Koh Lanta Bridge

Krabi Province, Thailand

Draft Extended Non-Technical Summary (NTS)

of the

Environmental Impact Assessment

and

Draft Supplementary Lenders Information Package (SLIP)

Thailand Resilient Transport Connectivity and Irrawaddy Dolphin Conservation Project (P509460)

Draft version: 13-May-2025

Koh Lanta Bridge
draft Extended Non-Technical Summary and Supplementary Lenders Information Package

1 EXECUTIVE SUMMARY 3

2 INTRODUCTION 8

3 LEGAL AND INSTITUTIONAL FRAMEWORK 12

3.1 Thai Legal Framework Relevant to the Project 12

3.2 The World Bank Environment and Social Standards (ESSs) Relevant to the Project 18

3.3 Key Gaps between the Requirements of WB ESF and National Requirements 19

4 PROJECT DESCRIPTION 23

4.1 Project Location 23

4.2 Bridge Component Layout and Composition 24

4.3 Associated Facilities 26

4.4 Earthquakes and Tsunami Risk 26

4.5 Project Implementation 27

4.6 Economic Analysis 28

5 ANALYSIS OF ALTERNATIVES 30

6 BASELINE DATA 32

6.1 Physical Environmental Resources 32

6.2 Biological Environmental Resources 35

6.3 Human Use Values 39

6.4 Quality of Life Values 41

7 ENVIRONMENTAL AND SOCIAL RISKS AND IMPACTS 44

7.1 Summary of Project Impacts 44

7.2 Impacts to Physical Environmental Resources 45

7.3 Impacts to Biological Environmental Resources 50

7.4 Impacts to Human Use Values 54

7.5 Impacts to Quality of Life Values 56

7.6 Cumulative Impacts 59

8 MITIGATION AND MONITORING MEASURES 66

8.1 ESMP Structure 66

8.2 Summary of Mitigation and Monitoring Requirements 66

8.3 Physical Environmental Resources 67

8.4 Biological Environmental Resources 71

8.5 Human Use Values 76

8.6 Quality of Life Values 79

8.7 Residual Impact Assessment 85

8.8 SUPPORTING ENVIRONMENTAL ACTION PLANS 85

8.9 Summary of the ESMP Budget 88

9 REFERENCES 90

Acronyms used in the Text

Acronym	Description
AO	Administrative Organization
AoA	Area of Analysis for critical habitat assessment
BOD	Biological Oxygen Demand
CHA	Critical Habitat Assessment
CIA	Cumulative Impact Assessment
CO	Carbon Monoxide
CR	Critically Endangered with extinction
DMCR	Department of Marine and Coastal Resources
DO	Dissolved Oxygen
DRR	Department of Rural Roads
E&S	Environment and Social
EIA	Environmental Impact Assessment
EN	Endangered with extinction
ESF	Environmental and Social Framework
ESMP	Environmental and Social Management Plan
ESS	Environmental and Social Standards of the World Bank ESF
IBAT	Integrated Biodiversity Assessment Tool
IUCN	International Union for the Conservation of Nature
MoNRE	Ministry of Natural Resources and Environment
NEB	National Environment Board
NGO	Non-governmental Organization
NO_2	Nitrogen Oxide
NT	Near Threatened species
NTS	Non-Technical Summary
ONEP	Office of Natural Resources and Environment Policy
OSH	Occupational Safety, Health and Environment Act
PEA	Provincial Electricity Authority
PM_{10}	Dust Particulate Matter
PPE	Personal Protective Equipment
PWDs	Persons with Disabilities
RFD	Royal Forestry Department
ROW	Right of Way
SLIP	Supplementary Lenders Information Package
SS	Suspended Solids
TOT	Thai state-owned telecommunications company
TSP	Total Suspended Particulates
TTNHA	Thung Thale Non-hunting Area
VEC	Valued Environmental and Social Component
VU	Vulnerable to extinction

1 EXECUTIVE SUMMARY

The Koh Lanta Bridge forms part of the proposed Thailand Resilient Transport Connectivity and Irrawaddy Dolphin Conservation Project (P509460) implemented by the Department of Rural Roads (DRR) of the Ministry of Transport and the Department of Marine and Coastal Resources, Ministry of Natural Resources and Environment, with financial support from the World Bank. The Project is implemented in accordance with the World Bank Environmental and Social Framework (ESF), Thai regulations and includes the nearby Songkhla Lake Bridge. This document refers specifically to the Koh Lanta Bridge and is compiled based on content of the Environmental Impact Assessment (EIA) approved by the Thai Government[1] and a *Draft* Supplementary Lenders Information Package (SLIP) prepared to satisfy the WBG Environmental and Social Framework (ESF) requirements. The final SLIP will include a Critical Habitat Assessment, Cumulative Impact Assessment, an Environmental and Social Management Plan (ESMP), Labor Management Plan, Resettlement Framework, Stakeholder Engagement Plan and other document required by WB ESF. The final SLIP will be disclosed on the World Bank's and DRR's websites. Public information on the bridge projects available in the EIA and results of the stakeholder consultations had been disclosed on the Project websites (https://xn--12clj9bgle6dub5byb0bogff9e3hfe9noa.com/index.html) during August 2020 – February 2021 as part of the EIAs preparation and consultation processes. The final approved EIA report that meets requirements of the Personal Data Protection Act[2] was disclosed on the same website in August 2023.

Project Location: The Koh Lanta Bridge is located in Koh Lanta District, Krabi Province and crosses the Khlong Chong Laad sea channel of the Andaman Sea in southern Thailand. The bridge will connect the subdistricts of Koh Klang and Koh Lanta Noi. The length of the project route is 2.527 km with a total bridge span of 1405 meters. Construction cost is estimated at 1,600 million baht and annual maintenance cost of 692,924 baht (equivalent to US$ 50.9 million and US$ 22,026 respectively, at July, 1st 2020 exchange rate). An economic analysis for a 30-year period post construction reveals the project is a feasible investment as the economic rate of return of the project is 21.12%; and a benefit to cost ratio of 1.99.

Executing Agency: The Department of Rural Roads (DRR) of Ministry of Transport is the main Executing Agency, collaborating on specific environmental and social issues with the Department of Marine and Coastal Resources (DMCR) and the Department of National Parks, Wildlife and Plant Conservation (DNP) and the Royal Forest Department (RFD) of the Ministry of Natural Resources and Environment (MONRE).
Benefits of the Project: Koh Lanta Bridge route will provide transportation connectivity between Koh Lanta Noi island and the mainland. A privately operated car ferry service is established but is unable to handle the traffic demand and does not operate after hours. The bridge will attract tourism to the area, which will create jobs for the local population and boost economic growth. Students living on Koh Lanta will be able to attend schools on the mainland. The Koh Lanta Bridge Project will contribute towards Krabi Province to achieving its vision as an "Internationally-acclaimed tourist destination, Sustainable agriculture and industry, Livable city, Ability to adapt to changes".

[1] The Final Environmental Impact Assessment Report for Koh Lanta Bridge Project (Thai), August 2022.
[2] The Final Environmental Impact Assessment Report for Koh Lanta Bridge Project (Thai), February 2023.

Project Description: The Koh Lanta Bridge will be a new bridge with two traffic lanes (one in each direction) that includes three bends to pass around the small Koh Pling Island. The bridge will be supported by 40 piers each based on a single column and constructed using a concrete mix able to withstand the corrosive effects of chloride and sulfate components of sea water. The bridge is designed to accommodate a tsunami wave similar to that which struck the Koh Lanta coast in 2004 (approx. 4 meters). The bridge design includes two pedestrian viewpoints accessible via stairs, elevator and walkways from the Koh Klang side.

The Koh Lanta Bridge will be constructed over a 3-year period with a labor force of 229 project workers (excluding 21 direct workers in the PMU which is shared between two projects and Lanta's share of primary supply workers for estimation by the contractor). Of the 229 project workers, about 180 are construction workers (79%). The other 49 workers (21%) comprise the construction supervision and support team, a group of 45 technical specialists, working with 3 project engineers and 1 PIU admin staff. A construction workers camp and construction facilities will be established to the beginning point of construction. Heavy construction materials will be transported by land to Krabi Port and then transported by barge via the Khlong Chong Laad to the construction site. Other construction materials will be transported to site by trucks. Sediments and debris from the drilling of bored piles foundations in the sea will be disposed in disturbed land of the Koh Klang Sub-district Administrative Organization (SAO) and Koh Lanta Noi SAO.

An analysis of three alternative route scenarios was conducted to compare engineering, financial and environment and social (E&S) factors. The key parameters that identified the preferred route was the reduced impact on designated mangrove forest and the Thung Thale Non-hunting Area. The preferred route has the lowest cost but the most complex geometry.

Baseline Description: Baseline data is presented which covers the following components:

- Physical Environmental Resources - air quality, surface sound, vibration, freshwater quality, marine water quality, geology and earthquakes, soil resources, and oceanography.
- Biological Environmental Resources – protected areas, marine coastal ecosystem and marine aquatic ecosystem, habitats and vegetation, terrestrial fauna, marine mammals, and critical habitat.
- Human Use Values - land use, land and water transportation, public utilities, public health, sanitation, accidents and safety, history and archaeology, and aesthetics.

A critical habitat assessment has revealed six endangered marine species qualify as critical habitat features, namely Irrawaddy Dolphin, Dugong, Green Hawksbill, Leatherback and Olive Ridley sea turtles. No significant impacts to these species are expected although mitigation and monitoring measures are provided. Endangered Long-tailed Macaque monkeys are the only terrestrial species recognized as a critical habitat feature. These monkeys could be exposed to limited impacts through scavenging from the construction camp and some Macaque-tourist conflict, however mitigation can be applied to avoid

significant impacts. Net Gain measures therefore do not need to be demonstrated for any of the critical habitat species.

The Project passes through a short stretch of mangrove habitat within a national forest reserve, which is not a critical habitat. Mangrove habitat will be impacted but mitigation is provided for the DMCR to identify a suitable site 20 times larger than the impacted site and plant appropriate mangrove trees. This mitigation will exceed the scope of the impact and yield a net gain outcome for mangroves as a result of the project.

The marine environment supports some degraded corals around the Koh Pling Island which do not qualify as critical habitat. The project route bypasses these coral habitats and temporary impacts will be minimized. There will be considerably less boat activity and many of the current pressures on the corals will be alleviated during the bridge operational phase and therefore no offset approach is proposed.

Land has been donated for development of the Koh Lanta Bridge and a land process review was carried out to ensure that the land is formally secured for the Project as confirmed by the Department of Rural Roads, meets national legal requirements and is in accordance with ESS5. The land subject to the land process review was a small piece of land donated to DRR by a private landowner measuring 44 square wah (176 square meters). The complete land process review that covers the Lanta land donation is expected by September 2023. An additional piece of land was donated by the Krabi Provincial Administration Office (PAO) for the construction of additional structures to make the project inclusive, e.g., U-turn, elevator access on April 2023. This property is occupied by a multi-purpose facility where the government owner, the Krabi PAO, agreed to allow shop renters to complete their lease while the project is ongoing (up to 2025 before the project is completed). The EA also designed the additional structures in a way that avoids land take in the multipurpose facility. These agreements are documented in an email report submitted by the consultants to the Bank on 22 May 2023.

Impact Assessment: Impacts of the project have been assessed for the construction and implementation phases. The following table presents a summary of the impacts and their pre-mitigation and residual significance ratings.

Environment and Social Factors and their Impacts	**Stage of Mitigation**	**Project Phase**	
		Construction	**Implementation**
Physical Environmental Resources			
Air Quality: Spread of dust (TSP and PM_{10}) and pollutants such as CO and NO_2 on environmentally sensitive areas.	Pre-mit:	Low -ve	Low -ve
	Residual:	Low -ve	Low -ve
Surface Noise: Terrestrial sound effects from construction activities assessed against the national standard.	Pre-mit:	Moderate -ve	Moderate -ve
	Residual:	Low -ve	Low -ve
Vibration: Vibration effects from construction activities assessed against national and international standards.	Pre-mit:	Moderate -ve	Low -ve
	Residual:	Low -ve	Low -ve
Surface Water Quality: Impacts of erosion sediments and wastewater from construction sites and facilities	Pre-mit:	Moderate -ve	Moderate -ve
	Residual:	Low -ve	Low -ve
	Pre-mit:	Moderate -ve	Not significant

Environment and Social Factors and their Impacts	Stage of Mitigation	Project Phase	
		Construction	Implementation
Marine Water Quality: Impact of sediments and contaminants in the sea water	Residual:	Low -ve	
Geology, Earthquake and Tsunami: Bridge structural capacity to withstand seismic activity.	Pre-mit:	Moderate -ve	Positive
	Residual:	Moderate -ve	
Soil Resources and Erosion: Effects on soil structure changes and soil erosion	Pre-mit:	Moderate -ve	Not significant
	Residual:	Low -ve	
Oceanography: Assessment of change in currents and sediment dispersion from jetties and bridge structures.	Pre-mit:	Low -ve	Not significant
	Residual:	Low -ve	
Biological Environmental Resources			
Protected Areas: Impacts to the habitat and associated protected areas.	Pre-mit:	Moderate -ve	Not significant
	Residual:	Moderate -ve	
Marine Coastal Ecosystem: Loss of mangrove trees on the Koh Lanta side.	Pre-mit:	Moderate -ve	Not significant
	Residual:	Low -ve	
Marine Aquatic Ecosystem: Impacts to the marine ecology including coral reefs and sea grass meadows.	Pre-mit:	Moderate -ve	Not significant
	Residual:	Low -ve	
Habitats and Vegetation: Loss of trees with emphasis on mangrove species	Pre-mit:	Moderate -ve	Not significant
	Residual:	Low -ve	
Terrestrial Fauna: Impacts to vertebrates with an emphasis on Long-tailed Macaque and Smooth-coated Otter	Pre-mit:	Moderate -ve	Moderate -ve
	Residual:	Moderate -ve	Moderate -ve
Marine Mammals: Impacts to Indo-Pacific humpback dolphins	Pre-mit:	Moderate -ve	Positive
	Residual:	Low -ve	
Human Use Values			
Land Acquisition: The impact of asset compensation.	Pre-mit:	Low -ve	Not significant
	Residual:	Low -ve	
Land Use: Impact on land use and change in future land use patterns across Koh Lanta	Pre-mit:	Moderate -ve	Moderate -ve
	Residual:	Moderate -ve	Moderate -ve
Land and Water Transportation: Road and boat traffic risks and disruptions.	Pre-mit:	Moderate -ve	Positive
	Residual:	Low -ve	
Public Utilities: Impacts from the relocation of public utilities such as electric poles, water pipes, and drainage systems.	Pre-mit:	Low -ve	Positive
	Residual:	Not significant	
Quality of Life Values			
Public Health: Impact on the health of workers and people in the community.	Pre-mit:	Moderate -ve	Moderate -ve
	Residual:	Low -ve	Low -ve
Sanitation: Risks associated with solid waste and waste water management.	Pre-mit:	Moderate -ve	Low -ve
	Residual:	Low -ve	Low -ve
Accidents and Safety: Assessment of safety risks	Pre-mit:	Moderate -ve	Positive
	Residual:	Low -ve	
Occupational Health: Risk of injury and accidents to construction and maintenance workers.	Pre-mit:	Moderate -ve	Low -ve
	Residual:	Low -ve	Low -ve

Environment and Social Factors and their Impacts	Stage of Mitigation	Project Phase	
		Construction	Implementation
Socioeconomic: Impact on social structure, local economy and potential for conflict with construction workers.	Pre-mit:	Positive	Positive
History and Archaeology: impacts to archeology and sites of religious importance	Pre-mit:	Low -ve	Low -ve
	Residual:	Low -ve	Low -ve
Aesthetics: Assessment of the visual impact of the Koh Lanta Bridge	Pre-mit:	Moderate -ve	Low -ve
	Residual:	Low -ve	Low -ve
Where: Pre-mit = Pre-mitigation impact; Residual = Residual (post-mitigation) impact; -ve = negative impact			

Mitigation and Monitoring: The Koh Lanta ESMP outlines the roles and responsibilities for mitigation, summary of E&S impacts, mitigation measures and management controls, monitoring programs and budget, reporting requirements, capacity development and training requirements, a workplan and implementation schedule and requirements for review of the ESMP. The ESMP incorporates the following action plans:

1. Noise Preventive and Corrective Action Plan
2. Surface Water Quality Prevention and Remediation Action Plan
3. Marine Water Quality Prevention and Remediation Action Plan
4. Transportation, Accidents, and Safety Preventive and Corrective Action Plan
5. Public Relations and Complaint Handling of the Project Action Plan
6. Mangrove Reforestation Action Plan
7. Reforestation Action Plan (National Reserved Forest)
8. Prevention and Remediation Action Plan on the Impacts towards Dolphins

The ESMP mitigation and monitoring budget is estimated at 36.564 million baht (equivalent to US$ 1,163,843), with 24.87 million baht and 11.694 million baht for construction and implementation phases respectively.

2 INTRODUCTION

The Koh Lanta Bridge is located in Koh Lanta District, Krabi Province and crosses the Khlong Chong Laad sea channel of the Andaman Sea in southern Thailand. The bridge will connect the subdistricts of Koh Klang and Koh Lanta Noi (Figure 1 and Figure 2). The length of the project route is 2.527 km with a total bridge span of 1405 meters. Construction cost is estimated at 1,600 million baht and annual maintenance cost of 692,924 baht (equivalent to US$ 50.9 million and US$ 22,026 respectively, at July, 1st 2020 exchange rate).

The Bridge forms part of the Thailand Resilient Transport Connectivity and Irrawaddy Dolphin Conservation Project (P509460). The project comprises the following three components:

- Component 1: Lanta Island and Songkhla Lake bridges construction.
- Component 2: Irrawaddy Dolphin Conservation and Ecosystem Management in Songkhla Lake
- Component 3: Institutional Development and Project Management.

The Project is implemented in accordance with the World Bank Environmental and Social Framework (ESF) and Thai regulations. This document refers specifically to the Koh Lanta Bridge and is compiled based on content of the Environmental Impact Assessment (EIA) and a Supplementary Lenders Information Package (SLIP).

The Department of Rural Roads (DRR) of Ministry of Transport is the main Executing Agency, collaborating on specific environmental and social issues with the Department of Marine and Coastal Resources (DMCR) and the Department of National Parks, Wildlife and Plant Conservation (DNP) of the Ministry of Natural Resources and Environment (MONRE), and the Department of Fisheries of the Ministry of Agriculture and Cooperatives.

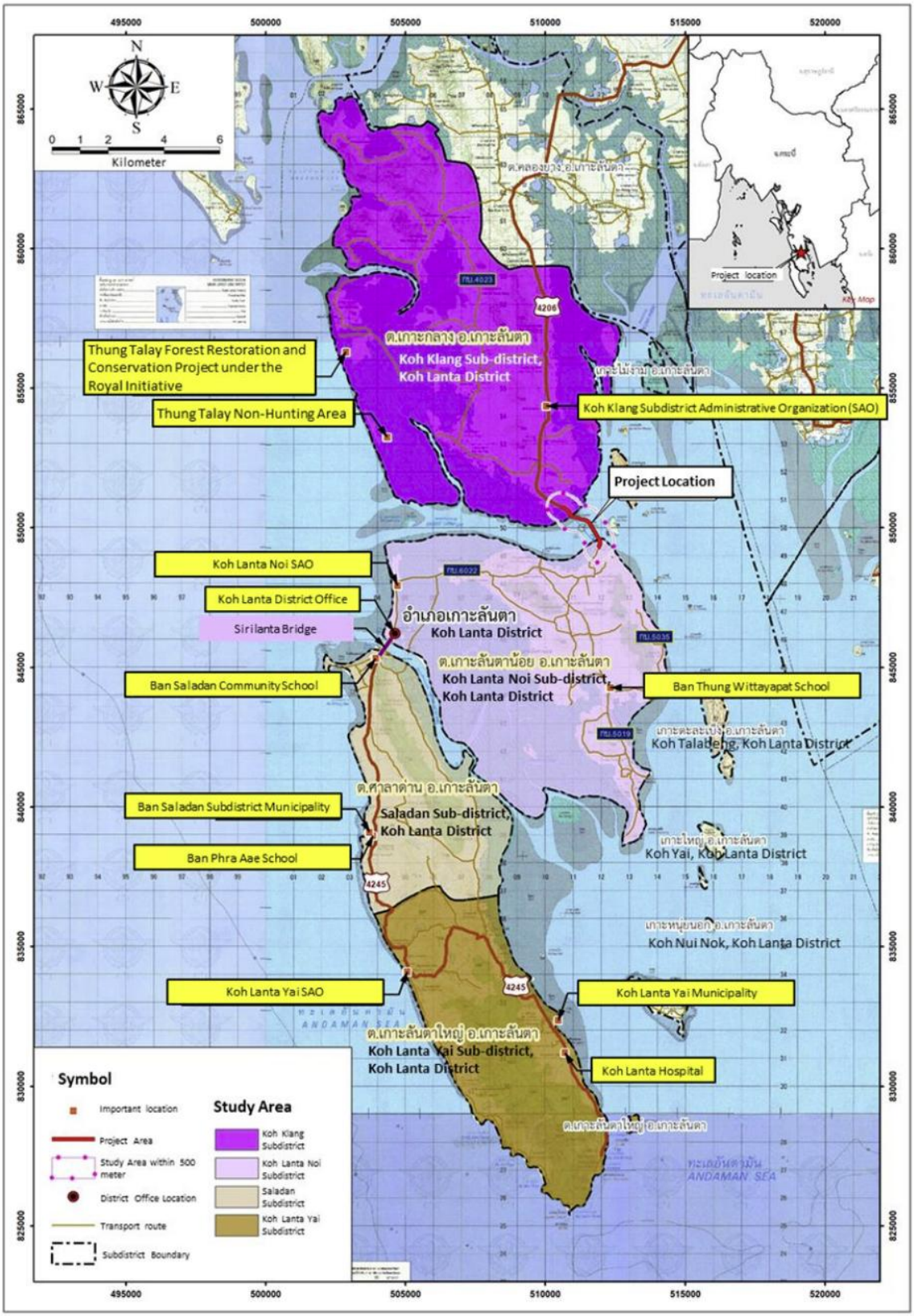


Figure 1 Project location showing Koh Klangand Koh Lanta Noi subdistricts of Krabi Province

Figure 2 Topographical map presenting the layout of the Project route and 1 kilometer chainage measurements

2.1.1 Benefits of the Koh Lanta Bridge

Currently to travel between Koh Klang to Koh Lanta sub-districts requires a 1 km trip on a car ferry, yet this presents an important obstruction to the development of Koh Lanta as it is unable to accommodate the traffic demand, particularly during the holiday season from December to May causing traffic congestion to back up for many kilometers. The ferry is also unable to respond to after-hours emergencies, ferry delays are unpredictable during operational hours and tourists cannot have confidence to meet scheduled flights and other itineraries. In the event of emergency at night, people needing to cross the Khlong Chong Laad must pay 2,500 Baht per trip for a private car ferry, if available.

Koh Lanta Bridge route will provide transportation connectivity from north to south and alleviate current challenges associated with the car ferry service. Road users will be able to commute with increased convenience and elevate the safety standards for the public. Tourism will be attracted to the area, which will create jobs for the local population and boost economic growth. Students living on Koh Lanta will be able to attend schools on the mainland. The Koh Lanta Bridge Project will contribute towards Krabi Province to achieving its vision as an "Internationally-acclaimed tourist destination, Sustainable agriculture and industry, Livable city, Ability to adapt to changes".

The region is vulnerable to earthquakes and experienced a severe tsunami event on 26 December 2004. The Koh Lanta Bridge is designed to resist in the event of a strong earthquake or tsunami of similar magnitude (approx. 4-meter height) and remain operational. In such an event, the bridge will serve as an important emergency route for Koh Lanta and other islands allowing fast and effective rescue operations and subsequent restoration of affected areas.

2.1.2 Institutional Structure

The Koh Lanta Bridge Project is administratively under the Koh Lanta District Administration Offices. The Department of Rural Roads (DRR) of Ministry of Transport is the main Executing Agency (EA), collaborating on specific environmental and social issues with other Departments, including the Department of Marine and Coastal Resources (DMCR) and the Department of National Parks, Wildlife and Plant Conservation (DNP) and Royal Forestry Department (RFD) of the Ministry of Natural Resources and Environment (MONRE), the Department of Fisheries of the Ministry of Agriculture and Cooperatives. The Departments are well established with permanent presence at the regional and provincial levels and extensive track record of developing similar large infrastructure throughout the country.

3 LEGAL AND INSTITUTIONAL FRAMEWORK

Thailand has a well-defined legislative framework covering various aspects including the Environmental and Social components. This chapter discussed an overview of Thai legal framework requirements apply to the project, the relevant Environmental and Social Standards (ESSs) under the World Bank Environmental and Social Framework (ESF), key gaps between the two systems and gaps filling measures.

