructure	
Air-borne pollutants	Low
Earthquakes/tsunamis	
Excess energy	
Fishing, killing and harvesting of aquatic resources	
Garbage and solid waste	
Household sewage and urban wastewater from outside the wetland site	
Invasive animal species	
Invasive plant species	
Logging and timber harvesting	
Restoration for conservation	
Storm and flooding	
War, civil unrest and military exercises	

[2] Asian Development Bank. (2023, November 27-29). Thailand: Wetland Ecosystem Services Workshop [Workshop]. Thailand. https://events.development.asia/learning-events/thailand-wetland-ecosystem-services-workshop

5.2. Potential alternative state of Khlong Yai under current drivers of change

Stakeholders at the RFI workshop[3] defined the most plausible future alternative state (to 2035), and how this will translate to a net change in the cover of different types of wetland habitat types within this site (current habitat cover vs future alternative cover; Figure 3). The alternative state of the site assumes there will be no changes in the current drivers of change impacting the site, and the current management regime.

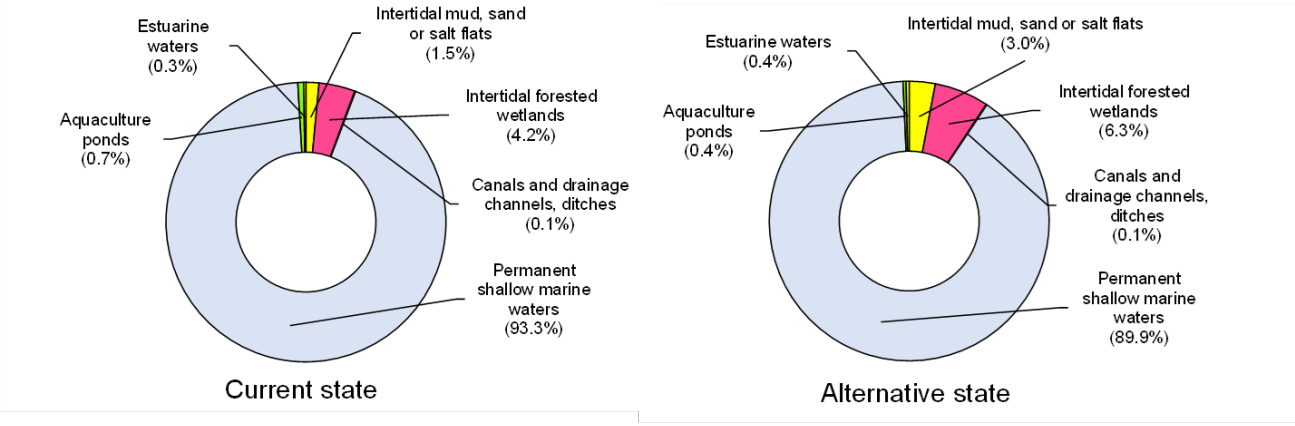

Figure 3. The proportional change in the extent of different habitat types between the current and alternative states of Khlong Yai.

5.3. Expected changes in the ecosystem services of Khlong Yai

Stakeholders at the RFI workshop[4] documented the future trends in the provision of ecosystem services in Khlong Yai, indicating if the ecosystem services provided by this site (to 2035) will increase, decrease, or will remain stable if the current drivers of change impacting this site will continue in their present condition, with the intervention remains unchanged.

Figure 2 and Table 2 highlight that provisioning services, particularly food provision, are expected to increase in the long term. However, there is concern that regulating services, such as air quality and global climate regulation, as well as flood and storm hazard regulations may decrease in the long term, while cultural services, particularly recreation and tourism, remain stable.

