Regional Flyway Initiative · Site Study

January 2026

RFI Priority Site · Khlong Tamru (Bang Pakong)

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General Site Information

Country	Thailand			
RFI Site Name	Khlong Tamru			ID132
City/ Municipality, Province, Region	Khlong Tamru, Chon Buri District (*mueang*), Chon Buri Province			
Geographical coordinates	13.48ºN, 100.94ºE		Area (has)	3,000 has
Key species	Spotted Greenshank (EN)			
Key habitats (biomes)	Mangroves and intertidal mudflats.			
Key ecosystem services	Regulating services			
Key drivers of change	Industrial and wastewater pollution, infrastructure expansion			
Conservation status (mark all that applies)		Protected Area		Flyway Network Site
		Ramsar Site		Others _____
IBA/ KBA name (and number) and other designations	Inner Gulf of Thailand			
Management Stakeholders	Department of Water Resources, Department of Marine and Coastal Resources, Bang Pakong River Basin Committee, Khlong Tamru TAO			
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. Construction of water and ecotourism infrastructure may impact wildlife.			
Estimated Project Budget (US$)	13,000,000			
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
DMC	Developing Member Country
DMCR	Department of Marine and Coastal 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
OECM	Other Effective area-based Conservation Measure
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

Khlong Tamru and the Bang Pakong River mouth (3,000 ha) is a coastal site in the north-eastern part of the Gulf of Thailand on the border of Chon Buri and Chachoengsao provinces. It comprises, a mosaic of estuarine and intertidal mudflats, mangrove and *Nypa* palm stands, saltpans, aquaculture ponds, and brackish marshes. Khlong Tamru lies within the wider Inner Gulf of Thailand Important Bird Area (IBA), supporting high congregations of migratory species. Khlong Tamru supports at least two waterbirds' species exceeding 1% of the population thresholds, alongside species of conservation concern such as the Spot-billed Pelican *Pelecanus philippensis* (NT), Curlew Sandpiper *Calidris ferruginea* (NT), Spoon-billed Sandpiper *Calidris pygmaea* (CR), Red-necked Stint *Calidris ruficollis* (NT) and Spotted Greenshank *Tringa guttifer* (EN). There are not protected area within Khlong Tamru although some areas of salt pans may receive nominal protection from local people. Regulating services from flood protection, water quality and salinity control were considered the most important ecosystem services for Khlong Tamru and the Bang Pakong River Mouth while cultural services through heritage and recreation were also rated highly.

Presently, the main economic activities in Khlong Tamru are aquaculture, fisheries (fish and shellfish), salt production and to a lesser extent, timber and non-timber forest products. There has been increasing pressure on the site as result of developments in the surrounding areas and upriver areas of the Bang Pakong through large scale industrial development and settlements given the site's location in Thailand's eastern economic corridor. Industrial and residential activity upstream from the site has resulted in increased pollution from effluent and wastewater while infrastructural expansion at Khlong Tamru, including road expansion is expected to encroach and impact some areas of wetlands, including a site known to be important for the Spotted Greenshank. Overall, the site is low-lying and is extremely vulnerable to climate change and sea-level rise. A dam to prevent saline ingress to the Bang Pakong River has resulted in reduced sediment flow into the estuary and increased erosion.

Important interventions to improve the condition of the site is the better management of the Bang Pakong River through reducing wastewater and solid-waste pollution, and improved dam management. There are also opportunities to engage local communities to maintain the traditional production of salt from salt pans, through incentives and community-driven initiative, alongside work to expand wetland restoration work with a focus on 'mangrove zones' as nature-based solutions to strengthen shoreline stability at suitable areas, notwithstanding the coastal erosion challenges. This can be complemented by work to enable, and up-scale the (economic) infrastructure nature-based tourism, through capacity building and expansion of tourism infrastructure (some areas are highly visited by local birdwatchers). One other important intervention is to promote the biodiversity-friendly approaches to aquaculture (for shellfish and fish) through incentives, further training and mechanisms to provide credit for local communities to undertake changes to aquaculture practices.

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 Tamru (Bang Pakong)

Location: The Khlong Tamru RFI site includes the Bang Pakong River mouth, and the nearby salt pans and fishponds. It is located in Chonburi Province, in the northeastern part of the Inner Gulf of Thailand, about 70 km southeast of central Bangkok.

Area: The Khlong Tamru RFI site covers an area of approximately 3,000 ha.

Altitude: Sea level.

Geographical coordinates: 13.48ºN, 100.94ºE

Description of site: This site includes an area of saltpans and fishponds, with intertidal mudflats along the adjacent shoreline and areas of brackish marshes with low scrub. The area formerly supported extensive mangroves but only remnants remain, as the largest areas have been cleared and replaced by the saltpans and aquaculture. The human population level is extremely high and there is an increasing amount of industry and other developments.

Site administration, management, and land tenure: Khlong Tamru (Bang Pakong) is not a formally protected area. The wetlands are mostly state-owned, and the saltpans and fishponds are occupied by operators (either legally or illegally). The surrounding areas are privately owned farmland and households. There have been ongoing community-led conservation efforts, including lobbying to register wetlands in the area as a Ramsar Site (Parr et al. 2012, Chaiyarak *et al.* 2019).