3.1 THAI LEGAL FRAMEWORK RELEVANT TO THE PROJECT

Table 1 Overview of Thai legal framework requirements apply to the Project

Regulations	Relevant Requirements
Environmental and Social Impact Assessment	
• The Constitution of the Kingdom of Thailand B.E. 2560 (2017) • Enhancement and Conservation of the National Environmental Quality Act (NEQA) (No. 2) B.E. 2561 (2018), amended in B.E. 2535 (1992) and B.E. 2561 (2018) • Notification of the Ministry of Natural Resources and Environment (MONRE) Re: Rule, Procedure, Method, and Guideline for Preparation of the Environmental Impact Assessment (EIA) for Project or Activity requiring an EIA report (B.E. 2561 (2018), (No.2) B.E.2562 (2019), and (No.3) B.E. 2564 (2021)). • Notification of MONRE Re: Rule, Procedure, Method, and Guideline for Preparation of the Environmental and Health Impact Assessment (EHIA) for Project or Activity which may seriously affected quality of the environment, natural resources and community health and quality of life (B.E.2561 (2018) and B.E. 2562 (2019)). • Notification of the Office of Natural Resources and Environment Policy and Planning (ONEP) Re: Guideline for public participation in Environmental Impact Assessment process (B.E. 2562 (2019)).	The NEQA (2018) is the fundamental legislation that stipulates the existing EIA system in Thailand with provisions on EIA screening, preparation, review process, timing, public consultation, mitigation measures and monitoring. The types and sizes of projects and activities which are required to submit an Environmental checklist, an Initial Environmental Examination (IEE), EIA and EHIA including rules, procedures and guidelines for the preparation of an IEE, EIA and EHIA are specified in the Ministerial Notifications of MoNRE issued under the NEQA. The Ministerial Notifications have been regularly updated to meet the changing need and situation. Content of the IEE, EIA and EHIA include social aspects and social impact assessment. Additionally, the Constitution of the Kingdom of Thailand B.E. 2560 (2017) requires public consultation and evaluation of the impacts on the quality of the environment and health of the people in communities for any project or activity which may have serious impacts to communities in respect to the quality of environment, natural resources and biological diversity. Projects and activities which are required to prepare an EHIA are issued in the Ministerial Notifications of MoNRE. The IEE, EIA, EHIA requires screening, scoping and terms of reference. The instruments must consider the direct and indirect impacts, short and long-term impacts on physical, biological, human use values, and quality of life. Analysis of alternatives, including “no project” scenario, is required to select the preferred option including site and design

Regulations	Relevant Requirements
	alternatives. An ESMP with budget, timeline, and responsible parties is required.
Stakeholder Engagement and Information Disclosure	
• Regulations on Environmental and Social Impact Assessment described in the earlier section • Notification of the Office of the Prime Minister Re: Public Consultation by Public Hearing (1996)	Provisions from the Enhancement and Conservation of National Environment Quality Act, B.E. 2535 (1992) and the Constitution of the Kingdom of Thailand requires public participation and availability of information to the public in relation to the development process and matters concerning the enhancement and conservation of environmental quality. Thai EIA regulations require the project proponent to consult seven major groups of stakeholders and takes their view into account. These seven groups of stakeholders include: (1) affected groups; (2) agencies responsible for EIA preparation; (3) units responsible for EIA report review and consideration; (4) relevant government agencies and state enterprises; (5) non-government organizations, academic institutions and independent researchers; (6) mass media and the (7) general public. Stakeholders are to be consulted during consideration of project alternatives and TOR preparation before it is finalized; and again once a draft EIA report is available. Relevant materials are to be provided in a timely manner prior to consultation and in an understandable format and language and may be disclosed on the Project's website. Public participation guidelines for consultation and information dissemination shall be followed.
Natural Resources Management	
• The Wildlife Conservation and Protection Act 2019	The Act governs the conservation, protection, care, and restoration of wildlife and their habitats administration of wildlife sanctuaries and non-hunting areas, management wildlife ecosystems, and other natural resources in a sustainable manner. The Act prohibits hunting of preserved or protected wild animals. It is required that a management plan be developed for each wildlife sanctuary and non-hunting area. The Act governs the management of Non-hunting areas including designation, expansion or reduction, acceptable use of resources and prohibited uses.

Regulations	Relevant Requirements
• The Cabinet Resolution of 22 Aug 2000 and 14 Oct 2000 on Mangrove Conservation and Management	Key requirements include that logging and mining in mangrove forest areas to continue only until the termination of concessions, with contracts to be strictly enforced. Remaining forest to be reclassified for conservation or development-related activities. Aquaculture to be permitted only in areas behind mangrove forests. Department of Fisheries, Royal Forest Department and Department of Pollution Control to co-operate in promoting sustainable management of aquaculture operations without detriment to surrounding ecosystems or mangroves.
• The National Reserved Forest Act (No. 4), B.E. 2559 (2016).	The Act provides for the marks showing the boundary lines of National Reserved Forests, establishment of the Provincial Committee on National Reserved Forests Control and Maintenance, the Committee Considering Exploitations within Boundaries of National Reserved Forests, the power of the competent official, offences/penalties, etc. In the case where a Government agency or a State agency intends to use certain areas within the boundary of a national reserved forest as a workplace or for any other public interest, the Director-General, with the approval of the Committee Considering Exploitations within Boundaries of National Reserved Forests, shall have the power to issue a Notification designating such areas as the areas of official use within the boundary of the national reserved forest. The Director-General, with the approval of the Committee Considering Exploitations within Boundaries of National Reserved Forests, has the power to grant any particular person permission for the exploitation or habitation within the boundary of a national reserved forest.
• Notifications of MoNRE Re: Environmental protection areas in Ao Luek District, Mueang Krabi District, Nuea Khlong District, Khlong Thom District, and Koh Lanta District, Krabi Province	There are areas in eleven provinces, namely Phuket, Krabi, Pang-nga, Suratthani, Petchaburi, Prajuab-Kirikan, Chonburi, Samutprakarn, Prachinburi, Lampoon, and Chiengmai which are designated as Environmental Protection Areas. The Krabi Province Environmental Protection Areas requirements apply to protected areas and building control areas following the established criteria. The Notification classified Krabi Environmental Protection Areas into five zones include: (i) mangrove conservation and restoration zone; (ii) forest reserve and protection zone; (iii) marine resources fisheries and coastal resources protection zone; (iv) Coastal zone and islands management zone; and (v) other areas not included in (i) to (iv) except for Krabi Municipality areas. Specific measures for each zone to protect environmental value including requirement on EIA and IEE have been specified.

Regulations	Relevant Requirements
• DMCR Order on Replantation and maintenance of mangrove forests for conservation or environmental preservation B.E. 2556 (2013); • DMCR Order on Mangrove Plantation and Maintenance B.E. 2564 (2021);	The 2013 Order requires mangrove replantation 20 times of those areas affected by public development project providing that the impact is unavoidable and approved by responsible agency/s. The Project proponent need to allocate sufficient budget for DMCR as part of the Project implementation budget. It is required that a survey, identification of replantation site, replanted species is carried out by DMCR staff or qualified third party under their supervision. The 2013 Order is complimented by detailed guidelines within the DMCR Order on Mangrove Plantation and Maintenance B.E. 2564 (2021) which require a survey, mapping, and identification of replantation area, selection of replantation species (list of species provided in the guideline), preparation of seedling, site preparation, plantation and maintenance, signboard posting, monitoring and reporting (with report templates provided). DRR is required to report implementation status of mangrove replantation in the mandatory EIA monitoring report to the ONEP on Annually basis both during construction and operation phase.
Pollution control	
• Enhancement and Conservation of the National Environmental Quality Act (NEQA) (No. 2) B.E. 2561 (2018), amended in B.E. 2535 (1992) and B.E. 2561 (2018)	This Act is a fundamental environmental law in Thailand. It covers wide range of pollution issues such as water pollution, air pollution, waste management, noise and vibration.
• The Navigation in Thai Territorial Waters Act (No.14), B.E. 2535 (1992) • Fisheries Act, B.E. 2558 (2015).	These acts prohibit discharging into a watercourse anything that could cause pollution, harm aquatic plants and animals, or obstruct navigation unless permitted otherwise.
• Notifications of MoNRE Re: Environmental protection areas in Ao Luek District, Mueang Krabi District, Nuea Khlong District, Khlong Thom District, and Koh Lanta District, Krabi Province	It is required that project proponent for IEE/EIA project submit wastewater treatment report to the Krabi Natural Resources and Environmental provincial office.
• The Public Health Act, B.E. 2535 (1992) and Building Control Act, B.E. 2522 (1979)	These Acts regulate the discharge of wastewater into watercourses. The Public Health Act assures the health, hygiene and living environment of citizens and prescribes duties of the local municipalities as well as the private entities. Municipal wastes are managed by local municipalities under this act.

Regulations	Relevant Requirements
• The City Cleanliness and Orderliness Act, 1992, amended in 2017 (No. 2)	This Act sets the standards and regulates the collection, transportation, and disposal of sewage and solid waste.
• Various Notifications of the National Environment Board (NEB), MONRE and Pollution Control Department (PCD)	These legislations set environmental quality standards include ambient air quality, noise and vibration, surface (freshwater and coastal water) and soil and groundwater quality standards. These include criteria and guideline regarding solid waste management, discharge of effluent, air and noise emission, etc.
Labor and Working Conditions	
• The Constitution of the Kingdom of Thailand B.E. 2560 (2017)	Provisions for fair wages and welfare, safety of work conditions, and the right to form and join labor unions are included in the Constitution.
• The Occupational Safety, Health and Environment Act, B.E. 2554 (2011)	This Act is the primary legislation regulating OHS and working conditions and is largely consistent with ESS2. Extensive OHS regulations are also in place under the Labor Protection Act, including appointment of safety officers, responsibilities of OSH committee, establishment of safety department, disaster management and chemical safety. Pertinent to the project, specific safety regulations apply such as safety guidelines for construction work over/near water prescribed by Marine Industrial Safety Section, Marine Department, which includes mitigation measures for water-related risks in bridge construction. Another is the safety management guidelines for working at heights (ISO 101: 2018).
• The Labor Protection Act B.E. 2541 (1998) amended B.E. 2562 (2019)	The Labor Protection Act is the main labor law and provides basic rights and protection for all workers, including migrant workers.
• The Compensation Act B.E. 2537 (1994)	The Compensation Act provides compensation to employees who are injured, disabled or killed as a result of work-related accidents or illnesses.
• The Civil Service Act B.E. 2551 (2008)	Government workers in Thailand are governed by the Civil Service Act B.E. 2551 (2008) which establishes rules and procedures for the recruitment, selection, appointment, promotion, rights and obligations.
• Public Health Act B.E. 2535 (1992)	This Act is the primary public health law. For COVID-19 measures related to construction, the Department of Health (DOH) of the Ministry of Public Health issued Measures and Operational Guidelines for the Management of Construction Sites and Temporary Accommodation for Construction Workers in the Prevention and Control of the COVID-19
• Applicable ILO conventions include the C 100 - Equal Remuneration 1951; and C111-	

Regulations	Relevant Requirements
Discrimination (Employment and Occupation 1958) Conventions.	
Land Acquisition, Restrictions on Land Use	
• The Land Code Act B.E. 2497 (1954) and its Amendments	Land ownership and land issues are governed primarily by the Land Code Act. The following content provides an overview of the land documentation system in Thailand: • A Land Title Deed (Chanote) is issued by the local provincial office of the Thai Land Department, and is based on accurate surveys, pegged into the ground and plotted, in relation to a national survey grid. • Sor. Kor. 1 are the legal land document applicable to Koh Lanta Bridge. This document can be inaccurate and land boundaries should be confirmed with neighbors. • Nor. Sor. 3 is issued and maintained by the District Land Office and allows land to be sold, leased, or mortgaged. • Por. Bor. Tor. 5, 6 is a document filed with the District Office, as opposed to the District Land Office, establishing a squatter's or settler's claim. Banks will not accept such land as collateral, permanent structures may not be constructed on such land, and the land may not be leased. • Sor. Por. Kor. is issued by the Agricultural Land Reform Office and grants rights for agricultural purposes only.
• The Cabinet Resolution Re: Ministerial Guidelines in Government Soliciting Land Dedication from the Public or for Permission to Operate on Private Land for Mutual Benefit, August 02, 2007 • Various Supreme Court Decisions	The Thai Cabinet has set out the guidelines for governmental bodies to accept the donation of land or permission to operate on private land for mutual benefits. This guideline was circulated and given to every Ministry and Department on 02 August 2007. These guidelines also stipulate the forms and evidence of the donation of land, including the details contained in the letter of donation. Supreme Court decisions also support the legality of land donations in accordance with social and cultural norms, some of which include: (1) the effectiveness of the land donation without registration of the transfer of ownership required (No. 4377/2549 (2006)); (2) verbal donation of the land is considered legally valid (No. 264/2555 (2012); and, (3) the donation of land to the public may be done implicitly or by default, such as allowing the people to use without restriction. (Supreme Court's Decision No. 6067/2552 (2009), 2526/2540 (1997).
Community Health and Safety	
• Ministerial Regulations (Thai Govt Gazette, March 4, 2021) specify requirements for earthquake resistance.	These legislation and design standards and guideline stipulate requirements related to community safety aspects including disaster prevention (earthquake, Tsunami), roadway safety, and water safety.

Regulations	Relevant Requirements
• DRR Design Standards and other international standards including American Association of State Highway and Transportation Officials (AASHTO) Guide Specification for LRFD Seismic Bridge Design 2nd Edition, and Engineering Institute of Thailand and the Department of Public Works and Town & Country Planning, Ministry of Interior Standard 1301/1302-61 on the building design standards for earthquake resistance • The Land Transport Act, 1979. • The Highway Act, 1992 (Revised 2006). • The Navigation in Thai Waters Act, 2003. • The Thai Vessels Act (No. 7), 2007. • The Marine Carriage of Goods Act, 1991. • The Ministerial Regulations, No. 71, 1999 of the Navigation in Thai Waters Act, 1913 and Navigation in Thai Waters Act No. 6, 1938.	
Cultural Heritage	
• The Act on Ancient Monuments, Antiques, Objects of Art and National Museums B.E. 2535 (1992) • The Promotion and Conservation of Intangible Cultural Heritage Act B.E. 2559 (2016) • The Amendment Act on Ministries, Sub-Ministries, and Departments (2002).	Thes Acts cover the scope and definition of tangible and intangible cultural heritage for the protection and conservation under national laws. The law designates the Fine Arts Department as the government agency responsible for creating, preserving, conserving, promoting, and disseminating the art, archaeology, and culture of the nation. It covers various fields such as fine arts, museums, antiquities, literature, history, traditional customs, rituals, the National Library, the National Archives, as well as dance, music, theater, architecture, and craftsmanship, to ensure their enduring presence.

3.2 THE WORLD BANK ENVIRONMENT AND SOCIAL STANDARDS (ESSS) RELEVANT TO THE PROJECT

The following ESSs are relevant to the Project.

ESS 1 – Assessment and Management of Environmental and Social Risks and Impacts;
ESS 2 – Labor and Working Conditions;
ESS 3 – Resource Efficiency and Pollution Prevention and Management;
ESS 4 – Community Health and Safety;
ESS 5 – Land Acquisition, Restrictions on Land Use and Involuntary Resettlement;
ESS 6 – Biodiversity Conservation and Sustainable Management of Living Natural Resources;
ESS 8 – Cultural Heritage; and
ESS 10 – Stakeholder Engagement and Stakeholder Disclosure.

3.3 KEY GAPS BETWEEN THE REQUIREMENTS OF WB ESF AND NATIONAL REQUIREMENTS

At the time of the Thailand Resilient Transport Connectivity Project preparation, Koh Lanta Bridge EIA had been reviewed and approved by the National EIA Review Expert Panel and the National Environmental Board (NEB). Public consultations had been carried out throughout the EIA preparation period to gather stakeholders' concerns and feedbacks and include the following key meetings:

- Project Pre- orientation meeting – this meeting was conducted during TOR stage to present project information and scope of works for EIA;
- Focus group meetings – to present information on criteria and project alternatives considered;
- Public consultation meeting – to present results of project alternative analysis; and
- Project Final orientation meeting – to present draft EIA including proposed mitigation measures and monitoring program.

Seven different groups of stakeholders including the project affected people as required by the ONEP public consultation guideline were consulted. Information presented in each meeting were disseminated to stakeholders through various media such as a summary report, information board, leaflet, power point presentation, video, etc. These materials and results of the stakeholder consultations had been disclosed on the Project websites. The approved EIA was also disclosed on the Project's website and ONEP's website on August 11, 2023 and August 18, 2023, respectively.

While the requirements of National regulatory systems are largely consistent with the requirements of the ESSs relevant to this Project, certain gaps exist between these two systems and are outlined in ***Table 2***.

Table 2 Key Gaps in National Requirements vis-à-vis Relevant ESSs under WB ESF's

Potential Gaps	**Gaps filling measures**
ESS1 (Assessment and Management of Environmental and Social Risks and Impacts)	
There are few gaps between the ESF and Thai EIA requirements including that Thai EIA regulations require impact assessment of ancillary facilities such as source of construction materials, materials storage, worker camps, spoil disposal site, etc but do not mention requirement regarding Associated Facilities. Cumulative Impact Assessment and independent experts deployment is not explicitly mentioned but is requested on case-by-case basis during the EIA review process. Thai system requires that EIA monitoring being carrying out by Third Party i.e. a licensed EIA firm. There is no reference to the need for the EA to provide for capacity development and training to address environmental and social aspects of the	In addition to the EIA report required by National requirements, the EA has prepared a Supplementary Lender Information Package (SLIP) to provide the additional information, assessments and management measures needed to fill the gaps arising from differences between the national and ESF compliance requirements. Specific instrument to address specific ESS requirements are also included as part of the SLIP. The SLIP identified associated facilities and assessed impacts and measures to manage the risks and impacts identified. In addition, the SLIP included a Rapid Cumulative Impact Assessment (RCIA) and ESMP that incorporate training requirements and estimate budget.

Potential Gaps	Gaps filling measures
project. Use of precautionary principle is not required by Thai EIA system.	
ESS10 (Stakeholder Engagement and Information Disclosure)	
Thai legislation framework on stakeholder engagement in EIA process are comprehensive and require project proponent to consult with stakeholders early during alternative selection and TOR stage and throughout project development stages. EIA regulations require that the project proponent provides relevant materials in a timely manner prior to consultation and in an understandable format and language. However, disclosure of a full draft EIA is not mandatory. The final approved EIA and EIA monitoring report is required to be disclosed on the ONEP's EIA website. Stakeholder consultation and information disclosure for Koh Lanta Bridge Project had been discussed earlier. Between disclosure and consultation activities conducted by the EA from 2020 to 2022, and the present, the gaps in information disclosure and consultations for the Lanta project gathered on these aspects: (1) additional stakeholder identification and analysis (e.g., ferry operator and workers affected by bridge opening, shop renters and informal vendors found in construction ROW); and (2) need for consultations with disadvantaged and vulnerable groups (e.g., persons with disabilities (PWDs), hospital patients in need of emergency and urgent health care, women's groups).	In preparing the Stakeholder Engagement Plan (SEP) in accordance with ESS10, stakeholder analysis was conducted. This exercise informed the formulation of information disclosure and consultation strategies developed to address outstanding concerns. A corresponding SEP work plan and budget was developed.
ESS2 (Labor and Working Conditions)	
A gap analysis conducted on ESS2 and labor laws and policies in Thailand indicated no major gaps. Where gaps exist, these are on: (1) the Labor Protection Act mandating the disclosure of work regulations (e.g., working days, rest periods, overtime pay, wages, leaves, grievances, and termination of employment) for employers hiring ten or more workers; (2) non-discrimination policy in employment operating only for discrimination based on gender; (3) national laws on workers' organizations not applying for informal sector workers; and, (4) on the national appeals process, simultaneous use of the Labor Court and the Labor Inspector is not allowed.	Gaps 1 and 2 do not apply to the project which will employ more than 10 workers and will be covered by formal work contracts. For Gap 3, the non-discrimination of other vulnerable groups like migrant workers are covered under robust national policies on migrant labor. On Gap 4, the Labor Management Plan (LMP) laid out various channels and entities for appeals other than those found in the Ministry of Labor and the judiciary.

Potential Gaps	Gaps filling measures
ESS3 (Resource Efficiency and Pollution Prevention and Management)	
The pollution control laws in the country are comprehensive and organized into the following key legislations: the Enhancement and Conservation of the National Environmental Quality Act; the Navigation in Thai Territorial Waters Act; Fisheries Act; various Notifications of the National Environment Board (NEB), MONRE and Pollution Control Department (PCD); the Public Health Act; and the City Cleanliness and Orderliness Act.	These requirements were addressed in the Koh Lanta Bridge EIA. No materials gaps pertaining to requirements relevant to the project are identified. However, mitigation measures for potential impacts from minor oil spill/leakage has been included in the ESMP that will be part of the SLIP.
ESS4 (Community Health and Safety)	
Requirements regarding community health and safety applicable to the Project are outlined in major legislations including: the Ministry of Interior Ministerial Regulations; DRR Design Standards and other international standards; the Land Transport Act; the Highway Act; the Navigation in Thai Waters Act; the Thai Vessels Act; and the Navigation in Thai Waters Act. Thai EIA requirements also cover community health and safety aspects and guideline on health impact assessment.	The requirements of the relevant legislative framework, design standards and guideline on community safety aspects including disaster prevention (earthquake, Tsunami), roadway safety, and water safety were covered in the Koh Lanta Bridge EIA. However, management measures related to water safety and traffic management have been strengthened and included in the ESMP that will be part of the SLIP.
ESS5 (Land Acquisition, Restrictions on Land Use, and Involuntary Resettlement)	
The Cabinet Resolution (August 02, 2007) has set out guidelines and forms for governmental bodies to accept the donation of land or permission to operate on private land for mutual benefits. There are also various Supreme Court's Decisions that were granted and that verified the subject of legality of the donation of land. Gaps exist between Thai legal framework requirements and ESS5 regarding voluntary land donation include that Thai legal framework does not specify requirements: on consultation with donor on choice available to them (including refusal); that the amount of land being donated is minor and will not reduce the donor's remaining land area below that required to maintain the donor's livelihood at current levels; (d) no household relocation is involved. Gap analysis also shows that under Thai law, donor's taxes do not apply for land donated for public purposes.	Land Process Review has been carried out to confirm that land donation for Lanta Bridge was carried consistent with the requirements for VLD per ESS5.

Potential Gaps	Gaps filling measures
ESS6 (Biodiversity Conservation and Sustainable Management of Living Natural Resources)	
Existing regulatory framework applies No Net Loss, Net Gain concept in case negative impacts on mangrove forest by necessary public sector development project is unavoidable. However, there is No requirements on: (i) the application of hierarchy of measures; (ii) the preparation of Biodiversity Management Plan for individual project; and (iii) differentiated measures on types of habitats.	A Critical Habitat Assessment (CHA) has been prepared as a component of the SLIP for Koh Lanta Bridge to inform construction and operation management plans. The results of the CHA will determine whether the proposed offset approach for the impacted mangroves (as well as the Mangrove Action Plan and Reforestation Action Plan) are sufficient and/or whether additional mitigation or management measures will be required as they relate to both flora and fauna conservation.
ESS8 (Cultural Heritage)	
Gap analysis indicates congruence between national laws and ESS8 on chance find procedures. National laws prescribe protocols and responsible parties on notification, disturbance avoidance (fencing-off), and the assessment of found objects or sites. The gap is on the training of contractors and project workers on chance-find procedures which the project would have to develop in collaboration with the Fine Arts Department and related agencies (e.g., local police).	A Chance-find procedure has been prepared for Koh Lanta Bridge Project. The ESMP will include requirement for Contractor to provide a training for its employee and project workers on the Chance-find procedure.

•

4 PROJECT DESCRIPTION

4.1 PROJECT LOCATION

The Koh Lanta Bridge is located on the shore of the Andaman Sea in southern Thailand, entirely within Koh Lanta District, Krabi Province. The bridge crosses the Khlong Chong Laad, the sea channel between Koh Klang sub-district and Koh Lanta Noi sub-district. The beginning point of the project route (milestone 0+000) connects to Highway no. 4206 at the Ban Hua Hin pier. The ending point of the project (milestone 2+527) connects to local Rural Road no. 5035 in Ban Thung Toh Yum area. The length of the project route is 2.527 km with a total bridge span of 1405 meters. Table 3 presents the coordinates of the origin and destination points of the bridge.

Table 3 Origin and destination coordinates of the Koh Lanta Bridge, within Koh Lanta District of Krabi Province

Point	Sub-District	Village	Location Coordinates	
			UTM (Zone 47 N)	Decimal Degree (Lat/Long)
Origin	Koh Klang	Moo 8, Ban Hua Hin	510535 E; 850757 N	7.696592°; 99.095530°
Destination	Koh Lanta Noi	Moo 2, Ban Thung To Yum	511762 E; 849015 N	7.680831°; 99.106653°

Figure 3 Current situation photographed from Koh Klang Sub-district side with a view of Khlong Chong Laad, Koh Pling Island and Koh Lanta Noi Sub-district on the other side

4.2 BRIDGE COMPONENT LAYOUT AND COMPOSITION

4.2.1 Bridge Design

The Koh Lanta Bridge and connecting roads consists of two traffic lanes (one in each direction). Each lane is 3.75 m wide, separated by a painted median (1 m width) and road shoulders on each side (2.5 m width) giving a total width of 13.5 meters (Figure 5). The project is designed to the following standards:

- AASHTO Guide Specification for LRFD Seismic Bridge Design 2nd Edition, 2011;
- Standards of the Engineering Institute of Thailand; and
- Department of Public Works and Town & Country Planning Standard 1301/1302-61 on the Design of Buildings to withstand Seismic Waves (Department of Public Works and Town & Country Planning, Ministry of Interior).

The Koh Lanta Bridge includes three bends to pass around the small Koh Pling Island. The bridge crosses the Khlong Chong Laad (110 meters width) close to the Koh Klang side and a broad shallow area between Koh Pling and the Koh Lanta Noi side. The bridge design will comprise an extradosed bridge (prestressed box girder and cable-stayed bridge) over the Khlong Chong Laad and a balanced cantilever bridge (combination of supported structure and continuous structure) over the shallow sea (Figure 4). The profile of the bridge considers the average high tide level of +1.08 meters and will accommodate a tsunami wave similar to the tsunami that struck the Koh Lanta coast in 2004 (approx. 4 meters).