The Khlong Yai coastline overlaps with diverse wetland habitats, providing valuable provisioning, regulating, and cultural ecosystem services (Figure 2). The results from the RFI workshop[5] highlights the

[3] Asian Development Bank. (2023, November 27-29). Thailand: Wetland Ecosystem Services Workshop [Workshop]. Thailand. https://events.development.asia/learning-events/thailand-wetland-ecosystem-services-workshop

[4] Asian Development Bank. (2023, November 27-29). Thailand: Wetland Ecosystem Services Workshop [Workshop]. Thailand. https://events.development.asia/learning-events/thailand-wetland-ecosystem-services-workshop

[5] Asian Development Bank. (2023, November 27-29). Thailand: Wetland Ecosystem Services Workshop [Workshop]. Thailand. https://events.development.asia/learning-events/thailand-wetland-ecosystem-services-workshop

top ecosystem services provided by the site, emphasising their essential and non-substitutable nature (Table 2). Provisioning services, particularly food provision, benefit communities both within and adjacent to the site. This service has seen an increase in the past but is projected to decrease in the future. Genetic resources, benefiting distant communities, have experienced a decrease and are expected to continue declining. Regulating services such as storm hazard regulation and erosion regulation are crucial, primarily benefiting communities within the site. Storm hazard regulation has increased in the past and is projected to continue rising, while erosion regulation has remained stable and is expected to stay unchanged in the future. Cultural services, specifically knowledge systems and education, benefit adjacent communities. This service has remained unchanged in the past but is anticipated to increase in the future, emphasizing the site's growing importance for local knowledge and learning.

In the alternative state, the gain of mangrove (50%) and intertidal mudflat (100%) will result in a gain of stored carbon, estimated to be between 2,220 and 9,540 tonnes, and an increase in carbon sequestration rate (carbon accumulation) by approximately 34 to 239 tonnes per year.

A gain of 17.6 ha of mangroves as presented in Table A5, which is equivalent to 2% of the total land use for the site, is expected to result in roughly a 0.2% increase in coastal protection. This may amount to approximately 655 USD in gained total benefits per year (based on 37 USD per hectare of mangroves).

6. Capacity needs in Khlong Yai

The Khlong Yai RFI site is only recently identified as important for migratory species, but it currently lacks formal designation and recognition, unlike most other RFI sites. Local government agencies, including the town and TAO government are as yet unaware of the site’s importance to migratory species. There is a clear need to raise awareness of the wetlands and its value to local stakeholders through further consultations and work closely with the TAO government to demarcate the ecologically most valuable sector of this coastline for migratory species. The fishery industry is the single largest source of employment for coastal communities and migrant workers. Capacity interventions should aim to improve local stakeholders’ knowledge of the site, and also advance sustainable and environmentally friendly fishing practices, while promoting livelihood development for both local and migrant workers.

7. Opportunities for RFI interventions

7.1. Recommended Interventions

The most significant risks to the coast of Trat are related to human disturbance from ports, fishing, and pollution. The proposed interventions aim to mitigate these impacts through improved site management and monitoring, pollution control, and improving (and promoting) sustainable fishing practices for small-scale fishers operating on the Khlong Yai coastline.

Table 4. Summary of key RFI interventions proposed for Khlong Tamru (Bang Pakong)

Intervention	Outcome	Indicators	Cost (USD)	Timeframe	Potential Stakeholders
Component 1. Wetland habitat restoration and management					
Undertake environmental and social impact assessments	Best practices, guidelines, and standards for proposed RFI interventions	Environmental and social impact assessment report finalized and disseminated with key local stakeholders. Guidelines for evaluating proposed project components on their positive and negative impacts, taking into account local planning law, developed. Guidelines and standards for an iterative process on redesigning project components developed and implemented. Number of consultations conducted with local stakeholders for a participatory process in developing standard and	100,000	Up to 1.5 years.	ONEP DMCR DWR Khlong Yai (town) government Khlong Yai *tambon* government Consultancy companies

