SCOPING STUDY: BIODIVERSITY, WATER AND JAPANESE INVESTMENTS IN SAI GON- DONG NAI RIVER BASIN AND MEKONG DELTA

Prepared by CBES

Title	Scoping study: biodiversity, water and Japanese investments in Sai Gon-Dong Nai River basin and Mekong Delta
Authors	**Vu Long** **Truong Anh Tho** **Phan Minh Tam** **Nguyen Khanh Luong** **Nguyen Hoang Thien** **Nguyen Trong Duc** **Nguyen Hoang Thien** **Dong Nguyen Tuong An** **Pham Ngoc An** **Nguyen Thi Thu Hien** **Dang Le Anh Tuan**
Corresponding author	**Vu Long**
Prepared by	**Center for Biodiversity conservation and Endangered Species (CBES)**

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ACRONYMS

asl	Above sea level
AZE	Alliance for Zero Extinction
BR	Biosphere Reserve recognized by UNESCO's Man and the Biosphere Programme
CBES	Center for Biodiversity conservation and Endangered Species
CR	Critically Endangered
Decree 06/2019/NĐ-CP	Decree on the management of endangered, rare, and valuable forestry flora and fauna and the practicing of the Convention on International Trade in Endangered Species of Wild Fauna and Flora
Decree 26/2019/NĐ-CP	Decree on detailing several articles and measures to enforce fishery law, specifying the provisions of the Fisheries Law
EN	Endangered
EBSA	Ecological or Biological Significant Areas
FFI	Fauna and Flora International (now Fauna and Flora)
GIS	Geographic Information Systems
IBA	Important Bird and Biodiversity Area, recognized by the BirdLife International
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
JETRO	Japan External Trade Organization
LC	Least Concerned
MONRE	Ministry of Natural Resources and Environment
MIP	Ministry of Planning and Investment
MRC	Mekong River Commission
NE	Not Evaluated
NL	Not Listed
NP	National Park
NR	Nature Reserve
NT	Near Threatened
PA	Protected Area
UNESCO	United Nations Educational, Scientific and Cultural Organization
VRDB	Vietnam Red Data Book
VU	Vulnerable
VMD	Vietnamese Mekong Delta
VNRB	Vietnam Red Data Book on endangered fauna and flora (2007)
WWF	World Wide Fund for Nature

WDPA	**World database of protected areas**

EXECUTIVE SUMMARY

The Sai Gon-Dong Nai River Basin and the Mekong Delta are ecologically rich regions, holding a wealth of biodiversity and serving as vital water resources. However, these areas face significant environmental challenges, heightened by the impacts of climate change and human interventions. This study delves into the interplay between biodiversity, water resources, and Japanese investments in these regions, aiming to understand their mutual influence and the potential for sustainable development.

Through intensive literature review and data screening, this study was able to consolidate a complex collection of information regarding the Sai Gon-Dong Nai River Basin and the Mekong Delta. The key findings are:

- Environmental Context: Both regions are biodiversity hotspots. The Mekong Delta is one of the world's largest deltas, playing host to numerous aquatic species. The Sai Gon-Dong Nai River Basin's forests and waters are home to several endangered species. But these areas are grappling with issues like habitat destruction, water pollution, and overfishing.

- Climate Change Vulnerabilities: Rising sea levels, erratic rainfall, and increasing temperatures are transforming these landscapes. Japanese investments, particularly in the Mekong Delta, are vulnerable to these changes, with potential ramifications for business continuity, local communities, and ecosystems.

- Japanese Investments and connection: Japanese enterprises have invested significantly in sectors like manufacturing, energy, ICT, and agriculture in these regions. While these investments bolster the local economy, concerns arise regarding their environmental footprint, especially concerning proximity to vital water sources and protected areas.

Based on those findings, we highlighted the need of collaboration between conservation sectors in Vietnam and Japan in various fields, including water management, sustainable fisheries management, conservation of endangered species and habitats, strengthening climate resilience and education. This scoping study highlight the need of leveraging Japanese technological advancements and Vietnam's rich biodiversity knowledge to tackle the complex challenges in Sai Gon- Dong Nai River Basin and Vietnamese Mekong Delta.

PART 1 INTRODUCTION

A river basin, sometimes called a drainage basin or catchment area, is an area of land drained by a river and its tributaries (smaller streams and rivers). It encompasses all the land surface drained by a particular river system. A river basin collects all the water within its boundaries and directs it towards the main river, which eventually flows out to the sea, another river, or evaporates in an inland drainage basin. A delta forms where a river meets a body of water, like an ocean, sea, or lake. Here, the river loses its energy and deposits the sediment it has been carrying. Over time, this sediment accumulates and forms a delta, which can be seen as a part of a river basin. River basins are formed primarily by topographical and geological features, whereas deltas are formed by sediment deposition.

River basins and their deltas are hotspots of sustainable development and climate risks (PBL Netherlands Environmental Assessment Agency The Hague 2021). These areas are often teeming with biodiversity, acting as ecological hotspots that host a myriad of species, from plants to aquatic life. These regions also attract human settlements due to their fertile soils, access to fresh water, and strategic locations for trade and transportation. However, this convergence of high biodiversity and human development in the limited space of river basins and deltas poses significant challenges. The increasing human footprint can lead to habitat fragmentation, pollution, and over-exploitation of resources. Consequently, there's an elevated risk of biodiversity loss as natural habitats is altered or destroyed. Additionally, unchecked development can strain these ecosystems, making them unsustainable in the long run. Balancing human needs with conservation in these areas is thus essential to ensure both the survival of biodiversity and the sustainable growth of human communities.

Vietnam is recognized as a country with significant biodiversity hotspots, harboring a diverse range of species and ecosystems. Its unique geographical position, spanning various ecological zones, contributes to this rich tapestry of life. However, despite this biological wealth, there is a relatively limited understanding of the biodiversity present along its river basins and deltas. These aquatic systems play crucial roles in supporting various terrestrial and aquatic life forms, but comprehensive studies and documentation in these areas remain sparse. This knowledge gap poses challenges for effective conservation efforts, as well-informed strategies are essential for protecting and sustainably managing these vital habitats. As Vietnam continues to develop and urbanize, prioritizing research in these regions becomes increasingly important to safeguard its natural heritage and ensure the health of its riverine ecosystems.

Among various river basins and deltas in Vietnam, perhaps the Sai Gon- Dong Nai River Basin and the Mekong Delta (Figure 1-1) need utmost conservation attentions. The Dong Nai River, which start from Lam Vien plateau in Vietnam central highland, interact with its tributaries to shape a unique and dynamic basin that pan across a wide range of landscapes and four distinctive ecoregions (Figure 1-2), namely the Southern Annamites Montane Rain Forest, Southeastern Indochina Dry Evergreen Forests, Southern Vietnam Lowland Dry Forests and the Indochina Mangroves (Dang et al. 2020a; Khoi et al. 2021; Wikaramanayake 2023a, 2023b, 2023c, 2023d). All of those ecoregions are houses of various endemic fauna and flora, which highly vulnerable from development. On the other hand, the vast Mekong Delta are generally flatted as it was formed by the sediment deposition of Mekong River. Except for some scattered limestone hills in the western part of the delta, the area does not have any tall mountains. Even through, the delta area have characteristics of four distinctive ecoregions (Figure 1-2), namely the Cardamom Mountain Rain Forest, Tonle Sap-Mekong Peat Swamp Forest, Tonle Sap Freshwater Swamp Forest and Indochinese Mangrove (Wikaramanayake 2023e, 2023f, 2023b). Those ecoregions are known for high aquatic biodiversity and enormous ecosystem services that had been enjoyed by local communities throughout the history of the area.

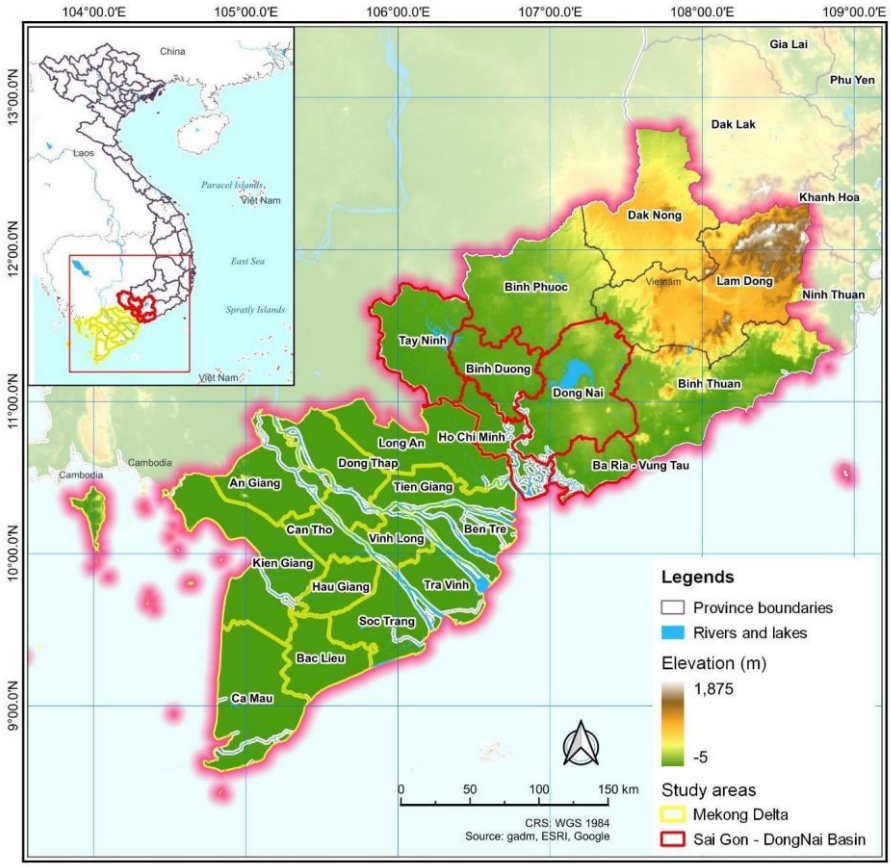

Figure 1-1 Locations of Sai Gon-Dong Nai River Basin and the Vietnamese Mekong Delta

Figure 1-2 Ecoregions within the Sai Gon- Dong Nai River Basin and Mekong Delta

Both Sai Gon-Dong Nai River Basin and Mekong Delta are subjected to rapid developments. Ho Chi Minh City, the most populated and the most economically important city in Vietnam locates in Sai Gon- Dong Nai River Basin. Parallelly, the Mekong Delta has always been an agricultural hub that vital for food production of the country. Rapid developments sometime overlook the value of biodiversity, ecosystem services and sustainability in these regions (Thuaire et al. 2021). Therefore, it is necessary to understand the biodiversity of these regions to inform decision makers and ensure sustainable development.

This assessment not only aims to illuminate the staggering biodiversity of the Mekong Delta and the Sai Gon-Dong Nai basin but also to spotlight the potential threats to biodiversity. Our goals are to consolidate available data on both biodiversity and potential impacts of development in these regions and establish connections between conservation issues and

investment trends whenever possible. We will also emphasize into the conservation efforts, broader environmental landscape, and the initiatives undertaken by WWF-Viet Nam in the Mekong Delta and Sai Gon-Dong Nai River Basin and their nexus with Japan. This can highlight potential collaborative ventures between WWF-Viet Nam and WWF-Japan in the near future.

PART 2 SCOPE, APPROACHES AND LIMITATIONS OF THIS STUDIES

2.1 SCOPE

This study did not conduct primary research, but only extracted and summarized relevant information from published peer-reviewed publication, grey literature, and available database. The scope of this study includes the existed conservation efforts, broader environmental landscape, and relevant socioeconomical aspects of the Mekong Delta and Sai Gon-Dong Nai River Basin.

As this study mainly focus on Sai Gon-Dong Nai River Basin and the Mekong Delta, there is a pronounced emphasis on freshwater ecosystems and affiliated species, as opposed to marine varieties. Therefore, information on distance islands such as Con Dao Archipelago (Ba Ria- Vung Tau Province), Phu Quoc Island (Kien Giang Province) were not included in this report.

For the Sai Gon- Dong Nai River Basin, this study focusses on five provinces namely Dong Nai, Binh Duong, Tay Ninh, Ba Ria-Vung Tau and Ho Chi Minh City only. Meanwhile, the Mekong Delta analysis encompasses all 13 provinces.

One important objective of this study is to highlight potential collaborative ventures between WWF-Viet Nam and WWF-Japan in the near future. Therefore, information that link the biodiversity conservation in the study area with Japanese investment were prioritised. There was also a specific emphasis on rare species, migratory species with connections to Japan, especially, Ariake ecoregion in Kyushu.

2.2 SYSTEMATIC LITERATURE REVIEW

Systematic reviews were conducted to assess and extract relevant information on available literature and database. For this study, the literature reviews mainly focused on mammals, birds (with a specific emphasis on rare species, migratory species with connections to Japan, especially, Ariake ecoregion in Kyushu, and waterbirds), herpetofauna, fish and flora (flowering plants), freshwater ecosystems and conservation needs by landscape.

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The search was performed in both Vietnamese and English via Google Scholar (for peer-reviewed publication) and standard Google Search (Alphabet Inc, USA). In addition, searches were also performed on both international scientific publication websites (e.g. Web of Science, Science Direct, Willey Online Library, and NRC Research Press) and on Vietnamese

academia databases (e.g. Tap chi Sinh hoc - Academia Journal of Biology). For grey literature, only articles from creditable organizations that have been well-recognized in the field of biodiversity conservation (e.g. Fauna and Flora International - FFI, International Union for Conservation of Nature - IUCN, World Wild Fund for Nature – WWF, and Wildlife Conservation Society – WCS) were included. Additionally, published reports or articles of local authorities, namely Department of Agriculture and Rural Development (DARD), Department on Nature Resources and Environment (DONRE), and Department of Science and Technologies (DOST).

Search strings were constructed from different combinations of terms from two groups, namely location terms (e.g. 'Mekong Delta', 'Dong Nai River', name of province in the study area) and topic terms (e.g. 'birds', 'avifauna', 'amphibian', 'reptile', 'mammal', 'biodiversity', 'conservation',' ecosystem', 'development', 'hydropower', 'hydrology', 'groundwater', 'habitat', 'climate change'…). Articles returned from databases were scanned for crucial information that related to the scope of this study. Attempts were made to filter and validate data and information. Only creditable information was included in this report.

2.3 BIODIVERSITY DATABASES

Four reliable biodiversity databases were used to obtain information regarding the potential occurrences of birds and bat species in the project area and its vicinity. Those databased were:

- Database of the species distribution range of species from The International Union for Conservation of Nature's Red List of Threatened Species" (available at https://www.iucnRed List.org/)
- Occurrence database of the Global Biodiversity Information Facility (available at https://www.gbif.org/)

2.3.1 IUCN's species distribution data

The IUCN Red List provides data in the form of distribution range (polygons in ESRI shapefiles format) of most species of major taxonomic groups. Such data were condensed from various research on species distributions, scientific evidence and expert's opinion. Most distribution data used for this desktop study was directly acquired from the official IUCN Red List website except for the avian fauna distribution. For the avian fauna, IUCN Red List uses the data provided by the BirdLife International (http://www.BirdLife.org/), an organization that specialized in ornithology (BirdLife International 2019). Thus, data of birds' distribution range

was acquired directly from Birdlife International following the IUCN Red List recommendations (BirdLife International 2019).

Data (in the form of polygons) were visualized alongside the study area using QGIS 3.28. Species with distribution ranges intersecting the study area were identified as potentially present. To further assess the likelihood of a species' presence, supplementary information from the IUCN Red List website was consulted. Expert opinions and the insights of the CBES team were also leveraged to determine the probability of encountering a potentially present species within the study zone. Notably, the IUCN data does not provide distribution ranges for plants. This data void will be addressed using GBIF data in the subsequent section.