Social and economic values: The main economic activities in Khlong Tamru (Bang Pakong) include fishing from boats using trawl nets and gill nets, salt production from saltpans, and aquaculture for penaeid prawns. The area is also a rich source of crabs and shellfish, and there is an important fishery for Green Mussel *Perna viridis* at the mouth of the Bang Pakong River. Fruits of the *Nypa* palm are harvested for food and mangroves are cut for pulpwood (used in construction and fencing) and for charcoal production. The land uses in adjacent areas include cultivation of wet-season rice, coconuts, orange groves and vegetables, and housing and industry. The wetlands in the Inner Gulf of Thailand make an immense contribution to the living standards of the local inhabitants and the people of Bangkok, as a source of seafood through its vast aquaculture industries and raw materials.

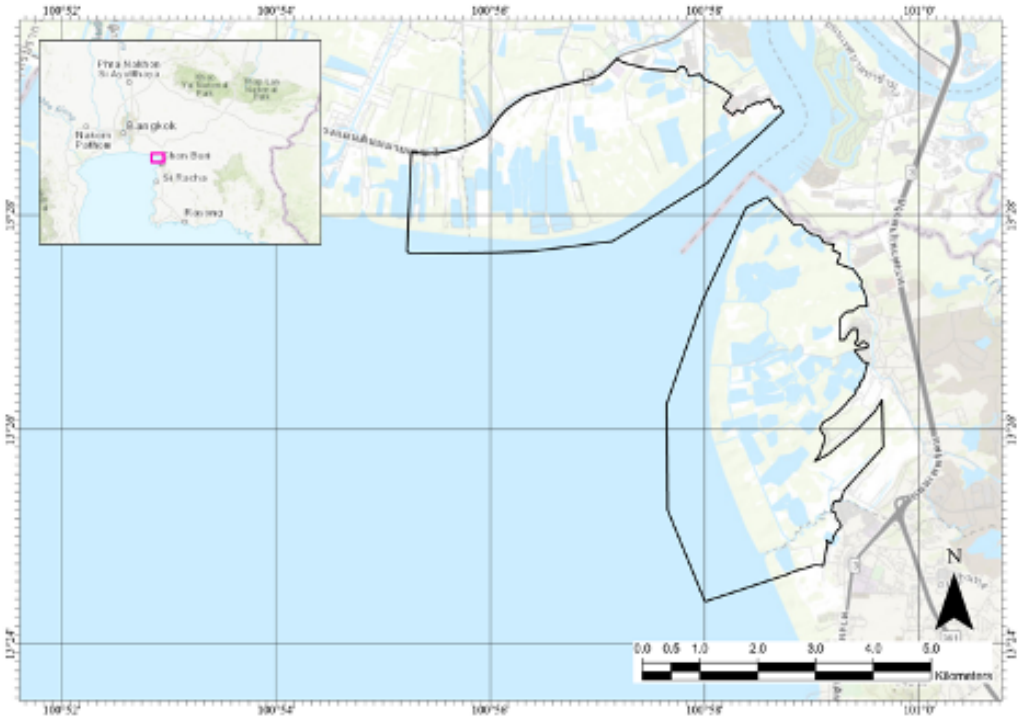

Figure 1. Map of Khlong Tamru (Bang Pakong), showing its boundary (in black) and location within Thailand (in pink) (Map: Evelyn Pina Covarrubias; data from EAAFP Site Information Sheet).

3. Biodiversity value of Khlong Tamru (Bang Pakong)

3.1. Key habitats

This site includes an area of saltpans and fishponds, with intertidal mudflats along the adjacent shoreline and areas of brackish marshes with low scrub. The area formerly supported extensive mangroves but only remnants remain, as the largest areas have been cleared and replaced by the saltpans and aquaculture.

3.2. Importance of Khlong Tamru (Bang Pakong) for migratory waterbird species

Khlong Tamru (Bang Pakong) holds international importance as a staging and wintering area for shorebirds. Count data from the 2017 and 2018 Asian Waterbird Census (AWC) and the Thailand Shorebird Survey 2021-2022, supplemented by data on Spotted Greenshank from Zöckler et al. (2018), was averaged

in the RFI analysis for Khlong Tamru (Bang Pakong), and then compared to the Conservation Status Review (CSR1) 1% population estimates to calculate a score for each species. Two species were found to regularly exceed the 1% population estimate over these three years (Table 1), and the CSR1 score for these species was summed to provide the overall site score. In total 21 globally threatened and near-threatened waterbird species have been recorded at Khlong Tamru (Bang Pakong). The site supports five species in significant numbers; Spot-billed Pelican *Pelecanus philippensis* (NT), Curlew Sandpiper *Calidris ferruginea* (NT), Spoon-billed Sandpiper *Calidris pygmaea* (CR), Red-necked Stint *Calidris ruficollis* (NT) and Spotted Greenshank *Tringa guttifer* (EN). Additionally, 16 have been recorded in lower numbers; Grey Plover (VU), Far Eastern Curlew (EN), Eurasian Curlew (NT), Bar-tailed Godwit (NT), Black-tailed Godwit (NT), Asian Dowitcher (NT), Long-billed Dowitcher (NT), Ruddy Turnstone (NT), Great Knot (EN), Red Knot (NT) Broad-billed Sandpiper (VU), Sharp-tailed Sandpiper (VU), Dunlin (NT), River Lapwing (NT), River Tern (VU) and Milky Stork (EN).

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 *Anarhynchus atrifrons*	LC	754	300	2.5
Ruff *Calidris pugnax*	LC	7	7	1.0

3.3. Other notable biodiversity

Several globally threatened mammal and fish species occur at Khlong Tamru (Bang Pakong), including Irrawaddy dolphin *Orcaella brevirostris* (EN) and Largetooth Sawfish *Pristis pristis* (CR). To protect the Irrawaddy dolphins, fishermen on the Bang Pakong River have been persuaded by authorities to stop shrimping and 30 to 40 fishing boats have been modified so they can offer dolphin sightseeing tours.