Intervention	Outcome	Indicators	Cost (USD)	Timeframe	Potential Stakeholders
		guidelines for project interventions Number of stakeholder groups engaged in the assessment and development of project interventions' guidelines			
Undertake hydrological and climate change impact assessment.	Best practices, guidelines, and standards for proposed RFI interventions	Hydrological and climate change impact assessment report that identify preferred areas for habitat restoration and build resilience across the site finalised and disseminated with key stakeholders. Number of consultations conducted with local stakeholders for a participatory process in the impact assessment study Number of stakeholder groups engaged in the impact assessment study	100,000	Up to 1.5 years.	
Restore targeted degraded mangrove forests and habitat along the Khlong Yai coast to improve climate resilience.	Improved management and conservation of Khlong Yai through increased mangrove cover along the Khlong Yai coast. Mangroves / other degraded habitat such as disused fishponds	Area (target of up to 50 ha) of degraded coastal habitat restored with suitable mangrove species. Coastal area (for at least XX km) protected using natural materials.	200,000	5 years	DMCR DWR Khlong Yai (town) government Khlong Yai tambon government Research institutions

Intervention	Outcome	Indicators	Cost (USD)	Timeframe	Potential Stakeholders
	and salt pans restored. Suitable nature-based solutions applied on the Trat coastline.	Number of stakeholder groups engaged in the mangrove restoration activities.			
Establish community-led site management organisations and committee	Improved management for Khlong Yai through community-led site management and organizations.	Multi-stakeholder management committee established Number of agreements for a coordinated management approach for the site among stakeholders established. Number of committee meetings conducted.	100,000	1.5 years	Khlong Yai (town) government Khlong Yai *tambon* government Conservation organisations (including BCST, BirdLife)
Establish OECM for Khlong Yai including a medium to long term site management plan. Strengthen site mitigation against the impacts of climate change.	Improved management for Khlong Yai through OECM establishment, site management, and climate change mitigation strategy.	Wetland management plan with threats, disturbance, and site conditions, developed, finalised and endorsed by government agencies and local stakeholders. Number of OECMs established. Number of consultations conducted with local stakeholders for a participatory process in the management planning Number of stakeholder groups engaged in the	100,000	5 years	

Intervention	Outcome	Indicators	Cost (USD)	Timeframe	Potential Stakeholders
		management planning.			
		Resilience strategy for local communities for climate change developed, approved and disseminated to key stakeholders Number of consultations conducted with local stakeholders for a participatory process in the resilience strategy. Number of stakeholder groups engaged in the resilience strategy	100,000	1 year	
Establish and implement a long-term community-led biodiversity monitoring programme.	Improved conservation of biodiversity through a biodiversity monitoring program and increased capacity of key stakeholders and community members for biodiversity monitoring	One biodiversity monitoring framework and programme focusing on key species indicators (e.g. Spotted Greenshank) established and implemented. A capacity-building program for the biodiversity monitoring framework. Number of people trained in biodiversity monitoring. Number of people engaged in biodiversity monitoring.	50,000	3 years	ONEP Research institutions (e.g. KMUTT) Conservation organisations (including BCST, BirdLife)

Intervention	Outcome	Indicators	Cost (USD)	Timeframe	Potential Stakeholders
		A biodiversity monitoring group established. Number of biodiversity monitoring activities implemented with regular field-based counts and assessments of threats Indicator species identified and included in the monitoring framework and program.			
Component 2. Improving water and pollution management					
Develop a wider environmental management plan for the Khlong Yai coast, including addressing pollution discharges from major pollutant sources e.g. industry, residences, ports (Khlong Yai and Kitrawan seaports).	Improved management for the Khlong Yai coast through an environmental management plan with guidance on land use and water pollution.	Environmental management plan with guidance on land use and water pollution for the Khlong Yai port and other polluting industries, finalized and approved by government agencies. Number of stakeholder groups engaged in the management planning. Number of consultations conducted with local stakeholders for a participatory process in the management planning.	150,000	3 years	DMCR DWR Khlong Yai (town) government Khlong Yai *tambon* government
Component 3. Strengthening local livelihoods for small-scales fishers and aquaculture businesses					