2.3.2 GBIF Species occurrence data

In contrast to the IUCN Red List data, GBIF data is provided in points format, in which each point represents locations where fauna or flora specimen were historically collected, or where an organism was sighted and recorded (e.g. through photographs or acoustic records). At its core, GBIF data consists of an enormous amount of georeferenced specimen records from their vast network of the natural-history museum around the world, who's involved with scientific expeditions in Vietnam (e.g. French National Museum of Natural History, Smithsonian Institution). With the current advance in mobile technology, now GBIF also integrates validated georeferenced records from various citizens sciences platforms such as iNaturalist (https://www.inaturalist.org/) or eBird (https://ebird.org/home).

The GBIF data has been updated rapidly compared to IUCN data. GBIF also has an advantage on plants' data, which generally lacked from IUCN Red List databases. To extract relevant data, we download all GBIF occurrence records in Vietnam. Later, polygon shape files of the study areas were overlayed those records in QGIS 3.28. Only records that fall inside the polygon of the study areas were extracted and inventory. Various fauna and flora were reported under their old scientific names, which have become invalid in the recent day of taxonomy. For these cases, we will use the most recent taxon name.

2.3.3 World Databases of Protected Area

The World Database of Protected Areas (WDPA) is an authoritative global platform that provides comprehensive information on terrestrial and marine protected zones. Accessible via Protected Planet (https://www.protectedplanet.net/), the WDPA is a collaborative effort between the United Nations Environment Programme (UNEP) and the International Union for Conservation of Nature (IUCN). It is regularly updated with data supplied by national governments and various non-governmental organizations. For our report on the biodiversity

of the Dong Nai River basin and Mekong Delta, the WDPA offers invaluable insights into existing protected areas, thus allowing for a detailed assessment of conservation efforts and biodiversity protection strategies in these regions. Data downloaded from WDPA/Protected Planet website (in the form of polygons) were visualized alongside the study area using QGIS 3.28. Any protected area overlapping or bordering the study zone was identified and catalogued. Additional details on these protected areas were collated from the WDPA database and the respective websites of the areas when available.

2.4 ENVIRONMENTAL AND SOCIAL DATABASES

2.4.1 The global trade data

To assess the impact of development on biodiversity within the study area, data was sourced from the global trade databases available at the Observatory of Economic Complexity (OEC). The OEC, accessible at https://oec.world/en/profile/country/vnm, stands as a comprehensive platform detailing the trade profiles of countries, inclusive of Vietnam. It provided an in-depth look into Vietnam's historical economic activities, trade relationships, and product exchanges. This information was crucial to the report as it facilitated an understanding of the potential pressures on the region's biodiversity stemming from past developmental and economic activities.

2.4.2 Government's Statistical Yearbook 2022

The Government's Statistical Yearbook 2022, obtained from the General Statistics Office of Vietnam, played a pivotal role in our study focusing on the Sai Gon-Dong Nai River basin and the Mekong Delta. This authoritative annual compilation offers a spectrum of official statistics specifically tailored to these regions, detailing their socio-economic dynamics. The data encompasses various sectors like agriculture, industry, trade, and environment, highlighting the particular developmental trajectories within the Sai Gon-Dong Nai River basin and the Mekong Delta. By leveraging this yearbook, we were able to deeply understand the localized progress and its ramifications on the focal areas of our research. This dataset was acquired directly from General Statistics Office of Vietnam.

2.4.3 Data and publication from Japan International Cooperation Agency (JICA)

The JICA is a Japanese agency that facilitate development and cooperation efforts in countries that have diplomatic relationships with Japan. Notably, JICA manages a significant portion of the Official Development Assistance (ODA) from Japan to Vietnam. Through its comprehensive reports and data, JICA provides valuable insights into diverse sectors,

including foreign investments and environmental conservation. Our study aims to leveraging this rich dataset, to assess the possible linkage between Japanese investment on on biodiversity conservation within the Dong Nai River basin and the Mekong Delta. The used data were downloaded from JICA website (available at https://www.jica.go.jp/english/overseas/vietnam/).

2.4.4 Data and publication from Japan External Trade Organization (JETRO)

JETRO is a central entity dedicated to promoting mutual trade and investment between Japan and the rest of the world. As one of the main repositories for data on Japan's external trade and economic dynamics, JETRO offers a wealth of information on various sectors, including foreign investments. In Vietnam, JETRO provides the most comprehensive list of Japanese companies that do business in Vietnam, or Vietnamese companies that receive investment from Japan. By incorporating JETRO's comprehensive data and publication into our analysis, our study aims to shed light on the impact of Japan busines on biodiversity conservation within the Dong Nai river basin and the Mekong Delta. The used data for this report were downloaded from JETRO website (available at: https://www.jetro.go.jp/en/)

2.4.5 Vietnam authorities' data

Data of land use through years were acquired from website of Vietnam Ministry of Natural Resources and Environment (available at http://thongke.monre.gov.vn) and Vietnam Ministry of Planning And Investment (available at https://quyhoachquocgia.mpi.gov.vn/Pages/default.aspx). These data were used interchangeably to visualize the change in land usage in the study area in the past 5 years, thus allowing the projection of future change.

2.5 MAPS AND DATA VISULISATIONS

In this study, consolidated data and information from various sources were used to construct maps and charts. All maps presented in this report were to visualize, analyses and edit by CBES team using QGIS 3.28 unless stated otherwise. Major GIS data that we used include:

- Google Satellite Image
- Google Map
- Open Street Map
- Digital Elevation Model elevation data from Shuttle Radar Topography Mission (SRTM), United State of Geological Survey. Available at: https://dwtkns.com/srtm30m/
- Polygons of species distribution range from IUCN Red List/ Birdlife International
- GBIF point data
- Polygons of protected area from WDPA

- Polygons from AZE
- Polygons of important bird areas from BirdLife International
- European Space Agency (ESA) Global land cover product at 10 m resolution (Available at: https://esa-worldcover.org/en)
- Published GIS data package from Planning database – Vietnam Ministry of Planning And Investment (Available at https://quyhoachquocgia.mpi.gov.vn/Pages/default.aspx)

2.6 FLOOD RISK AND BIODIVERSITY RISK CALCULATIONS

2.6.1 Flood risk

For the purpose of visualizing which Japanese investment are subjected to environmental issues such as flood, a simple flood risk raster was calculated from DEM, slope, distance to river, distance to coastline area and level of built-up. The calculation flood risk calculation method was mainly follow Kimura et al. (2023), Osman & Das (2023) and Avand et al. (2020). The risk index was normalized, ranging from 0 to 1, where 0 associated with low/ no risk and 1 associated with very high flood risk. The calculation were simplified with expert opinion weighting. Hydropower dams, river dikes and other water management structures that can impact flood have not been integrated into the model due to the limited information.

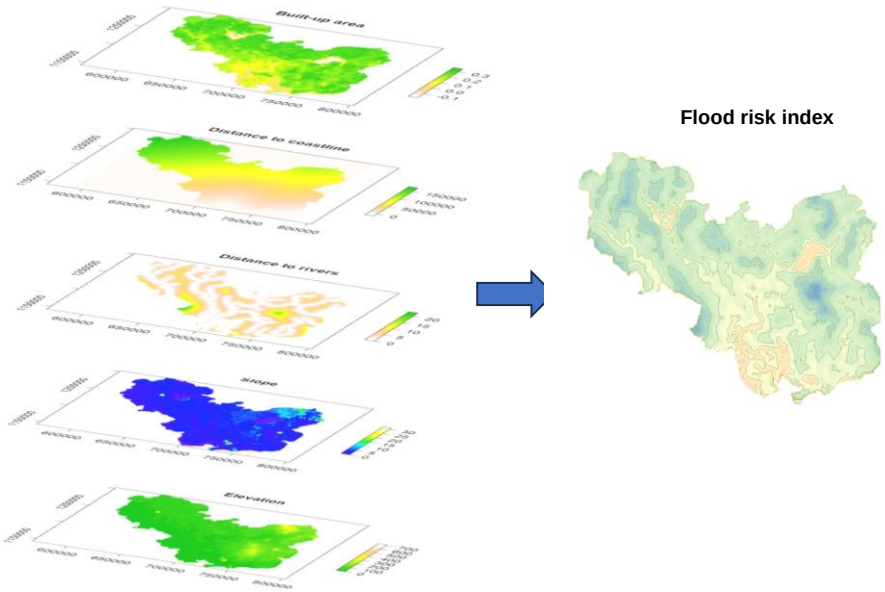

Figure 2-1 Analysis scheme and data used for deriving flood risk raster

Risk/pressure from Japanese investment for key biodiversity area

2.7 LIMITATIONS OF THIS STUDY

Limitations of the literature review for ecosystem level are due to the limited available information and data. Additionally, the available information from the search engines may not capture adequately the desired information. To address this limitations, searches were conducted as systematically as possible and on multiple search engines.

The obtained information and data may be out of date because lots of data are not available online and require access from the government database e.g., systematic information on threats, ecosystem diversity etc. For some information such the total areas of protected areas, years of establishment, key biodiversity features… may be outdated and need updates. Regarding the connections between biodiversity, policies and the economic sectors, it was challenging to acquired primary data from relevant sectors. In some case, data from different sources may be inconsistent with each other. Therefore, information from newspapers (especial government owned news outlets), indirect sources (e.g. reports acquired from protected areas) and experts' networks were used to narrow these gaps as much as possible.

Within the Sai Gon-Dong Nai River Basin, this study will primarily concentrate on five provinces/city: Dong Nai, Binh Duong, Tay Ninh, Ba Ria-Vung Tau, and Ho Chi Minh City. It should be noted that these provinces do not encompass the entirety of the Sai Gon-Dong Nai River Basin. However, those focused provinces were represented to the socioeconomical development of this region.

PART 3 SAI GON – DONG NAI RIVER BASIN

3.1 GENERAL INFORMATION

3.1.1 Geography, hydrology and demographics of Sai Gon – Dong Nai River Basin

3.1.1.1 Geography

The Sai Gon- Dong Nai River Basin is extensive, covering an area of approximately 38,000 km^2, spreading across seven provinces/city namely Lam Dong, Dak Nong, Binh Phuoc, Dong Nai, Binh Duong, Ba Ria-Vung Tau and Ho Chi Minh City. The Dong Nai River, which start from Lam Vien plateau in Vietnam central highland. The Sai Gon River is a major tributary of Dong Nai River, which passing through the second largest city in Vietnam: Ho Chi Minh City. The main Dong Nai River and its tributaries also collect water from a large number of creeks, stream and even man-made channel, thus formed a highly complex river system. The diverse topography of the basin (Figure 3-1) supports a wide range of ecosystems, from montane forests, low-land forest, wetland to mangroves, making it a vital region both ecologically and economically. Its waterways serve as crucial lifelines for transportation, agriculture, and industrial activities, underpinning the socioeconomic fabric of the region (Figure 3-2).

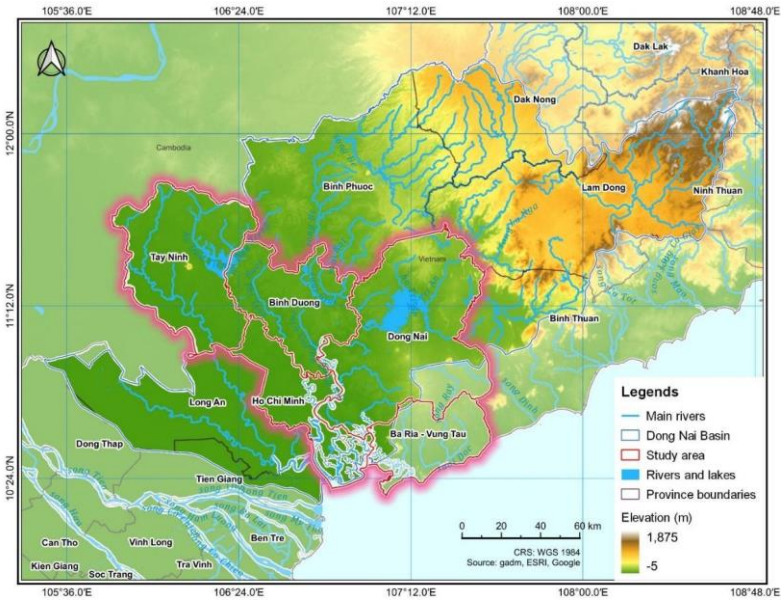

Figure 3-1 Elevation of Sai Gon- Dong Nai River Basin

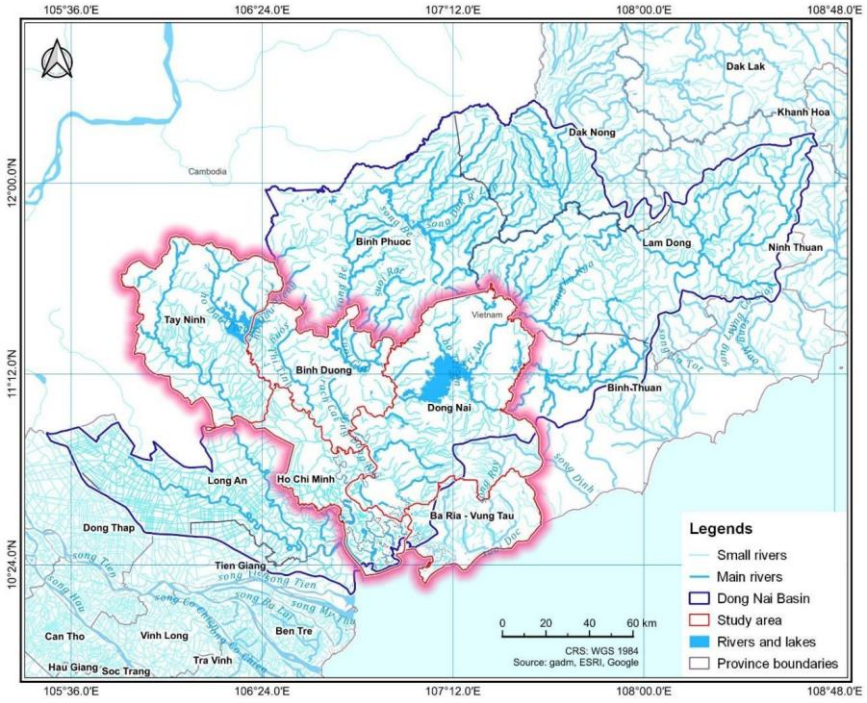

Figure 3-2 Rivers networks and hydrological connections in Sai Gon- Dong Nai River Basin

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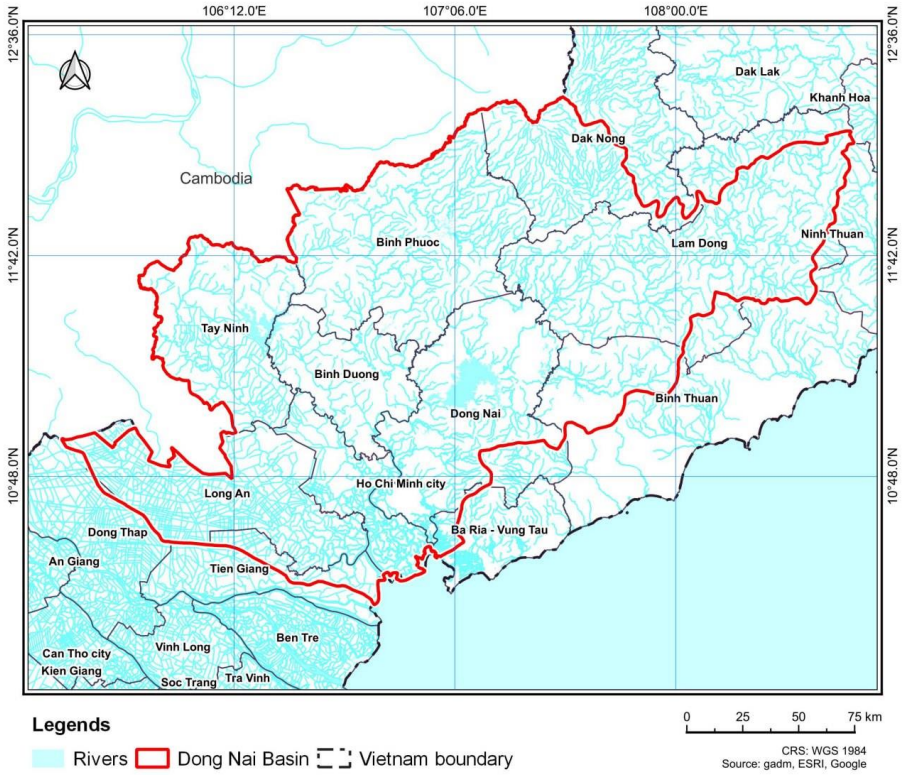

Figure 3-3 Dong Nai River catchment (red boundary) derived from Digital Elevation Model (DEM)

Technically, the Sai Gon- Dong Nai River Basin include seven provinces/city. However, in this study we only focus on four provinces and one megacity that located in the lower part of the basin. Those area of focus were Dong Nai, Binh Duong, Tay Ninh, Ba Ria-Vung Tau and Ho Chi Minh City. This focused area intersects three unique ecoregions: Southeastern Indochina Dry Evergreen Forests, Southern Vietnam Lowland Dry Forests, and the Indochina Mangroves (Figure 3-3) (Dang et al. 2020a; Khoi et al. 2021a; Wikaramanayake 2023a, 2023b, 2023c, 2023d). The watershed in this region has relatively fertile soil, with nearly 75% of the area being alluvial soil, suitable for agricultural development. The total area of our focused area is 166,779 km^2, with the total population of more than 17.7 million people (General Statistics Office - Statistical Yearbook 2022 in Vietnam). Water from the Dong Nai River is used to supply drinking water to approximately 19 million people, irrigate 22,874 km^2 of agricultural land, and provide electricity to the southern region of Vietnam through hydroelectric power plants (Truong et al. 2018a).