4. Ecosystem services

4.1. Ecosystem services provided by Khlong Tamru (Bang Pakong)

Khlong Tamru (Bang Pakong) overlaps with diverse wetland habitats, offering valuable regulating and cultural ecosystem services (Figure 2). The results from the RFI workshop[1] highlight the top ecosystem services provided by the site, emphasising their essential and non-substitutable nature (Table 2). Regulating services, such as flood hazard regulation, water purification and waste treatment, and salinity regulation, benefit communities within, adjacent to, and, in the case of salinity regulation, distant from the site. These services have shown an increase in the past; however, they are projected to decrease in the future, indicating potential challenges for environmental health and resilience. Cultural services, including cultural identity and heritage, as well as recreation ecotourism, significantly benefit communities at all distances. Cultural identity and heritage have remained stable in both the past and future. In contrast, recreation ecotourism has experienced an increase in the past and is expected to continue growing in the future, underscoring the site's importance for both local enjoyment and broader tourism.

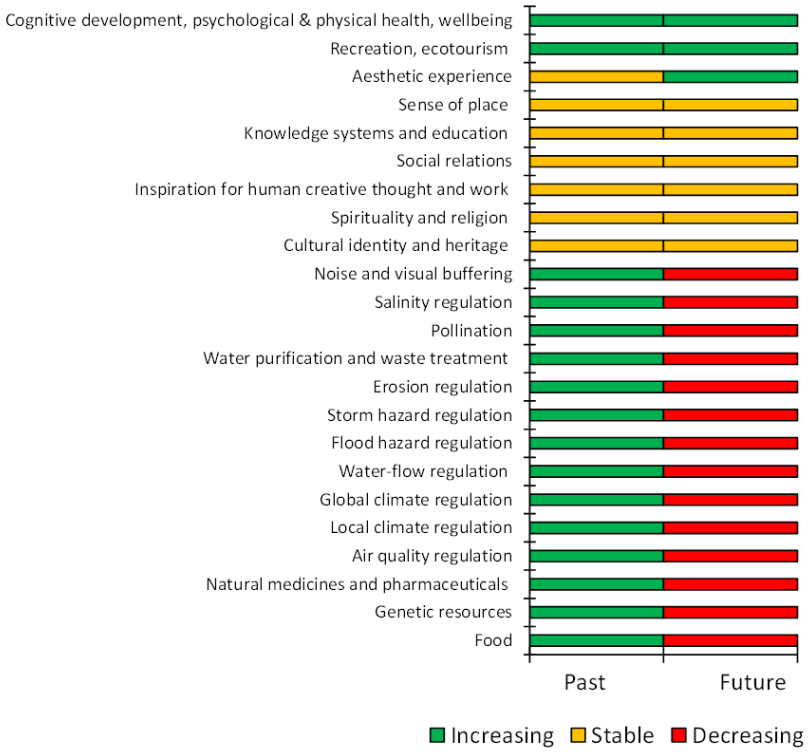

Figure 2. List of ecosystem services provided by Khlong Tamru (Bang Pakong), as identified through stakeholder consultation at the Regional Flyway Initiative workshop.

[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

Table 2. List of top ecosystem services provided by Khlong Tamru (Bang Pakong).

Ecosystem services	Essential or non-substitutable	Benefits to communities			Change	
		Within the site	Adjacent to the site	Distant to the site	Past	Future
Regulating services						
Flood hazard regulation	Yes	✓	✓		Increase	Decrease
Water purification and waste treatment	Yes	✓	✓		Increase	Decrease
Salinity regulation	Yes	✓	✓	✓	Increase	Decrease
Cultural services						
Cultural identity and heritage	Yes	✓	✓	✓	No change	No change
Recreation, ecotourism	Yes	✓	✓	✓	Increase	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 Tamru (Bang Pakong) is estimated to range from 90,600 to 220,000 tonnes, while the annual carbon sequestration rate is estimated to be between 1,370 and 3,800 tonnes per year.

4.3. Coastal protection services

The coastal protection services provided by Khlong Tamru (Bang Pakong) 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 Tamru shows some fairly consistent results in terms of risk level:

(1) for the potential exposure to coastal hazards, Khlong Tamru is consistently above average (index: 3.22 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 Tamru is also above average (147 vs. 63 people/ha for RFI coastal sites and 30 people/ha for all other coastal areas); and

(3) for the contribution to reducing coastal risk as a percentage of the maximum potential exposure, Khlong Tamru is below average compared to RFI coastal sites (4.87% vs. 5.44%) but again above average compared to all other coastal areas (4.87% vs. 3.92%).

In monetary terms (Table A4 in Annex 1), Khlong Tamru ranks slightly below the national RFI average (1,698 vs. 1,987 USD/ha) in terms of total annual benefits per ha of mangroves. At the same time, these benefits for the total area of Khlong Tamru are consistently above average (4.0 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 Tamru (Bang Pakong)

5.1. Current drivers of change and their level of impact

Of all the wetland areas along the Bang Pakong River and its estuary, Chaiyarak *et al.* (2019) considered the estuary to be at highest risk, with infrastructure development, pollution, wastewater and sensitivity to water level changes being significant factors affecting the site; the Mangrove and *Nypa* forests are also affected by land use change and development, though restoration efforts have helped to reduce the impacts. However, the Bang Pakong dam has reduced sediment flow into the estuary and exacerbated riverbank collapse, and thus there may be a contradiction between mangrove planting and erosion.