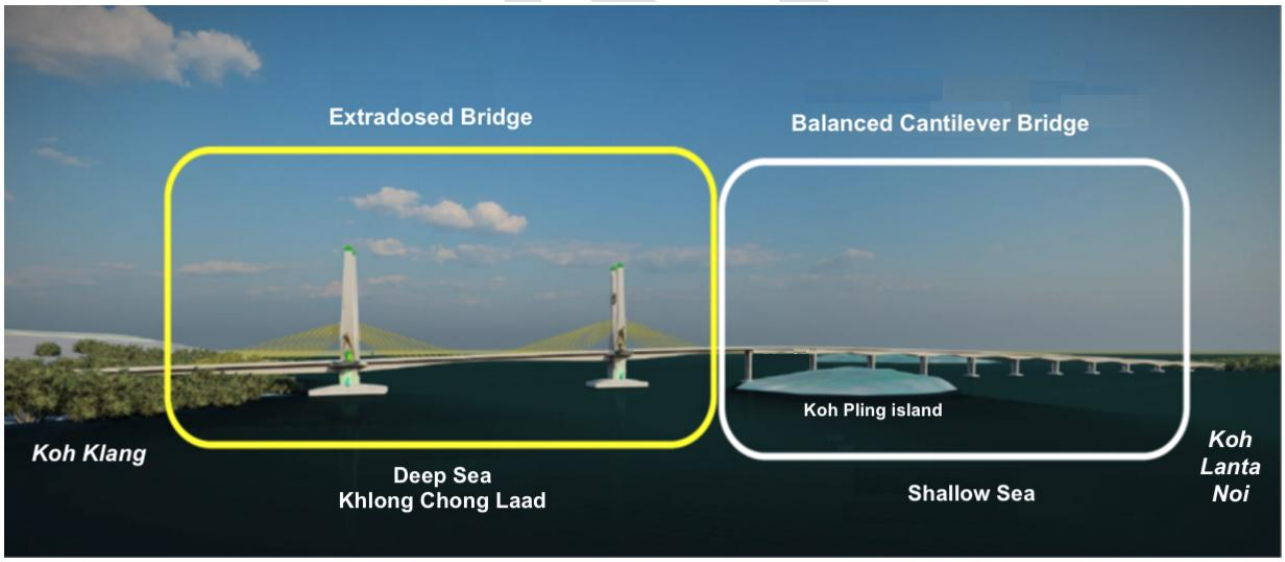


Figure 4 Architectural layout of the extradosed bridge and balanced cantilever bridge components of the Koh Lanta Bridge relative to the Khlong Chong Laad channel and Koh Pling Island

Figure 5 ***Architectural renditions of Koh Lanta Bridge illustrating width components of the bridge (left), cable structures suspended from pylons on piers P17 and P18 and pedestrian viewpoints (right)***

The extradosed bridge will be constructed between piers P16, P17, P18 and P19, with P17 and P18 being the two large structures shown in Figure 4. Piers P17 and P18 will require 18 bored piles each while P16 and P19 require 12 bored piles each. The extradosed bridge upper structure will be cast *in situ* with a prestressed box girder to hold the cable suspending the superstructure to the pylon (Figure 5).

The Balanced Cantilever Bridge will extend for 875 meters with 13 piers from P20 to P32. The height of the bridge clearance is 3 to 8 meters. The piers will be based on a single column with a 2.5-meter depth and 6.2-meter width. The superstructure of the bridge will be cast *in situ*.

The approach and end bridge pier structures will consist of precast box girders that require four bored piles each. Fifteen approach piers (P1 to P15) will be built on the Koh Klang Sub-district to support 280 meters of the bridge. Eight piers (P33 to P40) will be built on the Koh Lanta Noi side supporting 140 meters of the bridge.

The bridge will be constructed using a concrete mix that can withstand Chloride and Sulfate components of sea water that are dangerous for reinforced steel and concrete. Permanent steel casings will additionally act as a prevention from seawater corrosion.

Reflective road studs will be embedded into the road surface at 12-meter intervals to clearly designate the traffic lanes (Figure 5). Non-metal road studs will be used to prevent seawater corrosion. U-turn points will be incorporated on each side of the bridge with sufficient size to allow all types of single unit trucks to turn.

4.2.2 Viewpoints on the Bridge

The balanced cantilever bridge will not be accessible to pedestrians, but two pedestrian viewpoints will be incorporated into the extradosed bridge design (Figure 5) and accessible from the Koh Klang side via pedestrian walkways on each side. Concrete barriers (1.5 meters height) will be installed between traffic lanes and pedestrian walkways. Elevators and stairways will be installed on the Koh Klang side to access the pedestrian walkways. The Koh Lanta Rural Roads Office will be responsible for the safety of the elevators. Procedures for conducting a routine equipment check are presented in the EIA.

4.2.3 Approach Roads, Drainage and Lighting

The approach roads will consist of 2 to 4 traffic lanes, covering 340 meters and 527 meters on the Koh Klang and Koh Lanta Noi sides respectively. Drainage pipes (100 mm diameter) will be installed on both sides of the bridge at 3-meter intervals. These will drain into a clarifier at the base of every bridge pier which then drains into the sea. V-ditch drainage will be installed along the shoulder of the approach roads which drain into the mangroves and the sea.

Lighting will be provided by energy saving low lux yellow light bulbs with a color temperature of 3,000 Kelvin which does not attract insects and installed to avoid road reflection towards the sky. Light poles will be 9-meter in height and spaced 30 meters apart in a zig zag manner. Lights will also be installed on bridge pier structures and at the bridge clearance between piers to alert boat traffic at night or during periods of poor visibility. The lights will connect to the 33 kV power distribution system of the Provincial Electricity Authority (PEA).

4.3 ASSOCIATED FACILITIES

According to the Environmental Impact Assessment (EIA) report, the project requires relocation of public utilities such as electric poles and communication cables on both sides of the bridge. Relocation of these utilities are not funded by the project. It will be carried out and funded by responsible agencies. This activity meets all of three criteria of Associated Facilities as defined in WBG ESF include (a) directly and significantly related to the project; and (b) carried out, or planned to be carried out, contemporaneously with the project; and (c) necessary for the project to be viable and would not have been constructed, expanded or conducted if the project did not exist. Impacts for this activity are assessed under the heading Public Utilities and implementation will need to comply with mitigation measures included in the EIA and in accordance with the ESF.

4.4 EARTHQUAKES AND TSUNAMI RISK

Section 6.1.5 explains the Krabi Province is included within Zone 1 of the earthquake prone regions based on the Ministerial Regulation (B.E. 2564). The design of the Koh Lanta Bridge must therefore be able to resist seismic waves that qualify as a “Strong quake” with PGA acceleration values of 0.092 to 0.18. Everyone would feel an earthquake of such magnitude, many people will run outside the building, home furniture will move and things inside a building will fall and be damaged.

The extradosed bridge and balanced cantilever bridge across the Khlong Chong Laad are designed to function normally and at full capacity after a "Strong quake" earthquake with no damage that is unrepairable to the main bridge structure. Designs are developed in accordance with the following international standards:

- AASHTO LRFD Bridge Design Specifications, 4th Edition, 2007, SI Unit. (LRFD2007)
- AASHTO LRFD Bridge Design Specifications, 6th Edition, 2012. (LRFD2012)
- AASHTO/AWS D.15M/D1.5:2002 Bridge Welding Code.
- Post-Tensioning Institute (PTI): PTI DC45.1-12: Recommendations for Stay Cable Design, Testing and Installation, 2012.
- *Fédération International du béton's (fib) Bullentine* 30: Acceptance of Stay Cable Systems using Prestressing Steels, 1st Edition, 2005.
- *Commission Interministèrielle de la Précontrainte* (CIP): CIP Recommendations on Cable Stays, 1st Edition, 2002.
- CEB-FIP Model Code for Concrete Structures, 1990.

The EIA presents an action plan to be followed by the Koh Lanta Rural Roads Office for inspection of the bridge structure should there be any seismic activity.

The region was exposed to a severe tsunami on December 26, 2004 (see Section 6.1.5). The Koh Lanta Bridge is designed to be able to withstand a tsunami of similar magnitude (approx. 4-meter height) and will not obstruct an evacuation in the event of another tsunami incident in Koh Lanta District. Instead the bridge will serve as an emergency rescue route that will benefit the disaster prevention and assistance plan. The Koh Lanta Bridge EIA outlines tsunami evacuation measures for people on land and in a boat.

4.5 PROJECT IMPLEMENTATION

Construction of the Koh Lanta Bridge requires a period of 3 years, and a detailed Gantt Chart for the construction schedule is presented in the EIA. The project will require an estimated 229 project workers (excluding estimates of primary supply workers to be generated by the contractor before construction) and construction machinery such as backhoes, compactors, graders, trucks, cranes, barges and other equipment. Local labor hiring is a priority pursued by the EA although the mechanism for determining the share of local labor to total requirements is still to be determined with the contractor before construction.

A construction worker camp, site office, concrete mixing plant, maintenance facility and casting yard is planned on the left side of Highway 4206 close to the beginning point of construction. When this site was consulted with the EA in September 2022, the EA advised that the site may be provisional or temporary as additional sites would be evaluated by the contractor before the start of construction. With this position of the EA, land requirements for workers' camps and construction work areas like material depots found in the EIA may not be final. This condition merits the preparation of a Resettlement Framework (RF) by DRR to contain principles and guidelines for land acquisition for these and other similar structures and activities in accordance with national laws and regulations and the World Bank's ESF. The relocation of utilities will take place within the right-of-way of connecting roads to the bridges and will not entail

additional land acquisition. In case during construction, land acquisition is found necessary, a Utilities Relocation Plan will be prepared by the contractor in accordance with the RF.

Large and extremely heavy precast piles and steel reinforcement materials required for construction will be transported by land to Krabi Port and then transported by barge via the Khlong Chong Laad to the construction site. Existing ferry services in Lanta are being considered by the EA for materials transport by sea as a form of project-related transitional support to the ferry owner and its workers. The final arrangements are being worked out by the EA with the ferry owner through an ongoing dialogue that also involves the Krabi Provincial Administration Office (PAO). Other construction materials that will be transported by trucks through Highway No. 4206. Materials, including aggregates for concrete mix, prestressed concrete pile, clean water, powder cement, steel bars and prestressed wire are regularly transported on this road and do not cause problems for the bridge over the Klong Yang. The Koh Lanta Bridge EIA presents proposed sources for these materials. Cables and associated equipment for construction of the extradosed bridge will be imported and brought to site in containers.

Sediments and debris from the drilling work for bridge bored piles foundations in the sea will be transported to land using barges and lifted into trucks using large cranes. These sediments will be disposed in open areas of the Koh Klang Sub-district Administrative Organization (SAO) and Koh Lanta Noi SAO, covering ±4.6 rai (0.73 ha) and 2 rai (0.32 ha), located 4.2 km and 9.1 km from the project area respectively. These areas are not fit for agricultural use, lack trees and have no issue with deposition of alkaline soil.

4.6 ECONOMIC ANALYSIS

The construction budget was priced in 2020 at 1,600 million baht and the annual maintenance costs approximately 692,924 baht (Table 4).

Table 4 Construction and Maintenance Costs for the Koh Lanta Bridge (based on 2020 prices)

Construction Components	Cost (Million baht)	US$ Equivalent
1. Main extradosed bridge	667.0	US$ 21,230,544
2. Balanced cantilever bridge	753.6	US$ 23,987,013
3. Slopes and flat roads	35.7	US$ 1,136,327
4. Contingency	146.4	US$ 4,659,898
Total Construction Cost	**1,600.0**	**US$ 50,927,842**
Estimated Annual Maintenance Cost	0.692	US$ 22,026
USD equivalent calculated based on an exchange rate of 31.417 baht/USD for 1-Jul-2020.		

An economic analysis has been conducted based on the construction budget and the annual budget but did not consider environmental and social factors or costs of implementing mitigation to address impacts (a 23.57 million baht budget is proposed in the EIA for E&S mitigation and monitoring, see Section 8.9). For estimating the value of economic investment, monetary value is used and multiplied by the economic conversion factor resulting in economic prices.

An economic feasibility analysis compared the cost of the project and all other expenses with the benefits received from the project over the project lifecycle. Indicators were the Net Present Value, Economic Rate of Return and Benefit to Cost Ratio. Indicators were calculated for two scenarios, namely a normal construction period and a fast-tracked construction, with results in Table 5. The results present a clear Benefit to Cost ratio regardless of the construction period.

Table 5 Economic analysis of the Benefit to Cost ratio of the Koh Lanta Bridge Project

Indicators	**Case 1: Fast track construction**	**Case 2: Normal track construction**
Project Net Present Value (million Baht) USD equivalent (exchange rate 31.417 on 1 July 2020)	945.62 US$ 30,098,990	828.36 US$ 26,366,616
Economic rate of return (%)	20.46%	21.12%
Benefit to Cost Ratio	1.91	1.99

5 ANALYSIS OF ALTERNATIVES

An analysis of alternative routes is provided in the EIA. Three route scenarios were developed that each had a beginning point on highway no. 4206 in Koh Klang sub-district and an end point on local highway KB. 6022 (Figure 6). These routes were evaluated on engineering and traffic factors, Investment factors and environment and social (E&S) factors at weightings of 30%, 30% and 40% respectively (a greater emphasis was therefore placed on E&S factors). Engineering factors comprised five parameters, investment comprised three parameters and E&S comprised eight different parameters (Figure 7). E&S parameters include protected areas (mangrove forest, Thung Thale Non-hunting area and national reserved forest), air noise and vibration impacts, oceanographic impacts, migration impacts, land and water transport and future development.

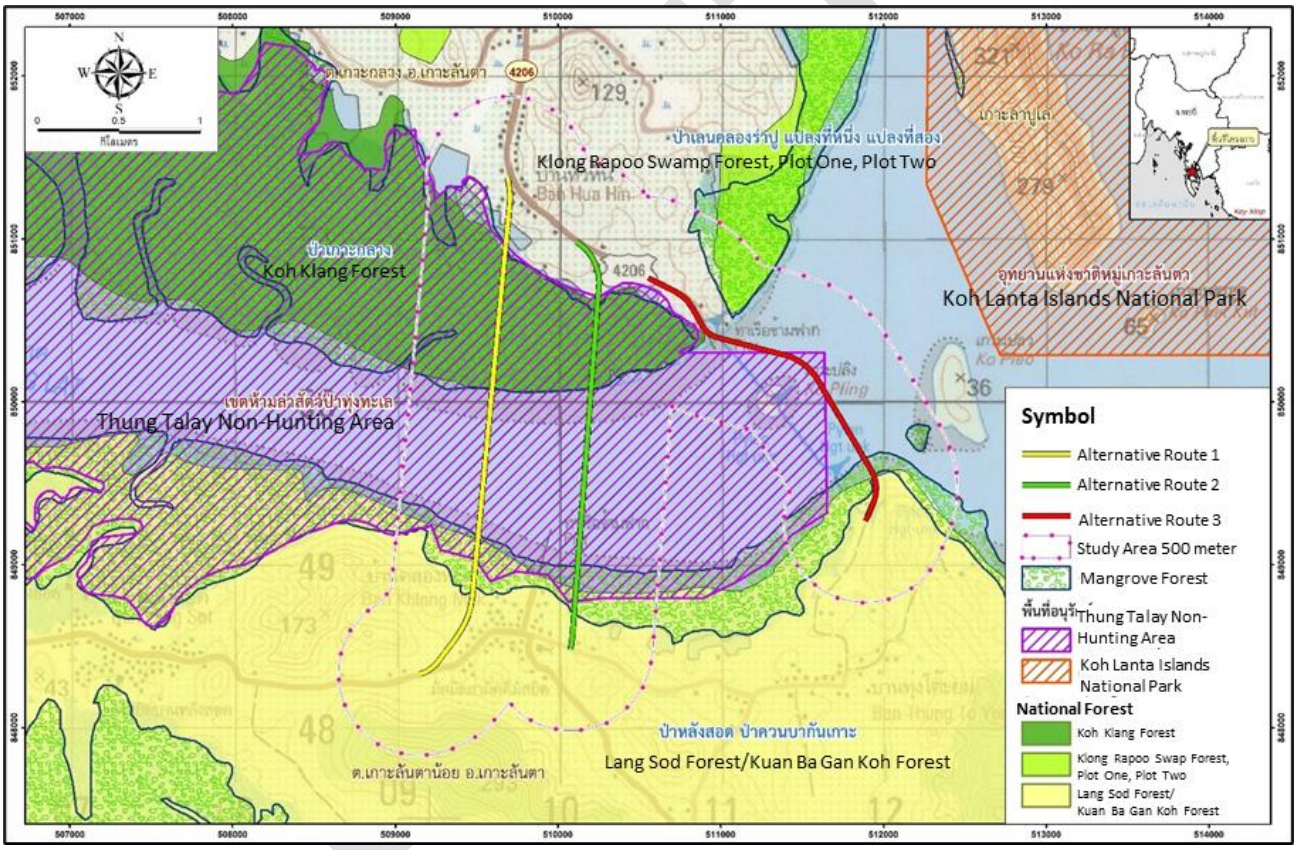


Figure 6 Three route scenarios used in an analysis of alternatives used to determine the optimal project route

The analysis revealed that Alternative Route 3 (Figure 6) was the optimal route and was therefore selected as the preferred route. The key determining factor was the reduced impact on protected areas, namely on designated mangrove forest as per a cabinet resolution and the Thung Thale Non-hunting Area as illustrated in Figure 6. This route has the shortest bridge length but is the longest route, has the most complex geometry (three bends) and requires the highest number of bridge piers. Alternative Route 3

has the lowest construction cost, land value and future maintenance cost. A summary of results of the alternative analysis is illustrated in Figure 7.

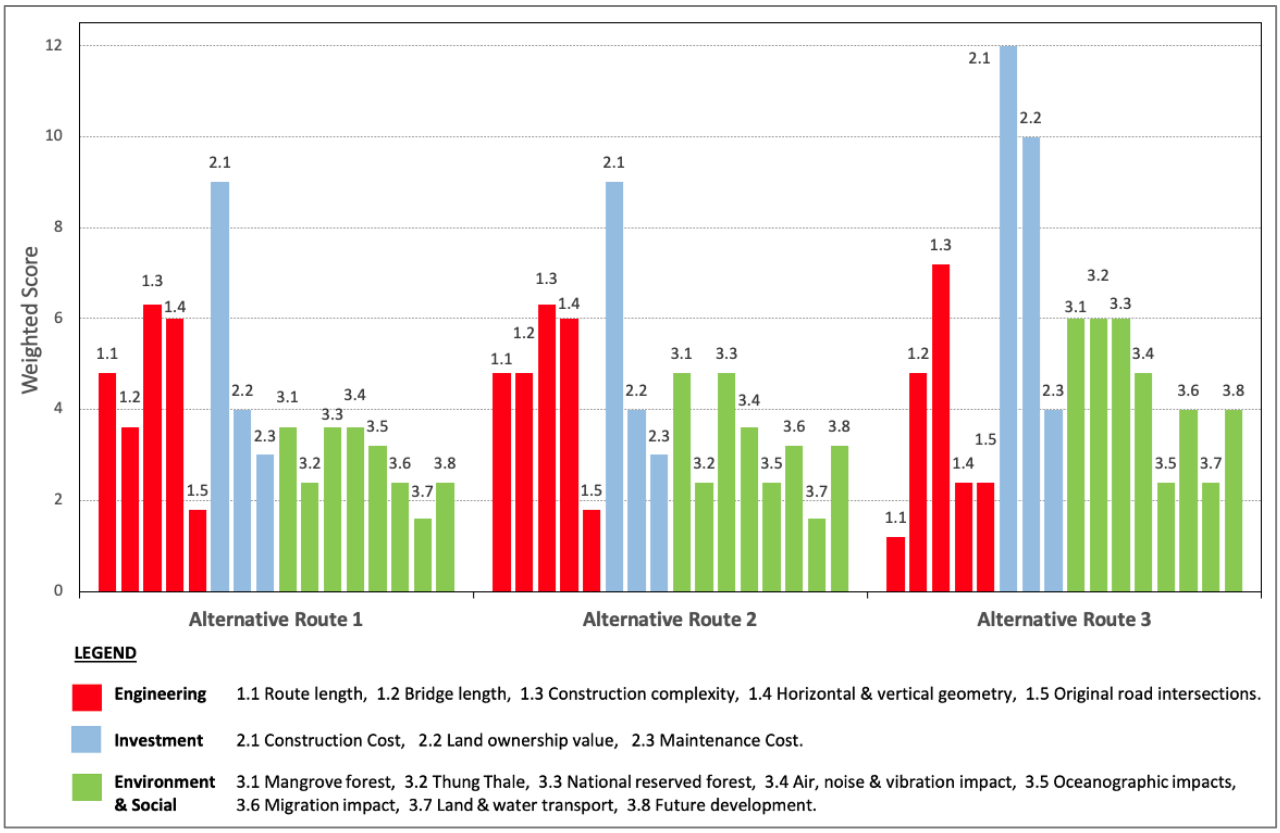


Figure 7 Results of a weighted analysis of 16 parameters separated into engineering, investment and E&S factors applied to three alternative project routes

6 BASELINE DATA

This chapter summarizes baseline data considered necessary to understand the project and to support the assessment of impacts. Baseline data is extracted from the EIA and supplemented from components of the SLIP.

6.1 PHYSICAL ENVIRONMENTAL RESOURCES

6.1.1 Air Quality, Noise and Vibration

Monthly air quality data were obtained for the Koh Lanta agricultural weather station and air monitoring was conducted at four locations representative of project conditions (Table 6). Baseline air quality conditions for Total Suspended Particulates (TSP), PM_{10} dust particulate matter, carbon monoxide (CO) and nitrogen oxide (NO_2) were measured for three consecutive days during Dec-2020 and repeated in Feb-2021. Results were compared against national air quality standards as presented in Table 7 and all parameters were within the ambient requirements.

Table 6 Details of the Weather Station and Project Monitoring Stations

Parameter	Weather Station
Station Name	Koh Lanta
Station Code	48566
Latitude & Longitude	7° 32' 0.0" N; 99° 3' 0.0" E
Station altitude	2 meters
Monitoring stations for air quality, noise and vibration assessment and monitoring.	Station 1: Moo 8 Ban Hua Hin (before entering the port), Koh Klang Station 2: Moo 8 Ban Hua Hin (Baan Tha Ruea) , Koh Klang Station 3: Moo 2 Ban Thung To Yum, Koh Lanta Noi Station 4: Ban Thung To Yum Mosque, Koh Lanta Noi

Table 7 Details of National Air Quality Standards

Pollutants	Period of avg concentration	Standard value	National Environment Board (NEB) Notifications and Announcements
Carbon monoxide (CO)	1 hour	< 30 ppm. (34.2 mg/m^3)	No. 10 (B.E.2538)
	8 hours	< 9 ppm. (10.26 mg/ m^3)	
Nitrogen dioxide (NO_2)	1 hour	< 0.17 ppm. (0.32 mg/ m^3)	No. 10 (B.E.2538), No. 28 (B.E.2550), No. 33 (B.E.2552)
	1 year	< 0.03 ppm. (0.057 mg/ m^3)	
Ozone (O_3)	1 hour	< 0.10 ppm. (0.20 mg/ m^3)	No. 10 (B.E.2538), No. 28 (B.E.2550)
	8 hours	< 0.07 ppm. (0.14 mg/ m^3)	
Sulphur dioxide (SO_2)	1 year	< 0.04 ppm. (0.10 mg/ m^3)	No. 10 (B.E.2538), No. 24 (B.E.2547)
	24 hours	< 0.12 ppm. (0.30 mg/ m^3)	
	1 hour	< 0.3 ppm. (780 microgram/ m^3)	
Lead (Pb)	1 month	< 1.5 microgram/ m^3)	No. 10 (B.E.2538)
Particulate matter < 100 microns	24 hours	< 0.33 mg/ m^3)	No. 10 (B.E.2538), No. 24 (B.E.2547)
	1 hour	< 0.10 mg/ m^3)	

Background sound for the terrestrial environment was measured at the same four stations used for air quality measurements. Results were compared against the national standards for noise (Table). Cars and motorcycles were the main sources of noise in the project area with more noise during the dry season than the rainy season, however all stations complied with national noise standards.

Table 8 National Standards used for the Noise Assessment

Noise Level Standard	NEB Notifications and Announcements
Maximum sound level not more than 115 decibels	NEB No. 15 (1997) Notification of the Pollution Control Board (31 Aug 2007) Announcement of the Pollution Control Department (11 Aug 1997)
Average sound level over 24 hours, not more than 70 decibels	

Baseline vibration levels were obtained through monitoring during both the rainy season and dry season at the same stations used for air quality monitoring (Table 6). Baseline vibration monitoring was done during three consecutive days which revealed the Peak Particle Velocity (PPV) in the range of <0.300 to 0.662 mm/second which is far below the limits of acceptable vibration provided by the following standards:

- National standard on Vibration Level to Prevent Impact to Buildings from the Notification of the National Environmental Board No. 37, B.E. 2553, which categorizes buildings into Building type 1 (PPV = 10 mm/s): Factories and commercial buildings; Building type 2 (PPV = 5 mm/s): Residential building, hospital, place of study or religious activity; and Building type 3 (PPV = 2.5 mm/s): Ancient monuments, antiques, objects of art, national museums, or structures of any other nature that are not stable and strong but have cultural value.
- German system for vibration impact to a building according to (Report DIN 4150:1999 by the *Deutsches Institut für Normung*, 1999).
- Guidance on Effects of Vibration Levels on Construction and Open Sites of the UK Environment Agency (British System Standard No. 5228) that assesses vibration effects on humans. Tremors are rated into four categories, namely: Just perceptible; Perceptible in residential environments; Can be tolerated with advance notice in the event of construction activities; and Tremors likely to be intolerable for any more than a very brief exposure.

6.1.2 Freshwater Quality

The survey of surface water sources within a 500-meter of the project area and the study area from the project route did not find any surface water sources in the project area. The volume of water from rainfall flows along the geological conditions of the area to other water sources in the vicinity.

Krabi Province is located in the area of 2 freshwater basins, namely the West Coast Southern Basin covering 64.34% of the area and the Tapi River Basin. Water for consumption is insufficient to meet current demand and there is a projected increase in tourism in the future. The current water demand for consumption is 25.70 million m^3/year but will double in the next 20 years. Water demand for human

consumption competes with demand for downstream ecological system reservation, agriculture and industry.

6.1.3 Marine Water Quality

Marine water quality was sampled in the project area during Jan, Feb and Jun 2021from three stations, (Station 1 - Ban Hua Hin, Koh Klang side; Station 2 - Koh Pling; and Station 3 - Ban Tung Toh Yum, Koh Lanta Noi side). Parameters recorded included water depth, temperature, transparency, turbidity, pH, dissolved oxygen, Biochemical Oxygen Demand (BOD), electrical conductivity, salinity, suspended particulate matter, arsenic, lead and mercury, coliform bacteria and fecal coliform bacteria. These surveys demonstrated that the physical and chemical qualities of the surface water and benthic water at all three stations zone fall under the first category of the marine water standard for environmental conservation.