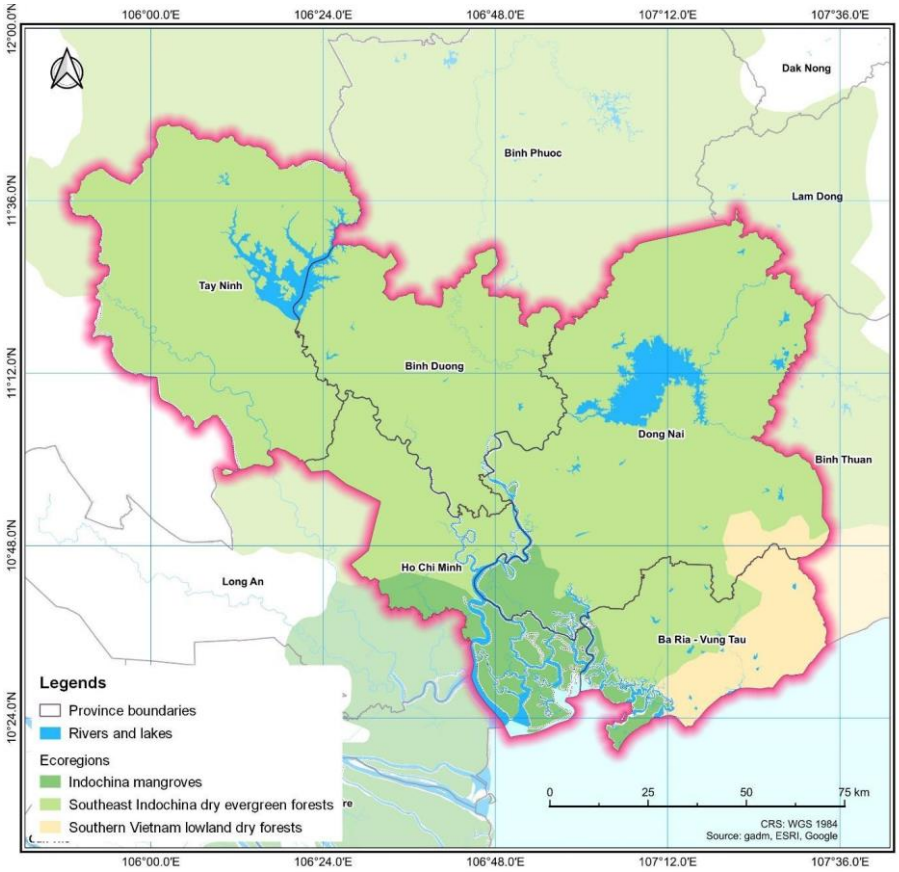

Figure 3-4 Ecoregions found in the focused area of Sai Gon-Dong Nai River Basin

3.1.1.2 Hydrology

The hydrology of the Sai Gon-Dong Nai River system is a complex interplay of rain fall, terrain and anthropogenic factors that dictate its flow patterns, water quality, and overall health. Originating from the Central Annamite Range, the Dong Nai River traverses diverse terrains before merging with the Sai Gon River, which subsequently drains into the South China Sea. As the rivers flow through varied landscapes, they are fed by numerous tributaries and are subject to seasonal variations, predominantly influenced by the monsoon cycles (Tran 2011a; Nguyễn & Lê 2012).

Various hydrological characteristics of Sai Gon-Dong Nai River system corresponds with monsoon cycles. During the wet season, strong water flow and greater water volume transport sediment and nutrients essential for the downstream ecosystems (Gugliotta et al. 2020). Conversely, during the dry season, water levels and flows recede, concentrating pollutants and lowering water quality.

The Dong Nai River and its tributary – Sai Gon River discharges their water into the South China Sea (Vietnamese East Sea) through a series of estuaries that passing through Ho Chi Minh City (particularly Can Gio District) and Dong Nai Province. Some of these estuaries are recognized by various names, with Long Tau River and Xoai Rap River being the most prominent estuaries associated with the Dong Nai River. The hydrological dynamics of these estuaries and their surrounding areas are predominantly influenced by the tidal patterns. Exhibiting a semidiurnal tidal cycle, this region experiences two roughly equal high tides every day, approximately 12 hours apart.

Direct human interventions, such as dam constructions, water diversions for agriculture, and urbanization, have been modified the natural hydrological regime of Dong Nai River. In the mainstream of Dong Nai River, eight large-scaled hydropower dams have been constructed and operated, while many are being proposed (Vietnam Energy Online 2013). For the La Nga and Song Be tributaries, at least eight other hydropower dams have been operated. All of those dams created a “cascading hydropower scheme’, in which a downstream dam is dependent on the discharge from an upstream dam. The assemblages of hydropower dams on Dong Nai River and its tributary, along with other water diversions structures, have heavily reduce the natural flow of this river system. For our study area (Dong Nai, Binh Duong, Tay Ninh, Ba Ria-Vung Tau and Ho Chi Minh City), the Tri An hydropower (Dong Nai) and Phuo Hoa hydropower (Binh Duong province) and Dau Tieng dam/water reservoir plays the key role in modified the natural hydrological regime of the region.

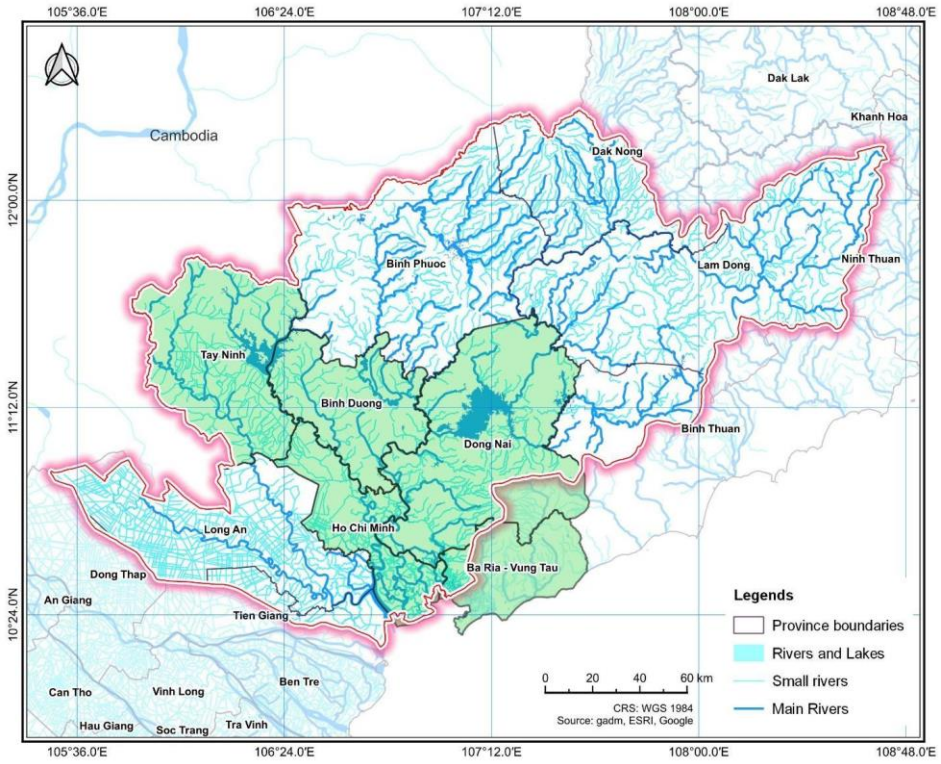

Figure 3-5 The Sai Gon - Dong Nai River Network System

Note: the red boundary indicates the Dong Nai river catchment based on DEM data

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3.1.1.3 Demographics

The total population of the five concerned provinces[1] in the Sai Gon- Dong Nai River Basin was 17.7 million people (General Statistics Office of Vietnam 2022). Total population and density of each province were showed in Figure 3-5 below. Overall, there was a diverse demographic landscape in the study area. Ho Chi Minh City stands out with the highest population, nearing 9.3 million people, and an impressive average density of 4,481 persons per square kilometer, marking it as a significant urban hub. Binh Duong and Dong Nai follow with populations of 3,2 million and 2.7 million people, respectively, and densities of 3,644 and 2,806 persons/km^2. On the lower spectrum, Tay Ninh and Ba Ria-Vung Tau have populations of 1.188 million and 1.178 million respectively, with Tay Ninh having an average density of

[1] Dong Nai, Binh Duong, Tay Ninh, Ba Ria-Vung Tau, and Ho Chi Minh City

1,969 persons/km^2. The varied population densities across these provinces reflect the blend of urbanization, industrial activities, and rural landscapes within the basin.

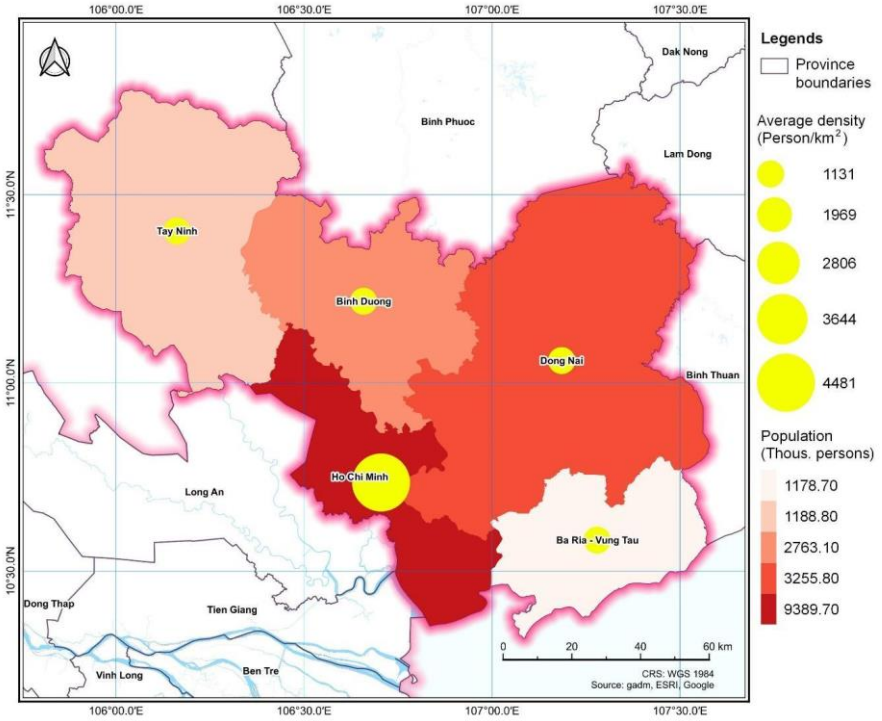

Figure 3-6 Population and average density in 5 province of Sai Gon-Dong Nai River Basin

Note: data was calculated from Statistical Yearbook 2022

In the Sai Gon-Dong Nai River Basin, the age distribution reveals a relatively balanced demographic between the working and non-working age groups. Although the working age regulated by laws was 18 years old, there were a large amount of young people from 15 to 17 that have already join the workforce (General Statistics Office of Vietnam 2022). Collectively, across the entire study area, there are approximately 9.55 million individuals of working age (15 years of age and above), while the non-working age population stands at 8.19 million (Figure 3-6). Most of the workforce concentrated in Ho Chi Minh City due to its urban nature and vast population (Figure 3-7). All provinces and city in this area show evenly distributed age groups, with each having balance working and non-working age populations.

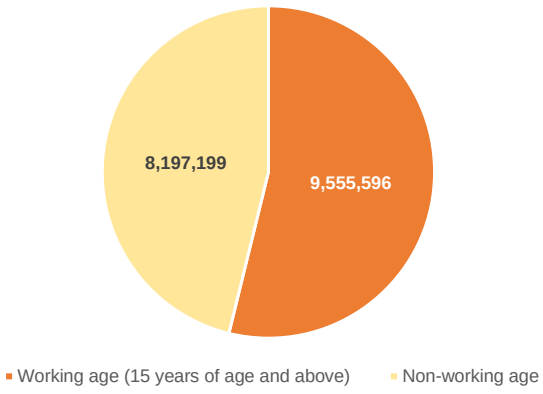

Figure 3-7 Age group of concerned area in Sai Gon- Dong Nai River Basin

Note: data was calculated from Statistical Yearbook 2022

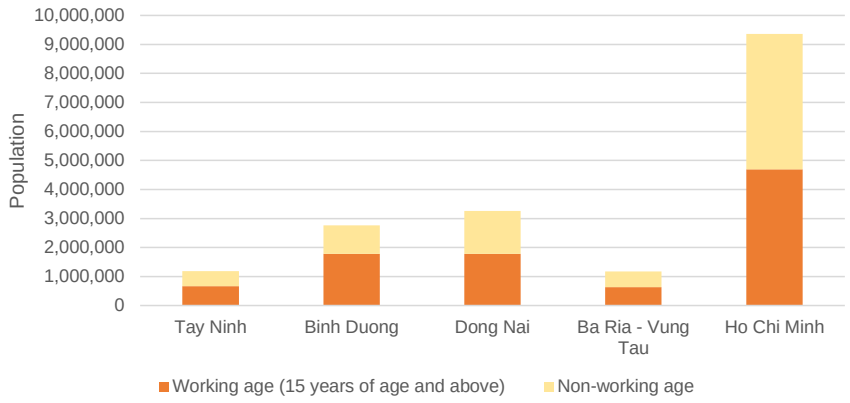

Figure 3-8 Age group by provinces in Sai Gon- Dong Nai River Basin

Note: data was calculated from Statistical Yearbook 2022

Within the Sai Gon-Dong Nai River Basin, there is a notable disparity between the urban and rural populations. In the overall study area, the rural population significantly outnumbers the urban population, with 12.18 million individuals residing in rural areas compared to 5.56 million in urban settings (Figure 3-8). This trend is further evident when analyzing the provincial data. Ho Chi Minh City, a major urban hub, stands out with a substantial urban population about 7 million, near 80% of the total population of the city (Figure 3-9).. Rural dwellers of Ho Chi Minh City mainly live Can Gio and Cu Chi districts (General Statistics Office of Vietnam 2022). Binh

Duong also has a larger urban population because the great number of industrial parks established in this province (Figure 3-9). On the other side of the spectrum, Tay Ninh province predominantly consists of rural dwellers (Figure 3-9). Dong Nai and Ba Ria-Vung Tau exhibits a more balanced distribution between its urban and rural residents. The data highlights the contrasting lifestyles and development stages of these provinces, with Ho Chi Minh City acting as the primary urban center in the region.