Stakeholders at the RFI workshop[2] further identified several drivers of change impacting Khlong Tamru. High-impact drivers include activities of site managers, which significantly modify the wetland's natural state (Table 3). Commercial and industrial areas, along with dams and hydrological modifications, further alter water flow and habitat conditions, while driving habitat loss. The expansion of industrial development and road infrastructure in Nong Mai Deng, a well-known habitat for roosting shorebirds including the Spotted Greenshank is expected to drive further land-use change and habitat loss for biodiversity (insert citation). Additional high-impact factors include erosion and siltation, fishing and harvesting of aquatic resources, garbage and solid waste accumulation, habitat clearing, and household sewage and urban wastewater. Development activities, such as housing and settlement, increase fragmentation within the wetland, while industrial mining, logging, and loss of hydrological connectivity exacerbate habitat degradation. Marine and freshwater aquaculture, sewage from site facilities, and other edge effects also pose substantial threats to the ecosystem.

Medium-impact drivers encompass air-borne pollutants, droughts, and hunting of terrestrial animals, which affect both habitat quality and biodiversity. Invasive species (both plant and animal), loss of keystone species, and recreational activities, including tourism infrastructure, moderately modify the wetland. Other medium-impact factors include shipping lanes, canals, storm and flooding events, temperature extremes, and agricultural and forestry effluents.

[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

Table 3. Drivers of change and their potential impact on the integrity of Khlong Tamru (Bang Pakong) based on consultations with stakeholders.

Driver of change	Impact
Activities of site managers	High
Commercial and industrial areas	
Dams, hydrological modification and water management/use	
Erosion and siltation/deposition	
Fishing, killing and harvesting of aquatic resources	
Garbage and solid waste	
Habitat clearing	
Household sewage and urban wastewater from outside the wetland site	
Housing and settlement	
Increased fragmentation within the wetland site	
Industrial, mining and military effluents	
Isolation from other natural habitats	
Logging and timber harvesting	
Loss of hydrological connectivity	
Marine and freshwater aquaculture	
Other 'edge effects' that degrade the wetland site values	
Sewage and wastewater from wetland site facilities	
Air-borne pollutants	Medium
Droughts	
Hunting, killing and collecting of terrestrial animals	
Invasive animal species	
Invasive plant species	
Loss of keystone species	
Recreational activities and tourism	
Shipping lanes and canals	
Storm and flooding	
Temperature extremes	
Tourism and recreation infrastructure	
Agricultural and forestry effluents	Low
Annual and perennial non-timber crop production	
Collecting terrestrial plants or plant products (non-timber)	
Research, education and other work-related activities	
Restoration for conservation	
Wood pulp and plantations	

Low-lying coastal sites are at risk from the effects of climate change effects, implications for Bang Pakong vary depending on the models and assumptions used. For example, Chaiyarak *et al.* (2019) suggest that sea level will increase by 0.2m by 2049, whereas Norris *et al*. (2024) indicate 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 the scenarios both studies there will be increased flooding, increased saline intrusion, changes to the extent of mangroves and changes to the available area for sea-bird food foraging. 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.

5.2. Potential alternative state of Khlong Tamru (Bang Pakong) 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.

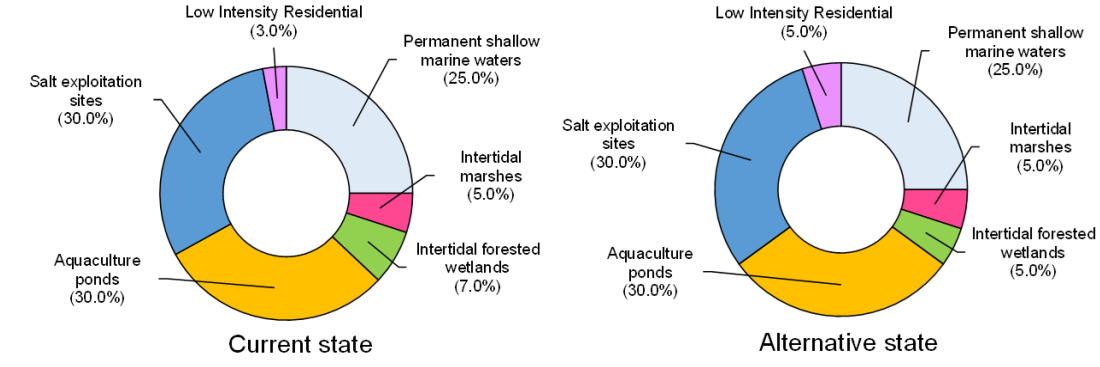

Figure 3. The proportional change in the extent of different habitat types between the current and alternative states of Khlong Tamru (Bang Pakong).