6.1.4 Geology and Earthquake

The geology within a 500-meter radius of the project route (excluding the sea area) is composed entirely of sedimentary rock from the Carboniferous-Permian period comprising pebbled mudstone, shale, slit stone, chert, pumice stone and brown silica sandstones with invertebrate fossils. The orientation of the rocks on the west side of Koh Lanta Yai is tilted to the west, and the east side is tilted to the east, with most faults are in northeast-southwest and northwest-southeast directions. No mineral deposits occur although thick layers of limestone are suitable for industry but may not be viable due to transport constraints and environmental impacts. There is also an area of marine clay that accounts for 10.7% of the area. The hydrogeology within the 500-meter radius of the study area comprises a groundwater layer and an aquifer layer. The majority of the area comprises a fluvial deposits aquifer, accounting for 32.72% of the total area.

The Seismic Hazard Map of Thailand (Department of Mineral Resources, B.E. 2559) places the project area in the lowest earthquake intensity however the risk increases substantially within a 150 km radius of the project. The closest active geological fault to the project area is the Khlong Marui Fault approximately 70 km northwest of the project location. The EIA presents a log of 351 seismic events from 1975 to 2020 maintained by the Department of Mineral Resources seismic events which reveals there have been no significant earthquakes (severity of at least 4.0 magnitude) in the project area within the past 40 years. Krabi Province is however included within Zone 1 of the earthquake prone regions based on the Ministerial Regulation (B.E. 2564).

A severe Tsunami earthquake disaster with a magnitude of 9.2 occurred on 26-Dec-2004. The epicenter was about 30 km deep under the Indian Ocean northwest of Sumatra Island, Indonesia, which caused a sudden vertical shift in the seafloor. A huge amount of sea water was suddenly displaced and a 4-meter rise in water caused extensive damage to life and property in the six southern Andaman provinces including Ranong, Phang Nga, Phuket, Krabi, Trang and Satun. The communities in Koh Lanta were severely impacted.

6.1.5 Soil Resources and Erosion

Soils were investigated within a 500 m buffer of the project route. Soils within the terrestrial landscape comprised of five soil series. The greatest representation (15.3%) comprised the 13th soil series (Bang Pakong Series) are saline clays flooded with sea water on a daily basis. The 51st soil series (Huai Yot Series) covering 14.6% of the area are shallow soils on bed rock with low fertility. The soil series SC covers 5.9% coverage is the area used for agricultural production. The soil series 53 (Naton Series) covers 5.8% of the area has good drainage but is acidic with low fertility.

A survey of the sea bed in the Khlong Chong Laad found that the soils are more than 3 meters deep (to reach a hard layer) and consist of silty sands and sand silt mixtures at high density to silty clay at medium density.

6.1.6 Oceanography

The regional Oceanography was assessed using an AQUASEA mathematical model using a 90 x 83 km study area defined by the Krabi water level station in the north and the Haad Jao Mai water level station in the south. A second lesser study area focused on the Khlong Chong Laad channel. The AQUASEA model was supported by data on the water channel depth, water level and local physical conditions.

The average water level in the project area is 2.425 meters above mean sea level (MSL) with an average current velocity of 0.044 m/s. During high tide, the flow direction of the current is towards the east with a peak velocity is 0.450 m/s. During low tide, the flow direction is towards the west with a peak velocity of 0.463 m/s.

Thailand is located between two tropical cyclone sources, namely the Pacific Ocean and the Bay of Bengal. The southern part of Thailand is characterized as a peninsula without mountains to provide shelter from storms and is thus vulnerable to extensive storm damage. Data from the Meteorological Department (1951 to 2019) showed that the tropical cyclones generally move towards Thailand in September and October. The probability of cyclone activity in Thailand has decreased in the past 20 years to approximately 2 to 3 tropical cyclones per year. Previously, there were 4 to 5 tropical cyclones moving through Thailand each year.

6.2 BIOLOGICAL ENVIRONMENTAL RESOURCES

6.2.1 Protected Areas

The project route cuts through the Thung Thale Non-hunting Area (TTNHA) from chainage 0+922 to 1+369. The TTNHA covers 25.72 km² in extent (Figure 8), is declared under the Wildlife Conservation and Protection Act and recognized as an IUCN Management IV legally protected area. The reserve supports a diversity of wildlife species and protects large expanse of Melaleuca Forest and connects between Melaleuca beach and mangrove forest. The project route between chainage 1+828 to 1+957 is additionally recognized as a mangrove forest area and part of the Pa Lang Sod National Forest/Kuan Ba Gan Koh National Forest.

The TTNHA forms part of the larger Krabi Environmental Protected Area B.E. 2016 (Figure 8) which covers 1925 km² and extends along the Krabi coast and is recognized as an IUCN Management VI legally protected area. The Mu ko Lanta National Park (IUCN Management Category II) is a fragmented marine park east of the project route (Figure 8) and protects coral reefs and sea grass meadows important for supporting dolphins, manatees and marine turtles. The Mu ko Lanta National Park is not directly impacted, however there may be indirect and cumulative impacts that have not been assessed.

There are no internationally recognized areas of biodiversity value (such as key biodiversity areas and Ramsar wetlands) in the vicinity of the project.

Where protected areas are impacted, ESS6 requires additional programs to promote and enhance the conservation aims and effective management of the area. This requirement is achieved through the following programs presented in EIA for which DRR will provide the appropriate financial support:

- Support for the DMCR to promote education campaigns, and disseminate knowledge about coral and seagrass for fisherfolk, tourists and general public to encourage their improved protection.
- Support for the DMCR to monitor the protection, status and restoration of the degraded corals and seagrass around the project area.
- Support to the Thung Thale Non-hunting Area conservation authority for preventative measures and ethical management of long-tailed macaque population to avoid human-wildlife conflict arising in response to the project construction and operation.
- Support to the DMCR for the restoration and subsequent monitoring of mangrove habitats at least 20 times greater than the area impacted during bridge construction.

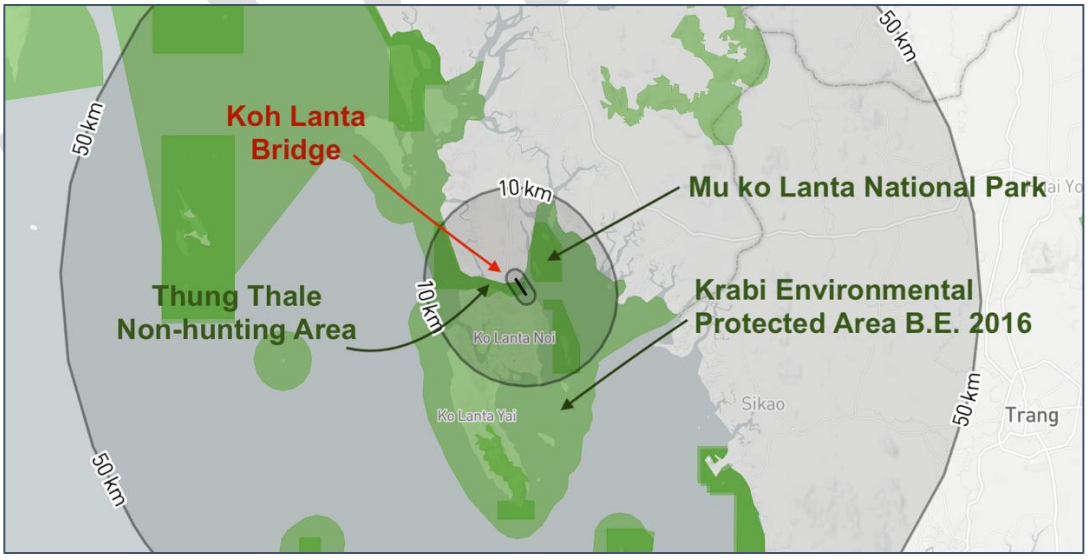


Figure 8 Annotated map of legally protected areas in the vicinity of the Koh Lanta Bridge provided by IBAT

6.2.2 Marine Coastal Ecosystem

Sampling of aquatic plants revealed a rich diversity of mangrove vegetation including *Phoenix paludosa*, *Avicennia marina*, *A. alba*, *Lumnitzera racemosa*, *Excoecaria agallocha*, *Xylocarpus granatum*, *X. moluccensis*, *Ceriops tagal*, *Dillenia obovata*, *Bruguiera gymnorhiza*, *Rhizophora apiculata*, *R. mucronata*, *Sonneratia griffithii* and *S. caseolaris*. A healthy mangrove ecosystem exists in the greater area, however mangrove vegetation associated with the project route has been anthropogenically affected and is relatively exposed with 37 trees from six species counted within the project footprint.

6.2.3 Marine Aquatic Ecosystem

Assessment of the marine ecology has revealed moderate diversity and abundance indices for phytoplankton and zooplankton, which indicates a healthy marine environment. Sampling of benthic fauna revealed a moderate diversity of 3 to 8 species per sample site dominated by Polychaetas, Snapping shrimp, Stone crab and Brittle stars. The survey on species and richness of fish larvae in the project area in January and February 2019 found that the richness is low but fish diversity ranged from 7 to 17 species per sample site. The standing crop of fish at each station is low between 0.44-0.81 and 0.84-1.34 kilograms/rai. Most are fishes of common species that are not of economic significance. Therefore, the fisheries' production is low. The EIA baseline presents the results of underwater surveys of corals around Koh Pling and seagrass meadows along the Koh Lanta shore.

6.2.4 Habitats and Vegetation

Terrestrial habitats (excluding mangrove habitat) associated with the project route are dominated by cultivated and invasive plant species is therefore a modified habitat. Dominant trees include Mango, Jenkol tree, Tamarind, *Cassia*, *Leucaena*, *Chromolaena*, *Hibiscus*, *Trema*, and *Ziziphus* species.

6.2.5 Terrestrial Fauna

Faunal surveys were conducted within a 500-meter distance of the project route, which revealed the presence of at least 7 amphibian species, 13 reptiles, 55 bird species and 5 mammals. These represent fauna associated freshwater, brackish water, and saltwater wetland and species commonly associated human habitation. The mammals included Smooth-coated Otter (*Lutrogale perspicillata*, VU) and Long-tailed or Crab-eating Macaque (*Macaca fascicularis*, EN).

Long-tailed Macaque is a protected wild animal according to the Wild Animal Conservation and Protection Act B.E. 2562 but are abundant in the Project area. The Head of the TTNHA (Mr. Suwat Suksiri), estimated in July 2019, there were 250 to 300 Crab-eating Macaques on Koh Klang side and 200 to 300 individuals on the Koh Lanta Noi side. These monkeys are problematic as they cause disturbances to people by stealing food and valuables and injure tourists. The TTNHA has coordinated with the Krabi Province to seek a budget for ethical management of the population through sterilization to minimize the disturbance they cause. The monkey groups are territorial and there is a low likelihood of individuals moving between the sub-districts as a result of the bridge construction.

6.2.6 Marine Mammals

A field survey of marine mammals observed groups of Indo-Pacific humpbacked dolphin or Chinese white dolphin (*Sousa chinensis*, VU) in shallow waters not far from the project route. These included a pod of 13 dolphins and females with infants. The Indo-Pacific humpbacked dolphin have a localized home range and seldom venture far from the area. Interviews with fishing communities revealed these dolphins are found near Khlong Mak Harbor and La Pu Le Island, 1.5 km and 1.3 km from the car ferry respectively. These interviews revealed there is no evidence of sea turtles nesting on Koh Lanta.

A review of stranding of dolphins, dugongs, and other marine mammals suggest there is no hunting of dolphins or other marine mammals in Koh Lanta District. However, these animals are being accidentally entangled in fishing nets which is the main cause of stranding.

6.2.7 Critical Habitat Assessment

Critical habitats are relevant to the project and a critical habitat assessment was conducted as a component of the SLIP. Critical habitat is defined within ESS6 by any one of the following five criteria:

(a) Habitat of significant importance to Critically Endangered (CR) or Endangered (EN) species, as listed in the IUCN Red List of threatened species or equivalent national approaches;

(b) Habitat of significant importance to endemic or restricted-range species;

(c) Habitat supporting globally or nationally significant concentrations of migratory or congregatory species;

(d) Highly threatened or unique ecosystems;

(e) Ecological functions or characteristics that are needed to maintain the viability of the biodiversity values described above in (a) to (d).

The assessment of critical habitat was based on an area of analysis defined as the Koh Lanta Noi Subdistrict plus an approximately 5 km marine buffer. An analysis of the above criteria for species present and potentially present within the area of analysis revealed six marine species qualify as critical habitat features, namely Irrawaddy Dolphin, Dugong and sea turtles (Green, Hawksbill, Leatherback and Olive Ridley sea turtles). Indo-Pacific humpbacked dolphin were not included as a critical habitat feature as the species does not meet the ESS6 critical habitat criteria, namely they are not endangered, endemic or form nationally significant congregations. Long-tailed Macaque monkeys are the only terrestrial species recognized as a critical habitat feature. However, no critical habitat features will require mitigation to demonstrate net gain outcomes for the following reasons:

- The Irrawaddy Dolphin, Dugong and sea turtles do occur in the greater vicinity, but the EIA and consultations with conservation authorities do not predict significant impacts to these species although mitigation and monitoring measures are provided in the EIA. Net gain outcomes are therefore not required for these species.

- Long-tailed Macaque monkeys may have a limited impact as a construction camp will be established and their scavenging behavior could bring the monkeys into conflict with the camp management. Also the Koh Lanta Bridge will attract tourists during the implementation phase resulting in some Macaque-tourist conflict. However, mitigation can be applied to avoid significant impacts and alleviate the requirement for net gain outcomes.

6.2.8 Natural Habitat Features

The Project passes through a short stretch of mangrove habitat within a national forest reserve. The mangrove forest is recognized as a natural habitat but does not qualify as a critical habitat. An area of 1.2 rai (0.192 ha) of mangrove habitat will be impacted based on calculations within the EIA. Funds have been allocated within the ESMP budget for the DMCR to identify a suitable site 20 times larger than the impact site for planting appropriate mangrove plant species. Mangrove restoration is an established science for which the DMCR have the expertise. This mitigation is therefore expected to exceed the scope of the impact and yield a net gain outcome for mangroves as a result of the project. No additional offset measures are therefore proposed, however construction monitoring will determine if impacts remain and whether additional conservation measures are required to achieve the ESS6 No Net Loss requirements.

The marine environment supports some degraded corals around the Koh Pling Island. These corals do not qualify as a critical habitat although the marine environment is considered a natural habitat. The project route bypasses these coral habitats although construction of the bridge will result in some temporary impacts which are minimized. During the operational phase of the bridge, there will be considerably less boat activity and many of the pressures on the corals will be alleviated. No offset approach is therefore proposed.

6.3 HUMAN USE VALUES

6.3.1 Land Use

The project route is within an open land area for environmental protection and forest conservation. A review of the Department of Land Development's land use data within 500 m of the project route found that 17% of the area was dominated by mangrove habitat, followed by rubber tree plantations (16.7%), and oil palm plantations (5.1%). The remaining areas are used for residential purpose, shrimp farms, oil palm plantations, perennial trees, abandoned rice fields, and other uses.

Land has been donated for development of the Koh Lanta Bridge. A land process review covering a private land donation was carried out to ensure that the land is formally secured for the Project, meets national legal requirements and is in accordance with ESS5. An additional piece of land was donated by the Krabi Provincial Administration Office (PAO) for the construction of additional structures to make the project inclusive, e.g., U-turn, elevator access on April 2023. This property is occupied by a multi-purpose facility where the government owner, the Krabi PAO, agreed to allow shop renters to complete their lease while the project is ongoing (up to 2025 before the project is completed). The EA also designed the additional structures in a way that avoids land take in the multipurpose facility. These agreements are documented in an email report submitted by the consultants to the Bank on 22 May 2023.

6.3.2 Land and Water Transportation

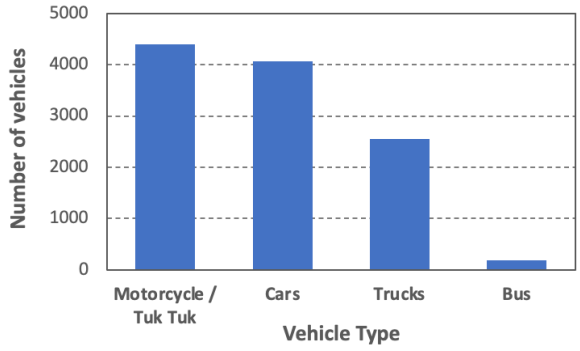
Currently to travel between Koh Klang to Koh Lanta sub-districts requires a trip on a car ferry covering a distance of 1 km. The car ferry can accommodate 60 vehicles per trip with a duration of 1 to 2 hours during the hours of 6:00am and 10:00pm. The car ferry service is not sufficient to respond to the demand and traffic congestion backs up for many kilometers, especially during the holiday season from December to May. The frequency of service usually depends on the number of users. Once the car ferry is at full capacity, the ferry leaves the harbor. Outside of rush hour, the frequency of service is at every two hours for one ferry. The fee for the ferry differs depending on the type of vehicle with a sample of the ferry fare presented in Figure 9.

The ferry presents an obstruction to the development of Koh Lanta Noi as it is unable to respond to after-hours emergencies, ferry delays are unpredictable during operational hours and tourists cannot have confidence to meet scheduled flights and other itineraries. In the event of emergency at night, people needing to cross the Khlong Chong Laad must pay 2,500 Baht per trip for a private car ferry.

A detailed regional traffic analysis is presented in the Koh Lanta Bridge EIA based of field surveys. Table presents the traffic volume for Highway 4206 which connects to the Koh Lanta Bridge. The most abundant vehicles were motorcycles, followed by cars, trucks then buses (Figure 9). Heavy vehicles represented less than 2% of traffic. Most travelers (46%) travel for work, 43% travel for personal businesses and 10% travel for tourism, however tourism traffic is under-represented as field surveys were conducted during the Covid pandemic when tourism was severely suppressed. The traffic load is expected to increase when the bridge is built, but the traffic analysis concluded that a two-lane highway will be sufficient for future traffic volume.

Table 9 Traffic data from Highway 4206 representing use of the Koh Lanta ferry

Date	Traffic Direction	Vehicles/day
Friday, 31 July 2020	Krabi-Koh Lanta	2,497
	Koh Lanta-Krabi	2,970
	TOTAL	5467
Saturday, 1 August 2020	Krabi-Koh Lanta	2,734
	Koh Lanta-Krabi	3,004
	TOTAL	5,738



Description	Fare (Baht)
Government official in uniform	None
Local resident	3
Foreign tourist	20
Motorcycle	5
Car, with driver, excluding passengers	100
Bus (6 wheel) with driver, excluding passengers	400
Truck (6 wheel) with load	400
Large trailer (10 wheel)	1,100

Figure 9 Traffic data from Highway 4206 and a select sample of Koh Lanta ferry fares

6.3.3 Public Utilities

Various public utilities cross the Khlong Chong Laad to provide services in Koh Lanta Noi. The public utilities that will be affected by the project construction are those located along Highway No. 4206 (Koh Klang side) and Local Highway No. 6022 (Koh Lanta Noi side) and include the following:

- 69kV and low voltage power poles of the PEA located along the road and single bracket street light poles on both sides of Highway No. 4206
- 22 kV and low-voltage electricity poles of the PEA on both sides of Highway KB. 6020 and KB. 5035 with associated single bracket street light poles
- Two circuits of 33 kV cables including 1 aerial cable and 1 subsea cable of the PEA located to the east of Koh Pling
- Communication cables of CAT, TOT, TUC, and PEA also occur in front of Kubor Thung Yum in Moo 2, Koh Lanta Noi Subdistrict.

Communities on Koh Lanta suffer shortages of water due to the lack of waterworks system and freshwater sources. The current electricity distribution is also not sufficient to meet the power demand on the island.

6.4 QUALITY OF LIFE VALUES

6.4.1 Public Health

Koh Lanta District as 9 health facilities, 1 district public health office, 1 hospital (Koh Lanta Hospital), and 7 subdistrict health promoting hospitals. There are no health facilities within 500 m from the Project route. Upper respiratory infections were the most commonly reported causes of disease from 2018 to 2020, which may have been influenced by the Covid Pandemic. Other common illnesses include pneumonia, arthropod-borne viral fevers, hypertension, soft tissue disorders, diseases of the esophagus, stomach and duodenum, disorders of teeth and supporting structures, complications of pregnancy and delivery, acute pharyngitis and tonsillitis.

6.4.2 Sanitation

The Koh Klang Sub-district Administrative Organization manages solid waste in the communities. Solid waste collection occurs every day and there are activities to raise the awareness of local residents to reduce waste production in the community. Solid waste is compiled at the waste bank of Koh Klang Sub-

district before being transferred to Khlong Thom District to be transformed to electric energy. There are no major issues with unmanaged waste in Koh Klang Sub-district. Households have proper toilets according to sanitation standards. Wastewater of the community goes through pipelines.

Solid waste in Koh Lanta Yai communities is managed and collected by the Koh Lanta Yai Sub-district Administrative Organization and the Koh Lanta Yai Sub-district Municipality. Waste is separated for further use. There are two landfill sites in the area, a new site of Koh Lanta Yai Sub-district Administrative Organization and the site of Koh Lanta Yai Sub-district Municipality. The landfill site of Koh Lanta Yai Sub-district Municipality is almost full. For solid waste management of Saladan Sub-district Administrative Organization, there is one landfill which is almost full. This is the most populated area of Koh Lanta with communities, residences, hotels and resorts. There is no central water treatment system available for wastewater from the communities. Hotels and resorts on the island have wastewater treatment systems that meet the necessary standards.

6.4.3 Accidents and Safety

Analysis of highway accident statistics in 2020 has revealed that 4-wheel drive pickup trucks cause the highest number of accidents (34 %), followed by passenger cars (28.5%), and motorcycles (16%). The majority (86%) of accidents were caused by the direct driver errors (e.g. risky driving behavior and violation of traffic signs), followed by indirect driver errors (9%; e.g. drunk driving, falling asleep at the wheel) and vehicle errors (4 %; e.g. excessive loading, damaged equipment). Traveling by ferry at night or during the monsoon season with strong winds and wave condition also increase the risk of accidents.

6.4.4 History and Archaeology

Analysis of the Department of Fine Arts geographical database of archaeological sites in Krabi Province has revealed there are no known archaeological sites or past discoveries of archaeological artifacts within a 1 km radius of the project route. Field surveys including an underwater survey by archaeologists and interviews with community leaders and elders in the project area have similarly revealed no evidence of archaeological sites, artifacts, or ancient settlements on either side of the Khlong Chong Laad. The field survey revealed three religious sites as described in Table 10. One of these sites, the Thung Toh Yum Cemetery is located less than 1 km away from the project area and various impacts to the site are assessed (Section 7).

Table 10 Religious sites in the vicinity of the Koh Lanta Bridge route

Sub-district	Site name	Distance from project
Koh Klang Sub-district	Darus Sunnah Mosque	> 1 km
Koh Lanta Noi Sub-district	Thung Toh Yum Mosque	> 1 km
	Thung Toh Yum Cemetery	34 meters

6.4.5 Aesthetics

The Koh Klang sub-district is mountainous and blanketed with tropical rainforest. Prominent plants include Borneo teak, iron wood, and mangrove species, etc. Agricultural land is established in the foothills

with rubber, oil palm, and coconut plantations. Flatland and slopes are used for residential, agricultural (including rice paddies) and artisanal fishery purposes. Koh Lanta comprises 2 large islands including Koh Lanta Yai and Koh Lanta Noi, and many small islands. The topography is mountainous with many high slope, while flatland is found only at the beach. Koh Lanta District Office is situated on the island and is the center of growth and tourism business, with development of many tourist attractions and facilities.

7 ENVIRONMENTAL AND SOCIAL RISKS AND IMPACTS

7.1 SUMMARY OF PROJECT IMPACTS

The Koh Lanta Bridge EIA presents a detailed assessment of project impacts. These impacts are assessed for the construction and implementation phases and are classified as having a positive or negative effect on receptors. Impacts were rated based on size using parameters such as indices of environmental standards, extent of the impact, duration of the impact, and/or effects on health and sanitation of the public. Significance of the impact was classified into four categories, namely no significant impact, low, moderate and high. Table presents a summary of the impacts and their pre-mitigation and residual significance ratings. It is noted there were no impacts of high significance resulting from the project.

Mitigation to address negative impacts is presented in Section 8 with key mitigation measures indicated. The effectiveness of mitigation is used to estimate the significance of residual impacts as reflected in Table . A discussion on residual impacts is provided in Section 8.7.