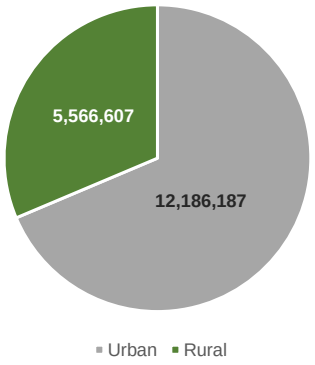

Figure 3-9 Distribution of population between urban and rural in Sai Gon-Dong Nai River Basin

Note: data was calculated from Statistical Yearbook 2022

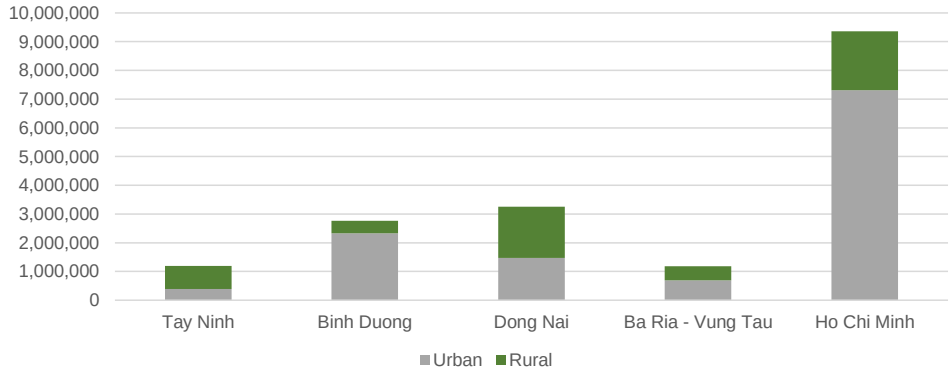

Figure 3-10 Distribution of population between urban and rural in each province

Note: data was calculated from Statistical Yearbook 2022

3.1.2 Current and projected land use

3.1.2.1 Current land use

The total land area of the five concerned provinces[2] in the Sai Gon- Dong Nai River Basin a is 1.67 million hectare (16,700km^2) (General Statistics Office of Vietnam 2022). In 2022, the land use distribution within this area predominantly leans towards agricultural production, accounting for a substantial 54.1% of the total land (General Statistics Office of Vietnam 2022). This emphasizes the area's agricultural significance. Parallelly, the region allocates about 20% of its lands for forestry. Specially used forests, which are areas set aside for specific purposes like research, conservation, or recreation, comprise 9.05% of the land. Protective forests, crucial for conservation and shielding against environmental hazards, make up 6.79%, while productive forests, used primarily for timber and other resources, cover 3.47%. When examining the provincial data, a consistent pattern of dominant agricultural production land is evident across all provinces. However, variations in forest cover types and other land use categories reflect the unique priorities and resources of each province. Overall, the Dong Nai Province allocated the largest proportion of its land to conservation of nature (Figure 3-11)

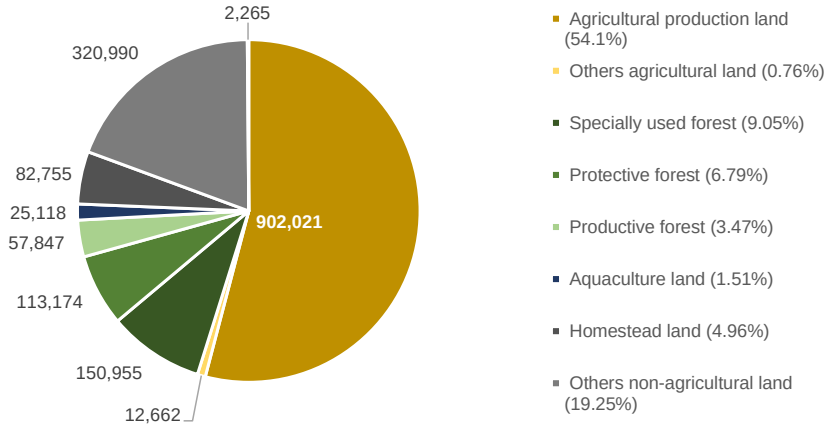

Figure 3-11 Land use statistic of Sai Gon – Dong Nai River Basin in 2022

Note: data was calculated from Statistical Yearbook 2022

[2] Dong Nai, Binh Duong, Tay Ninh, Ba Ria-Vung Tau, and Ho Chi Minh City

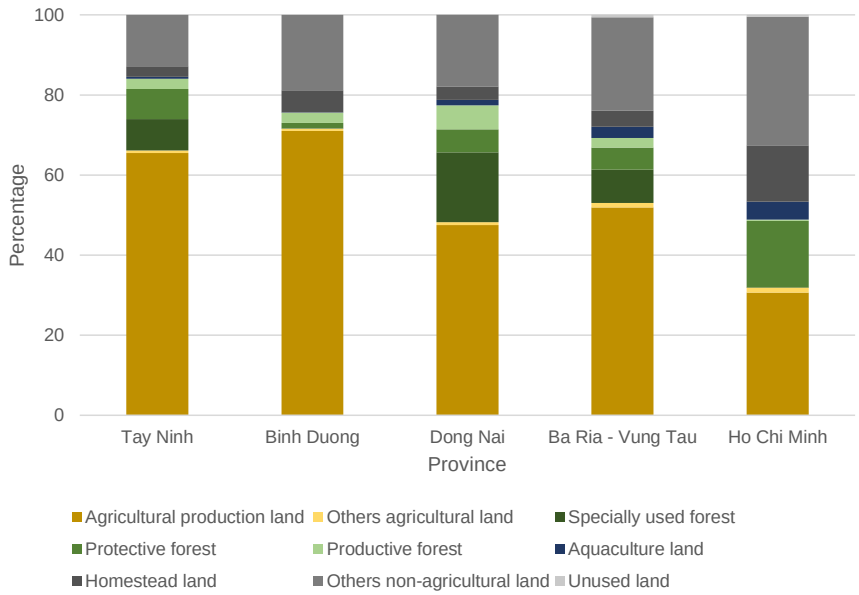

Figure 3-12 Land use by each province in Sai Gon – Dong Nai River Basin in year 2022

Note: data was calculated from Statistical Yearbook 2022

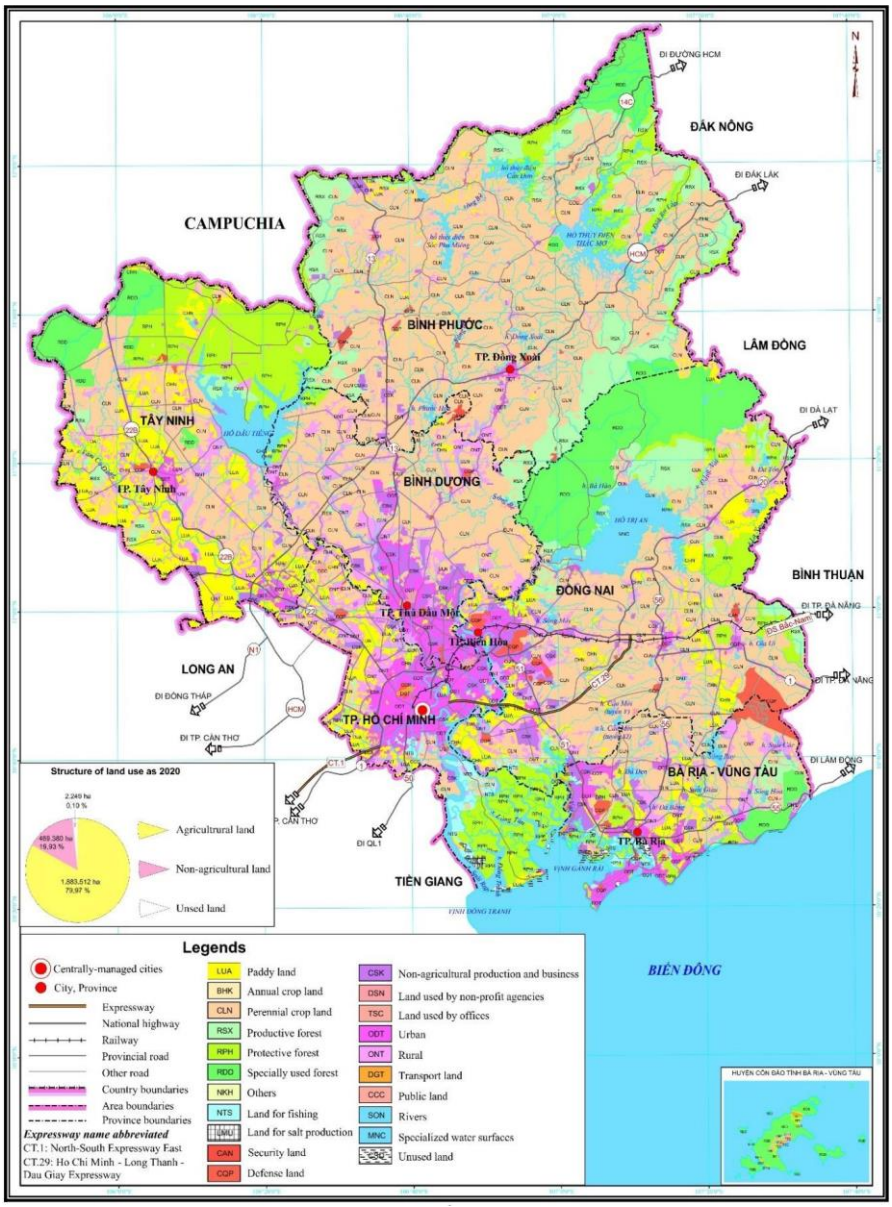

Figure 3-13 Map of land use in Southern Vietnam in 2023 from Vietnam Ministry of Planning and Investment

Note: available at https://quyhoachquocgia.mpi.gov.vn/Pages/default.aspx

3.1.2.2 Projected land use

According to MONRE data from 2017 to 2020, the land use in the Sai Gon- Dong Nai River Basin (only 5 focused provinces) appear to maintain consistent proportion (Figure 3-13). On the regional scale, agricultural lands keep accounted for more 50% total land in the area. Specially used forests, vital for conservation, research, or recreation, only accounted for a marginal proportion of land. However, observing the actual land use change across different province revealed provincial oscillation (Figure 3-14). Between 2017 and 2020, Dong Nai experienced a pronounced increase in agricultural production land, aligning with a surge in protective forests, indicating simultaneous expansions in agricultural activities and conservation measures. The reduction of productive forest in this province could be correlated with the declining in agroforestry practices such as rubber trees plantations, which were once popular in this province. The slight reduction in area of special-used forest showed the pressure of developing on conservation efforts. For Binh Duong, Tay Ninh, Ba Ria Vung Tau and Ho Chi Minh city, the area of agricultural lands reduced. Those area were replaced with residence and built-up land that corresponding with developments. Interestingly, there were increments in area of protective forests in Tay Ninh and Ho Chi Minh City, which might relate to attempt to protect the environment and combatting climate changes of stakeholders in those two areas. For Ba Ria-Vung Tau, special-used and protective forest areas sharply reduce, which raises concerns on the status of wildlife conservation and environmental protection in this province.

On a regional scale, both special use forest and protective forests and protective forest in Sai Gon- Dong Nai River basin do not show any significant changes (Figure 3-13). While the constancy in forested areas can be viewed as a positive sign, indicating no drastic deforestation over the period, it also signifies that there hasn't been a marked increase in areas allocated for conservation. A stagnant forest cover can have potential implications. If other land uses, especially agricultural or infrastructural development, increase in the future, there could be pressures on these forested areas, posing challenges to conservation. Furthermore, the constant forest cover also hints that proactive measures to increase afforestation or reforestation might not have been implemented during this timeframe. Sustainable land management strategies will be crucial in upcoming years to ensure a balance between developmental needs and conservation priorities.

In its report for development planning of Southeastern Region of Vietnam, the Ministry of Planning and Investment stated that “the goal is to develop Southeast Vietnam into a dynamic region with high economic growth, becoming the driving force for the country's growth” (MPI 2023). With that, the region is planned to be a hub for science, technology, innovation, high-

tech industries, logistics, and an international financial centre with high competitiveness in the region (MPI 2023). Such planning involved a rapid construction of new highways, maritime ports, industrial parks and residence areas. All of those may put direct or indirect high pressure on the conservation effort in this region (particularly on the remain forests that aim to protect biodiversity).

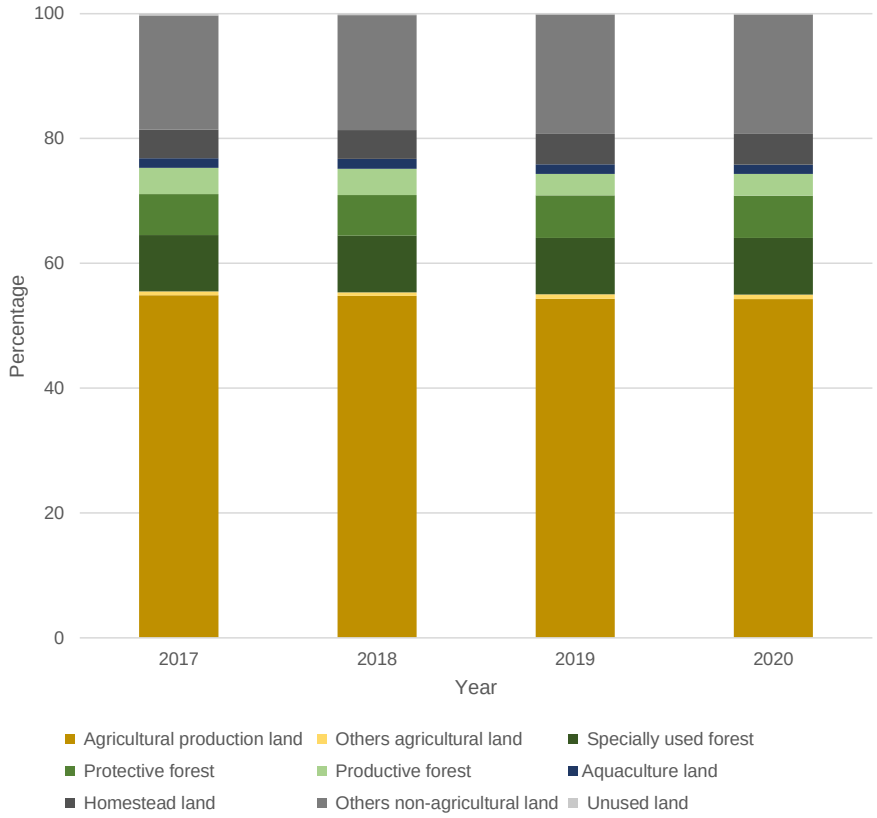

Figure 3-14 Proportion of land use from 2017 to 2020 in Sai Gon- Dong Nai River Basin