[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

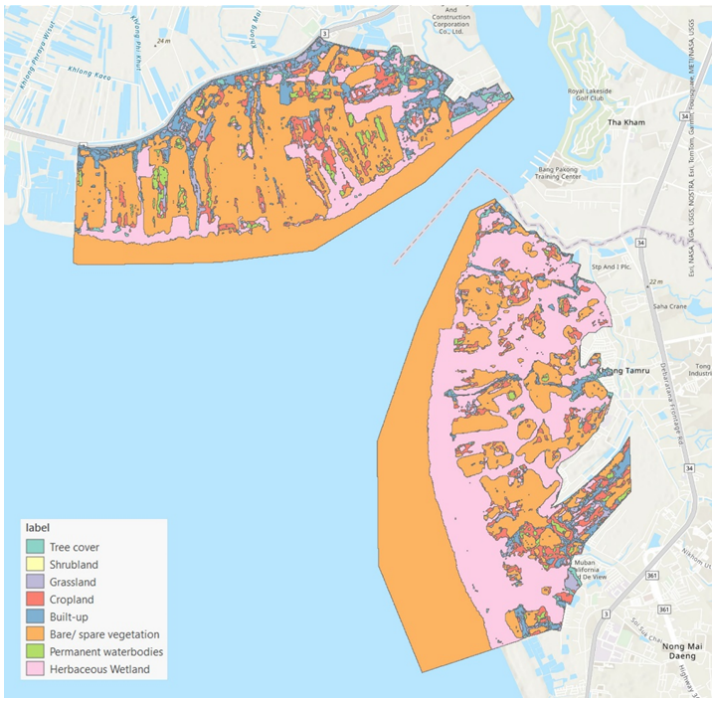

Figure 4. Land cover in the Khlong Tamru coastal wetland based on remote sensing (Map: Radhika Bhargava)

5.3. Expected changes in the ecosystem services of Khlong Tamru (Bang Pakong)

Stakeholders at the RFI workshop[4] documented the future trends in the provision of ecosystem services in Khlong Tamru (Bang Pakong), 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.

Provisioning services, particularly food provision, are expected to increase in the long term (Figure 2 and Table 2). 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.

Khlong Tamru (Bang Pakong) overlaps with diverse wetland habitats, offering valuable regulating and cultural ecosystem services (Figure 2). The results from the RFI workshop[5] highlights the top ecosystem services provided by the site, emphasising their essential and non-substitutable nature (Table 2). Regulating services, such as flood hazard regulation, water purification and waste treatment, and salinity regulation, benefit communities within, adjacent to, and, in the case of salinity regulation, distant from

[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

the site. These services have shown an increase in the past; however, they are projected to decrease in the future, indicating potential challenges for environmental health and resilience. Cultural services, including cultural identity and heritage, as well as recreation ecotourism, significantly benefit communities at all distances. Cultural identity and heritage have remained stable in both the past and future. In contrast, recreation ecotourism has experienced an increase in the past and is expected to continue growing in the future, underscoring the site's importance for both local enjoyment and broader tourism.

In the alternative state, the 29% loss of mangrove will result in a loss of stored carbon, estimated to be between 3,790 and 26,200 tonnes, and a decrease in carbon sequestration ~~rte~~ (carbon accumulation) by approximately 60 and 754 tonnes per year.

A loss of 59.7 ha of mangroves (see Table A5) which is equivalent to only 2% of the total land use for the site, is expected to result in roughly a 2.5% reduction in coastal protection. This may amount to approximately 101,000 USD in lost total benefits per year (based on 1,698 USD per hectare of mangroves) and 26,000 USD in lost total benefits per 100-year return period storm (based on the same 2.5% reduction in coastal protection).

6. Capacity needs in Khlong Tamru (Bang Pakong)

The stakeholder consultation and analyses with government and civil society stakeholders identified four stakeholder groups with clear roles in the long-term sustainable management of Khlong Tamru (Bang Pakong). Table 4 summarizes the current and potential roles of these stakeholder groups in relation to the management of the Khlong Tamru (Bang Pakong) wetlands. There are opportunities to strengthen tourism, sustainable resource use, and public relations.

Table 4. Capacity needs for key stakeholders involved in the management of Khlong Tamru (Bang Pakong).

Stakeholder group	Current role in wetland management (Positive or Negative)	Possible future role in wetland management	Current capacity for sustainable wetland management	Capacity development needed to improve wetland management	Form of capacity development (e.g. training, organisational strengthening etc.)
Local Communities	User of resources (e.g. fisheries) Generate waste and pollution.	Sustainable use of (fishery) resources. Strong community	Extensive knowledge of the area over time.	Improved understanding of resource stewardship, and sustainable use of resources.	Training to provide knowledge and understanding of the proper approach in using resources and managing pollution.

Stakeholder group	Current role in wetland management (Positive or Negative)	Possible future role in wetland management	Current capacity for sustainable wetland management	Capacity development needed to improve wetland management	Form of capacity development (e.g. training, organisational strengthening etc.)
		networks for conservation			
Private sector	Alter/modify landscapes through infrastructure development and expansion. Release waste and other pollutants	Waste management efficiency to reduce pollution Support work to conserve coastal landscapes Provide a source of funds for field research, and conservation activities	Interventions to manage and reduce waste discharge.	Become grantor of funds for field research and resource protection.	Training (through workshops) to build stronger understanding of environmental stewardship, and provide incentives to invest in education, restoration, and management of wetlands.
Government administrative offices	Land administration through public participation involving conservation activities.	Responsible for levy usage and depreciation fees that occur from benefits from ecosystem services.	Supports a learning centre for studying and conserving mangroves.	Learning centre, conservation tourism, and ecotourism. Stronger public relations.	Upskill government personnel on approaches to restore land for biodiversity. Expand network of community, government, and private sector cooperatives.
Visitors (including tourists)	Contribute revenue Publicise the area.	Instil awareness of conservation tourism and ecotourism.	User of (recreational) ecosystem services.	Organise conservation activities. Advertise the attractions and ecotourism. Agree/willing to pay usage fees.	Promote conservation activities. Awareness of payment (of fees) to access sites

7. Opportunities for RFI interventions

7.1. Recommended Interventions

Khlong Tamru is well recognised as an important landscape/coastscape for wetlands and migratory species, supporting some of the largest congregations of the Spotted Greenshank in the Inner Gulf of Thailand. Besides being a haven for migratory shorebirds, it also contributes to Thailand's blue carbon contribution. The dominant land uses in this landscape are salt production, aquaculture and fisheries (fish and shellfish) but over time it is expected that there will be increased industrial development as it lies in Thailand's Eastern Economic Corridor. Further development of Khlong Tamru is expected to impact migratory species, drive wetland degradation and increase pollution. There is a need for this coastal landscape to be managed in a way to encourage biodiversity, while expanding on restorative work for wetlands in this landscape. There is also a need to address upstream factors i.e. environmental flows, sediment transfer and wastewater / industrial pollution along the Bang Pakong River that will expectedly affect the wetlands in Khlong Tamru.