Intervention	Outcome	Indicators	Cost (USD)	Timeframe	Potential Stakeholders
Develop a co-management system for small-scale artisanal fisheries (to strengthen value chains) – as part of an existing large sustainable fisheries and coastal management program for Thailand. Improve livelihood and income-generating activities for local communities with a focus on small-scale fisheries (for mackerel).	Improved management for Khlong Yai through sustainable fisheries and coastal management, local fishing cooperatives, and livelihood opportunities. Improved provisioning services (for food resources, e.g. fish) Fishery resources are better managed and conserved.	A co-management framework and plan for small-scale fishers finalised and approved by Department of Fisheries and other government agencies. Number of community-led agreements on sustainable fishing practices, supported with improved storage and processing capability to increase market access and reduce wastage. Number (target of up to 150) of fishing households engaged in sustainable fisheries and coastal management across at least 10 fishing ports in Trat Number of fishing cooperatives and communities supported.	500,000	5 years	Fishery cooperatives Department of Fisheries Khlong Yai (town) government Khlong Yai *tambon* government Conservation organisations
Strengthen and promote sustainable management and production processes for crab aquaculture. Strengthen local resilience by improving local community	Standards for sustainable fishing practices introduced. Compliance mechanism with penalties and incentives developed. Microfinance facility established	Standards for sustainable fishing practices agreed and approved, including local certification, with key stakeholders. Compliance mechanism established.	500,000	6 years	Department of Fisheries Khlong Yai (town) government Khlong Yai *tambon* government Fishery cooperatives

Intervention	Outcome	Indicators	Cost (USD)	Timeframe	Potential Stakeholders
access to microcredit.	(or strengthened), with governance structures in place, and involving key stakeholders.	Skill training and financial training for fishery workers. Number of fishery workers engaged in sustainable fishing practices. Number of fishery workers trained on skills and financial management. A grant mechanism/ small loan scheme established. Number (up to 200) of households involved in aquaculture and fisheries benefitting from the grant and small loan scheme.			Aquaculture companies
Implement initiatives to promote gender inclusion, better work conditions, skill training and finance management for women and migrant workers (from Cambodia and Myanmar)	Improved management through inclusive conservation.	Assessment study to identify barriers, determine needs for job market entry and better working conditions for fishery workers, and next steps for inclusive practices finalized and disseminated with key stakeholders. Training program for up to 200 women from local and migrant communities to improve skills Number of people, focused on women and migrant workers, trained	100,000	2 years	Khlong Yai (town) government Khlong Yai *tambon* government Fishery cooperatives

Intervention	Outcome	Indicators	Cost (USD)	Timeframe	Potential Stakeholders
		Number of training activities implemented.			
Total investment for 6 years			**USD 8,350,000**		

7.2. Potential Financing

The estimated project cost is USD 8,350,000 over 6 years. This budget supports environmental and social impact assessments, mangrove restoration, establishment of co-management, site, and environmental management plans, promotion of sustainable fisheries and microfinancing, and capacity-building for local stakeholders in biodiversity monitoring, sustainable fishing, and financial management. Table 4 summarizes the projected budget distribution across the proposed project components.

If the proposed USD 200,000 investment over five years is allocated to restoring degraded coastal habitat along the Khlong Yai coastline, it could support the rehabilitation of up to 50 hectares of mangroves and other degraded areas such as disused fishponds and salt pans. With estimated coastal protection benefits of USD 37 per hectare annually (see Section 5.3), this intervention could yield approximately USD 1,850 in annual benefits—totalling over USD 9,250 over five years. This results in a benefit–cost ratio of just under 0.05:1 for the nature-based component alone, suggesting limited direct returns if coastal protection is considered in isolation. However, when paired with complementary measures—such as enhancing natural infrastructure using suitable materials along the Trat coastline—the intervention supports a hybrid, ecosystem-based approach to climate resilience. In addition to buffering Khlong Yai town and surrounding settlements from coastal hazards, restoration would contribute to broader ecological recovery and sustainable wetland management. Leaving these areas unrestored could prolong environmental degradation and reduce the long-term protective potential of the landscape.

7.3. Proposed Institutional Arrangement

The project is expected to be led and coordinated on-site by the town (and *tambon*) government, potentially with support from conservation organisations and national government agencies. The timeframe of the project is expected to span at least six years.

7.4. Project Beneficiaries

There are no indigenous peoples in this landscape. However, there are opportunities for improving working conditions for migrant workers (especially female workers from Cambodia) and building the capacity and skillsets of aquaculture and fishery workers, given the high proportion of migrant workers in the fisheries sector in Trat.