Note: data was calculated from MONRE data

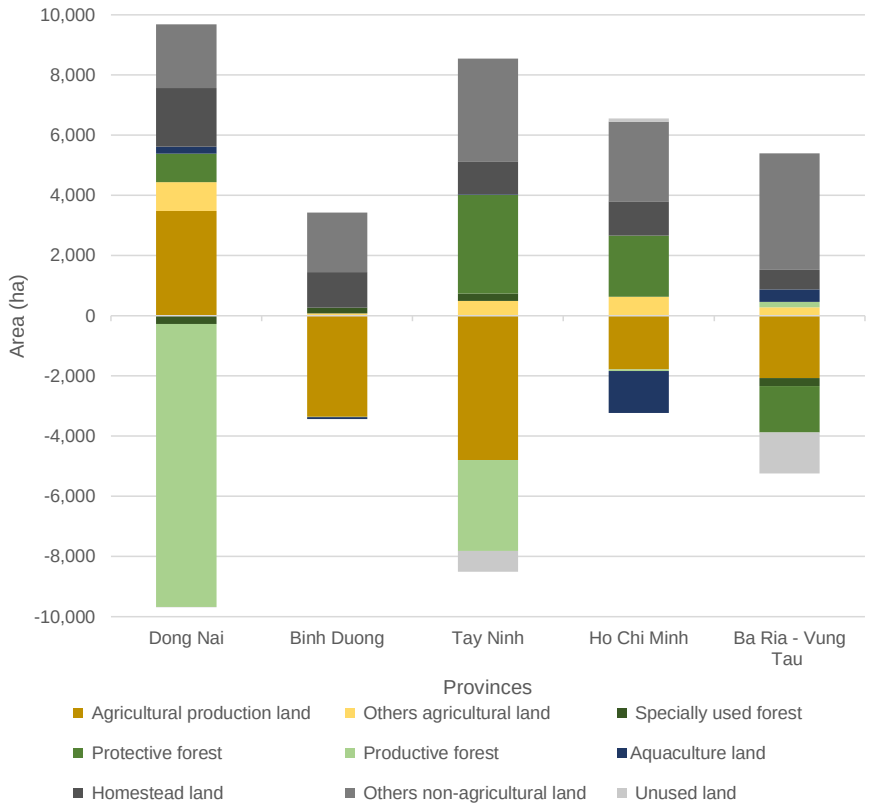

Figure 3-15 Land use change in Sai Gon- Dong Nai River Basin from 2017 to 2020

Note: data was calculated from MONRE data

3.1.3 Biodiversity

3.1.3.1 Mammals

The Dong Nai River Basin are well-known for its mammalian diversity. On the broad-scale level, species' distribution data from IUCN Red List showed 130 mammal species that have their distribution range overlap with Sai Gon - Dong Nai River Basin, suggesting their potential occurrence. Data retrieved from GBIF, which included using 1176 georeferenced records made Dong Nai – Sai Gon Rivers Basin[3], were able to confirm 100 species from 130 potentially occurred species. Furthermore, various studies and field surveys that focused on

[3] Only records within the 5 focused provinces (Dong Nai, Binh Duong, Tay Ninh, Ba Ria- Vung Tai and Ho Chi Minh City) were included.

mammals have been conducted in the Sai Gon - Dong Nai River Basin. A systematic review found 16 papers that relevant to cover the mammalian diversity in a defined area within the Sai Gon - Dong Nai River Basin. Appendix 1 provided all data and information from IUCN, GBIF and found literature. All those data confirmed the high mammalian diversity in this region, especially in Cat Tien National Park (Dong Nai Province). Available information suggested the mammalian fauna in this region may reach up to 120 species, many of which are listed as conservation concerned species (listed as VU, EN or CR in the IUCN Red List 2023 or in the VNRD 2007). Table 3-1 provided the list of conservation concerned species that have been confirmed to occurred in the focused Sai Gon- Dong Nai River Basin.

Table 3-1 List of conservation-concerned mammal species in the Sai Gon – Dong Nai Rivers Basin

S/N	Scientific name	English name	IUCN status	VRDB status	GBIF confirmed	Studies that provided confirmed records
1	*Panthera pardus*	Leopard	**VU**	**CR**	Yes	Nguyen & Okolelova (2015)
2	*Arctonyx collaris*	Greater Hog Badger	**VU**	NL	No	Nguyen & Okolelova (2015)
3	*Helarctos malayanus*	Sun Bear	**VU**	**EN**	No	Scotson et al. (2009); Cat Tien National Park (2017)
4	*Arctictis binturong*	Binturong	**VU**	**EN**	No	Nguyen & Okolelova (2015)
5	*Viverra megaspila*	Large-spotted Civet	**EN**	**VU**	Yes	Nguyen & Okolelova (2015)
6	*Bos gaurus*	Gaur	**VU**	**EN**	No	WWF Indochina Programe (2004); Nguyen (2009); Nguyen & Okolelova (2015); Cat Tien National Park s.2017s.; Phạm et al. (2021)
7	*Rusa unicolor*	Sambar	**VU**	**VU**	Yes	Phạm et al. (2021)

S/N	Scientific name	English name	IUCN status	VRDB status	GBIF confirmed	Studies that provided confirmed records
8	*Macaca arctoides*	Stump-tailed Macaque	**VU**	**VU**	No	Nguyen & Okolelova (2015)
9	*Macaca fascicularis*	Long-tailed Macaque	**EN**	LR	Yes	Nguyen & Okolelova (2015).; Cat Tien National Park (2017); Phạm et al. (2021)
10	*Macaca leonina*	Northern Pig-tailed Macaque	**VU**	**VU**	Yes	Nguyen & Okolelova (2015); Cat Tien National Park (2017); Phạm et al. (2021)
11	*Pygathrix nigripes*	Black-shanked Douc Langur	**CR**	**EN**	Yes	WWF Indochina Programe (2004); Nguyen & Okolelova (2015); Cat Tien National Park (2017); Phạm et al. (2021)
12	*Trachypithecus margarita*	Elliot's Silver Langur	**EN**	NL	Yes	Nguyen & Okolelova (2015); Cat Tien National Park (2017); Phạm et al. (2021)
13	*Nomascus gabriellae*	Red-cheeked Gibbon	**EN**	**EN**	Yes	WWF Indochina Programe (2004); Nguyen & Okolelova (2015); Cat Tien National Park (2017); Phạm et al. (2021)
14	*Nycticebus pygmaeus*	Pygmy Slow Loris	**EN**	**VU**	Yes	(Nguyen & Okolelova (2015); Cat Tien National Park (2017); Phạm et al. (2021)
15	*Elephas maximus*	Asian Elephant	**EN**	**CR**	Yes	WWF Indochina Programe (2004); Varma et al. 2008; Nguyen & Okolelova (2015); Cat Tien National Park (2017); Phạm et al. (2021)

S/N	Scientific name	English name	IUCN status	VRDB status	GBIF confirmed	Studies that provided confirmed records
16	*Manis javanica*	Sunda Pangolin	**CR**	**EN**	No	Nguyen & Okolelova (2015); Cat Tien National Park (2017)
17	*Aonyx cinereus*	Asian Small-clawed Otter	**VU**	**VU**	Yes	(Nguyen & Okolelova (2015); Cat Tien National Park (2017)
18	*Axis porcinus*	Hog Deer	**EN**	**EN**	Yes	(Nguyen & Okolelova (2015)
19	*Pteropus lylei*	Lyle's Flying Fox	**VU**	NL	Yes	Vu et al. (2015)
20	*Orcaella brevirostris*	Irrawaddy Dolphin	**EN**	NL	Yes	**CBES unpublished work, SIE 2023**

As most conservation concerned mammals require relatively intact habitats to live, it is natural that those mammals will likely concentrate in existing protected areas where their habitats are protected. Cat Tien National Park and the adjacent Dong Nai Nature and Culture Reserve are the hotspot for endangered species that associated with evergreen forest (particularly the Southern Indochina Dry Evergreen Forest Ecoregions) such as Asian Elephant *Elephas maximus* (IUCN: EN) or Black-Shanked Douc Langur *Pygathrix nigripes* (IUCN: CR). Additionally, the Can Gio Mangrove Biosphere Reserve, a great sample of the Indochina Mangrove Ecoregion, is the important area for conservation of mangrove and estuary associated mammal species such as the Lyle's Flying Fox *Pteropus lylei* (IUCN: VU) or the Irrawaddy Dolphin *Orcaella brevirostris* (IUCN: EN)

Figure 3-16 A famous Asian elephant named Nga Lech recorded in Dong Nai Nature and Culture Reserve

Photo: Vietnam News Agency (Available at: https://en.vietnamplus.vn/)

Figure 3-17 A family of Yellow-cheeked Gibbon in Cat Tien National Park

Photo: CBES

Figure 3-18 Irrawaddy dolphins observed in Can Gio Mangrove Biosphere Reserve

Photo: CBES

3.1.3.2 Birds

The Sai Gon- Dong Nai River Basin is renowned for its diverse avifauna. Data retrieved from BirdLife International revealed that a total of 353 bird species (belonging to 80 Families of 20 Orders) that have their distribution range overlap with the Sai Gon – Dong Nai River Basin. The Birdlife International considered the basin as a part of the South Vietnamese Lowlands Endemic Bird Area (BirdLife International 2023a). Supporting this, the GBIF database furnishes a staggering 98,632 historical records of 471 bird species in this region. The avian species within protected areas of the Sai Gon-Dong Nai River Basin have been the focus of at least 26 scholarly articles and reports. Key information from those reports as well as Birdlife International and GBIF data can be found in the Appendix 2 of this report. As derived from the existing data and information, the avian fauna in this area may consist of up to 450 species, many of which are listed as conservation concerned species (listed as VU, EN or CR) in the IUCN Red List 2023. Table 3.7 provided the list of conservation concerned species that have been confirmed to occurred in the focused Sai Gon- Dong Nai River Basin.

Three regional avian hotspots punctuate the Sai Gon-Dong Nai River Basin: Cat Tien National Park in Dong Nai, Can Gio Biosphere Reserve in Ho Chi Minh City, and the Lo Go-Xa Mat National Park in Tay Ninh. BirdLife International has distinguished each of these areas as Important Bird Areas (IBA) (BirdLife International 2023b, 2023c, 2023d). While Cat Tien and Lo Go – Xa Mat are important for forest and freshwater birds, the Can Gio beach and mangrove serve as vital stopovers for migratory birds navigating the East Asian–Australasian

Flyway, many of which winter in Vietnam. Among those, the critically endangered Spoon-billed Sandpiper *Calidris pygmaea* and the locally rare Great Cormorant *Phalacrocorax carbo* known to halt in the Ariake ecoregion in Kyushu, Japan during their journey southward.

Figure 3-19 Migratory Spoon-billed Sandpiper in Tan Thanh beach (Tien Giang), adjacent to Can Gio beach

Photo: Le Khac Quyet

Figure 3-20 Great Cormorant in Dong Nai River Basin

Photo: CBES

Commented [6]: Do your office have any activity for the conservation of the spoon-billed sandpiper ?

Commented [7R6]: For CBES: we only have education and awareness raising campaign for migratory birds in general.

For WWF Vietnam: awaiting comments from the WWF team.

Commented [8]: Phalacrocorax carbo is commonly inhabited in Japan but japanese population breeds domesticary and doesn't migrate across the country, I think.. I want your comments/ advice on this

Commented [9R8]: This is interesting. Based on IUCN and BirdLife International data, the Great Cormorant is a still a migratory species. I know that birds migratory behaviors may change with areas and availability of resources. The population in Japan may change their behaviour due to the abundance of resources there (especially during winter) and the good protection in Japan.

In this case, we can use the bird as a symbol for awareness raising. WWF can advocate different corporates in Vietnam to protect the environment and wildlife in similar standards as in Japan.

Figure 3-21 Green Peafowl in Cat Tien National Park

Photo: CBES

Figure 3-22 Lesser Adjutant in Can Gio

Photo: CBES

Table 3-2 List of conservation-concerned bird species in the Sai Gon – Dong Nai River Basin

Commented [10]: Please add a column to descrive the decreasing drivers for each species.

Commented [11R10]: Okay, information added

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Migratory	Studies that provided confirmed records	Known drivers for population decreasing	Recorded or potentially occur in Ariake ecoregion in Kyushu, Japan
1	*Icthyophaga humilis*	Lesser Fish-eagle	NT	VU	Yes	Not a Migrant	Ngô & Trương (2006); Ngô et al. (2009); Ban Quản lý Khu Dự trữ Sinh quyển Đồng Nai (2022)	Habitat loss	No
2	*Icthyophaga ichthyaetus*	Grey-headed Fish-eagle	NT	VU	Yes	Not a Migrant	Ngô & Trương (2006); Ban Quản lý Khu Dự trữ Sinh quyển Đồng Nai (2022)	Habitat loss	No
3	*Asarcornis scutulata*	White-winged Duck	EN	CR	Yes	Not a Migrant	Ngô & Trương (2006); Ban Quản lý Khu Dự trữ Sinh quyển Đồng Nai (2022)	Habitat loss, hunting	No
4	*Nettapus coromandelianus*	Cotton Pygmy-goose	LC	EN	Yes	Full Migrant	Ngô et al. (2009); Ban Quản lý Khu Dự trữ Sinh quyển Đồng Nai (2022)	Habitat loss, hunting	No
5	*Buceros bicornis*	Great Hornbill	VU	VU	Yes	Not a Migrant	Lê & Tordoff (2003); Ngô & Trương (2006); Ngô et al. (2009); Le et al. (2011); Ban	Habitat loss, hunting	No

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Migratory	Studies that provided confirmed records	Known drivers for population decreasing	Recorded or potentially occur in Ariake ecoregion in Kyushu, Japan
							Quản lý Khu Dự trữ Sinh quyển Đồng Nai (2022)		
6	*Rhyticeros undulatus*	Wreathed Hornbill	VU	VU	Yes	Not a Migrant	Ngô & Trương (2006); Ngô et al. (2009); Ban Quản lý Khu Dự trữ Sinh quyển Đồng Nai (2022)	Habitat loss, hunting	No
7	*Anastomus oscitans*	Asian Openbill	LC	VU	Yes	Not a Migrant	Lê & Tordoff (2003); Ban Quản lý Khu Dự trữ Sinh quyển Đồng Nai (2022)	Habitat loss, hunting	No
8	*Ciconia episcopus*	Asian Woollyneck	NT	VU	Yes	Not a Migrant	Lê & Tordoff (2003); Ngô & Trương (2006); Ngô et al. (2009); Ban Quản lý Khu Dự trữ Sinh quyển Đồng Nai (2022)	Habitat loss, hunting	No
9	*Leptoptilos dubius*	Greater Adjutant	EN	DD	Yes	Full Migrant	(Ban Quản lý Khu Dự trữ Sinh quyển Đồng Nai (2022)	Habitat loss	No

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Migratory	Studies that provided confirmed records	Known drivers for population decreasing	Recorded or potentially occur in Ariake ecoregion in Kyushu, Japan
10	*Leptoptilos javanicus*	Lesser Adjutant	VU	VU	Yes	Full Migrant	Ngô & Trương (2006); Ngô et al. (2009); Le et al. (2011); Ban Quản lý Khu Dự trữ Sinh quyển Đồng Nai (2022)	Habitat loss	No
11	*Sterna acuticauda*	Black-bellied Tern	EN	NL	Yes	Not a Migrant	Le et al. (2011); Ban Quản lý Khu Dự trữ Sinh quyển Đồng Nai (2022)	Habitat loss	No
12	*Calidris pygmaea*	Spoon-billed Sandpiper	CR	NL	Yes	Full Migrant	NONE	Habitat loss	Yes
13	*Arborophila davidi*	Orange-necked Partridge	NT	EN	Yes	Not a Migrant	Ngô & Trương (2006); Ngô et al. (2009); Ban Quản lý Khu Dự trữ Sinh quyển Đồng Nai (2022)	Habitat loss, hunting	No
14	*Lophura diardi*	Siamese Fireback	LC	VU	Yes	Not a Migrant	Lê & Tordoff (2003); Ngô & Trương (2006); Ngô et al. (2009); Le et al. (2011); Ban	Habitat loss, hunting	No