To strengthen management and conservation of the wider Khlong Tamru (Bang Pakong) estuarine landscape, there is a need to:

(1) Sustain and improve the existing management of coastal wetlands through
    a. Understanding future risks to the landscape and planning interventions accordingly to ensure the long-term success of interventions.
    b. Work towards better management of the Bang Pakong River, reducing wastewater and pollution, and improved dam management.
    c. Maintain the traditional production of salt from salt pans, through incentives and community-driven initiative
    d. Expansion of wetland restoration work with a focus on 'mangrove zones' to strengthen shoreline stability at suitable areas, notwithstanding the coastal erosion challenges the site faces.
    e. Strengthen and formalise co-management structures involving the local community and government agencies
(2) Enable, and up-scale (economic) infrastructure for compatible forms of economic activity for local communities
    a. Promoting and expanding nature-based tourism for local and overseas visitors, through capacity building and expansion of tourism infrastructure.
    b. Promoting sustainable approaches to aquaculture (for shellfish and fish) that are biodiversity friendly.

Table 5. Summary of key RFI interventions proposed for Khlong Tamru (Bang Pakong)

Intervention	Outcome	Indicators	Cost (USD)	Timeframe	Potential Stakeholders
Component 1. Strengthening landscape and water resource management in Bang Pakong estuary					
Undertake an environmental and social impact assessment of project implementation in the Bang Pakong estuary	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 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 guidelines for project interventions Number of stakeholder groups engaged in the assessment and development of project interventions' guidelines	100,000	1.5 years	Bang Pakong River Basin Committee DMCR DWR Chon Buri District government Khlong Tamru TAO Consultancy companies

Intervention	Outcome	Indicators	Cost (USD)	Timeframe	Potential Stakeholders
Undertake a climate, topographical and hydrological survey.	Best practices, guidelines, and standards for proposed RFI interventions Land use planning is optimised and sustainable, through science-driven prediction of sea level rise impacts	Hydrological and climate change impact assessment report with site identification for mangrove restoration, impacts of sea-level rise and shifts in hydrology to guide proposed interventions, and proposed guidelines for land use planning and further stages of intervention, finalized, 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	1 year	
Develop a zoning and management plan (ICZ), potentially supported by an enforced planning permit system	Improved site management for Khlong Tamru through a zonation plan developed considering the predicted sea level changes to the area over	Zonation plan that takes into account emerging threats, and sea-level rise over appropriate timeframes, developed, disseminated with key	150,000	Up to 2 years	Khlong Tamru TAO Consultancy companies Conservation organisations

Intervention	Outcome	Indicators	Cost (USD)	Timeframe	Potential Stakeholders
	time with clear management goals identified over short and medium term.	stakeholders and endorsed by the management authority Number of consultations conducted with key stakeholders for participatory process in the development of the zonation plan. Number of stakeholder groups engaged in the development of the zonation plan.			
Conduct a study on the ecological impacts of seawall construction and its long-term impact on mangrove restoration works on the Bang Pakong.	Improved management and conservation of Khlong Tamru through better understanding of hydrological shifts needed for a successful mangrove restoration planning and implementation.	Study of seawall impact on Bang Pakong estuary completed, with recommendations for mangrove restoration completed and disseminated to key stakeholders. Number of consultations conducted with local stakeholders for a participatory process in the study Number of stakeholder groups engaged in the study	50,000	0.5 years	
Restore targeted degraded areas of fishponds, salt pans and disused coastal land,	Improved management and conservation of Khlong Tamru through	Mudflat benthos and pollution study conducted and disseminated	200,000	5 years (at least)	Khlong Tamru TAO

Intervention	Outcome	Indicators	Cost (USD)	Timeframe	Potential Stakeholders
informed by a study (see above).	increased mangrove cover and vegetation cover in degraded areas of the Bang Pakong coastline.	with local stakeholders. Area (target of up to 150 ha) of mangrove replanted / protected / restored in the Bang Pakong Estuary. Number of stakeholder groups engaged in the mangrove restoration activities.			Chon Buri District government Research institutions
Review management / agreement for freshwater discharge from Bang Pakong Dam.	Environmental flows from Bang Pakong are sustained and that sediment is deposited in the estuary to help reduce erosion.	Dam management agreement produced, adopted, and actively implemented with key stakeholders. Number of stakeholder groups engaged in the review. Number of consultations conducted with local stakeholders for a participatory process in the review.	50,000	1 year	Khlong Tamru TAO Chon Buri District government
Strengthen wastewater management (industrial effluents and pollutants from industries) from canals and drains	Better water quality in the Bang Pakong estuary. Reduced coliform load and other water	Strategy for wastewater management developed and disseminated to local stakeholders	500,000	5 years	Special Eastern Region Economic Zone Board Khlong Tamru TAO