Table 11 Summary of significance of pre-mitigation and residual impacts for the construction and implementation phases of the Koh Lanta Bridge Project

Environment and Social Factors and their Impacts	Stage of Mitigation	Project Phase	
		Construction	Implementation
Physical Environmental Resources			
Air Quality: Spread of dust (TSP and PM_{10}) and pollutants such as CO and NO_2 on environmentally sensitive areas.	Pre-mit:	Low -ve	Low -ve
	Residual:	Low -ve	Low -ve
Surface Noise: Terrestrial sound effects from construction activities assessed against the national standard.	Pre-mit:	Moderate -ve	Moderate -ve
	Residual:	Low -ve	Low -ve
Vibration: Vibration effects from construction activities assessed against national and international standards.	Pre-mit:	Moderate -ve	Low -ve
	Residual:	Low -ve	Low -ve
Surface Water Quality: Impacts of erosion sediments and wastewater from construction sites and facilities	Pre-mit:	Moderate -ve	Moderate -ve
	Residual:	Low -ve	Low -ve
Marine Water Quality: Impact of sediments and contaminants in the sea water	Pre-mit:	Moderate -ve	Not significant
	Residual:	Low -ve	
Geology, Earthquake and Tsunami: Bridge structural capacity to withstand seismic activity.	Pre-mit:	Moderate -ve	Positive
	Residual:	Moderate -ve	
Soil Resources and Erosion: Effects on soil structure changes and soil erosion	Pre-mit:	Moderate -ve	Not significant
	Residual:	Low -ve	
Oceanography: Assessment of change in currents and sediment dispersion from jetties and bridge structures.	Pre-mit:	Low -ve	Not significant
	Residual:	Low -ve	
Biological Environmental Resources			
Protected Areas: Impacts to the habitat and associated protected areas.	Pre-mit:	Moderate -ve	Not significant
	Residual:	Moderate -ve	
Marine Coastal Ecosystem: Loss of mangrove trees on the Koh Lanta side.	Pre-mit:	Moderate -ve	Not significant
	Residual:	Low -ve	
	Pre-mit:	Moderate -ve	Not significant

Environment and Social Factors and their Impacts	Stage of Mitigation	Project Phase	
		Construction	Implementation
Marine Aquatic Ecosystem: Impacts to the marine ecology including coral reefs and sea grass meadows.	Residual:	Low -ve	
Habitats and Vegetation: Loss of trees with emphasis on mangrove species	Pre-mit:	Moderate -ve	Not significant
	Residual:	Low -ve	
Terrestrial Fauna: Impacts to vertebrates with an emphasis on Long-tailed Macaque and Smooth-coated Otter	Pre-mit:	Moderate -ve	Moderate -ve
	Residual:	Moderate -ve	Moderate -ve
Marine Mammals: Impacts to Indo-Pacific humpback dolphins	Pre-mit:	Moderate -ve	Positive
	Residual:	Low -ve	
Human Use Values			
Land Acquisition: The impact of asset compensation.	Pre-mit:	Low -ve	Not significant
	Residual:	Low -ve	
Land Use: Impact on land use and change in future land use patterns across Koh Lanta	Pre-mit:	Moderate -ve	Moderate -ve
	Residual:	Moderate -ve	Moderate -ve
Land and Water Transportation: Road and boat traffic risks and disruptions.	Pre-mit:	Moderate -ve	Positive
	Residual:	Low -ve	
Public Utilities: Impacts from the relocation of public utilities such as electric poles, water pipes, and drainage systems.	Pre-mit:	Low -ve	Positive
	Residual:	Not significant	
Quality of Life Values			
Public Health: Impact on the health of workers and people in the community.	Pre-mit:	Moderate -ve	Moderate -ve
	Residual:	Low -ve	Low -ve
Sanitation: Risks associated with solid waste and wastewater management.	Pre-mit:	Moderate -ve	Low -ve
	Residual:	Low -ve	Low -ve
Accidents and Safety: Assessment of safety risks	Pre-mit:	Moderate -ve	Positive
	Residual:	Low -ve	
Occupational Health: Risk of injury and accidents to construction and maintenance workers.	Pre-mit:	Moderate -ve	Low -ve
	Residual:	Low -ve	Low -ve
Socioeconomic: Impact on social structure, local economy and potential for conflict with construction workers.	Pre-mit:	Positive	Positive
History and Archaeology: impacts to archeology and sites of religious importance	Pre-mit:	Low -ve	Low -ve
	Residual:	Low -ve	Low -ve
Aesthetics: Assessment of the visual impact of the Koh Lanta Bridge	Pre-mit:	Moderate -ve	Low -ve
	Residual:	Low -ve	Low -ve
Where: Pre-mit = Pre-mitigation impact; Residual = Residual (post-mitigation) impact; -ve = negative impact			

7.2 IMPACTS TO PHYSICAL ENVIRONMENTAL RESOURCES

7.2.1 Air Quality

To determine the expected air quality during the construction period, a model was developed using data from the Compilation of Air Pollutant Emission Factors of the U.S. Environmental Protection Agency (1995). The model takes into account various types of vehicles, including motorcycles, heavy trucks with full trailers, dozers, cranes, slurry trenching machines, and others. The expected speeds and levels of use for each type of vehicle were also considered. The predicted average 24-hour emissions of TSP, PM_{10}, CO,

and NO_2 for all construction activities, including soil excavation, road construction, lower and upper structure of the bridge construction, and transportation of materials and equipment, do not exceed the Notifications of the NEB No. 10 B.E.2538, No. 24 B.E. 2547, and No.33, B.E.2552 (2009). This indicates that the expected air quality during the construction period will meet the relevant standards. The air quality deterioration during the construction phase has a low significance pre-mitigation that needs to be mitigated to ensure the health and safety of the workers and the public.

During the implementation phase, traffic volume is expected to increase each year with corresponding increases in emissions of pollutants TSP, PM_{10}, CO and NO_2 from traffic on the bridge. However, emissions of each of these pollutants are expected to remain within the air quality standard for normal circumstances. This is a negative impact with a low significance pre-mitigation.

7.2.2 Noise

A model was developed to predict the noise emissions from 33 types of mechanical equipment used for construction and transportation of materials. The model was based on a 24-hour period and a distance of 15 meters from the construction activities. The noise emissions for the equipment were obtained from the Handbook of Noise Assessment by the U.S. Federal Highway Authority (1975). The highest sound emissions were observed during pile driving (impact device), with a predicted noise level of 101 decibels at a distance of 15 meters. The model was used to estimate the sound volume at four sound-sensitive locations, including two sites associated with the Moo 8 Ban Hua Hin pier (Kho Klang) and Moo 2 Ban Tung Toh Yum, as well as the mosque and cemetery of Ban Tung Toh Yum (Koh Lanta Noi).

The results were compared against the national standard for noise emissions provided by the Notification of the NEB, which stipulates a maximum safe sound limit of 70 decibels. The analysis of the results (Table) indicates that the Moo 8 Ban Hua Hin pier (Koh Klang) and the Muslim cemetery of Ban Tung Toh Yum (Koh Lanta Noi) will experience noise impacts during the construction phase that exceed the recommended limit. Overall, the pre-mitigation significance of the construction noise impact is assessed as moderate.

Table 1 Estimated noise emissions from various construction activities

Construction activities	Calculated noise emissions	Sensitive receptors for where noise limits are exceeded
Land works	57.9 to 76.7 decibels	Moo 8 Ban Hua Hin (Ban Tha Rua); Ban Tung Toh Yum Cemetery
Road surface and pavement	58.2 to 78.4 decibels	
Lower bridge structure	58.3 to 81.7 decibels	
Upper bridge structure	57.9 to 78.3 decibels	
Transportation of construction materials	57.5 to 63.0 decibels	Noise limits not exceeded

Noise emissions during the implementation phase were modelled based on forecasts of traffic volume for a 20-year period from 2027 to 2047 (B.E. 2570-2590) for a broad range of vehicle types. The average sound level in a 24-hour period revealed the range of 57.6 to 70.7 decibels which exceeds the safe noise

limit (70 decibels) for the Moo 8 Ban Hua Hin (Ban Tha Rua) site. This negative impact during implementation is similarly assessed as a moderate significance pre-mitigation.

7.2.3 Vibration

Construction activities that could cause vibration include land work, soil excavation, drilling of bored piles, and use of heavy trucks for transportation of materials and equipment. The assessment of vibration impact from construction activities followed the Guidance Manual for Transit Noise and Vibration Impact Assessment of the U.S. EPA (2006). Data was applied for 11 types of machinery ranging from a impact device pile driver, a jackhammer and small bulldozer, with vibration effects (peak particle velocity or PPV) calculated at 7.62 meters (25 feet). Results were compared against national, German and British standards (Section 6.1.1).

Table presents the results of the vibration analysis, which reveals the highest levels of vibration will be associated with construction of the lower and upper bridge structures. The Moo 8 Ban Hua Hin Pier (Ban Tha Rua) in Koh Klang is an area of concern and vibration impacts will need to be mitigated. The pre-mitigation significance of the negative vibration impact is assessed as moderate.

Table 13 Results of the vibration analysis for five construction activities and compliance to standards

Construction activity	Expected Peak Particle Velocity (PPV)	Compliance to standards
Land work (construction preparation)	0.002 to 0.390 mm/s	Do not exceed the national standard; Do not affect old buildings, and lower than will cause complaints.
Traffic surface and pavement work	0.004 to 0.921 mm/s	
Bridge lower structure (bored pile drilling)	0.021 to 3.218 mm/s	Does not exceed the national standard; Presents a danger to old buildings but would not damage architectural structures. British standard: Will cause annoyance to people but tolerated if prior warning is given.
Bridge upper structure	0.001 to 0.334 mm/s	Does not exceed the national standard; Does not affect old buildings, but perceptible and likely to cause a nuisance to people.
	Construction at Moo 8 Ban Hua Hin (Ban Tha Rua) will cause high vibration levels over a short period and impacts will need to be mitigated.	
Transportation of construction materials	0.064 to 0.734 mm/s	Does not exceed the national standard; Does not affect old buildings, but perceptible and likely to cause a nuisance to people.

Vibration was assessed for 12 heavy vehicle types up to a weight of 50.5 tons driving at speeds from 45 to 80 km/h during the implementation phase. The maximum PPV ranged from 0.032 to 0.367 mm/s, which does not present a threat based on the national, German or British standards. This was assessed as a negative impact with low significance pre-mitigation.

7.2.4 Freshwater Quality

No surface freshwater sources occur within 500 meters of the project area although project activities will affect water quality. During construction a worker's camp will be established to accommodate 229 workers close to the project area,. Approximately 23 m^3/day of wastewater will be produced from daily activities of construction workers and staff. Additional wastewater will be generated from toilets, canteen, concrete mixing plant, equipment maintenance facility and leachate from solid waste.

- Wastewater from the concrete mixing plant will range from 12 to 20 m^3/day with a higher alkalinity than the standard of greywater. This wastewater will be processed through two coagulation pits with acid added to neutralize the pH level. Water from the second pit (sedimentation tank) will be used for cleaning trucks, other activities in the plant or released outside of the plant. Once the pit is full, the sludge will be disposed in a landfill.
- Wastewater from the maintenance facility will be contaminated with oil and other substances that do not readily dissolve and can have a harmful effect on the environment and creates an unpleasant appearance if discharged into natural water bodies.
- Leachate is any liquid that leaks out and passes through solid waste which can contaminate water sources in the vicinity. Leachate is high in Chemical Oxygen Demand which reduces the water's oxygen level and could be life-threatening for marine life.

Wastewater impacts have the potential to occur throughout the construction period but are contained within the nearby surrounding areas. The pre-mitigation significance of the negative impact is assessed as moderate.

During the implementation phase, bathroom and toilet facilities will be available at the parking space below the bridge structure in Koh Klang Sub-district for tourists who visit the viewpoint area. The continuous arrival of tourists will generate wastewater and solid waste that could cause pollution and spread of diseases, and the pre-mitigation significance of the impact is assessed as moderate.

7.2.5 Marine Water Quality

Marine water quality could be impacted during the construction phase by increased turbidity resulting from construction of bridge pier structures and approach slabs. Sediments may also originate from land construction leading to soil erosion and run-off into the sea. Water drainage from the maintenance facility, construction sites and workers camp can also introduce oil and other contaminants into coastal water sources.

Vulnerable receptors include the benthic environment, corals and sea grass. Marine fauna such as fish, crabs, mollusks and other benthic fauna can adjust their behavior and/or move away. The impacts will occur over a limited period and localized to specific areas in response to the transport of sediments by the tide (see Oceanography assessment). The significance of this impact prior to mitigation is assessed as moderate.

During the implementation phase, impacts may occur from dust or oil leaked from vehicles on the bridge that washes into the sea. However, the bridge design will capture such contaminants. Vehicles mostly are regularly maintained and undergo annual checks and the probability of oil leakage is low. The impact on marine water quality is therefore assessed as not significant.

7.2.6 Oceanography

The oceanography impact assessment is based on the potential for coastal erosion due to changes in current velocity and flow direction, and increased turbidity due to sediment dispersion. Water flow was modelled with results supplemented from field measurements. The temporary jetties constructed on each side the channel and the construction of bridge piers have the potential for oceanography impacts.

Results of modelling reveal similar results for both jetties (Table) with changes in water current velocity and flow direction greatest during the westward outflowing current (low tide), but changes will be minimal and will not influence coastal erosion.

Table 14 Results of Oceanography Changes caused by the Construction of Temporary Jetties

Temporary Jetty location	Change in Flow Velocity	Change in Flow Direction	Maximum extent of impact
Koh Klang	0.005 m/s (1.33% change)	0.6 degrees (0.40%)	20 meters
Koh Lanta Noi	0.005 m/s (1.33% change)	1.3 degrees (0.70%)	20 meters

Sediment dispersion resulting from the drilling of steel piles for the temporary jetties will occur in an oval shape according to the direction of the current, towards the southwest for low tide and northeast for high tide. The highest concentration of sediment will be 6.3 ppm within 1 meter from the position of pile drilling. The Koh Klang temporary jetty has the worst impacts with a sediment plume that extends of 67 meters (in the absence of mitigation) from the during low tide but will return to normal within 20 minutes after pile drilling is completed. The maximum dispersion from the Koh Lanta Noi jetty will be marginally less (65 meters at low tide). Sediment dispersal will also occur from the bored piles for construction of pier structures. The sediment load will be 6 ppm within 3 meters of the pile drilling and will extend to a maximum distance of 70 meters during low tide with conditions returning to normal within 20 minutes after the pile drilling is completed. The significance of this is pre-mitigation impact during construction is assessed as low.

The bridge piers have the potential to alter current velocity and flow direction during implementation. Results reveal a maximum change of velocity of 0.035 m/s will occur within a 20-meter radius of a F2 type 2 bridge pier. The change of velocity will be minimal (0.003 m/s) at a 50-meter distance. The highest change of flow direction is 7.2° at a 20-meter distance from a bridge pier structure F2 Type 2, and minimal (< 1°) at 50 meters. These changes will not cause coastal erosion and the oceanography impact of bridge pier structures is not significant and mitigation measures are not required.

7.2.7 Geology and Earthquake Risk

The geology will be unaffected by the construction or implementation of the project. Earthquakes are natural disasters, and their intensity is a measure of the effects on people, buildings, structures in nature. The intensity depends on the distance from the earthquake epicenter. The aftermath of a large earthquake could include landslides, land subsidence or tsunami with severe consequences. There are active geological faults 70 km from the project location and, while project will not be the cause of seismic activity, the consequence of an event during the construction phase is considered a moderate significant impact.

The Koh Lanta Bridge is designed to resist in the event of a strong earthquake or tsunami and remain operational. The bridge, once operational will serve as an important emergency route for Koh Lanta and other islands allowing fast and effective rescue operations and subsequent restoration of affected areas. The implementation impact is therefore assessed as positive.

7.2.8 Soil Resources and Erosion

Potential impacts to soils during the construction phase could result from contamination with polymer solution used to hold the structure of bored holes during pile drilling. Such soils are not appropriate for agriculture or road building and the sediments must be removed from the construction area. In addition, soil excavated from the sea will have an excess of soluble salts which makes them unsuitable for plant growth. The impact on these soil resources is assessed as moderate.

Construction activities, such as excavation, drilling, and embankment filling, can lead to the loss of vegetative ground cover and soil erosion, particularly during the rainy season. The severity of soil erosion is influenced by the volume and speed of run-off water, as well as human activities in the area. To assess the potential for erosion caused by the Koh Lanta Bridge construction, the EIA considered rainfall erosivity, soil erodibility, slope length, and crop management factors. The results indicate a moderate soil erosion rate of 0.256 tons/rai/year (1.6 tons/ha/year), which falls within the Thai erosion classification's moderate range (< 2-5 tons/rai/year) as issued by the Land Development Department (B.E. 2545). However, a high volume of soil washing into the water drainage system or spillway could pose obstructions to water drainage in the area. As a result, the construction impact is assessed as moderate due to the potential for soil sediments washing off into the sea.

7.3 IMPACTS TO BIOLOGICAL ENVIRONMENTAL RESOURCES

7.3.1 Protected Areas

The project passes through a habitat that transforms into a mangrove and is declared as the TTNHA. The area is also recognized as a Mangrove Forest and a National Forest Area. Mu ko Lanta National Park occurs nearby but is outside of the project footprint. These areas support a wide diversity of species and represent sensitive biodiversity features.

Construction of the project will involve increased presence of people, transportation of materials, heavy vehicle movement, air quality, noise and vibration impacts, potential pollution from oil spillage, lighting,

felling of trees and clearing of vegetation. A construction workforce of 170 people will be accommodated on site for 3 years and will create a demand for natural resources. Workers may engage in illegal hunting or harvesting activities and create a demand for illegally harvested products. The wildlife species will need protection from hunters but are small, agile, can hide well and able adapt to changes in the environment. The disturbance created by construction activities is assessed as a negative impact with moderate significance pre-mitigation.

Activities during the implementation phase will include regular maintenance of the bridge and road conditions to improve or add facilities for road users. There will be no cutting of trees or use of forest areas. No direct impacts to the terrestrial habitat and associated protected areas are expected. The project is expected to increase tourist arrivals to the area, which may result in indirect and cumulative impacts to natural resources within the protected areas, such as corals, seagrass and long-tailed macaque. Section 6.2 outlines some of the measures included within the EIA to support the conservation aims and effective management of protected areas. Section 7.6 discusses the cumulative impacts.

7.3.2 Marine Coastal Ecosystem

The start and end points of the bridge are in mangrove habitat where a total of 40 trees were located, 37 of which represent six species of mangroves. These do not include any threatened species. These trees will need to be cleared or relocated for construction of the bridge. The significance of the negative impact on the coastal mangrove ecosystem is assessed as moderate.

There will be no cutting of trees during the implementation phase therefore no impact to the marine coastal environment is expected.

The regulation of the DMCR Order on Replantation and maintenance of mangrove forests for conservation or environmental preservation B.E. 2556 (2013) specifies that "Article 6: Any government agency utilizing and benefiting from mangrove forests shall allocate a budget for the DMCR for the planting of mangrove forests not less than 20 times of the area that was utilized. This shall be considered part of the development project. The budget shall be according to the standards of the Bureau of the Budget. Regulations and guidelines shall be according to the NEB." This Order requires that a survey, identification of replantation site, replanted species is carried out by DMCR staff or qualified third party under their supervision. The 2013 Order is complimented by detailed guidelines within the DMCR Order on Mangrove Plantation and Maintenance B.E. 2564 (2021) which require a survey, mapping, and identification of replantation area, selection of replantation species (list of species provided in the guideline), preparation of seedling, site preparation, plantation and maintenance, signboard posting, monitoring and reporting (with report templates provided). DRR is required to report implementation status of mangrove replantation in the mandatory EIA monitoring report to the ONEP on Annually basis both during construction and operation phase.

These requirements are included in mitigation measures provided in the EIA. A budget for mangrove replantation has been prepared by DRR that will be transferred to DMCR for replanting of mangroves covering 20x the area of mangrove forest impacted by the project. An appropriate restoration area will

be identified nearby but not necessarily within the Project AoI and a long-term monitoring program be applied to ensure the success of the initiative and identify whether additional actions are necessary to meet ESS6 No Net Loss requirements (refer to Chapter 8 table of mitigation and monitoring measures).

7.3.3 Marine Aquatic Ecosystem

The marine habitat supports phyto- and zooplankton, benthic fauna, fish and fish larvae, and marine plants dominated by mangrove species. Development of the bridge requires construction of 17 pier structures in the marine environment. This will cause turbidity and dispersal of sediments which will disrupt the growth of sunlight dependent plants and corals. Polymer solution used to bind soils for boring piles could spill and contaminate the marine environment, similarly oils could spill from machinery, but the likelihood is low. Impacts will be short term and localized but influenced by the velocity and flow direction of currents as described under the Oceanography impacts (Section 7.2.6). The pre-mitigation significance of this negative impact is assessed as moderate.

Live corals occur around Koh Pling and are present within 6 meters of the bridge route between the Koh Klang side and the island. These corals are alive and healthy but will be impacted by vibration and dispersal of sediment as described above. This impact is assessed as a negative impact of moderate significance.

Sea grass in the area is limited to small, fragmented patches near the Koh Lanta Noi side. The closest patch is within two meters of the bridge route and will be impacted by the dispersal and settling of sediments during the construction of bridge footings, which is assessed as a negative impact of moderate significance.

During the implementation phase there will be movement of vehicles, bridge maintenance and emergency work. These activities will be restricted to the existing infrastructure and there will be no changes to the marine ecosystem, including coral reefs and sea grass meadows. In addition, there will be considerably less boat activity and many of the current pressures on the corals will be alleviated during the bridge operational phase. Therefore, no significant impact on the marine aquatic is expected.

7.3.4 Habitat and Vegetation

The terrestrial habitat is dominated by plants cultivated by local households and classified as a modified habitat but gradually changes to a natural mangrove habitat. During construction, the project will need to remove or relocate 40 large trees for construction of the bridge approach slabs. Trees in the adjacent areas will be trimmed to a size not more than 4 meters to avoid branches grating against utility poles and suspended wires. The trees needing to be cleared include 37 mangrove trees from six species (*Rhizophora apiculata*, *Xylocarpus granatum*, *Xylocarpus moluccensis*, *Ceriops tagal, Dillenia obovata* and *Avicennia alba*). The mangrove habitat in the construction footprint is relatively open and is also considered a modified habitat. The mangrove species are listed as restricted woods by the Department of National Parks, Wildlife and Plant Conservation (DNP 2017). Removal of restricted woods requires a logging permit issued by the Director-General of the Royal Forest Department (RFD). This is assessed as a negative impact of moderate significance.

No significant impacts to plants are anticipated during the implementation phase.

7.3.5 Terrestrial Fauna

Field surveys have identified 80 species of amphibians, reptiles, birds and mammals in the project area. The majority are associated with wetland or human-modified habitats.

Smooth-coated Otter have an elusive behavior and are able to avoid areas of human activity. Construction activity will create considerable noise and vibration disturbance which will drive otters away from their local habitats and foraging areas. Vibration impacts could also impact fish which are the food source for otters. The impact to otters is assessed as moderate. During the implementation phase, there will be reduced movement of ferries and otters may benefit from reduced disturbance within their foraging areas.

Long-tailed Macaque are abundant at both ends of the bridge and their presence is considered a problem as they steal food and injure tourists and the TTNHA authorities have requested funds to reduce the population to minimize the human-macaque conflict. However, the species is listed as Endangered on the IUCN Red List (2022) as there is concern at the recent rapid decline in populations across their range. Long-tailed Macaque are therefore included as a critical habitat feature (Section 6.2.7).

During construction, a camp will be established to accommodate 229 workers at the project site. Long-tailed Macaque will be unable to resist the temptations to steal food from the canteen and scavenge from the kitchen waste, which will foul the facilities, spread garbage, lead to aggressive encounters with workers and bring them into conflict with the camp management. Monkeys may get injured and killed, and there will be increased demands on TTNHA authorities to control their numbers.

The Koh Lanta Bridge is designed to attract tourists and during the implementation phase the project may exacerbate the Macaque-tourist conflict and raise additional pressure on TTNHA authorities to further control the numbers of Long-tailed Macaque. Endangered Long-tailed Macaque monkeys are the only terrestrial species recognized as a critical habitat feature and could be exposed to limited impacts through scavenging from the construction camp and some Macaque-tourist conflict, however mitigation can be applied to avoid significant impacts.

7.3.6 Marine Mammals

Field surveys revealed the presence of pods of Indo-Pacific humpbacked dolphin (*Sousa chinensis*) listed as Vulnerable on the IUCN Red List. Members of the fishing community stated these dolphins are frequently seen in the area, but there is no evidence of marine turtles nesting in the area.

During construction the drilling of bridge pier structures the noise and vibration will have an underwater impact which could affect the hearing and behavior of dolphins. They could be injured by boats from the water transportation of materials and equipment. Dolphins can flee the area, but the impact is assessed as moderate.

There will be no underwater noise emissions during the implementation phase and there will be reduced boat activity as there will be reduced dependence on ferry services. The bridge could therefore have a positive impact on dolphins.

7.4 IMPACTS TO HUMAN USE VALUES

7.4.1 Land Acquisition

Construction of the Koh Lanta Bridge Project will require expropriation of 44 square wa (176 m^2) of private land. The owner of the land has submitted a donation letter expressing his willingness to dedicate the land to the government to conduct activities for a shared benefit. Therefore, the Project (Koh Klang Sub-district) does not have to pay a land ownership fee nor land expropriation fee. Land process review on the land donated by a private landowner was carried to ensure that the land is formally secured for the Project, meets national legal requirements and is in accordance with ESS5. No impacts are anticipated during the implementation phase. The complete land process review that covers the Lanta land donation is expected by September 2023. Government property was donated by the Krabi PAO on April 2023 in a manner that did not entail physical or economic displacement based on the earlier information provided.

7.4.2 Land Use

Most of the project route passes through the sea, but the terrestrial component is dominated by mangrove forest, rubber and oil palm plantation. The project route is within an open land area for environmental protection and forest conservation. The project is designed to create the least possible impact on the environment although construction of the bridge approach slabs will change the land use to transportation. The significance of this negative impact is assessed as moderate.

During the implementation phase there will be no local impact, however the presence of the bridge will foster economic growth which will cause land use in Koh Lanta to gradually change in response to the social and economic development. Studies reveal that tourism of Koh Lanta is approaching the upper capacity with water availability being a limiting factor. A future water works system will connect to the Koh Lanta Bridge structure and will increase the tourism capacity of the greater area. Waste and wastewater management are also critical issues. There is a cumulative impact which needs to be alleviated through development of sustainable tourism. However the significance of the negative impact is currently assessed as moderate.

7.4.3 Land and Water Transportation

During construction, project activities will require transportation of machines, materials, equipment, and workers to the construction site using trucks, trailers and buses. However, based on a calculation of the traffic volumes on Highway No. 4206, there will be a minimum impact to transportation conditions along this road. The construction activities will involve soil excavation, soil filling and compaction as well as piles of construction material which will encroach on Highway no. 4206 and could pose obstructions to road usage. Activities could increase risks of accidents on the route, and the significance of this impact is assessed as moderate prior to mitigation.

Water transportation in the area involves the car ferry that operates across the Khlong Chong Laad, long-tail boats used by fishing communities, and speedboats of Pimalai Resort for transport of tourists. Obstructions to water transportation are expected and there is an increased risk of accidents, especially in areas where the construction of bridge footings take place. The Ban Hua Hin fishing community have expressed their concerns in this regard. This negative impact similarly has a moderate significance prior to mitigation.

During implementation, the Koh Lanta Bridge route will provide transportation connectivity from north to south and alleviate current challenges associated with the car ferry service. Road users will be able to commute with increased convenience and elevate the safety standards for the public. The project will also boost economic development at the local and regional level and increase the capacity to accommodate growing numbers of tourists in the future. The impact on land transportation is assessed as positive.