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Migratory	Studies that provided confirmed records	Known drivers for population decreasing	Recorded or potentially occur in Ariake ecoregion in Kyushu, Japan
							Quản lý Khu Dự trữ Sinh quyển Đồng Nai (2022)		
15	*Pavo muticus*	Green Peafowl	EN	EN	Yes	Not a Migrant	Ngô & Trương (2006); Ngô et al. (2009); Ban Quản lý Khu Dự trữ Sinh quyển Đồng Nai (2022)	Habitat loss, hunting	No
16	*Polyplectron germaini*	Germain's Peacock-pheasant	NT	VU	Yes	Not a Migrant	Lê & Tordoff (2003); Ngô & Trương (2006); Ngô et al. (2009); Le et al. (2011); Ban Quản lý Khu Dự trữ Sinh quyển Đồng Nai (2022)	Habitat loss, hunting	No
17	*Acrocephalus tangorum*	White-browed Reed-warbler	VU	NL	Yes	Full Migrant		Habitat loss	No
18	*Emberiza aureola*	Yellow-breasted Bunting	CR	NL	Yes	Full Migrant	Ban Quản lý Khu Dự trữ Sinh quyển Đồng Nai (2022)	Habitat loss, hunting	No

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Migratory	Studies that provided confirmed records	Known drivers for population decreasing	Recorded or potentially occur in Ariake ecoregion in Kyushu, Japan
19	*Pelecanus philippensis*	Spot-billed Pelican	NT	EN	No	Full Migrant	Ban Quản lý Khu Dự trữ Sinh quyển Đồng Nai (2022)	Habitat loss, hunting	No
20	*Pseudibis davisoni*	White-shouldered Ibis	CR	CR	Yes	Not a Migrant	Ngô & Trương (2006); Ban Quản lý Khu Dự trữ Sinh quyển Đồng Nai (2022)	Habitat loss, hunting	No
21	*Threskiornis melanocephalus*	Black-headed Ibis	NT	VU	Yes	Full Migrant	NONE	Habitat loss, hunting	No
22	*Mulleripicus pulverulentus*	Great Slaty Woodpecker	VU	NL	Yes	Not a Migrant	Ngô et al. (2009); Le et al. (2011); Ban Quản lý Khu Dự trữ Sinh quyển Đồng Nai (2022)	Habitat loss	No
23	*Anhinga melanogaster*	Oriental Darter	NT	VU	Yes	Not a Migrant	Ngô & Trương (2006); Ban Quản lý Khu Dự trữ Sinh quyển Đồng Nai (2022)	Habitat loss, hunting	No

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Migratory	Studies that provided confirmed records	Known drivers for population decreasing	Recorded or potentially occur in Ariake ecoregion in Kyushu, Japan
24	*Phalacrocorax carbo*	Great Cormorant	LC	EN	Yes	Full Migrant	Ban Quản lý Khu Dự trữ Sinh quyển Đồng Nai (2022)	Habitat loss, hunting	Yes

3.1.3.3 Herpetofauna

The Sai Gon-Dong Nai River Basin is a vibrant epicenter for herpetofauna diversity, a testament to its unique ecological settings. According to the IUCN's data, the Sai Gon – Dong Nai River Basin is the potential habitat for as many as 153 herpetofauna species. This includes an intriguing mix of 111 reptile species and 41 amphibian species distributed across 32 families within five distinct orders. Corroborating this, the GBIF database presents 881 historical records, identifying 112 distinct herpetofauna species: 78 reptile species and 34 amphibian species that have been documented within the confines of the basin. Our literature review found 25 scholarly articles focusing on the herpetofauna of the Sai Gon – Dong Nai River Basin, provides profound insights into the basin's herpetological diversity. All of those mentioned data can be found in the Appendix 3 of this report.

Synthesizing the vast amount of available information, our conservative estimates place the herpetofauna count in this region at approximately 215 species. A point of particular concern is that 55 of these species are flagged for conservation concerned, with their presence confirmed within the basin, as elaborated upon in Table 3-4.

A remarkable facet of the Sai Gon-Dong Nai River Basin's herpetological significance is the discovery of 21 endemic species, underscoring the region's pivotal role in herpetofauna evolution. Such a high level of endemism accentuates the intrinsic value of the region and underscores the pressing need for tailored conservation measures. The presence of these unique species propels the basin to the forefront of conservation discussions, spotlighting the imperative to balance developmental objectives with biodiversity preservation. Decisions made regarding this basin will likely have lasting implications, not only for these species but also for the understanding of evolutionary processes in Southeast Asian riverine ecosystems.

Table 3-3 List of conservation-concerned herpetofauna species in the Sai Gon – Dong Nai River Basin

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Endemic	Studies that provided confirmed records
1	*Ichthyophis bannanicus*	Mengla County Caecilian	LC	VU	No	No	Nguyễn & Nguyễn (2007); Lê (2010); Lương et al. (2022); Poyarkov et al. (2023)
2	*Ichthyophis catlocensis*	Cat Loc Caecilian	DD	NL	No	Yes	Nguyễn & Hồ (2002); Cat Tien National Park (2021a)
3	*Ichthyophis nguyenorum*	Nguyen's Caecilia	LC	NL	Yes	Yes	Nguyễn & Hồ (2002); Cat Tien National Park (2021a)
4	*Ingerophrynus galeatus*	Bony-headed Toad	LC	VU	Yes	No	Nguyễn & Hồ (2002); Hồ & Nguyễn (2009); Lê (2010); Tống & Nguyễn (2016); Cat Tien National Park (2021a, 2021b); Nguyễn et al. (2021); Lương et al. (2022); Poyarkov et al. (2023)
5	*Microhyla minuta*	Tiny Narrow-Mouth Frog	DD	NL	Yes	Yes	Nguyễn & Hồ (2002); Cat Tien National Park (2021a)
6	*Microhyla picta*	Painted Rice Frog	DD	NL	Yes	Yes	Nguyễn & Nguyễn (2007); Nguyễn & Hoàng (2013); Phạm & Lê (2016)
7	*Rhacophorus helenae*	Helen's Flying Treefrog	EN	NL	Yes	Yes	Poyarkov et al. (2021)
8	*Theloderma laeve*	Smooth Bug-eyed Frog	LC	NL	No	Yes	Nguyễn & Hồ (2002); Lê (2010); Cat Tien National Park (2021)a; Lương et al. (2022)
9	*Amyda ornata*	Asiatic Softshell Turtle	VU	VU	No	No	Nguyễn & Hồ (2002); Nguyễn & Nguyễn (2007); Hồ & Nguyễn

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Endemic	Studies that provided confirmed records
							(2009); Lê (2010); Nguyễn & Hoàng (2013); Cat Tien National Park (2021); Poyarkov et al. (2023)
10	*Argyrophis giandinhensis*	Gia Dinh Blind Snake	DD	NL	No	Yes	Poyarkov et al. (2023)
11	*Bronchocela vietnamensis*		VU	NL	No	Yes	Lê (2010); Poyarkov et al. (2023)
12	*Bungarus fasciatus*	Banded Krait	LC	EN	Yes	No	Nguyễn & Hồ (2002); Nguyễn & Nguyễn (2007); Hồ & Nguyễn (2009); Nguyễn (2009); Lê (2010); Nguyễn & Hoàng (2013); Phạm & Đỗ (2014); Cat Tien National Park (2021); Nguyễn et al. (2021); Poyarkov et al. (2023)
13	*Coelognathus radiatus*	Copper-head Trinket Snake	LC	VU	Yes	No	Nguyễn & Hồ (2002); Nguyễn & Nguyễn (2007); Hồ & Nguyễn (2009); Nguyễn (2009); Lê (2010); Nguyễn & Hoàng (2013); Phạm & Đỗ (2014); Cat Tien National Park (2021); Nguyễn et al. (2021); Poyarkov et al. (2023)
14	*Crocodylus siamensis*	Siamese Crocodile	CR	CR	Yes	No	Nguyễn & Hồ (2002); Cat Tien National Park (2021b, 2021a); Poyarkov et al. (2023)
15	*Cuora amboinensis*	Southeast Asian Box Turtle	EN	VU	Yes	No	Nguyễn & Hồ (2002); Nguyễn & Nguyễn (2007); Hồ & Nguyễn (2009); Lê (2010); Nguyễn & Hoàng (2013); Cat Tien

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Endemic	Studies that provided confirmed records
							National Park (2021b); Nguyễn et al. (2021a); Poyarkov et al. (2023)
16	*Cuora trifasciat*	Chinese Three-striped Box Turtle	NL	CR	Yes	No	Poyarkov et al. (2023)
17	***Cyclemys oldhamii***	Southeast Asian Leaf Turtle	EN	-	No	No	Nguyễn & Hồ (2002); Hồ & Nguyễn (2009); Lê (2010); Cat Tien National Park (2021); Poyarkov et al. (2023)
18	*Cyclemys pulchristriata*	Eastern Black-bridged Leaf Turtle	EN	NL	No	No	Nguyễn & Hồ (2002); Cat Tien National Park (2021b); Poyarkov et al. (2023)
19	*Cyrtodactylus badenensis*		VU	NL	No	Yes	Geissler et al. (2009); Poyarkov et al. (2023)
20	*Cyrtodactylus cattienensis*	Cat Tien Bent-toed Gecko	LC	NL	Yes	Yes	Nguyễn & Hồ (2002); Hồ & Nguyễn (2009); Lê (2010); Nguyễn & Hoàng (2013); Cat Tien National Park (2021b); Lê et al. (2022); Poyarkov et al. (2023)
21	*Cyrtodactylus dati*		VU	NL	No	Yes	Poyarkov et al. (2023)
22	*Cyrtodactylus huynhi*	Huynh's Bent-toed Gecko	VU	NL	No	Yes	(Nguyễn et al. (2021); Poyarkov et al. (2023)
23	***Cyrtodactylus irregularis***	Irregular Bow-fingered Gecko	DD	-	No	Yes	(Lê (2010); Tống & Nguyễn (2016)
24	*Cyrtodactylus nigriocularis*		CR	NL	No	Yes	Geissler et al. (2009); Poyarkov et al. (2023)

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Endemic	Studies that provided confirmed records
25	*Dibamus deharvengi*		DD	NL	No	Yes	Nguyễn & Hoàng (2013); Poyarkov et al. (2023)
26	*Dixonius minhlei*		LC	NL	No	Yes	Poyarkov et al. (2023)
27	*Elaphe taeniura*	Cave Racer	VU	NL	No	No	Poyarkov et al. (2023)
28	*Gekko badenii*		EN	NL	No	Yes	Poyarkov et al. (2023)
29	*Gekko gecko*	Tokay Gecko	LC	VU	Yes	No	Nguyễn & Hồ (2002); Nguyễn & Nguyễn (2007); Hồ & Nguyễn (2009), 2009; Lê (2010); Nguyễn & Hoàng (2013); Phạm & Đỗ (2014); Cat Tien National Park (2021); Nguyễn et al. (2021); Poyarkov et al. (2023)
30	*Gekko russelltraini*	Russell Train's Marble Gecko	VU	-	No	Yes	Van Tri et al. (2009); Nguyễn et al. (2021); Poyarkov et al. (2023)
31	*Heosemys annandalii*	Yellow-headed Temple Turtle	CR	EN	No	No	Nguyễn & Hồ (2002); Nguyễn & Nguyễn (2007); Hồ & Nguyễn (2009); Lê (2010); Cat Tien National Park (2021); Poyarkov et al. (2023)
32	*Heosemys grandis*	Giant Asian Pond Turtle	CR	VU	Yes	No	Nguyễn & Hồ (2002); Hồ & Nguyễn (2009); Lê (2010); Cat Tien National Park (2021b); Poyarkov et al. (2023)
33	*Indotestudo elongata*	Elongated Tortoise	CR	EN	Yes	No	Nguyễn & Hồ (2002); Nguyễn & Nguyễn (2007); Hồ & Nguyễn (2009); Lê (2010);

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Endemic	Studies that provided confirmed records
							Nguyễn & Hoàng (2013) ; Phạm & Đỗ (2014) ; Cat Tien National Park (2021b); Poyarkov et al. (2023)
34	***Leiolepis guentherpetersi***	Peters' Butterfly Lizard	EN	-	No	Yes	Tống & Nguyễn (2016); Poyarkov et al. (2023)
35	*Leiolepis guttata*	Spotted Butterfly Lizard	DD	NL	Yes	Yes	Nguyễn (2009a); Nguyễn & Hoàng (2013); Poyarkov et al. (2023)
36	*Leiolepis ngovantrii*	Ngo Van Tri's Lady Butterfly Lizard	VU	NL	Yes	Yes	Nguyễn & Hoàng (2013); Tống & Nguyễn (2016); Poyarkov et al. (2023)
37	*Malayemys subtrijuga*	Mekong Snail-eating Turtle	NT	VU	Yes	No	Nguyễn & Hồ (2002); Hồ & Nguyễn (2009); Lê (2010); Nguyễn & Hoàng (2013); Cat Tien National Park (2021b); Poyarkov et al. (2023)
38	*Malayopython reticulatus*	Reticulated Python	LC	CR	Yes	No	Nguyễn & Hồ (2002); Hồ & Nguyễn (2009); Nguyễn (2009); Lê (2010); Nguyễn & Hoàng (2013); Cat Tien National Park (2021); Nguyễn et al. (2021); Poyarkov et al. (2023)
39	*Manouria impressa*	Impressed Tortoise	EN	VU	No	No	Nguyễn & Hồ (2002); Cat Tien National Park (2021); Poyarkov et al. (2023)
40	*Naja siamensis*	Black And White Spitting Cobra	VU	NL	Yes	No	Nguyễn & Nguyễn (2007); Lê (2010); Cat Tien National Park (2021b); Nguyễn et al. (2021a); Poyarkov et al. (2023)

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Endemic	Studies that provided confirmed records
41	*Oligodon cattienensis*	Cat Tien Kukri Snake	NL	NL	Yes	Yes	Vassilieva et al. (2013); Cat Tien National Park (2021b)
42	*Ophiophagus hannah*	King Cobra	VU	CR	Yes	No	Nguyễn & Hồ (2002); Nguyễn & Nguyễn (2007); Hồ & Nguyễn (2009); Nguyễn (2009a); Lê (2010); Nguyễn & Hoàng (2013); Phạm & Đỗ (2014); Cat Tien National Park (2021b); Nguyễn et al. (2021a); Poyarkov et al. (2023)
43	*Pelochelys cantorii*	Asian Giant Softshell Turtle	CR	EN	No	No	Poyarkov et al. (2023)
44	*Pelodiscus sinensis*	Chinese Softshell Turtle	VU	NL	Yes	No	Phạm & Đỗ (2014); Tống & Nguyễn (2016); Poyarkov et al. (2023)
45	*Physignathus cocincinus*	Chinese Water Dragon	VU	VU	Yes	No	Nguyễn & Hồ (2002); Nguyễn & Nguyễn (2007); Hồ & Nguyễn (2009); Lê (2010); Nguyễn & Hoàng (2013); Phạm & Đỗ (2014); Tống & Nguyễn (2016); Cat Tien National Park (2021b, 2021a); Nguyễn et al. (2021a); Poyarkov et al. (2023)
46	*Ptyas korros*	Javan Rat Snake	NT	EN	Yes	No	Nguyễn & Nguyễn (2007); Hồ & Nguyễn (2009); Nguyễn (2009a); Lê (2010); Nguyễn & Hoàng (2013); Phạm & Đỗ (2014); Cat Tien National Park (2021b); Nguyễn et al. (2021a); Poyarkov et al. (2023)