Intervention	Outcome	Indicators	Cost (USD)	Timeframe	Potential Stakeholders
draining into the Bang Pakong River	pollutants that may contaminate fisheries.	Number of consultations conducted with key stakeholders, for a participatory process. Metrics and baselines on key chemical and biological contaminations in coastal waters established. Measured reduction in key chemical and biological contamination in the Bang Pakong River estuary / harvested shellfish; and sampled shellfish, based on the established baselines.			Chon Buri District government Chon Buri Provincial government
Establish new waste management facilities to manage plastic waste.	Improved management and conservation of Khlong Tamru through plastic waste reduction entering the site.	Number of waste management facilities (storage and disposal) established and improved at sensitive sites. Number of stakeholder groups engaged in the plastic waste management.	1,000,000	2 years	
Establish and implement a long-term biodiversity and threat monitoring framework, with a	Improved conservation of biodiversity through a biodiversity	One biodiversity monitoring programme established	100,000	5 years (and ongoing beyond).	Khlong Tamru TAO Conservation organisations

Intervention	Outcome	Indicators	Cost (USD)	Timeframe	Potential Stakeholders
focus at sites with high waterbird concentrations.	monitoring program	Adaptative management framework for biodiversity monitoring established. Number of people engaged in biodiversity monitoring. A biodiversity monitoring group established. Number of biodiversity monitoring activities implemented with regular field-based counts and assessments of threats			Research institutions
Establish a site management plan to address threats and disturbance, including through the recognition of an OECM in the Bang Pakong landscape (around the *Gluea* salt farm).	Improved management and conservation of Khlong Tamru through a site management plan	An agreed long-term vision and plan to govern the sustainable management of the Khlong Tamru Wetlands with key stakeholders A co-management council with relevant committees established. Number of consultations conducted with key stakeholders for participatory process in the development of	100,000	1 year	ONEP Khlong Tamru TAO DMCR Conservation organisations Gluea café

Intervention	Outcome	Indicators	Cost (USD)	Timeframe	Potential Stakeholders
		the site management plan Number of stakeholder groups engaged in the development of the site management plan			
Component 2. Upscaling of tourism infrastructure and other biodiversity-friendly livelihoods					
Build local capacity for nature-based tourism, targeting local operators and interested community members	Improved site management and protection through nature-based tourism benefits and increased capacity of local stakeholders on nature-based tourism.	Training programme established for nature guides, with regular training activities Training programme established for supporting businesses (cafes, shops) Number of training activities (target of up to 2 workshops) implemented to target participants Number of people (target of 100 individuals) trained at up to 2 workshops per year Number of businesses engaged in sustainable practices	100,000	3 years	Conservation organisations Khlong Tamru TAO Chon Buri District ONEP Gluea café
Develop infrastructure for tourism, including	Improved site management and protection	Number of nature-based	500,000	2 years	

Intervention	Outcome	Indicators	Cost (USD)	Timeframe	Potential Stakeholders
signages, trails on boardwalks and wetland interpretation facilities, shelters and bird hides	through nature-based tourism benefits and expanded ecotourism infrastructure for ecotourism.	tourism infrastructure (i.e. 0.5 km of boardwalks and up to 10 shelters and signage) established and improved. Number of people benefitting from ecotourism activities.			
Component 3. Maintain land use of coast for biodiversity-friendly salt farming and sustainable aquaculture.					
Improve and renovate of water management infrastructure such as canals and sluice gates, based on findings of hydrological report.	Strengthened site management through improved water management systems, including sluice gates, canals and other water management structures between salt pans and the sea.	Number of water management structures (i.e., canals and sluices) optimised to maintain water levels suitable for livelihoods and biodiversity. Metrics and baselines for healthy water conditions established. Water conditions substantially reduced against baselines, based on the metrics established. Number of stakeholder groups engaged in water management.	300,000	5 years	Khlong Tamru TAO Chon Buri District
Establish and develop salt-farming	Improved site management for Khlong Tamru by	Number of salt farming cooperatives	100,000	2 years	Khlong Tamru TAO

Intervention	Outcome	Indicators	Cost (USD)	Timeframe	Potential Stakeholders
cooperatives led by salt-farming households	supporting salt-farmers	(target of up to 3) established and supported, including the provision of dry, bagging sheds / office building.			Chon Buri District
Create enabling conditions for local communities for salt farming.	Improved site management for Khlong Tamru by supporting the maintenance of salt-farming livelihood Support the maintenance of salt-farming infrastructure, such as sheds and other tools.	Number of business and marketing plans developed to promote salt-based products, including obtaining certification. Number (target of up to 10) of salt farming households supported At least 100 ha of salt pans retained under traditional salt farming Number of salt-farming infrastructure (i.e., sheds) improved.	100,000	5 years	Khlong Tamru TAO Chon Buri District Conservation organisations Local conservation groups from other salt farming landscapes (e.g. Pak Thale, Khok Kham)
Build capacity and develop (artisanal) businesses for salt-based products (such as wildlife-friendly salt); loans and grants to incentivise biodiversity-friendly salt production	Improved site management through increased capacity for salt-based products, and better access to livelihood opportunities, inclusive engagement, and microfinance mechanisms.	Grant/ loan scheme in place for local salt-farming communities established. Number of salt farmers engaged in biodiversity-friendly salt production Capacity building for salt-farming	50,000	5 years	