The bridge will affect the vehicle ferry service Ban Hua Hin Pier (Koh Lanta) to Khlong Maak Pier operated by Songserm Tran Service Company Limited. The Krabi Provincial Administrative Organization granted a concession to Songserm Tran Service Company Limited for a 3-year duration which ended in 2022 but have extended the contract to allow the operator to continue the service during the project construction phase. However, operation of the bridge will reduce the disruption of other water transportation and thus have a positive impact.

7.4.4 Public Utilities

Various public utilities will be affected, the most important being PEA electrical power distribution lines 33 kV across Khlong Chong Laad towards Koh Lanta Noi. The development of the Koh Lanta Bridge Project requires the relocation of various public utilities as listed in Table . Relocation of utilities could result in power outages and other services, but the duration of relocation processes is short, so the impact is low.

Table 15 Public utilities required to be relocated for construction of the Koh Lanta Bridge project

Sub-district	Public Utility Item	Quantity
Koh Klang Sub-district	Electric power distribution line of PEA at the side of highway TL. 4206	24 posts
	Post lights of the Department of Highways at the side of highway TL. 4206	8 posts
	Traffic signs of the Department of Highways at the side of highway TL. 4206	4 signs
	Telecommunication lines on electricity posts at the side of highway TL. 4206	600 meters
Koh Lanta Noi Sub-district	Electric power distribution line of PEA at the side of Rural Road KB. 5035	8 posts
	Telecommunication lines on electricity posts at the side of road KB. 5035	340 meters
	Drainage pipes (Cross drain) through Rural Road KB. 5035	45 meters

The electricity distribution to Koh Lanta is not sufficient and communities currently face issues regarding electricity supply. There is also a shortage of water due to the lack of waterworks system and freshwater sources. The Koh Lanta Bridge has therefore been designed to support electrical power lines and two

water pipes of the Provincial Waterworks Authority. These will be sufficient to accommodate the future needs of the Koh Lanta community and the impact of the bridge is therefore positive.

7.5 IMPACTS TO QUALITY OF LIFE VALUES

7.5.1 Public Health

Public health facilities are widely available within Krabi Province. Construction of the project could result in physical health hazards such as dust from construction, exhaust fumes from machines, vehicles transporting machines and construction materials, noises and vibration. Exposure could lead to respiratory diseases, hearing loss, vision problems and/or psychological effects. Project activities may lead to accidents and there could be sicknesses of the local population and among the 229 project workers due to the activities of the project, which could increase the workload of the public health system.

The Koh Lanta Bridge EIA provides a detailed analysis of public health risks from air quality, noise, vibration, water quality, occupational health (accidents and sickness from work and inappropriate and unsafe environment), entry of migrant workers, transport accidents, waste management, water availability for consumption and communicable diseases from workers. Each of these risks is assessed as moderate and recommendations for public health management are provided.

A similar analysis of public health risks is provided for the implementation phase for air quality, noise, vibrations, accident and safety and occupational safety and health from working conditions and environment.

7.5.2 Sanitation

The Koh Klang Sub-district Administrative Organization acts as a center of waste collection and manages solid waste in the communities with no major issues. However, there is a large amount of unmanaged waste in Koh Lanta.

During the construction phase, the solid waste production from one construction worker is estimated at 1 kg/day, which equates to a total of 0.17 tons per day. Solid waste and wastewater, if not appropriately treated or managed can contaminate the environment, particularly water sources. This leads to deterioration of the ecology and presents health hazards to local communities. The significance of the impact on waste management is assessed as moderate.

During implementation, the project will provide one bathroom-toilet and parking space for tourists to visit the viewpoints on the bridge. A continuous flow of tourists is expected, which will lead to wastewater and solid waste which will need to be managed. This negative impact has a low pre-mitigation significance.

7.5.3 Accidents and Safety

Road markings, traffic lights and warning signs are provided for road users but numerous accidents still occur on the highways in Krabi Province. Construction activities, such as lifting and moving equipment and large and heavy bridge components will cause traffic congestion and obstruction in some areas. Road

users and pedestrians could be in danger from the traffic or machines used in construction and some road diversions may be necessary. The project route is on the main transportation crossing from Ban Hua Hin Pier to Koh Lanta Noi, there will be some inconvenience to road users and there is an increased risk of traffic accidents. The traffic disruption and risk of traffic accidents during construction presents a negative impact and its pre-mitigation significance is assessed as moderate.

On the side of the Ban Hua Hin Pier in Krabi is a fishing dock that will be temporarily removed during project construction for public safety purposes. The fishing dock is occupied by about 20 fisherfolk based on the number of boats. Consultations have taken place with those affected and a temporary mooring dock is being identified with the assistance of local fisherfolk associations to find a location accessible to fishing grounds. The impact to fisherfolk is considered negative, because of the disruption, but temporary, as return is allowed after project construction. The pre-mitigation significance is deemed moderate.
During implementation, the operation of Koh Lanta Bridge will improve the effectiveness of the transportation network in the area. Road markings, traffic lights, signs and lighting will be installed to facilitate the smooth flow of traffic and minimize the risk of accidents. Maintenance work will require the use of machines and could lead to traffic accidents but will be contained to specific areas and occur during short periods of time. Overall, the impact is positive and there is no need to assess its significance.

7.5.4 Occupational Health

The Project construction will involve various hazardous activities, including the use of heavy machinery, sharp tools, electrical equipment, welding and cutting work, as well as working at heights. These activities have the potential to cause occupational accidents and injuries to construction workers. The project will employ 229 project workers per day over a 3-year period, which increases the risk of accidents. Research shows that 85% of occupational accidents occur due to factors such as lack of knowledge, lack of attention, recklessness, or lack of experience. The remaining 15% of accidents are due to inadequate conditions of machines and equipment. To prevent and minimize the occurrence of accidents, PPE such as safety helmets, ear plugs, gloves, masks or nose cover, and safety shoes will be provided to construction workers and staff. The use of PPE will be enforced throughout the construction period. Overall, the pre-mitigation significance of the negative impact on occupational health during the construction phase is assessed as moderate.

During the implementation phase, transportation, regular maintenance, scheduled and special maintenance, rehabilitation and/or emergency work will take place. These activities have the potential to cause accidents in a similar manner to the construction risks, although each activity will be much smaller in extent. The pre-mitigation significance of the negative impact is assessed as low.

7.5.5 Socioeconomic Conditions

The communities of Koh Lanta are predominantly employees of companies/businesses, work in agriculture-gardening or traders. Community leaders have expressed their agreement to the project and will appreciate the greater convenience in transportation.

During the construction phase, project activities will lead to traffic obstructions and disruption of services, but local community members will be able to visit one another as normal and the socioeconomic impact will be low. No impacts on the existing transportation of tourists and the local population are expected. The construction activities will involve around 229 project workers during a 3-year period (900 working days) with preference given to the employment of local workers. This is expected to introduce a local cashflow up to 34,000 Baht/day which will benefit traders and local businesses. The management of migrant workers is contained in the Labor Management Procedures (LMP) that adopted comprehensive national legislation on migrant workers and contained a Sample Code of Conduct and procedures for the management of workers' camps vis-a-vis the health and safety of surrounding communities. Traders and local businesses may be inconvenienced by transportation in the area and temporarily forced to stop business activity, but construction activities will be conducted during the shortest time possible. The overall socioeconomic impact during construction is assessed as positive.

During implementation, the Koh Lanta Bridge Project will enhance the effectiveness of the transportation network, residents will be able to travel without the cost or inconvenience of the car ferry and visit each other more frequently. Tourism will be attracted to the area, which will create jobs for the local population and boost economic growth. Students living on Koh Lanta will be able to attend schools on the mainland. The Koh Lanta Bridge Project will contribute towards Krabi Province to achieving its vision as an "Internationally-acclaimed tourist destination, Sustainable agriculture and industry, Livable city, Ability to adapt to changes". The impact during implementation is assessed as positive.

7.5.6 History and Archaeology

There are no archaeological sites or evidence of archaeology within a 1-km buffer of the project route. The project route was designed to avoid the Thung Toh Yum Cemetery in Koh Lanta Noi Sub-district, a public property and not a cultural heritage site. The cemetery is close to the route (34 meters) and the site has been a focus for the assessment of air quality (PM_{10}, CO and NO_2), noise and vibration impacts. Activities during the construction phase that potentially affect the site include land work, road surface and pavement work, construction of the lower and upper bridge structures and transportation of construction materials. All impacts are within the limits set by the national standards except for noise which is exceeded across all the activities except transportation of materials. The significance of the pre-mitigation impact is assessed as low as there are no residents within this cemetery.

During the implementation phase, air quality, noise and vibration impacts to the Thung Toh Yum Cemetery will be within the limits set by the national standards and impacts are assessed as low.

7.5.7 Aesthetics

During construction there will be multiple activities taking place and parts of the construction site will become exposed. There will be equipment and materials used as well as piles of scrap material in the construction area and along the road zone. The physical environment that can be perceived by sight (visual impact) during transportation is not attractive and the visual impact is assessed as having a moderate significance.

During implementation the bridge will be a large and noticeable landmark that is visible from many locations. The Siri Lanta Bridge is already operational, and people have become accustomed to it. As a result, the Koh Lanta bridge will be a familiar looking structure to road users and the significance of the visual impact is assessed as low.

7.6 CUMULATIVE IMPACTS

A rapid cumulative impact assessment (RCIA) has been conducted as part of the SLIP. The primary goal of the RCIA was to assess and evaluate the Project's contribution to cumulative impacts on selected Valued Environmental and Social Components (VECs) in combination with other projects and activities within defined spatial and temporal boundaries, following the approach of the IFC Good Practice Handbook on CIA (IFC, 2013).

Seven environmental valued environmental components (VECs) were selected, namely Land Use, Coral Reef, Seagrass, Mangroves, Marine Mammals (Dolphin), Water Quality and Protected Areas. The spatial boundary for the Land Use VEC is represented by Koh Lanta and surrounding lesser islands (Figure 10), while the boundary for coral reefs, seagrass, mangroves and marine mammals comprises the coastline of Krabi Province. Water quality is assessed for Koh Lanta. The temporal boundary of the CIA encompasses the entire 30-year period of the project's operation in addition to the past ten years.

Figure 10 Spatial boundaries for the Land Use VEC of the Lanta Bridge Cumulative Impact Assessment

7.6.1 Selection of Projects and Activities

Four projects potentially impacting VECs were selected for the CIA, which include a high-speed train, new 4-lane highway, construction of a power generation system and construction of jetty and park (pier) (Table). Baseline descriptions of the VECs, impacts of the Koh Lanta Bridge and impacts of other projects are discussed thereafter.

Table 16 Projects identified for the Cumulative Impact Assessment

No	Project	Institution	Description	Location	Dates	Status
1	High-speed rail connection between tourist destinations of Donsak, Phuket and Krabi Airports.	Railway Authority of Thailand	A 68 km double-track railway network is proposed to connect Don Sak Port, a key tourist port of entry, to Phuket airport via through the area of Ban Tha Chatchai in Phuket Province and Krabi Airport including the districts of Thap Put, Ao Luek, and Mueang Krabi in Krabi Province.	Koh Samui to Phuket and Krabi Airport	No Date	Feasibility Study – in Planning Phase
2	New 4-lane highway construction to connect Plai Phrayao District in Krabi Province to Thap Put District in Phang Nga Province.	Department of Highways	This new highway will provide a shorter travel between Krabi and Pang Nga provinces, facilitating and expediting travel to other provinces in the South.	Plai Phrayao District in Krabi Province to Thap Put District in Phang Nga Province.	2022 – 2025	Construction
3	Construction of a power generation system	Mu Ko Lanta Marine National Park	Construction of a power generation system with Integrated clean energy at the National Park Protection Unit No. 2 (Koh Ngai) with a budget of 3.1 million Thai Baht (THB).	Ngai Island	2023	Implementing
4	Construction of jetty and park (pier)	Lanta Noi DAO/ Office of Public Works and Town plan, Krabi	Construction of jetty and park (or pier) at Lang Sod Beach with an annual budget of 25 million THB spanning 5 years from 2023 to 2027	Lang Sod Beach	2023 - 2027	Implementing

7.6.2 Land Use

Data on land use change in Koh Lanta reveals that urban residential land has increased by 225% while agricultural, forest and water courses have decreased between 2009 and 2020. Priorities of the Koh Lanta Yai city plan are to promote the development of tourist attractions, improve services, transportation, infrastructure and utilities to accommodate expanding communities, conserve traditional settlements and way of life, conserve the environment and natural resources and promote ecotourism and supporting agriculture.

Project Impacts: The project is designed to have the least possible impact on the environment but is expected to increase tourism, and the demand for commercial and residential activities is estimated to double the land conversion rate from 25% to 50% per year.

Impacts of Other Projects and Activities: Tourism demand is expected to drive the expansion of hotels, restaurants, and other tourist facilities with increasing impacts on the environment and communities, such as increased traffic and noise pollution. The railway and highway infrastructure will not have a direct impact, but it will have the potential to significantly boost tourism to the island. The cumulative impact on land use is estimated to be of moderate priority.

7.6.3 Coral Reefs

The Krabi coastline supports scattered coral reefs with a diversity of coral species covering up to 22.5 km². These corals are mostly in turbid shallow waters and surveys from 2011 to 2014 revealed less than 10% of these corals are in a good state of health while 70% were described as damaged or severely damaged. Coral reefs in Koh Lanta can be observed in Lanta Yai and Por Island but > 80% of these corals are severely degraded as a result of damage by tourists, boat anchors, ship propellors, fishing line, netting, discarded nets and use of fish poison.

Project Impacts: Live corals occur within 6 meters of the bridge route near Koh Pling Island but do not present a coral reef. These corals will be impacted by vibration and dispersal of sediment during project construction and the impact is assessed as negative with a moderate significance.

Impacts of Other Projects and Activities: Increased tourist activity will increase the damage and loss of coral and will drive the further expansion of tourist facilities leading to increased sedimentation, wastewater and solid waste, further polluting the waters around Lanta Island. The adverse impact of construction of the pier on the coral reef will be significant. The implementation of railway and highway infrastructure, as with the land use VEC, will not have a direct impact on coral reefs but the increased tourism as a result of improved access will have an impact. Cumulative impacts on coral are assessed to be of high priority.

7.6.4 Seagrass

Seagrass habitats in Krabi Province occur in turbid waters associated with Mangroves and high sediment accumulation, in shallow sandy areas protected from severe wave action and shallow waters around coral reefs. The seagrass around Lanta Island is currently in good condition but under threat from seasonal (natural) changes in sediment deposition during the monsoon and from boat activity which stirs up the sediments of seagrass beds.

Project Impacts: Seagrass patches in the project area are small and fragmented. These patches will be impacted by sediments during the construction with a negative impact of moderate significance.

Impacts of Other Projects and Activities: An estimated 1.27 million tourists are expected per year over the next 30 years resulting in increased boat traffic which will impact the seagrass beds. Untreated

wastewater could lead to eutrophication with negative impacts to seagrass. The construction of a pier will exacerbate these impacts. Construction of the railway and highway infrastructure will have an indirect impact as described for previous VECs. Cumulative impacts on seagrass are assessed to be of high priority.

7.6.5 Mangroves

Mangroves covered over 320 km² of Krabi Province in 2016 but experienced an 8% decline from 2009. DMCR (2016) attribute the decline in Lanta District to housing and agricultural development, tourism, construction of piers, establishment of shrimp ponds and other aquaculture. Wood is also harvested for construction, wood fuel and export to neighboring countries.

Project Impacts: A total of 40 mangrove trees will be removed for bridge construction which will have a negative impact on the coastal mangrove ecosystem of moderate significance. No impacts are anticipated during the operational phase.

Impacts of Other Projects and Activities: Increased tourism will impact the mangroves, particularly through habitat destruction to support the growing demand for infrastructure and development. Additional impacts include physical damage from boat activity, pollutants discharged from boats, increased fishing and demand for seafood. Construction of the pier will boost tourism and exacerbate these impacts, while the railway and highway infrastructure will have an indirect impact as described above. Cumulative impacts to mangrove are deemed to be of high priority.

7.6.6 Marine Mammals

DMCR (2018) have reported the presence of humpback, bottlenose, striped, spotted and jumping dolphins in coastal waters of Krabi Province. Many marine mammal strandings occur with the most common species being sperm whales, spotted dolphins and humpback dolphins. Autopsies have attributed 50% of strandings to be caused by natural illness and 7% to human activities. A finless porpoise and a bottlenose dolphin were recorded beached in Krabi Bay in 2017 although the rate of stranding of dolphins and whales has remained steady at approximately 2 per year.

Project Impacts: Underwater noise and vibration from bridge construction could affect the hearing and behavior of dolphins. They could also be injured by boats from the transportation of materials and equipment. Dolphins can flee the area, but the impact is assessed as a moderate significance on a precautionary basis. No impacts to dolphins are expected during operations.

Impacts of Other Projects and Activities: Increased tourist activity can disrupt dolphin behavior and habitat through increased noise, human presence and accidental discharges or spills of contaminants. Pier construction on Lanta Island is likely to increase these impacts directly, while the railway and highway infrastructure will have an indirect impact. Cumulative impacts to dolphins are considered to be of high priority.

7.6.7 Water Quality

Mismanagement of wastewater in Koh Lanta is causing water quality to deteriorate and health concerns are already affecting the tourism industry. Wastewater treatment facilities are not functioning, while there is rampant development and a lack of enforcement that results in many hotels and restaurants discharging their wastewater directly into natural water sources. The main pollutants affecting the water quality are total coliform bacteria, fecal coliform bacteria, and sediments. Effective measures are needed to control and manage the sources of pollution and supported by public awareness and encouragement of responsible tourism practices.

Project impacts: Impacts to water quality are expected to be minimal during construction and operation through the installation of water treatment facilities but needs to be managed appropriately.

Impacts of Other Projects and Activities: The construction of the jetty may result in sedimentation from soil disturbance and erosion causing increased turbidity, while use of machinery can result in oil and chemical spills. During operations, the jetty will result in increased vehicle traffic with potential wastewater and pollutant discharges. Changes in land use, such as converting forests to residential and building land, may also impact water quality if the current mismanagement of wastewater is not addressed. Construction of railway and highway infrastructure will increase tourism with indirect impacts as described above. The cumulative impact to water quality is expected to be of high priority.

7.6.8 Protected Areas

Protected areas in the islands associated with Koh Lanta include the Thung Thale Non-Hunting Area, Lanta National Park, national forest conservation areas and various environmental protected areas.

Project Impacts: The Project area is within the Thung Thale Non-hunting Area which supports a diverse range of floral and faunal species. The increased human presence, transportation of materials, felling of trees and clearing of vegetation, and pollution incurred by project construction will have negative impacts. A construction workforce of 170 people may create a demand for natural resources that triggers illegal poaching and extractive activities. No impacts to terrestrial habitats are expected during the operational phase.

Impacts of Other Projects and Activities: Construction of the pier, highway and railway projects are not expected to directly affect protected areas, but an increased influx of tourists will contribute to the degradation of protected areas by accelerating the encroachment of forest land for the development of tourist and associated facilities. The influx of tourists also leads to increased overcrowding, loss of natural resources, poor waste management and increased pollution of the land and marine environment. The cumulative impact on protected areas as a result is considered to be a high priority.

7.6.9 Management of Cumulative Impacts

The following management measures are proposed for addressing the cumulative impacts of the Lanta Bridge to multiple VECs, with additional measures required for specific VECs provided in Table :

- Develop a provincial tourism strategy and implement a Tourism Policy and Management Plan at the Lanta Islands level.
- Implement a tourism management plan for protected areas including limits on numbers.
- Encourage tourist enterprises to provide sustainable tourism practices.
- Implement improved wastewater and solid waste management for Krabi Province based on clear policies and guidelines in collaboration with relevant agencies, including the Provincial Office of Natural Resources and Environment.

Table 17 Overview of management measures required to address impacts to VECs and assessment of the Project capacity to address these measures

Management Measures	Project Capacity to Influence or Address
Land Use Management Measures • Land use planning, setbacks and enforcing zoning regulations • Strengthening environmental laws • Increase public awareness • Involve communities in management	**Low:** The Project has a low level of influence over land use management across the cumulative impact area. A regional spatial management plan is needed to coordinate land use beyond the project level.
Water Quality Management • Implement water conservation programs • Improve wastewater collection and treatment	**Moderate:** Project impacts to water quality are implemented, but the project has low influence over water quality management across the cumulative impact area. A regional water quality management strategy and management plan will be required.
Management of Coral Reefs, Sea Grass and Mangroves • Implement sustainable fishing practices • Educate and awareness of tourists and fishermen. • Temporary closure of sensitive areas that are vulnerable to impacts • Establishment of Protected Areas and "no go" zones • Improve Regulations on boat navigation • Implement alternative fisherfolk livelihood programs • Conduct regular mangrove monitoring and research	**Moderate:** The Project has avoided impacts within the vicinity of the project footprint. Funding will be provided to DMCR for improved management of protected areas and mangrove restoration, but will not be sufficient to influence the management of the vast extent of corals, seagrass and mangroves across the cumulative impact area Regional management plans and strategies for managing cumulative impacts to coral reefs, seagrass and mangroves will be required.
Protection of Marine Mammals • Promote sustainable fishing to reduce impacts to marine mammals	**Moderate:** The Project will provide funding for monitoring of marine mammal and critical habitat marine fauna, which will benefit the understanding of these species in the project

• Improve the management of marine protected areas • Develop and implement eco-tourism programs • Conduct regular monitoring and research on marine mammal populations • Collaborate with local communities, NGOs, and government agencies to implement marine mammal conservation and management plans	area. But the influence over the vast extent where these species occur within the cumulative impact area will be small. Implementation of a marine mammal management plan will be required to manage cumulative impacts.
Protected Areas Management • Delineate protected area boundaries • Improve monitoring, control and management of protected areas • Promote ecotourism development • Develop small-scale hospitality industry • Promote marine-based tourism • Develop sustainable agriculture practices • Promote handicrafts and local products • Collaborate with local communities to promote benefits of protected areas	**Moderate:** The Project will provide funds to DMCR for improved management of protected areas and mangrove restoration, but will have a limited influence over the large protected areas associated with the cumulative impact area. The Project will improve tourism but will not have influence over management of the tourism industry. A protected areas management plan and sustainable tourism management strategy will be required to manage broader cumulative impacts.

In summary, it is noted that the project will contribute to cumulative impacts on these seven identified valued components (VECs) and that project level mitigative actions will be implemented to manage these cumulative impacts on each VEC. However, the more significant and regional impacts as described in this assessment will require the implementation of a collaborative and coordinated cumulative impact management effort that would be best coordinated by DMCR, DRR or another responsible agency such as the Provincial Administrative Office or Provincial Office of Natural Resources and Environment. The scope of this effort and the required management actions are broadly described above but the implementation of these measures are considered beyond the scope of this NTS and of the project.

8 MITIGATION AND MONITORING MEASURES

8.1 ESMP STRUCTURE

The Koh Lanta Bridge Environmental and Social Management Plan (ESMP) defines the mitigation measures that can be used to eliminate the residual impacts of the project, if possible, or to reduce them to acceptable levels. It is a comprehensive document containing the following actions and management measures:

- Roles and Responsibilities
- Legal Framework
- Conditions (Implementing Agencies)
- Summary of Environmental and Social Impacts
- Mitigation Measures and Management Controls
- Monitoring Programs
- Reporting
- Responsibilities for Mitigation and Monitoring
- Capacity Development and Training
- Workplan, Implementation Schedule and Cost Estimate
- Review of the ESMP

8.2 SUMMARY OF MITIGATION AND MONITORING REQUIREMENTS

This chapter presents a summary of the mitigation and monitoring requirements for each impact provided within the Koh Lanta Bridge EIA. A total of 243 mitigation measures are listed although limited overlap does occur (approx. 5%). Responsibilities are assigned between the Department of Rural Roads (DRR) and the Contractor. Analysis reveals that 72% measures are the contractor's responsibility and 28% the responsibility of DRR and associated government institutions. Important mitigation to address each impact is prioritized in the list and identified within by the symbol (#). The anticipated effectiveness of this mitigation used in an assessment of the significance of residual impacts. Pre-mitigation and residual impact significance are discussed in Section 8.7 and summarized with the impacts in Table .