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Endemic	Studies that provided confirmed records
47	*Ptyas mucosa*	Oriental Ratsnake	LC	EN	Yes	No	Nguyễn & Hồ (2002); Nguyễn & Nguyễn (2007); Hồ & Nguyễn (2009); Lê (2010); Nguyễn & Hoàng (2013); Phạm & Đỗ (2014); Cat Tien National Park (2021); Nguyễn et al. (2021); Poyarkov et al. (2023)
48	*Python bivittatus*	Burmese Python	VU	CR	No	No	Nguyễn & Hồ (2002); Nguyễn & Nguyễn (2007); Hồ & Nguyễn (2009); Nguyễn (2009); Nguyễn & Hoàng (2013); Cat Tien National Park (2021); Poyarkov et al. (2023)
49	*Scincella badenensis*		NL	NL	Yes	Yes	Nguyen et al. (2019)
50	*Siebenrockiella crassicollis*	Black Marsh Turtle	EN	NL	No	No	Nguyễn & Hồ (2002); Hồ & Nguyễn (2009); Lê (2010); Nguyễn & Hoàng (2013); Cat Tien National Park (2021); Poyarkov et al. (2023)
51	*Subdoluseps vietnamensis*		NL	NL	Yes	Yes	Lê et al. (2022); Poyarkov et al. (2023)
52	*Takydromus madaensis*	Ma Da Grass Lizard	DD	NL	No	Yes	Vassilieva et al. (2016)
53	*Trimeresurus rubeus*	Ruby-eyed Green Pitviper	VU	NL	No	No	Nguyễn & Hồ (2002); Cat Tien National Park (2021); Lê et al. (2022); Poyarkov et al. (2023)
54	*Varanus nebulosus*		LC	EN	No	No	Nguyễn & Hồ (2002); Nguyễn & Nguyễn (2007); Hồ & Nguyễn (2009); Lê (2010);

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Endemic	Studies that provided confirmed records
							Nguyễn & Hoàng (2013); Cat Tien National Park (2021); Poyarkov et al. (2023)
55	*Varanus salvator*	Common Water Monitor	LC	EN	No	No	Nguyễn & Hồ (2002); Nguyễn & Nguyễn (2007); Hồ & Nguyễn (2009); Nguyễn (2009); Lê (2010); Nguyễn & Hoàng (2013); Cat Tien National Park (2021); Poyarkov et al. (2023)

Figure 3-23 **Huynh's Bent-toed Gecko *Cyrtodactylus huynhi,* a Vietnamese endemic species found in Chua Chan Moutain**

Photo: CBES

Figure 3-24 Ngo Van Tri's Lady Butterfly Lizard *Leiolepis ngovantrii* , a Vietnam endemic species found in Ba Ria- Vung Tau

Photo: CBES

Figure 3-25 Southeast Asian Leaf Turtle Cyclemys oldhamii EN

Elongated Tortoise *Indotestudo elongata* **CR**

3.1.3.4 Freshwater fishes

The Sai Gon – Dong Nai River Basin stands as a hub of freshwater fish biodiversity, a direct result of its intricate topographical variations coupled with the multifaceted hydrology of the Dong Nai River. Initial distribution data drawn from the IUCN Red List indicates the presence of 270 freshwater fish species, distributed across 63 families and 18 orders, that potentially reside within the confines of the Sai Gon - Dong Nai River Basin. Additionally, the GBIF database reinforces this diversity with records of 71 distinct fish species from 188 data points specific to the region. Our literature review also found 29 papers focusing on the ichthyofauna of the Sai Gon – Dong Nai River Basin, adding depth to our understanding. Appendix 4 of this report provided all data and information on freshwater fish acquired from IUCN, GBIF and literature. By synthesizing and comparing data from various sources, we project that the Sai Gon – Dong Nai River Basin is home to approximately 200 fish species. Disturbingly, 55 of these species have been flagged for conservation concerns as per the IUCN Red List and the Vietnam Red Databook, as delineated in Table 3-5.

Of particular note among these threatened species are five potamodromous species, which limit their migratory patterns to freshwater systems, such as moving upstream or downstream within the riverine ecosystem. Their specific migratory behaviors render them especially

susceptible to anthropogenic threats. Specifically, the proliferation of hydropower and irrigation dams within the river basin poses a significant hazard, as these infrastructures can obstruct their natural migratory routes, potentially leading to population declines and ecological imbalance. It's imperative to consider these ecological nuances when planning future infrastructure in the basin to ensure the sustainable coexistence of both human and aquatic life.

Figure 3-26 The endangered Yellow-tailed Brook Barb *Poropuntius deauratus* recorded in the Dong Nai River

Photo: CBES

Commented [12]: Pls add scientific name after the english name

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Table 3-4 List of conservation concerned fish species that potentially occur in the Sai Gon – Dong Nai Basin

S/N	Scientific name	IUCN	VRDB	GBIF confirmed	Studies that provided confirmed records	Migrant behaviors	Drivers for decreasing	Remark
1	*Wallagonia minostoma*	NE	**VU**	No	Thái & Hoàng (2009))	No-migrant	Habitat loss, overfishing	Poorly studied species
2	*Albula vulpes*	**NT**	**VU**	No	Tống et al. (2012); Tống & Nguyễn (2015)	Amphidromous	Habitat loss, overfishing	Marine and estuary fish in North America. The record in Vietnam can be a miss-identification or introduced species or simply outdated information
3	*Ambastaia nigrolineata*	**VU**	NL	No	Hoàng et al. (2022)	No-migrant	Habitat loss	Only live in clear, fast-flowing stream with sandy bottom.
4	*Anguilla marmorata*	LC	**VU**	No	Nguyễn (2012)	Catadromous	Habitat loss, overfishing	Spawn in the sea, juvenile eels return to the inland freshwater habitat. Sensitive

Commented [14]: Is that possible to add the characteristics and decreasing drivers of each fish species (such as spawning behavior (needs to migrate vertically/ needs other taxon such as freshwater mussels etc..), floodplain-dependent, needs specific environment for survival) in this table?

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S/N	Scientific name	IUCN	VRDB	GBIF confirmed	Studies that provided confirmed records	Migrant behaviors	Drivers for decreasing	Remark
								to obstacles such as sluice gates and dams.
5	*Anodontostoma chacunda*	LC	**VU**	No	Nguyễn (2012); Tống et al. (2012); Tống & Nguyễn (2014, 2015)	Anadromous	Habitat loss, overfishing	Spawn in freshwater and move to the sea. Sensitive to obstacles such as sluice gates and dams.
6	*Bagarius lica*	**VU**	NL	No	Hoàng et al. (2022)	No-migrant	Habitat loss, overfishing	typically associated with swift, clear rivers with a substrate of rocks and sand
7	*Betta splendens*	**VU**	NL	Yes		No-migrant	Habitat loss, overfishing	Wetland associated species. Sensitive to land-used change
8	*Catlocarpio siamensis*	**CR**	**EN**	No	Tống et al. (2019); Hoàng et al. (2022)	Potamodromous	Habitat loss, overfishing	Live in large river. Targeted by fishermen
9	*Channa micropeltes*	LC	**VU**	No	Tống (2005, 2007)	No-migrant	Habitat loss, overfishing	Wetland associated species. Sensitive to land-used

S/N	Scientific name	IUCN	VRDB	GBIF confirmed	Studies that provided confirmed records	Migrant behaviors	Drivers for decreasing	Remark
								change. Targeted by fishermen
10	*Chanos chanos*	LC	**VU**	No	Nguyễn (2012)	No-migrant	Habitat loss, overfishing	Wetland associated species. Sensitive to land-used change. Targeted by fishermen
11	*Chitala ornata*	LC	**VU**	No	Tống & Nguyễn (2009, 2010); Nguyễn (2012); Nguyen et al. (2019b); Tống et al. (2019); Huỳnh et al. (2021); Nguyen et al. (2021)	Potamodromous	Habitat loss, overfishing	Wetland associated species. Sensitive to land-used change. Targeted by fishermen
12	*Cirrhinus microlepis*	**VU**	**VU**	No	Nguyễn (2007); Thái & Hoàng (2009); Nguyễn &	Potamodromous	Habitat loss, overfishing	Inhabits large rivers and lowland floodplains

S/N	Scientific name	IUCN	VRDB	GBIF confirmed	Studies that provided confirmed records	Migrant behaviors	Drivers for decreasing	Remark
					Ngô (2015); Hoàng et al. (2022)			
13	*Cirrhinus molitorella*	**NT**	**VU**	No	Nguyễn & Ngô (2015)	Potamodromous	Habitat loss, overfishing	Medium river and wetland associated species. Sensitive to land-used change. Targeted by fishermen
14	*Coius microlepis*	LC	**VU**	No	Thái & Hoàng (2009)	No-migrant	Habitat loss, overfishing	Poorly studied species
15	*Coius quadrifasciatus*	NE	**VU**	No	Tống (2005); Tống et al. (2012)	No-migrant	Habitat loss, overfishing	Poorly studied species
16	*Coradion chrysozonus*	LC	**VU**	No	Tống & Nguyễn (2014, 2015)	Amphidromous	Habitat loss, overfishing	Mainly marine species
17	*Cosmochilus harmandi*	LC	**VU**	No	Nguyen et al. (2019b, 2021)	Potamodromous	Habitat loss, overfishing	Mostly found in mainstream and larger tributary rivers with sandy bottoms. May

S/N	Scientific name	IUCN	VRDB	GBIF confirmed	Studies that provided confirmed records	Migrant behaviors	Drivers for decreasing	Remark
								sensitive to river sand mining.
18	*Datnioides polota*	LC	**VU**	No	Tống & Nguyễn (2014, 2015); Huỳnh et al. (2021)	No-migrant	Habitat loss, overfishing	Poorly studied species
19	*Datnioides pulcher*	**CR**	NL	No	Hoàng et al. (2022)	No-migrant	Habitat loss, overfishing	The species inhabits mainstreams and tributaries, including larger lakes connected to rivers. It prefers habitats with submerged woods and rocky crevices.
20	*Datnioides quadrifasciatus*	NE	**VU**	No	(Tống & Nguyễn 2009; Nguyễn (2012); Nguyễn & Kiên 2014)	No-migrant	Habitat loss, overfishing	Poorly studied species
21	*Datnioides undecimradiatus*	**VU**	NL	No		**Potamodromous**	**Habitat loss, overfishing**	**A carnivorous species that is found in the**

S/N	Scientific name	IUCN	VRDB	GBIF confirmed	Studies that provided confirmed records	Migrant behaviors	Drivers for decreasing	Remark
								mainstreams and large tributaries.
22	*Eleutheronema tetradactylum*	**EN**	NL	No	Huỳnh et al. (2021)	Anadromous	Habitat loss, overfishing	Medium river and wetland associated species. Sensitive to land-used change.
23	*Elops saurus*	LC	VU	No	Nguyễn (2012); Tống et al. (2012); Tống & Nguyễn 2015; Huỳnh et al. (2021); Hoàng et al. (2022)	Anadromous	Habitat loss, overfishing	Medium river and wetland associated species. Sensitive to land-used change.
24	*Fluvitrygon oxyrhynchus*	**EN**	NL	No	Hoàng et al. (2022)	No-migrant	Habitat loss, overfishing	Freshwater ray species that associated with soft substrates in rivers and streams. Targeted by fishermen. Sensitive to sand mining and pollution

S/N	Scientific name	IUCN	VRDB	GBIF confirmed	Studies that provided confirmed records	Migrant behaviors	Drivers for decreasing	Remark
25	*Hemibagrus wyckioides*	LC	**VU**	No	Nguyen et al. (2021)	No-migrant	Habitat loss, overfishing	Found in large upland rivers; common in areas with rocky bottoms and irregular depths.
26	*Hilsa kelee*	LC	**VU**	No	Tống et al. (2012)	No-migrant	Habitat loss, overfishing	Estuary species
27	*Hypsibarbus lagleri*	**VU**	NL	No	Hoàng et al. (2022)	Potamodromous	Habitat loss, overfishing	Occurs in large rivers in the dry season and moves to medium-sized rivers in the wet season. Preferring rocks bottom.
28	*Konosirus punctatus*	LC	**VU**	No	Nguyễn et al. (2015)	Anadromous	Habitat loss, overfishing	Spawn in the sea, juvenile eels return to the inland freshwater habitat. Sensitive to obstacles such as sluice gates and dams.

S/N	Scientific name	IUCN	VRDB	GBIF confirmed	Studies that provided confirmed records	Migrant behaviors	Drivers for decreasing	Remark
29	*Labeo pierrei*	**VU**	NL	No	Hoàng et al. (2022)	Potamodromous	Habitat loss, overfishing	Wetland associated species. Sensitive to land-used change. Targeted by fishermen
30	*Megalops cyprinoides*	DD	**VU**	No	Nguyễn (2012); Tống et al. (2012); Tống & Nguyễn (2014), 2015; Huỳnh et al. (2021)	No-migrant	Habitat loss, overfishing	Estuary species
31	*Mystus bocourti*	**VU**	NL	No	Hoàng et al. (2022)	Potamodromous	Habitat loss, overfishing	Occurs in medium to large-sized rivers
32	*Mystus nemurus*	LC	**VU**	No	Nguyen et al. (2019b, 2021)	No-migrant	Habitat loss, overfishing	Wetland associated species. Sensitive to land-used change. Records in Vietnam need reviewing as they could be miss-identitication

S/N	Scientific name	IUCN	VRDB	GBIF confirmed	Studies that provided confirmed records	Migrant behaviors	Drivers for decreasing	Remark
33	*Nematalosa nasus*	LC	**VU**	No	Nguyễn et al. (2015)	Anadromous	Habitat loss, overfishing	mainly found in estuaries and coastal areas, especially mangrove
34	*Oxygaster pointoni*	**VU**	NL	No	Hoàng et al. (2022)	No-migrant	Habitat loss, overfishing	Wetland associated species. Sensitive to land-used change.
35	*Pangasius krempfi*	**VU**	NL	Yes	Hoàng et al. (2022)	**Anadromous**	**Habitat loss, overfishing**	**Travel long distance to spawn. Sensitive to dams**
36	*Plectorhinchus gibbosus*	LC	**CR**	No	Tống & Nguyễn (2014, 2015)	No-migrant	Habitat loss, overfishing	Estuary and mangrove species
37	*Poropuntius deauratus*	**EN**	NL	Yes	Hoàng et al. (2022)	Potamodromous	Habitat loss, overfishing	Associated with fast-flow small streams with clear water and gravel bottom. Sensitive to land-used change, dams and pollution
38	*Probarbus jullieni*	**CR**	**VU**	No	Nguyễn (2007); Nguyễn & Ngô	Potamodromous	Habitat loss, overfishing	mainly large rivers, with sand or gravel substrates

S/N	Scientific name	IUCN	VRDB	GBIF confirmed	Studies that provided confirmed records	Migrant behaviors	Drivers for decreasing	Remark
					(2015); Hoàng et al. (2022)			and abundant mollusc populations.
39	*Sardinella tawilis*	**EN**	NL	No	Huỳnh et al. (2021)	No-migrant	Habitat loss, overfishing	a freshwater, lacustrine species
40	*Scleropages formosus*	**EN**	**EN**	Yes	Hoàng et al. (2022)	No-migrant	Habitat loss, overfishing	Live in medium river with good vegetation. Targeted by fishermen because it is a high-value aquarium fish.
41	*Sewellia lineolata*	**VU**	NL	Yes	None	No-migrant	Habitat loss, overfishing	Inhabits rapids and riffles in small rivers and streams. Sensitive to land-used change, dams and pollution
42	*Tenualosa toli*	**VU**	**VU**	No	Tống et al. (2012); Nguyễn et al. (2015); Tống & Nguyễn (2015)	No-migrant	Habitat loss, overfishing	inhabits the fast-flowing turbid river and estuary.

S/N	Scientific name	IUCN	VRDB	GBIF confirmed	Studies that provided confirmed records	Migrant behaviors	Drivers for decreasing	Remark
43	*Toxotes chatareus*	LC	**VU**	No	Tống (2005); Thái & Hoàng (2009); Nguyễn (2012); Tống et al. (2012); Nguyễn & Kiên (2014); Tống & Nguyễn (2014, 2015); Huỳnh et al. (2021)	No-migrant	Habitat loss, overfishing	This species prefers areas with over-hanging vegetation, and is able to spit jets of water at distances of 1.5 m to dislodge insects from above vegetation. Sensitive to land-used change, dams and pollution
44	*Wallago attu*	**VU**	NL	No	Hoàng et al. (2022)	Potamodromous	Habitat loss, overfishing	Associated with large river and lake, but can also live in pond, channel and reservoirs.