7.5. Anticipated Implementation Risks

Stakeholder engagement: Proposed interventions rely on support from local communities, particularly in adopting sustainable fisheries, co-management, and inclusive conservation. Establishing strong stakeholder buy-in from local leaders and community engagement will facilitate better implementation of the proposed interventions.

Environment: Undertaking various assessments to better understand local conditions will ensure that restoration efforts are appropriate to those conditions. To address the project's socioeconomic impacts, scoping studies on gender and the wider benefits and risks to local communities are proposed. There is a genuine risk that coastal restoration work, if poorly designed and managed, may result in biodiversity loss, including increased disturbance to migratory shorebirds.

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Annex 1. Supplementary information on coastal protection services

To further validate the identification of the top ecosystem services by means of stakeholder consultation, an expectedly essential or non-substitutable regulating service across all RFI sites, namely coastal protection and flood mitigation (i.e., storm and flood hazard regulation), was assessed based on a combination of globally available datasets supplemented by web-based tool Co$tingNature (Mulligan, 2022). Estimates for coastal protection by mangroves (after the effects of coral reefs) were spatially inferred in QGIS from a selection of metrics expressing different biophysical and monetary values modelled by Chaplin-Kramer et al. (2023) and Menéndez et al. (2020), respectively.

The key metrics selected for biophysical values (Table A1) were current maximum potential exposure to coastal hazards, which is a vulnerability risk index calculated in InVEST[1] for several hazard variables (i.e., wind, waves, sea level rise, geomorphology, and bathymetry) in the hypothetical absence of current mangrove extent, and nature's (i.e., the mangroves') contribution to reducing this coastal risk, both as an absolute value multiplied by the local population affected and a percentage of the maximum potential exposure.

Table A1. Contribution of mangroves to coastal protection as a critical natural asset in Khlong Yai based on site-level (biophysical) values inferred from Chaplin-Kramer et al. (2023) and expressed as ranges to represent the resulting uncertainty. Key metrics are in italics.

Critical contribution of mangroves to coastal protection (metrics)	**Risk levels**
Current population density within 2.5 km of the coast (number of people per hectare)	371 – 388
Current maximum coastal risk to be mitigated, or potential exposure to coastal hazards (unitless index)	*2.09 - 2.22*
Maximum coastal risk to be mitigated, or potential exposure to coastal hazards in 2050 according to IPCC's Shared Socioeconomic Pathway #1 'Sustainability' (unitless index)	2.34 - 2.49
Maximum coastal risk to be mitigated, or potential exposure to coastal hazards in 2050 according to IPCC's Shared Socioeconomic Pathway #3 'Regional Rivalry' (unitless index)	2.51- 2.67
Maximum coastal risk to be mitigated, or potential exposure to coastal hazards in 2050 according to IPCC's Shared Socioeconomic Pathway #5 'Fossil-fueled Development' (unitless index)	2.73 - 2.90
Current proportional risk reduction, nature's contribution to reducing coastal risk as a proportion of maximum coastal risk (unitless index)	0.12 - 0.20
Nature's contribution to reducing coastal risk as a proportion of population density within 2.5 km of the coast (# of people per hectare)	*44 - 75*
Nature's contribution to reducing coastal risk as a percentage of the maximum potential exposure (%)	*5.36 - 9.18*

The key metrics selected for economic values (Table A2) were the annual expected flood protection benefits to total stock, which is the monetary value of the averted damages to the industrial and residential stocks (i.e., property) in 2015 US$, the same total annual benefits expressed per hectare of mangroves, and the total benefits in the event of a 100-year return period storm, which are the rarest of

cyclonic conditions but cause the most flood damages to property (i.e., maximum level of coastal protection by mangroves).

Table A2. Coastal protection benefits offered by mangroves in Khlong Yai based on site-level (monetary) values inferred from Menéndez et al. (2020) and expressed as ranges to represent the resulting uncertainty. Key metrics are in italics.