8.3 PHYSICAL ENVIRONMENTAL RESOURCES

Table 18 Mitigation and Monitoring of Physical Environmental Resources for the Koh Lanta Bridge Project

<table>
<tr><th colspan="3">Impacts and Mitigation Measures</th><th colspan="2" rowspan="2">Monitoring Measures</th></tr>
<tr><th>Construction Phase</th><th colspan="2">Implementation Phase</th></tr>
<tr><td rowspan="2">Air Quality</td><td rowspan="2">Pre-mitigation</td><td>Construction: Low negative</td><td rowspan="2">Residual Impact</td><td>Construction: Low -ve</td></tr>
<tr><td>Implementation: Low negative</td><td>Implementation: Low -ve</td></tr>
<tr><td><u>DRR Responsibilities</u>
1. Coordinate with sub-district AOs to inform the community of the implementation plan prior to construction.
<u>Contractor's Responsibilities</u>
1. Spray water at least twice per day over dust-affected areas such as soil excavation near the road towards bridge approach slab. (#)
2. Use a tarp to cover materials during transportation by trucks. (#)
3. Conduct regular maintenance checks of all vehicles and machinery to limit air pollution. (#)
4. Place stickers at the back of project vehicles with company name, contact person and contact number for complaints. (#)
5. Address complaints regarding dissemination of dust from the construction activities. (#)
6. Adhere to construction plan to complete activities as soon as possible.
7. Clean the wheels of every vehicle in allocated area before leaving the construction area.
8. Ensure no spillage of piling debris on the road during transportation.
9. Limit truck speed to 40 km/h in community and environmentally sensitive areas.
10. Allocate staff to frequently clean soil, rock and sand from road surface to prevent dust.</td><td colspan="2"><u>DRR Responsibilities</u>
1. Vacuum the road surface at night at least once a week to reduce dust accumulation.
2. Allocate staff to frequently clean the road surface and collect waste to prevent dissemination of dust.
3. Install signs indicating traffic directions, specifying the type and speed of vehicles to facilitate traffic flow and prevent the accumulation of pollutants in the area.
4. Address complaints received regarding impacts to air quality.</td><td colspan="2">Project phase: Construction
Description: Monitoring 5 indexes (TSP; PM10; CO; NO2; Wind speed and direction)
Location: Monitoring stations 1 & 2 (see Marine Water Quality for locations)
Timeline: At least four (4) times per year during construct.
Responsibility: DRR to hire specialist
Budget: 500,000 baht/year for 3 years, Total budget: 1,500,000 baht</td></tr>
<tr><td rowspan="2">Noise</td><td rowspan="2">Pre-mitigation</td><td>Construction: Moderate negative</td><td rowspan="2">Residual Impact</td><td>Construction: Low -ve</td></tr>
<tr><td>Implementation: Moderate negative</td><td>Implementation: Low -ve</td></tr>
<tr><td><u>DRR Responsibilities</u></td><td colspan="2"><u>DRR Responsibilities</u></td><td colspan="2">Project phase: Construction</td></tr>
</table>

Impacts and Mitigation Measures			Monitoring Measures	
Construction Phase	**Implementation Phase**			
1. Conduct a survey among homeowners regarding the need for installation of sound barriers and act according to the results. 2. Communicate the construction plan to communities at least 15 days prior to start and coordinate with sub-district AOs. ***Contractor's Responsibilities*** 1. Follow notification of Ministry of Interior on OHS for operating machinery. Duration of activities >90 decibels must be limited to prevent harm. (#) 2. Noise barriers made of acrylic glass or a higher quality material shall be installed after the project route is completed at the bridge railing. (#) 3. Install metal sheets for temporary soundproofing for Moo 8 Ban Hua Hin (Ban Tha Rua) and Thung Toh Yum Cemetery. (#) 4. Temporarily stop activities in the vicinity of Thung Toh Yum Cemetery during religious ceremonies. (#) 5. Limit truck speed to 40 km/h in community and environmentally sensitive areas. (#) 6. Address complaints received regarding noise emissions. (#) 7. Conduct regular maintenance checks of all vehicles and machinery to limit noise emissions. 8. Avoid simultaneous use of loud noise emitting machinery. 9. Provide noise PPE for staff and workers exposed to noisy conditions.	1. Conduct checkup and maintenance of the traffic surface to be in good conditions in order to minimize impact between wheels of vehicles and traffic surface. 2. Maintain and check the conditions of the acrylic glass noise barrier at the bridge railing. 3. Coordinate with local police in Krabi Province to strictly enforce laws on vehicles causing loud noises and to control the speed of vehicles using the project route according to the law.		**Description**: Monitoring 4 indexes (1-hr avg noise level; 24-hr avg noise level; Max volume; Avg day-night noise level) **Location**: Monitoring stations 1 & 2 (see Marine Water Quality for locations) **Timeline**: Five consecutive days at least four (4) times per year during construction. **Responsibility**: DRR to hire specialist. **Budget**: 24,000 baht/yr for 3 years; Total budget: 72,000 baht **Project phase**: Implementation. Monitoring as specified above for construction. **Timeline**: Once/year in years 1, 2, 3, 5, 10, 15 and 20 **Budget**: 4,200 baht/year for 20 years; Total budget: 84,000 baht	
Vibration	Pre-mitigation	Construction: Moderate negative Implementation: Low negative	Residual Impact	Construction: Low -ve Implementation: Low -ve
Contractor's Responsibilities 1. Use appropriate equipment and methods to minimize vibration effects. (#) 2. Inspect, take photos and record the condition of buildings and structures at the start of construction. (#) 3. Address complaints received regarding vibration impacts. (#) 4. Construction activities producing high vibration restricted to 8:30am to 17:30 hrs.	***DRR Responsibilities*** 1. Conduct frequent monitoring and control the payload of vehicles using the bridge. 2. Conduct checkup and maintenance of the traffic surface to be in good conditions in order to minimize impact between wheels of vehicles and traffic surface.		**Project phase**: Construction **Description**: 2 indexes (PPV; Frequency Hz) **Location**: Monitoring stations 1 & 2 (see Marine Water Quality for locations) **Timeline**: As specified for noise **Responsibility**: DRR to hire specialist	

<table>
<tr><th colspan="3">Impacts and Mitigation Measures</th><th rowspan="2" colspan="2">Monitoring Measures</th></tr>
<tr><th>Construction Phase</th><th colspan="2">Implementation Phase</th></tr>
<tr><td>5. Repair cracks and potholes in the diversion road surface throughout construction period.
6. Install speed limit signs and restrict truck speed to 40 km/h in community and environmentally sensitive areas.</td><td colspan="2">3. Install and maintain road traffic signs prior to maintenance activities to facilitate convenience and prevent accidents of road users.
4. Coordinate with the relevant police and traffic authorities to enforce speed limits.</td><td colspan="2">Budget: 144,000 baht/year for 3 years; Total budget: 432,000 baht</td></tr>
<tr><td rowspan="2">Surface Water Quality</td><td rowspan="2">Pre-mitigation</td><td>Construction: Moderate negative</td><td rowspan="2">Residual Impact</td><td>Construction: Low -ve</td></tr>
<tr><td>Implementation: Moderate negative</td><td>Implementation: Low -ve</td></tr>
<tr><td><u>Contractor's Responsibilities</u>
1. Construct temporary drainage and install sediment filter fence 1 m above ground level at construction sites near water bodies to prevent rainfall runoff. (#)
2. Determine a clear construction area and open the construction area when necessary. (#)
3. Compact soils to engineering standard for embankments as soon as they are brought to implementation area. (#)
4. Install appropriate septic tank-anaerobic filters and grease traps for the wastewater treatment from toilets, bathrooms, canteens and maintenance facility.
5. Build concrete grounds in areas where there may be oil spills, fat or grease such as in construction worker camps and maintenance facilities.
6. Machines, maintenance facilities, fuel & oil storage, vehicle washing, storage for construction materials located at least 100 m from water sources and water drainage.
7. Provide trash cans with lids which leachate cannot leak out.
8. Install mobile toilets with septic tank-anaerobic filters for wastewater treatment.
9. Implement two coagulation pit system for high pH wastewater treatment for concrete mixing plant.
10. Build a water sump to filter concrete sludge before releasing water back to water sources or to use for washing of trucks.</td><td colspan="2"><u>DRR Responsibilities</u>
1. Provide restrooms for tourists in Koh Klang and coordinate with Sub-district Admin. Organization on cleaning and maintenance.
2. Provide monkey-proof 240-liter trash cans with lids with capacity to separate Trash into recycling categories and labelled appropriately.
3. Install signs raising awareness for business owners and tourists not to use foam and plastic packaging.
4. Coordinate with Sub-district Admin. Organization for solid waste disposal according to sanitation guidelines with cognizance of busy tourism periods such as long weekends and holidays.</td><td colspan="2">Project phase: Construction
Description: Wastewater analysis of 6 indexes (pH; BOD SS; fat, oil & grease; total nitrogen & phosphorus) prior to discharge.
Location: Clarifier/anaerobic wastewater pond near the site office.
Timeline: At least every two (2) months during construction.
Responsibility: DRR to hire specialist.
Budget: 60,000 baht/year for 3 years; Total budget: 180,000 baht</td></tr>
<tr><td rowspan="2">Marine Water Quality</td><td rowspan="2">Pre-mitigation</td><td>Construction: Moderate negative</td><td rowspan="2">Residual Impact</td><td>Construction: Low -ve</td></tr>
<tr><td>Implementation: Not significant</td><td>Implement: Not significant</td></tr>
<tr><td><u>Contractor's Responsibilities</u></td><td colspan="2">None</td><td colspan="2">Project phase: Construction</td></tr>
</table>

<table>
<tr><th colspan="3">Impacts and Mitigation Measures</th><th rowspan="2">Monitoring Measures</th></tr>
<tr><th>Construction Phase</th><th colspan="2">Implementation Phase</th></tr>
<tr><td>1. Install silt curtains made from flexible materials, anchored to the sea floor and <5 m away from bored piles for duration of construction of temporary jetties and bridge piers. (#)
2. Install extended casing to prevent polymer solution from contaminating the sea during the casting of bored piles. (#)
3. Use steel casing and conduct integrity check of the mold and support columns before concrete is poured. (#)
4. Conduct checks and maintenance of machines and equipment used in the construction to prevent oil spills.
5. Store materials, scrap materials and equipment properly to not obstruct pathways.
6. Install safety nets and barriers to prevent materials and equipment accidentally falling into the sea.</td><td colspan="2"></td><td>Description: Monitoring of 15 indexes (Floating objects; Odor; Oil & grease; Temperature; pH; Transparency; Turbidity; SS; DO; Salinity; Pb; Hg; As; Total Coliform and Fecal Coliform)
Location: Monitoring Stations 1 (Ban Hua Hin Coast, Koh Klang); Station 2 (Koh Pling Coast); Station 3 (Ban Thung To Yum Coast, Koh Lanta Noi).
Timeline: At least every two months during construct.
Responsibility: DRR to hire specialist.
Budget: 108,000 baht/year for 3 years; Total budget: 324,000 baht</td></tr>
<tr><td rowspan="2">Geology, Earthquake and Tsunami</td><td rowspan="2">Pre-mitigation</td><td>Construction: Moderate negative</td><td rowspan="2">Residual Impact</td><td>Construction: Moderate</td></tr>
<tr><td>Implementation: Positive</td><td>Implementation: Positive</td></tr>
<tr><td><u>DRR Responsibilities</u>
1. Project to be surveyed immediately following earthquake event.
2. Install warning signs in tsunami hazard zones and tsunami evacuation routes in both sub-districts.</td><td colspan="2"><u>DRR Responsibilities</u>
1. Project to be surveyed immediately following earthquake event.
2. Install warning signs in tsunami hazard zones and tsunami evacuation routes in both sub-districts.</td><td colspan="2">Facilities to be assessed as per requirements in EIA immediately following any earthquake, other seismic or tsunami event.</td></tr>
<tr><td rowspan="2">Soil Erosion, Flood Control and Drainage</td><td rowspan="2">Pre-mitigation</td><td>Construction: Moderate negative</td><td rowspan="2">Residual Impact</td><td>Construction: Low -ve</td></tr>
<tr><td>Implementation: Not significant</td><td>Implement.: Not significant</td></tr>
<tr><td><u>Contractor's Responsibilities</u>
1. Disposal of drill sediments in locations as indicated in the project description. (#)
2. Clearly delineate construction sites and constrain activities accordingly. (#)
3. Compact soils to engineering standard for embankments as soon as they are brought to implementation area. (#)
4. Prepare pontoon boats or barges for drilling work in the sea for soil and sediments transportation.
5. Gypsum with hydraulic lime at a 1:1 ratio provided at the bed of the disposal area.</td><td colspan="2"><u>DRR Responsibilities</u>
1. Check the effectiveness of water drainage and issues of water clogging on both sides of the project route (on land) to verify the capacity of water drainage and water drainage system of the project. Rectify immediately as required.</td><td colspan="2">Project phase: Construction
Description: Monitor flooding and drainage efficiency
Location: Throughout project route (0+000 to 2+527)
Timeline: Twice/year during construction; During heavy rainfall events
Responsibility: DRR to hire specialist</td></tr>
</table>

Impacts and Mitigation Measures			Monitoring Measures	
Construction Phase	**Implementation Phase**			
6. Use a tarp to cover materials during transportation by trucks. 7. Transport sediments and debris outside of rush hours (7:30am to 9:00am and 5:00pm to 6:00pm) to minimize disruption of land and water transportation. 8. Allocate staff to clean debris/soil or rock sediments on traffic surface and prevent runoff of sediments into the drainage system.			**Budget**: 40,000 baht/year for 3 years; Total budget: 120,000 baht	
Oceanography	Pre-mitigation	Construction: Low negative Implementation: Low negative	Residual Impact	Construction: Low -ve Implement.: Not significant
DRR Responsibilities 1. Design bridge pier structures in the sea to have the least possible cross-sectional area in order to minimize obstructions of water currents. ***Contractor's Responsibilities*** 1. Install silt curtains to prevent dispersion of sediments at the depth of the seabed for installation of temporary jetties and bridge pier structures. (#) 2. Temporary jetties to be dismantled once bridge pier construction is completed. (#)	None		None	

8.4 BIOLOGICAL ENVIRONMENTAL RESOURCES

Table 19 Mitigation and Monitoring of Biological Environmental Resources for the Koh Lanta Bridge Project

Impacts and Mitigation Measures			Monitoring Measures	
Construction Phase	**Implementation Phase**			
Protected Areas (Terrestrial Ecosystem)	Pre-mitigation	Construction: Moderate negative Implementation: Not significant	Residual Impact	Construction: Moderate -ve Implementation: Not significant
DRR Responsibilities 1. Implement mitigations as required to minimize impacts to flora and fauna as required. 2. Specify regulations prohibiting contractor staff or relevant persons from inflicting damage to forest, wildlife and other natural resources.	***DRR Responsibilities*** 1. Mitigation measures of impact on plants and animals of the ecosystems shall be strictly implemented.		See: • Habitats and Vegetation • Terrestrial Fauna	

<table>
<tr><th colspan="3">Impacts and Mitigation Measures</th><th colspan="2" rowspan="2">Monitoring Measures</th></tr>
<tr><th>Construction Phase</th><th colspan="2">Implementation Phase</th></tr>
<tr><td><u>Contractor's Responsibilities</u>
1. Enforce regulations among staff and workers prohibiting damage to forest, wildlife and other natural resources. (#)
2. Mangrove habitats will be replanted to restore the ecology.
3. Clearly delineate construction sites and constrain activities accordingly.
4. Restrict tree cutting and vegetation clearing to minimum area required for construction.</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td rowspan="2">Marine Coastal Ecosystem</td><td rowspan="2">Pre-mitigation</td><td>Construction: Moderate negative</td><td rowspan="2">Residual Impact</td><td>Construction: Low -ve</td></tr>
<tr><td>Implementation: Not significant</td><td>Implement: Not significant</td></tr>
<tr><td><u>DRR Responsibilities</u>
1. Ensure replanting of mangroves as per Dept of Marine & Coastal Resources (DMCR), B.E. 2556 regulations.
2. Allocate budget to DMCR for local awareness-raising, knowledge campaigns and info dissemination on coral reefs and seagrass.
<u>Contractor's Responsibilities</u>
1. Restrict the cutting of mangrove trees to minimum required. (#)
2. Do not feed fish, hunt, bait, catch, take or collect aquatic animals or commit any acts with a purpose to hunt, catch, take or collect aquatic animals near coral reefs. (#)
3. Avoid dispersal of sediments into seagrass meadows and coral reefs to the extent possible.
4. Avoid seagrass meadows and coral reefs, e.g. mooring of boats or barges and dredging activities to avoid these areas.
5. Install silt curtains around all bored piles.
6. Do not dispose of solid waste, sewage, wastewater, or contaminants into the sea.
7. Do not step on corals.
8. Do not wash construction equipment or tools in the sea and ensure workers do not dispose of waste and scrap materials into the sea.</td><td colspan="2"><u>DRR Responsibilities</u>
1. Allocate a budget to replant 20 times the area of mangroves cleared and coordinate with DMCR and the Royal Forest Department for selection of areas and appropriate mangrove species for replanting in accordance with the DMCR regulation, BE. 2556.
2. Replanting of mangroves to be done within the first 5 years of implementation, within Krabi province or near vicinity.
3. Allocate budget to DMCR to monitor activities and rehabilitation of coral reefs and seagrass.</td><td colspan="2">See:
• Marine Aquatic Ecosystem
• Habitats and Vegetation</td></tr>
<tr><td></td><td></td><td>Construction: Moderate negative</td><td></td><td>Construction: Low -ve</td></tr>
</table>

<table>
<tr><th colspan="3">Impacts and Mitigation Measures</th><th rowspan="2" colspan="2">Monitoring Measures</th></tr>
<tr><th>Construction Phase</th><th colspan="2">Implementation Phase</th></tr>
<tr><td>Marine Aquatic Ecology</td><td>Pre-mitigation</td><td>Implementation: Not significant</td><td>Residual Impact</td><td>Implement.: Not significant</td></tr>
<tr><td><u>Contractor's Responsibilities</u>
1. Adhere to mitigation measures for erosion, surface water, marine water quality and oceanography impact. (#)
2. Check and maintain vehicles and equipment to prevent oil spills.
3. Prevent drilling debris and sediments from falling into the sea during transfer to trucks.</td><td colspan="2"><u>DRR Responsibilities</u>
1. Provide sufficient dustbins for solid waste collection at parking areas in Koh Klang and coordinate with Sub-district AO for regular waste collection.
2. Provide appropriate equipment to prevent fuel and chemical spills in the event of accidents of vehicles transporting such chemicals on the bridge.</td><td colspan="2">Project phase: Construction
Description: 5 indexes (Phyto- & Zooplankton, Aquatic plants, benthic fauna, fish))
Location: Monitoring stations 1, 2 & 3 (see Marine Water Quality for locations)
Timeline: At least every two (2) months during construction
Responsibility: DRR to hire specialist
Budget: 351,000 baht/year for 3 years; Total budget: 1,053,000 baht</td></tr>
<tr><td rowspan="2">Habitats and Vegetation (Plants of the Ecosystem)</td><td rowspan="2">Pre-mitigation</td><td>Construction: Moderate negative</td><td>Residual Impact</td><td>Construction: Low -ve</td></tr>
<tr><td>Implementation: Not significant</td><td>Implement.: Not significant</td></tr>
<tr><td><u>DRR Responsibilities</u>
1. Coordinate with the Royal Forest Department (RFD) to examine the boundaries of the construction area.
<u>Contractor's Responsibilities</u>
1. Enforce regulations among staff and workers prohibiting damage to forest, wildlife and other natural resources. (#)
2. Cutting trees of the restricted wood species will be strictly according to a permit issued by the RFD. (#)
3. Clearly delineate construction sites and constrain activities accordingly.
4. Establish a list of trees and other plants that have to be removed from the area with details on location, size and markings.
5. Clearing of vegetation must avoid any disturbance to vegetation surrounding the construction site.</td><td colspan="2"><u>DRR Responsibilities</u>
1. Allocate a budget for the RFD to replant forests three times more than the areas that were lost and utilized, and coordinate replanting in the first year of project implementation.</td><td colspan="2">Project phase: Construction
Description: Count of trees removed.
Location: Road construction site
Timeline: When timbers are cut and removed from site.
Responsibility: DRR to hire 3rd party
Budget: 10,000 baht/year for 3 years; Total Construct. Budget: 30,000 baht

Project phase: Implementation
Description: Monitor tree health, dead tree count, reforestation site size.
Location: Reforestation site
Timeline: Once/yr. in years 1, 2, 3, 5, 10, 15 and 20.
Responsibility: DRR to hire specialist
Budget: 3,500 baht/year for 20 years
Total Implemnt. budget: 70,000 baht</td></tr>
</table>

Impacts and Mitigation Measures			Monitoring Measures	
Construction Phase	**Implementation Phase**			
Terrestrial Fauna (Animals of the Ecosystem)	Pre-mitigation	Construction: Moderate negative Implementation: Moderate negative	Residual Impact	Construction: Moderate -ve Implement.: Moderate -ve
Contractor's Responsibilities 1. Adhere to regulations on forest, wildlife and natural resources and do not commit inappropriate acts such as shooting, fireworks or hunting of wildlife in the project area and the vicinity. (#) 2. Install signs prohibiting the feeding of monkeys to minimize conflict with humans. (#) 3. Holes from drilling of bored piles shall be closed immediately or escape routes provided to prevent animals from falling in (especially smooth-coated otter). (#) 4. In the event of a wildlife sighting, allow animal to leave the area safely or seek assistance from Mu Koh Lanta National Park authorities, Krabi Natural Resources and Environment Office and/or Forest Resources Management Office. (#) 5. If young otter or monkeys are seen, they are to be left alone and safe and allowed to reunite with their mothers naturally. 6. Do not cut trees where there are bird nests (incl. hollow tree trunks) or where birds lay eggs or nesting. Provide opportunities for birds to continue living on trees. 7. Prohibit staff and workers from catching or hunting wild animals in the project area throughout the construction period. 8. Clearly delineate construction sites and constrain activities accordingly. 9. Provide safe and ethical equipment in case animals need to be captured and handled. 10. Control traffic and implement air quality, noise and vibration mitigation. 11. Limit activities during the night to minimize disturbance to nocturnal wildlife.	***DRR Responsibilities*** 1. Install signs prohibiting the feeding of monkeys to minimize conflict with humans. This shall mitigate impact on changes of animal behavior due to viewpoints from the project. 2. Install warning signs for deceleration or speed limit to prevent accidents of crashing into wild animals or monkeys crossing the road. 3. Provide monkey-proof bins for garbage disposal. 4. Allocate budget for the Thung Thale Non-hunting area to manage Long-tailed Macaque populations to ensure survival and sustainable management of the population. 5. Install minimum required lighting on the bridge with sodium light to not attract insects. 6. Allocate a budget for maintenance of planted trees and replacement of dead trees by the Dept of Marine & Coastal Resources (DMCR) and RFD after planting, including mangrove planting.		**Project phase**: Construction **Description**: Monitor diversity, distribution & abundance; Threat. Status, land use and state of habitat; records of roadkill injuries & deaths. **Location**: 500 m buffer zone of project **Timeline**: At least four (4) times per year during construction **Responsibility**: DRR to hire specialist **Budget**: 600,000 baht/year for 3 years; Total Construction Budget: 1,800,000 baht **Project phase**: Implementation Monitoring as specified for construction. **Timeline**: Twice/yr. in years 1, 2, 3, 5, 10, 15 and 20 **Budget**: 105,000 Baht/year for 20 years; Total Implement. Budget: 2,100,000 baht	
Marine Mammals (Rare Species)	Pre-mitigation	Construction: Moderate negative Implementation: Positive	Residual Impact	Construction: Low -ve Implementation: Positive
Contractor's Responsibilities	None		**Project phase**: Construction	

Impacts and Mitigation Measures		Monitoring Measures
Construction Phase	**Implementation Phase**	
1. Keep a watch for bottlenose dolphin and the Indo-Pacific humpbacked dolphin through establishing a boat patrol team and monitor within 500 meters either side of the bridge route using binoculars. Alert construction teams immediately using a horn if a dolphin is sighted and continue monitoring until they leave the area. (#) 2. All construction activities in the sea must stop when there is a dolphin sighting in the construction area, and resume when the dolphin is > 500 meters away from the area. (#) 3. Mitigation for marine ecosystems, animals and plants of the ecosystems shall be strictly implemented. 4. Avoid construction of bridge pier structures during the monsoon season (May-Sept) to prevent effects on routes of the bottlenose dolphin and the Indo-Pacific humpbacked dolphin. 5. Contact the 10th Marine and Coastal Resources Office for assistance and rescue in case of stranding of dolphins or sea turtles. 6. Allocate parking for trucks and materials storage far from areas where there were smooth-coated otter footprints, scat, and traces are found. 7. Holes from drilling of bored piles shall be closed immediately or escape routes provided to prevent animals from falling in (especially smooth-coated otter).		**Description**: Observers to conduct boat patrol to alert for temporary shutdown of construction activities **Location**: Areas affected by construction, with emphasis north and south of bridge. **Timeline**: Throughout construction **Responsibility**: DRR to hire specialist **Budget**: 115,000 baht/year for 3 years; Total Construction Budget: 345,000 **Project phase**: Implementation **Description**: Observers to conduct boat patrol to assess diversity, abundance, condition, records of accidents, injuries and deaths and assess causes of accidents. **Location**: 500-meter radius of project route. **Timeline**: Twice per year (rainy & dry season) in year 1, 2, 3, 5, 10, 15 and 20th year since start of implementation. **Responsibility**: DRR to hire specialist **Budget**: 33,250 baht/year for 20 years; Total Implement. Budget: 665,000

8.5 HUMAN USE VALUES

Table 20 Mitigation and Monitoring of Human Use Values for the Koh Lanta Bridge Project

Impacts and Mitigation Measures			Monitoring Measures	
Construction Phase	**Implementation Phase**			
Land Acquisition	Pre-mitigation	Construction: Low negative Implementation: Not significant	Residual Impact	Construction: Low -ve Implement.: Not significant
DRR Responsibilities 1. Coordinate with affected people to inform them of the project implementation and give updated information prior to the start of construction. (#)	None		None	
Land Use	Pre-mitigation	Construction: Moderate negative Implementation: Moderate negative	Residual Impact	Construction: Moderate -ve Implement: Moderate -ve
DRR Responsibilities 1. Coordinate with relevant authorities (including Department of Lands, Agricultural Land Reform Office, Royal Forest Department, Land Development Department, Central Office of Land Consolidation, Treasury Department, Department of Public Works and Town & Country Planning, and local administrative organizations) regarding the categorization of land use according to their mandate prescribed by law such as the to specify urban planning measures. ***Contractor's Responsibilities*** 1. Clearly delineate construction sites and constrain activities accordingly. 2. Minimize disruption to agricultural areas and other local land uses.	***Krabi Provincial Public Works, Town & Country Planning Responsibilities*** 1. Control and develop areas in the city planning, especially areas in Koh Lanta Noi Sub-district, Saladan Sub-district and Koh Lanta Yai Sub-district, according to regulations to controlled urban sprawl, increase of hotels and buildings, in restricted areas according to the city plan. 2. Monitor and notify in case of any land use violation and impact from activities outside of the control according to reasons specified. 3. Update the Krabi city plan to be appropriate to the current situation and changing environment for the benefit of the state. ***Ministry of Natural Resources & Environment Responsibilities*** 4. Enforce and update the ministry's notification on designation of areas and environmental protection measures in Ao Leuk District, Mueang Krabi District, Nuea Khlong District, Khlong Thom District, and Koh Lanta District in Krabi Province,		None	

<table>
<tr><th colspan="2">Impacts and Mitigation Measures</th><th rowspan="2" colspan="2">Monitoring Measures</th></tr>
<tr><th>Construction Phase</th><th colspan="2">Implementation Phase</th></tr>
<tr><td></td><td colspan="2">according to environmental conditions in the area.</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Land and Water Transportation</td><td rowspan="2">Pre-mitigation</td><td>Construction: Moderate negative</td><td rowspan="2">Residual Impact</td><td>Construction: Low -ve</td></tr>
<tr><td>Implementation: Positive</td><td>Implementation: Positive</td></tr>
<tr><td><u>DRR Responsibilities</u>
1. Coordinate with Sub-district AOs to inform the community of the implementation plan prior to construction.
2. Coordinate with the Provincial Police Station and Highway Police to allocate officials to monitor and facilitate traffic flows for road users in the construction area.
3. Coordinate with Provincial Police Station and Highway Police to escort the transport of very large equipment and materials.
4. Control and monitor the implementation of contractors concerning the impact to the local population.
<u>Contractor's Responsibilities – Road Transportation</u>
1. Install large visible signs detailing info on area map, budget, duration of construction, contractor company, address, contact number, contractor and DRR at least two months prior to the start of construction. (#)
2. Prepare a traffic management plan prior to the start of construction.
3. Install nets below the bridge structure throughout construction, to prevent materials and equipment from falling on road or boat users.
4. Establish a complaints center for the project with a complaints box and information board.
5. Place stickers at the back of project vehicles with company name, contact person and contact number for complaints.
6. Install signs warning road users of construction 1 km before the site, and blinking lights 500 before the site warning of reduction of traffic lanes, and warnings of the presence of construction workers 100 m and 50 m prior to the site. Speed cones will be present 20 m before leaving the end of the construction site.</td><td colspan="2"><u>DRR Responsibilities</u>
1. Conduct maintenance of traffic surface, road shoulder, traffic markings, milestones, bridge, lighting to be in good conditions.
2. Inspect the installation of traffic signs and symbols that they are sufficient and in good conditions and can be viewed from a far distance.
3. Install traffic signs, road diversions, speed limit of vehicles prior to the start of road maintenance.
4. Coordinate with the relevant police and traffic authorities to enforce speed limits.</td><td colspan="2">Project phase: Construction and Implementation
Description: Count of vehicles transporting materials & equip; damages to road; gather accident statistics and transportation surveys
Location: Highway 4206 and Rural Road 5035.
Timeline:
Construction: Twice/year;
Implementation: Once/year.
Responsibility: DRR to hire specialist
Budget:
Construction: 60,000 baht/year for 3 years, Total budget: 180,000 baht
Implementation: 30,000 baht/year for 20 years, Total budget: 210,000</td></tr>
</table>

Impacts and Mitigation Measures		Monitoring Measures
Construction Phase	**Implementation Phase**	
7. Allocate staff to facilitate traffic flow for road users along the project route during construction. 8. Monitor the payload of trucks transporting materials and equipment. 9. Repair damage to roads inflicted by transport of materials and equipment and act on complaints from residents. 10. Install speed limit signs and restrict truck speed to 30 or 40 km/h in community and environmentally sensitive areas. Enforce adherence to speed limits among project drivers. 11. Avoid transport of materials during rush hours (7:30am to 9:00am and 5:00pm to 6:00pm). 12. Use a tarp to cover materials during transportation by truck. 13. Ensure that traffic markings, speed bumps, traffic lights and signs are in place immediately after construction to prevent accidents. ***Contractor's Responsibilities – Water Transportation*** 1. Install flashing lights on buoys, jetties, cranes and bridge pier structures. (#) 2. Coordinate with Krabi Marine Dept and notify local fisherfolk/long tail boats, ferries, speed boats providing services for tourists about the project implementation. (#) 3. Install reflective tapes (fenders) and lights around the extradosed bridge structure once completed to highlight the column positions for navigation and to prevent boat accidents. (#) 4. Allow at least 20 docking spaces for fishing/long-tail boats at the side of Ban Hua Hin Pier. (#) 5. Follow all regulations concerning navigation and use of docks. 6. Minimize the encroachment onto navigation channels. 7. Establish measures for control and management of water transportation according to the Act on Navigation in Thai Waters B.E.2456 of the Marine Department. 8. Any accident on the water to be reported to the Marine Dept. If a boat or articles sink into the lake, inform the Marine Dept immediately and follow their guidance to safely mark the area.		