Intervention	Outcome	Indicators	Cost (USD)	Timeframe	Potential Stakeholders
		communities (with a representative % of women) in biodiversity-friendly salt production and microfinance. Number of people benefitting from the capacity-building activities and microfinance mechanism established.			
Promote low impact, biodiversity-friendly production processes for aquaculture along the east bank of the Bang Pakong (Chon Buri and Chachoengsao) for tilapia and shellfish.	Improved conservation of biodiversity through the promotion of biodiversity-friendly production processes for aquaculture.	Training programme established low-intensity seafood production (including study tours) Grant/loan scheme with governance structure targeting aquaculture communities established. Number of aquaculture operators (target of up to 15) in the area accredited to a recognised international standard (that includes a strong biodiversity component). Number of people benefitting from the capacity-building activities	500,000	5 years	Department of Fisheries Khlong Tamru TAO Chon Buri District Conservation organisations Aquaculture companies and cooperatives

Intervention	Outcome	Indicators	Cost (USD)	Timeframe	Potential Stakeholders
		and microfinance mechanism established.			
Total investment for five years			**USD 13,000,000**		

7.2. Potential Financing

The estimated project cost is USD 13,000,000 over 5 years. This budget supports the development of site and zonation management plans, the promotion of biodiversity-friendly salt farming, water and wastewater management, ecotourism infrastructure, the establishment of a microfinancing mechanism, mangrove restoration, and capacity-building for local stakeholders on biodiversity monitoring, nature-based tourism, and financial management. Table 5 summarizes the projected budget distribution across the proposed project components.

If the proposed USD 200,000 investment over a five-year period is directed toward the restoration of degraded fishponds, salt pans, and disused coastal lands in Khlong Tamru, it could support the rehabilitation or protection of up to 150 hectares of mangroves in the Bang Pakong Estuary. With estimated coastal protection benefits of USD 1,698 per hectare annually (see Section 5.3), this intervention could yield approximately USD 254,700 in annual benefits—equivalent to over USD 1.27 million over five years. This results in a benefit–cost ratio of over 6:1, indicating a strong economic case for restoration as a nature-based solution. In addition to strengthening resilience to coastal erosion and extreme weather events, the intervention would contribute to wider ecological recovery, including improved vegetation cover and potential gains in benthic biodiversity and water quality, supported by the accompanying mudflat and pollution study. Failing to restore these degraded areas would represent a missed opportunity to recover valuable protective functions and improve the long-term sustainability of the Bang Pakong coastline.

7.3. Proposed Institutional Arrangement

The proposed project is expected to be implemented over a period of five years, with specific project components focusing on improved site management of Khlong Tamru (Bang Pakong). The wetlands are mostly state-owned, and the saltpans and fishponds are occupied by operators (either legally or illegally). The surrounding areas are privately owned farmland and households.

7.4. Project Beneficiaries

Initiatives to promote gender inclusion and participation of vulnerable groups in livelihood activities.

7.5. Anticipated Implementation Risks

Stakeholder engagement: Proposed interventions rely on support from local communities, particularly in adopting biodiversity-friendly salt-farming practices and in water and wastewater management. Establishing strong stakeholder buy-in from local leaders and community engagement will facilitate better implementation of the proposed interventions.

Environment: Most proposed interventions are relatively soft and have a low environmental impact, but it may be necessary to consider the effects of expanding tourism in Khlong Tamru (Bang Pakong), which could increase anthropogenic pressures and lead to greater disturbance of wildlife. Planning with stakeholders to reduce noise pollution during the construction of ecotourism facilities and ongoing ecotourism activities, as well as managing waste pollution from increased tourist traffic, is essential.

Undertaking various assessments to better understand local conditions will ensure that restoration efforts are appropriate to those conditions.

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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 Tamru (Bang Pakong) 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)	685 – 1,190
Current maximum coastal risk to be mitigated, or potential exposure to coastal hazards (unitless index)	*3.05 - 3.38*
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)	3.05 - 3.38
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)	3.26 - 3.62
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)	3.55 - 3.94
Current proportional risk reduction, nature's contribution to reducing coastal risk as a proportion of maximum coastal risk (unitless index)	0.16 - 0.16
Nature's contribution to reducing coastal risk as a proportion of population density within 2.5 km of the coast (# of people per hectare)	*107 - 186*
Nature's contribution to reducing coastal risk as a percentage of the maximum potential exposure (%)	*4.61 - 5.12*

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 Tamru (Bang Pakong) 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$)**
Mangrove extent (hectares)[2]	511 – 1,325
Annual expected flood protection benefits to people (number of people)	4,359 – 4,583
Annual expected flood protection benefits to Industrial Stock (US$)	2,508,877 – 2,637,784
Annual expected flood protection benefits to Residential Stock (US$)	1,749,860 – 1,839,769
Annual expected flood protection benefits to Total Stock (US$)	*3,962,982 – 4,166,602*
Annual expected flood protection benefits to Industrial Stock per hectare of mangroves (US$ per hectare)	*1,655 – 1,740*
1-in-100-year return period damage in terms of area flooded (number of hectares)	3,820 – 4.186
Total expected flood protection benefits of mangroves per 100-year return period storms (US$)	*981,700 – 1,075,576*

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)
Ta Libong	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 Tamru (Bang Pakong) 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 (%)
Permanent shallow marine waters	745.6	25.0	745.6	25.0
Intertidal marshes	149.1	5.0	149.1	5.0
Intertidal forested wetlands	208.8	7.0	149.1	5.0
Aquaculture ponds	894.7	30.0	894.7	30.0
Salt exploitation sites	894.7	30.0	894.7	30.0
Low Intensity Residential	89.5	3.0	149.1	5.0
Total	2982.3	100.0	2982.3	100.0