Benefits of mangroves in terms of coastal protection (metrics)	**Avoided costs (US$)**
Mangrove extent (hectares)[2]	134 – 5,906
Annual expected flood protection benefits to people (number of people)	195 – 247
Annual expected flood protection benefits to Industrial Stock (US$)	166,988 – 211,327
Annual expected flood protection benefits to Residential Stock (US$)	116,635 – 147,604
Annual expected flood protection benefits to Total Stock (US$)	*263,968 – 334,058*
Annual expected flood protection benefits to Industrial Stock per hectare of mangroves (US$ per hectare)	*33 – 42*
1-in-100-year return period damage in terms of area flooded (number of hectares)	0
Total expected flood protection benefits of mangroves per 100-year return period storms (US$)	*0*

Table A3. Biophysical benefits from RFI coastal wetland sites (expressed as ranges to represent the resulting uncertainty) and at the national level.

Site name	**Max pot exp (index)**	**Risk reduction (index * pop)**	**Risk reduction (% max pot exp)**
Bang Pu	No Data	No Data	No Data
Khlong Tamru (Bang Pakong)	3.22 (±0.17)	147 (±39)	4.87 (±0.25)
Khlong Yai	2.15 (±0.07)	59 (±16)	7.27 (±1.91)
Koh Kham	3.02 (±0.09)	0 (±0)	5.18 (±0.16)
Ta Libong	2.63 (±0.07)	21 (±1)	6.21 (±0.34)
Krabi Estuary	2.69 (±0.07)	17 (±1)	5.68 (±0.28)
Pak Nam Prasae	2.63 (±0.20)	53 (±1)	5.94 (±0.44)
Pak Thale	3.23 (±0.08)	28 (±8)	3.36 (±0.85)
Ao Phang Nga	2.45 (±0.10)	12 (±1)	6.02 (±0.35)
Thailand RFI average	2.75	63	5.44
Thailand national average	2,70	30	3.92

Table A4. Monetary benefits from RFI coastal wetland sites (expressed as ranges to represent the resulting uncertainty) and at the national level.

Site name	Total annual benefits (US$)	Per mangrove area (US$/ha)	For 100-yr return period storms (US$)
Bang Pu	723,608 (±1,023,384)	985 (±1,393)	1,252,086 (±1,252,144)
Khlong Tamru (Bang Pakong)	4,064,792 (±101.810)	1,698 (±43)	1,028,638 (±46,938)
Khlong Yai	299,013 (±35,045)	37 (±4)	0 (±0)
Koh Kham	9,699,944 (±5,444,336)	12,815 (±7,193)	17,562,472 (±14,369473)
Ko Libong and Hat Chao Mai	0 (±0)	0 (±0)	3,564,916 (±55,274)
Krabi Estuary	0 (±0)	0 (±0)	4,150,201 (±45,319)
Pak Nam Prasae	557,410 (±3,584,456)	300 (±1,929)	1,464,757 (±2,408,230)
Pak Thale	806,609 (±1,685,154)	1,967 (±4,109)	962,707 (±1,130,299)
Ao Phang Nga	81,744 (±96,861)	86 (±102)	5,723,399 (±12,351,015)
Thailand RFI average	1,803,680	1,987	3,967,686
Thailand RFI total	16,233,119	Not Applicable	18,146,703
Thailand national average	789,242	2,702	9,197,142
Thailand national total	85,257,773	Not Applicable	377,082,842

Table A5. Key habitat types in Khlong Yai based on stakeholder-based assessment at the Regional Flyway Initiative workshop in November 2023.

Habitat type	Current state		Alternative state (2035)	
	Area (ha)	Cover (%)	Area (ha)	Cover (%)
Intertidal mud, sand or salt flats	12.6	1.5	25.3	3.0
Intertidal forested wetlands	35.3	4.2	52.9	6.3
Canals and drainage channels, ditches	0.9	0.1	0.8	0.1
Permanent shallow marine waters	786.9	93.3	758.4	89.9
Aquaculture ponds	5.6	0.7	3.0	0.4
Estuarine waters	2.2	0.3	3.0	0.4
Total	843.4	100.0	843.4	100.0