Impacts and Mitigation Measures			Monitoring Measures	
Construction Phase	**Implementation Phase**			
Public Utilities	Pre-mitigation	Construction: Low negative Implementation: Positive	Residual Impact	Construction: Not significant Implementation: Positive
Contractor's Responsibilities 1. Coordinate with DRR Krabi office and authorities that own the public utility to inform details on construction type, positioning of public utility system that has to be relocated. (#) 2. Inform local residents regarding the plan to relocate public utilities at least one month in advance. (#) 3. Address complaints received regarding the relocation of public utilities. (#) 4. Relocation of utilities will be done at night from 10:00pm to 05:00am the following morning or on public holidays to minimize disruption to local communities and businesses. 5. Ensure that the area is clear of soil/rock sediments, or construction scrap materials once relocation is done.	None		None	

8.6 QUALITY OF LIFE VALUES

Table 21 Mitigation and Monitoring of Quality of Life for the Koh Lanta Bridge Project

Public Health	Pre-mitigation	Construction: Moderate negative Implementation: Moderate negative	Residual Impact	Construction: Low -ve Implementation: Low -ve
Contractor's Responsibilities 1. Maintain cleanliness in the construction area and construction worker camps according to sanitation standards with sufficient toilets, mobile toilets at sites and other facilities. (#) 2. Conduct pre-employment health screening for workers and staff to minimize effects from communicable diseases which could produce negative effects on the public health system in the area. (#) 3. Apply all air quality, sound, vibration, water quality and transportation mitigation. (#) 4. Provide sufficient clean drinking water for construction workers in the construction area. (#)	None		**Project phase**: Construction **Description**: Follow-up health issues of workers, state of services and results of socio-economic studies. **Location**: Construction workers; within 500 m of project route. **Timeline**: Once/year during construction **Responsibility**: DRR to hire specialist **Budget**: Included in socio-economic study **Project phase**: Implementation Monitoring as specified for Construction.	

5. Prepare a response to emergency situations/unforeseen circumstances such as water outage, power outage, floods, fire, illnesses. (#) 6. Provide appropriate psychosocial support for staff and workers, including support on living conditions, social needs, mental health of construction workers and their company, both for those that live in the camps and outside. 7. Upon the completion of construction activities, site offices, construction worker camps and wastewater septic tanks/sumps underground shall be dismantled and disposed of according to sanitation guidelines. 8. The contractor shall have policies to embrace discussion and consultation from external agencies and construction workers in the solving of issues. 9. Establish measures and regulations on the prevention and control in response to COVID19 in construction sites and construction worker camps. 10. Raise awareness on health issues, self-protection measures and prevent and control the spread of disease by reducing risk factors through appropriate sanitation behaviors, self-care, monitoring of symptoms of staff and construction workers. 11. Monitoring the incidence of symptoms and provide supplies of equipment such as masks, gloves, PPE suits, pulse oximetry, thermometer, oxygen concentrator etc. 12. Promote and support vaccination for employees and employers. 13. Coordinate and ensure that all workers have access to hospitals where they can receive treatment when they are sick. 14. Prepare quarantine facilities within the construction site and camps with food, water and transfer system to nearby hospitals.			**Timeline**: As specified for socio-economic study	
Sanitation	Pre-mitigation	Construction: Moderate negative Implementation: Low negative	Residual Impact	Construction: Low -ve Implementation: Low -ve
Contractor's Responsibilities 1. Solid waste collection stations will be equipped with trash cans with secure monkey-proof lids, which leachate cannot leak out	***DRR Responsibilities*** 1. Provide restrooms for tourists in Koh Klang. The restrooms shall be under the structure of the		None	

categorized according to types of waste, easy to clean, strong, durable and lined with bags for easy collection and disposal. (#) 2. Coordinate with Koh Klang Sub-district AO for collection and transfer of waste. (#) 3. Apply all air quality, sound, vibration, water quality and transportation mitigation. 4. Reduce usage or reduce waste from the source. Aim to reduce waste or avoid producing waste or pollution such as using canvas bag instead of plastic bags, reduce the use straws by drinking from glasses instead. 5. Avoid to the extent possible using materials that are non-biodegradable such as foam, disposable cutleries, aerosol insecticide.	bridge. The project shall coordinate with Koh Klang Sub-district Administrative Organization (AO) on cleaning and maintenance. 2. Install signs prohibiting waste disposal/littering at two viewpoints. 3. Coordinate with Sub-district Admin. Organization for solid waste disposal according to sanitation guidelines with cognizance of busy tourism periods such as long weekends and holidays.			
Accidents and Safety	Pre-mitigation	Construction: Moderate negative Implementation: Positive	Residual Impact	Construction: Low -ve Implementation: Positive
Contractor's Responsibilities 1. Monitor and provide trainings for drivers transporting construction materials and equipment. Drivers will be instructed to strictly follow traffic rules and drive with caution to prevent accidents to road users and local residents. (#) 2. Rigorously prohibit truck drivers from using stimulants or alcoholic drinks while working. (#) 3. Install traffic signs for road users that are large, clearly visible and comply with DRR standards, especially at intersections, curves connecting to local roads and community areas. (#) 4. Communicate project plans to the local population to be informed from prior to construction until the completion of the project. This includes follow-up consultations in coordination with DRR with fisherfolk affected by the temporary relocation of a mooring station from Ban Hua Hin pier to a new location. 5. Check and maintain traffic surface conditions of the transportation network. 6. Apply mitigation for Transportation below to reduce accident risks for road users and accident-prone zones.	***DRR Responsibilities*** 1. Apply mitigation for Transportation below to reduce accident risks for road users and accident-prone zones. 2. Check and maintain the road surface, lights, traffic signs and warning signs on the bridge and ground-level roads. 3. During project maintenance, install warning signs of areas being renovated and road diversions to alert road users prior to reaching the site at least 1,000 m, 500 m and 200 m before reaching the site. 4. Bridge pier structures near navigation channels shall have flashing lights and lights to warn approaching vessels to take caution.		See monitoring measures in Land and Water Transportation	
		Construction: Moderate negative		Construction: Low -ve

Occupational Health	Pre-mitigation	Implementation: Low negative	Residual Impact	Implementation: Low -ve
Contractor's Responsibilities 1. Establish preventive measures to minimize accidents and comply with the ministerial regulation specifying standards on the OHS for construction (B.E. 2564), from construction work. (#) 2. Provide trainings for construction workers on the correct usage and maintenance of machines and equipment prior to the start of work. (#) 3. Activities involving work at a height shall have the necessary strong scaffold, safety belts and lanyards for construction workers to wear at all times during operation. (#) 4. Provide workers with PPE appropriate to the type of work and instruct them to wear it every time while working. (#) 5. Apply all air quality, sound, vibration, water quality and transportation mitigation. 6. Ensure all staff and workers comply with safety regulations or laws. 7. Provide a background screening before employment. 8. Ensure workers follow the regulations of working in the local area concerning working hours, entry-exit from camp site, prohibition of alcoholic drinks & drugs to prevent conflict with local residents. 9. Provide first-aid kits and basic medication shall be provided at each site for care and immediate assistance. 10. Build fences/walls around the residential areas, specify entry-exit points and prohibit unauthorized access to the construction area. 11. Provide entry-exit points into residential areas without having to pass through hazardous zones. 12. Provide sufficient fire extinguishers appropriate to the type of fire in construction worker camps and construction site offices. 13. Electrical equipment shall be in safe and undamaged.	***DRR Responsibilities*** 1. Provide workers with PPE appropriate to the type of work and instruct them to wear it every time while working. 2. Provide equipment and tools for safety such as light signals for areas under maintenance, road safety barriers, cones, traffic surface markings, lights and flashing lights, for signaling and warning prior to reaching maintenance / renovation areas.		See monitoring measures in Public Health	

14. Ensure there is peace and order in construction worker camps and residential areas. 15. Install signs or announcement boards warning about the negative effects or legal penalties concerning drug use. 16. Comply with the notification of the Welfare Committee on the welfare of workers and residences of employees in construction. 17. Sufficient accommodation shall be provided according to the number of workers and shall have natural air circulation. 18. Clean bathrooms and toilets shall be sufficiently provided according to the number of workers with separation between male-female. 19. Mosquito breeding sites will be eliminated to the extent possible with wire screens on windows. 20. Provide sufficient drinking water of good quality that is produced according to standards with drinking fountains in clean areas.		
Socioeconomic	Pre-mitigation Construction: Positive Implementation: Positive		Residual Impact Construction: Positive Implementation: Positive
Contractor's Responsibilities 1. Consider local labor first to reduce impact on the society and issues with unemployment and migrant workers. Local residents shall be given as much opportunities as possible to work in the project. (#) 2. Foster good relationships and an understanding among project staff and workers on living in the community with residents. (#) 3. Construction activities taking place in front of businesses/companies shall be completed in the shortest possible duration. (#) 4. Establish a complaints center for the project with a complaints box and information board. (#) 5. Address complaints that are received and provide feedback to affected communities. (#) 6. Apply all air quality, sound, vibration, water quality and transportation mitigation.	***DRR Responsibilities*** 1. Maintain a complaints center for the project with a complaints box and information board, address complaints that are received and provide feedback to affected communities.	**Project phase**: Construction **Description**: Socio-economic and cultural changes of the project; Opinion of the community, comments and suggestions. **Location**: Greater project vicinity **Timeline**: Once/year during construction **Responsibility**: DRR to hire specialist **Budget**: 250,000 baht/year for 3 years; Total budget: 750,000 baht **Project phase**: Implementation As specified for construction. **Timeline**: Once/year in years 1, 2, 3, 5, 10, 15 and 20 **Budget**: 87,500 baht/year for 20 years; Total budget: 1,750,000 baht

7. Coordinate with Sub-district AOs to inform the community of the implementation plan prior to construction. 8. Create a registry of migrant workers to manage, monitor and not create disturbance or trouble for local residents.				
History and Archaeology	Pre-mitigation	Construction: Low negative Implementation: Low negative	Residual Impact	Construction: Low -ve Implementation: Low -ve
DRR Responsibilities 1. Coordinate with the 12th Regional Office of Fine Arts (Nakhon Sri Thammarat Province) prior to construction. If any archaeological artifacts/evidence are found on land, underground or underwater during project activities, the DRR shall immediately inform the above office for further examination to prevent issues to any party. ***Contractor's Responsibilities*** 1. Noise barriers made of acrylic glass or a higher quality material shall be installed at the bridge railing to prevent sound impact on Thung Toh Yum Cemetery where there often are religious ceremonies. (#) 2. Apply all air quality, sound, vibration, water quality and transportation mitigation. (#)	***DRR Responsibilities*** 1. Maintain acrylic glass noise barriers at the bridge railing to prevent sound impact on Thung Toh Yum Cemetery.		See Socioeconomic monitoring measures	
Aesthetics	Pre-mitigation	Construction: Moderate negative Implementation: Low negative	Residual Impact	Construction: Low -ve Implementation: Low -ve
Contractor's Responsibilities 1. Regularly clean and maintain the orderliness of construction areas with regular collection of trash. (#) 2. Branches, scraps or debris from relocation of obstructions, land excavation, drilling, soil filling work or other materials from construction shall be removed immediately after the construction is completed. (#)	***DRR Responsibilities*** 1. Strictly follow all mitigation measures on impact on sanitation. 2. Maintain the conditions of sculptures at viewpoints and the cleanliness of parking areas, stairs to the bridge, and walkways along the bridge to maintain a beautiful and orderly scenery of the project route.		See Socioeconomic monitoring measures	

8.7 RESIDUAL IMPACT ASSESSMENT

Section 8 summarizes the mitigation provided in the EIA to address impacts and identifies key mitigation that is expected to be effective in reducing the significance of impacts. Table presents an overview of the impacts that have been assessed with a breakdown of significance. A total of 25 impacts were assessed for the construction and implementation phases, of which 24 had a moderate negative significance pre-mitigation. Mitigation is anticipated to reduce 75% of these impacts to a low residual significance. The following impacts retain a residual moderate significance and their corresponding reasons:

1. Geology, Earthquakes and Tsunami (construction phase) – Earthquakes and tsunami are natural phenomena that cannot be mitigated. Likelihood is low but if they occur, there would be consequences during the construction phase, depending on the stage of construction. Once constructed the Lanta Koh Bridge is designed to withstand major seismic events and will serve as an emergency rescue and/or evacuation route during which is described as a positive impact.

2. Land Use (construction and implementation phase) – A cumulative impact to land use is expected to occur but is not addressed in the EIA. An assessment of cumulative impacts and development of mitigation is carried out as part of the SLIP and discussed in the Section 7.6.

3. Terrestrial fauna (construction and implementation phase) – The threatened status of Long-tailed Macaque has been raised to Endangered after the EIA was compiled. These monkeys could be exposed to limited impacts through scavenging from the construction camp and some Macaque-tourist conflict, however mitigation can be applied to avoid significant impacts.

Table 22 Analysis of the Pre-Mitigation and Residual Significance of Impacts

Impact Group	Count of Impacts	Pre-mitigation Significance			Positive Impacts	Residual Significance	
		Moderate Negative	Low Negative	Not significant		Moderate Negative	Low Negative
Physical Environ. Resources	8	8	4	3	1	1	11
Biological Environ. Resources	6	7	0	4	1	3	4
Human Use Values	11	9	7	2	5	2	13
Total	**25**	**24**	**11**	**9**	**7**	**6**	**28**

8.8 SUPPORTING ENVIRONMENTAL ACTION PLANS

The Koh Lanta Bridge EIA identifies many impacts and corresponding mitigation and monitoring measures, as summarized in Section 7 and Section 8. Mitigation within the EIA is supported by eight action plans with objectives, budgets, allocation of responsibilities and abundant details, species lists, maps, illustrations and other data to facilitate their implementation.

The ESMP incorporates the following action plans, with brief summaries hereafter:

1. Noise Preventive and Corrective Action Plan

2. Surface Water Quality Prevention and Remediation Action Plan
3. Marine Water Quality Prevention and Remediation Action Plan
4. Transportation, Accidents, and Safety Preventive and Corrective Action Plan
5. Public Relations and Complaint Handling of the Project Action Plan
6. Mangrove Reforestation Action Plan
7. Reforestation Action Plan (National Reserved Forest)
8. Prevention and Remediation Action Plan on the Impacts towards Dolphins

8.8.1 Noise Preventive and Corrective Action Plan

Objective: Minimize noise impacts from the construction and transportation activities.
Area: Environmentally sensitive areas affected by high noise levels and the Ban Tha Rua Community on the left side of the route.
Time Period: Continuously during construction and throughout Implementation
Responsibilities: Construction contractor under DRR supervision
Budget: Construction Phase: 1,517,925 baht; Implementation Phase: 1,236,070 baht

8.8.2 Surface Water Quality Prevention and Remediation Action Plan

Objective: Prevent and minimize impacts from the sediment runoff into water sources.
Area: Construction sites near two water sources in Koh Klang and Koh Lanta Noi Subdistricts.
Time Period: Throughout construction period.
Responsibilities: Construction contractor under DRR supervision
Budget: Construction Phase: 300,000 Baht (based on 60 silt fences with unit price of 5,000 Baht)
Implementation Phase: 605,000 baht
Evaluation: Inspection team and DRR project supervisor to assess alignment to the plan

8.8.3 Marine Water Quality Prevention and Remediation Action Plan

Objective: Minimize dispersal of sediments during the construction in the sea (Khlong Chong Laad) and cause the least possible impacts on the marine water quality and ecology.
Area: Bridge pier structures and temporary jetties
Time Period: Throughout construction period in the sea
Responsibilities: Construction contractor under DRR supervision
Budget: 3,346,450 baht

8.8.4 Transportation, Accidents, and Safety Preventive and Corrective Action Plan

Objective: Minimize the impacts on the transportation and risks of accidents
Area: Project route, approach structures and waterways where the bridge constructions are implemented.
Time Period: Continuously throughout the construction phase
Responsibilities: Construction contractor under DRR supervision.
Budget: Construction Phase: 3,400,000 baht

8.8.5 Public Relations and Complaint Handling of the Project Action Plan

Objective: Deliver clear, accurate news and information on the project development to locals, community leaders, and local government agencies.

Area: Road zone and a distance of at least 500 meters from the project area or more depending on the study.

Time Period: Continuously throughout the construction phase

Responsibilities: Construction contractor under DRR supervision.

Budget: 260,000 baht

8.8.6 Mangrove Reforestation Action Plan

Objective: Reforest the mangrove forests in accordance with the regulations of the Department of Marine and Coastal Resources on Reforestation and Maintenance of Mangrove Forest, B.E.2564 (2021). Regulation presents lists of suitable Mangrove species.

Area: Project area or surrounding areas considered suitable by the Department of Marine and Coastal Resources.

Time Period: Construction Phase: Starting in Year 1 and throughout the construction phase;
Implementation Phase: Maintain trees every year (2 to 6 years of age) for 5 years.

Responsibilities: DMCR using budget allocated by DRR. A 3rd party shall be hired for activities during the Implementation Phase.

Budget: Construction and Implementation Phase: 698,640 baht

8.8.7 Reforestation Action Plan (National Reserved Forest)

Objective: Reforest areas of National Reserved Forest lost due to the project development

Area: Sites selected by the DMCR, such as degraded forest areas.

Time Period: Construction Phase: Starting in Year 1 and throughout the construction phase;
Implementation Phase: Continuously maintain every year (2 to 10 years of age) for 9 years.

Responsibilities: DMCR using budget allocated by DRR. A 3rd party shall be hired for activities during the Implementation Phase.

Budget: Construction and Implementation Phase: 274,624 baht

8.8.8 Prevention and Remediation Action Plan on the Impacts towards Dolphins and critical habitat marine fauna

Objective: Monitor and be on alert for dolphins and all marine fauna described as critical habitat features and potentially affected by the construction activities

Area: North and south of the Koh Lanta Bridge construction sites, as well as areas along the bridge.

Time Period: Continuously throughout the construction phase;
Implementation Phase: Twice/year when the sea is calm (December) and during monsoon season (September) in year 1, 2, 3, 5, 10, 15 and 20.

Responsibilities: Construction Phase: Construction contractor under DRR supervision. DRR to hire 3rd party during the Implementation Phase.

Budget: Construction Phase: 115,000 baht;
Implementation Phase: 95,000 baht.

8.9 SUMMARY OF THE ESMP BUDGET

Budgets provided within the Koh Lanta Bridge EIA for ESMP implementation and monitoring. These budgets are summarized below and collectively provide cost of 27,839,458 Baht for E&S mitigation and 8,725,000 baht for monitoring.

Table 23 Budgets for ESMP Action Plans (baht)

Component	Construction	Implementation	Subtotal	Responsibility
Occupational Health and Safety	1,720,000		1,720,000	contractor
Road Maintenance and Traffic Impact Mitigation (Additional)	2,700,000		2,700,000	contractor
Environmental Mitigation Costs				
Water Quality Mitigation for Construction Office and Worker Camp	2,845,749		2,845,749	contractor
Surface Water Quality Prevention and Remediation Action Plan	300,000	605,000	905,000	contractor
Marine Water Quality: Silt Curtains around the pile construction sites	3,346,450		3,346,450	contractor
Noise Preventive and Corrective Plan	1,517,925	1,236,070	2,753,995	contractor
Mangrove Reforestation Action Plan	698,640		698,640	DRR - support DMCR
Reforestation Action Plan (National Reserved Forest)	274,624		274,624	DRR - support DMCR
Prevention and Remediation Action Plan on the Impacts towards Dolphins and critical habitat marine fauna	115,000	95,000	210,000	contractor
Transportation, Accidents, and Safety Preventive and Corrective Action Plan	3,400,000		3,400,000	contractor
Public Relations and Complaint Handling of the Project Action Plan	260,000		260,000	contractor
Environmental Monitoring	3,846,000	4,879,000	8,725,000	DRR to hire experts
Contractor Self-Monitoring Program				contractor
Total (baht)			**27,839,458**	
Contractor's Responsibility			18,141,194	

Table 24 Budget provided for Monitoring Activities

Component	Construction Phase			Implementation Phase		
	Budget per year	No. of years	Total Budget	Budget per year	No. of years	Total Budget
Air quality	500,000	3	1,500,000		20	

Noise	24,000	3	72,000	4,200	20	84,000
Vibration	144,000	3	432,000		20	
Surface water quality	60,000	3	180,000		20	
Marine water quality	108,000	3	342,000		20	
Drainage and flood protection	40,000	3	120,000		20	
Marine Aquatic ecology	351,000	3	1,053,000		20	
Flora (Habitats and Vegetation)	10,000	3	30,000	3,500	20	70,000
Fauna	600,000	3	1,800,000	105,000	20	2,100,000
Dolphins and all critical habitat marine fauna	115,000	3	345,000	33,250	20	665,000
Transportation and safety	60,000	3	180,000	10,500	20	210,000
Socio-economic	250,000	3	750,000	87,500	20	1,750,000
Totals			**6,804,000**			**4,879,000**

Table 25 Consolidated ESMP and Monitoring Budgets

Budget	**Project Phase**		**Total**
	Construction	**Implementation**	
ESMP Budget (baht)	21,024,388	6,815,070	27,839,458
Monitoring Budget (baht)	6,804,000	4,879,000	11,683,000
Total (baht)	27,828,388	11,694,070	39,522,458
USD Equivalent (exchange rate 31.417 on 1-Jul-2020)			US$ 1,257,996

9 REFERENCES

British Code of practice for noise and vibration control on construction and open sites – Part 1: Noise. BS 5228-1:2009+A1:2014. Online Link

DIN 4150:1999 by the Deutsches Institut für Normung, 1999 Guidelines for vibration impact to a buildings. Online Link

ERM. 2023. World Bank Land Process Review for 2 Bridges - Thailand Resilient Transport Connectivity Project. Report date 14 July 2023, Project No.: 0690942.

IBAT (Integrated Biodiversity Assessment Tool). Available through subscription at: https://www.ibat-alliance.org/

IUCN Red List of Threatened Species. Online database available at: https://www.iucnredlist.org/

National Oceanic and Atmospheric Administration (NOAA), Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing, July 2016.

Thailand Red List: Birds. Sanguansombat W., 2005. Office of Natural Resources and Environmental Policy and Planning, Bangkok, Thailand. 158 p. Online Link

Thailand Red List: Mammals, Reptiles and Amphibians. Nabhitabhata J. and T. Chanard. 2005. Office of Natural Resources and Environmental Policy and Planning, Bangkok, Thailand. Online link

Thailand Red List: Vertebrates. Office of Natural Resources and Environmental Policy and Planning. 2007. Ministry of Natural Resources and Environment. Bangkok. 98 pages. Online Link