3.1.3.5 Insects

In the Sai Gon- Dong Nai River Basin, the available data on insects is not as comprehensive as that for other fauna groups. Unlike other taxa, the IUCN Red List does not provide specific distribution data for insects, making it challenging to pinpoint species that might naturally occur in this area. Nevertheless, a thorough examination of the GBIF databases reveals the presence of 4,554 insect records, representing a diverse group of 1,304 species. These species span 214 families across 19 orders, underscoring the ecological diversity of this region. Our literature review further supports these findings: we identified 15 academic papers and reports that delve into the insect fauna of this basin. Readers seeking detailed information on these studies can consult Appendix 5 of this report. From the collated data, it's inferred that the insect diversity in the Sai Gon- Dong Nai River Basin could encompass over 1,300 species. Notably, among these, six species have been identified as conservation priorities, as highlighted in Table 3-5.

Table 3-5 List of conservation-concerned insect species in the Sai Gon – Dong Nai Rivers Basin

S/N	Scientific name	English name	IUCN2023	VNRB2007	GBIF recorded	WWF eDNA study	Study
1	*Chalcosoma atlas*	Atlas beetle	NL	CR	No	No	Nguyen & Okolelova (2015)
2	*Dorcus titanus westermanni*		NL	EN	No	No	Nguyen & Okolelova (2015)
3	*Papilio noblei*	Noble's Helen.	NL	VU	No	No	Nguyen & Okolelova (2015)

4	*Troides aeacus*	Golden Birdwing	LC	VU	Yes	No	Nguyen & Okolelova (2015)
5	*Troides helena cerberus*	Common Birdwing	NL	VU	No	No	Nguyen & Okolelova (2015)
6	*Stichophthalma uemurai*		NL	VU	No	No	Nguyen & Okolelova (2015)

3.1.3.6 Flora

The Sai Gon-Dong Nai River Basin seamlessly integrates three distinct ecoregions: the Southern Indochina Dry Evergreen Forest, the Indochina Mangrove, and the Southern Vietnam Lowland Dry Forest. This confluence results in a unique assemblage of flora from each ecoregion, culminating in an exceptionally rich and diverse botanical tapestry within the basin. The GBIF database offers a detailed snapshot of this botanical richness, documenting as many as 1,266 plant species. These species, representing 181 families and spanning 61 orders, underscore the ecological significance of the region. Literature review focused on the basin's unique flora found 29 dedicated research articles and reports. A consolidated repository of all mentioned data and information is accessible in Appendix 6 of this report. Notably, 77 of the catalogued species are listed as conservation concerned.

Table 3-6 List of conservation-concerned flora species in the Sai Gon – Dong Nai Rivers Basin

S/N	Taxa	English Name	IUCN2023	VRDB2007	GBIFconfirm	Study
1	*Adonidia merrillii*	Manila Palm	VU	NL	Yes	None
2	*Aeginetia indica*		LC	VU	Yes	Lê & Cao (2022); Lê et al. (2022); Cao et al. (2022); Kieu et al. (2020); Dang et al. (2020); Viet Hung & Potokin

						(2019); Nguyễn & Nguyễn (2017)
3	*Afzelia xylocarpa*		EN	EN	Yes	Phạm et al. (2022); Cao et al. (2022); Dang et al. (2020); Viet Hung & Potokin (2019)
4	*Aglaia pleuropteris*		CR	NL	Yes	None
5	*Anaxagorea luzonensis*		LC	VU	Yes	None
6	*Anisoptera costata*		EN	EN	No	Nguyen et al. (2023); Phạm et al. (2022); Nguyen et al. (2020); Dang et al. (2020); Phan (2019)
7	*Aquilaria crassna*	Agarwood	CR	EN	No	Phạm et al. (2022); Viet Hung & Potokin (2019)
8	*Ardisia silvestris*		NL	VU	No	(Kieu et al. (2020); Viet Hung & Potokin (2019); Nguyễn & Nguyễn (2017)
9	*Beilschmiedia argentata*		VU	NL	Yes	None
10	*Camellia piquetiana*	Purple Camellia	CR	NL	No	Phạm et al. (2022)
11	*Campestigma purpurea*		NL	EN	Yes	None
12	*Canarium tramdenum*		NL	VU	No	Viet Hung & Potokin (2019)
13	*Chukrasia tabularis*	Chittagong wood	LC	VU	No	Viet Hung & Potokin (2019)
14	*Cinnamomum cambodianum*		CR	VU	Yes	None
15	*Coffea arabica*	Arabica Coffee	EN	NL	Yes	None
16	*Curculigo orchioides*		NL	EN	No	Cao et al. (2022); Kieu et al. (2020)
17	*Cycas inermis*		VU	VU	Yes	Viet Hung & Potokin (2019); Nguyễn & Nguyễn (2017)
18	*Cycas lindstromii*		EN	VU	No	Cao et al. (2022); Dang et al. (2020)
19	*Cycas pectinata*		VU	VU	No	Cao et al. (2022); Dang et al. (2020)
20	*Dalbergia cochinchinensis*	Siamese Rosewood	CR	EN	Yes	Cao et al. (2022); Kieu et al. (2021); Nguyen et al. (2020)

21	*Dalbergia oliveri*	Burmese Rosewood	CR	EN	Yes	Kieu et al. (2021); Nguyen et al. (2020); Dang et al. (2020); Viet Hung & Potokin (2019)
22	*Dehaasia suborbicularis*		VU	NL	Yes	None
23	*Dendrobium moschatum*	Musk Dendrobium	NL	EN	Yes	None
24	*Dioscorea brevipetiolata*		VU	NL	Yes	None
25	*Dipterocarpus alatus*		VU	NL	Yes	None
26	*Dipterocarpus chartaceus*		EN	NL	No	Nguyen et al. (2023)
27	*Dipterocarpus costatus*		VU	NL	Yes	Dang et al. (2020)
28	*Dipterocarpus dyeri*		EN	VU	Yes	Phạm et al. (2022); (Lê et al. (2022); Cao et al. (2022); Nguyen et al. (2020); ; Viet Hung & Potokin (2019)
29	*Dipterocarpus intricatus*		EN	NL	Yes	Phạm et al. (2022)
30	*Dipterocarpus turbinatus*		VU	NL	Yes	None
31	*Drynaria bonii*		NL	VU	Yes	Lê & Cao (2022); Lê et al. (2022); Cao et al. (2022); Dang et al. (2020); Viet Hung & Potokin (2019)
32	*Drynaria fortunei*		NL	EN	No	Lê & Cao (2022); Kieu et al. (2020); Viet Hung & Potokin (2019); Nguyễn & Nguyễn (2017)
33	*Elaeocarpus hygrophilus*		NL	VU	Yes	Lê et al. (2022); Cao et al. (2022)
34	*Endiandra hainanensis*		EN	EN	Yes	None
35	*Helixanthera annamica*		NL	VU	No	Viet Hung & Potokin (2019)
36	*Homalomena gigantea*		NL	VU	No	Kieu et al. (2020); Nguyễn & Nguyễn (2017)
37	*Homalomena pierreana*		NL	VU	No	Kieu et al. (2020); Dang et al. (2020); Viet Hung & Potokin (2019); Nguyễn & Nguyễn (2017)

38	*Hopea ferrea*		EN	EN	Yes	Dang et al. (2020)
39	*Hopea odorata*		VU	NL	Yes	Nguyen et al. (2023); Dang et al. (2020); Phan (2019)
40	*Hyophorbe indica*	Palmiste Poison	EN	NL	Yes	None
41	*Kibatalia laurifolia*		NL	VU	No	Viet Hung & Potokin (2019)
42	*Knema pierrei*		VU	NL	No	Kieu et al. (2021)
43	*Latania lontaroides*	Latanier de la Réunion	EN	NL	Yes	None
44	*Lithocarpus fenestratus*		LC	VU	Yes	None
45	*Lithocarpus harmandii*		NL	EN	Yes	None
46	*Lithocarpus polystachyus*		NL	EN	Yes	None
47	*Lithocarpus vestitus*		NL	EN	Yes	Phạm et al. (2022)
48	*Machilus coriacea*		VU	NL	Yes	None
49	*Mangifera dongnaiensis*		EN	NL	Yes	Phạm et al. (2022)
50	*Markhamia stipulata*		LC	VU	Yes	Phạm et al. (2022); Lê et al. (2022); Cao et al. (2022); Dang et al. (2020); Phan (2019)
51	*Melanorrhoea laccifera*		NL	VU	No	(Lê et al. (2022); Cao et al. (2022); Phan (2019)
52	*Melanorrhoea usitata*		NL	VU	No	(Lê et al. (2022); Cao et al. (2022); Phan (2019)
53	*Millingtonia hortensis*		NL	VU	No	None
54	*Nervilia aragoana*		NL	VU	No	Lê et al. (2022)
55	*Nothaphoebe condensa*		VU	NL	Yes	None
56	*Oryza rufipogon*	Red Rice	LC	VU	Yes	None

57	*Peliosanthes teta*		NL	VU	Yes	Lê et al. (2022); Cao et al. (2022); Dang et al. (2020); Viet Hung & Potokin (2019)
58	*Prunus ceylanica*		EN	NL	No	Phạm et al. (2022)
59	*Psydrax dicoccos*		VU	NL	No	Cao et al. (2022); Nguyen et al. (2020); Dang et al. (2020)
60	*Pterocarpus dalbergioides*	East Indian Mahogany	VU	NL	Yes	None
61	*Pterocarpus indicus*	Burmese Rosewood	EN	NL	Yes	None
62	*Pterocarpus macrocarpus*	Burma Padauk	EN	NL	Yes	Phạm et al. (2022) ; Lê et al. (2022); Cao et al. (2022); Dang et al. (2020); Viet Hung & Potokin (2019)
63	*Quercus austrocochinchinensis*		VU	NL	Yes	None
64	*Quercus langbianensis*		NT	VU	Yes	None
65	*Shorea guiso*	Red Balau	VU	NL	Yes	None
66	*Shorea roxburghii*	White Meranti	VU	NL	Yes	Nguyen et al. (2023); Phan (2019)
67	*Sindora siamensis*		LC	EN	Yes	Nguyen et al. (2023); Phạm et al. (2022); Lê et al. (2022); Cao et al. (2022); Kieu et al. (2021); Nguyen et al. (2020); Dang et al. (2020); Viet Hung & Potokin (2019); Phan (2019)
68	*Spirolobium cambodianum*		NL	VU	Yes	Cao et al. (2022)
69	*Stemona pierrei*		NL	VU	No	Lê et al. (2022); Cao et al. (2022) ; Dang et al. (2020); Viet Hung & ; Potokin (2019)
70	*Strychnos nitida*		NL	EN	No	Cao et al. (2022)
71	*Tacca integrifolia*		NL	VU	No	Cao et al. (2022); Kieu et al. (2020); Dang et al. (2020); Viet Hung & Potokin (2019); Nguyễn & Nguyễn (2017)
72	*Tectona grandis*	Teak	EN	NL	Yes	

73	***Telectadium dongnaiense***		**NL**	**CR**	**Yes**	**Phạm et al. (2022) ; Viet Hung & Potokin (2019)**
74	***Terminalia acuminata***		**EN**	**NL**	**Yes**	
75	***Vitex ajugaeflora***		**NL**	**VU**	**No**	**Dang et al. (2020); Phan (2019)**
76	***Vitex ajugiflora***		**EN**	**NL**	**Yes**	
77	***Xylopia pierrei***		**VU**	**VU**	**Yes**	**Lê et al. (2022); Cao et al. (2022) Dang et al. (2020); Viet Hung & Potokin (2019); Phan (2019)**

3.1.4 Ecologically or Biologically Significant Areas in Sai Gon – Dong Nai River Basin

There is a total of 09 Ecological or Biological Significant Areas (EBSA) existed in the focused area of Sai Gon – Dong Nai River Basin (Figure 3-25). Among those, 02 EBSA have been designated as Biosphere Reserve by UNESCO, namely Can Gio Mangrove BR and Dong Nai BR. The Can Gio Biosphere is a prime example of the Indochina Mangrove ecoregions, enveloping the Dong Nai estuary. It plays a pivotal role in shielding Ho Chi Minh City from the ocean's adverse effects, capturing and storing carbon, and mitigating urban pollution. Cat Tien National Park, which include the Bau Sau Wetlands and Seasonal Floodplains RAMSAR site and Dong Nai Nature and Culture Reserve formed the Dong Nai Biosphere Reserve. This area has exceptional biodiversity, wide range of habitats of Southern Indochina Dry Evergreen Forest and remarkable potentials for sustainable developments. Lo Go- Xa Mat, which adjacent to the Vietnam-Cambodia border, act as forest oasis and wildlife sanctuary in the middle of a vast agricultural area. Further, the Binh Chau-Phuoc Buu Nature Reserve safeguards a distinct patch of coastal dry forest, characteristic of the South Vietnam Lowland Dry Forest ecoregion. Collectively, these areas form the vital conservation framework for nature within the Sai Gon-Dong Nai River Basin.

Table 3-7 offers a comprehensive summary of the EBSAs within the Sai Gon-Dong Nai River Basin. This table collates vital details, presenting a clear overview of each EBSA's characteristics, the ecoregion it belong to and key information on its biodiversity.

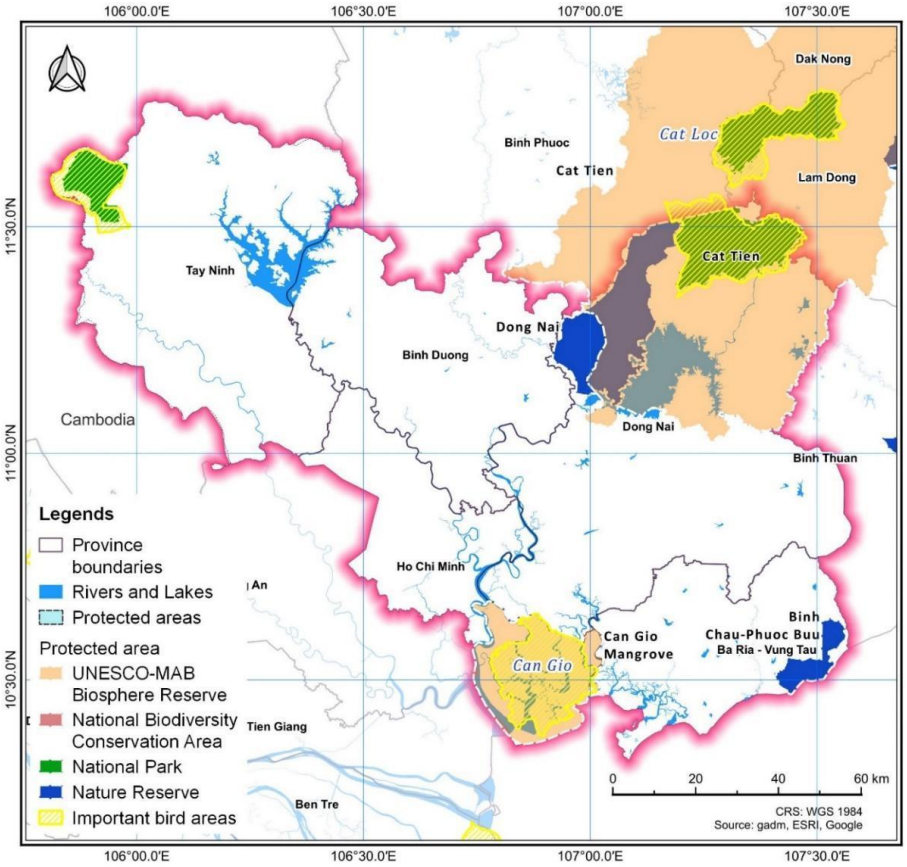

Figure 3-27 Location of EBAS in Sai Gon – Dong Nai River Basin

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Table 3-7 Summarized Information on ecologically or biologically important areas in Sai Gon – Dong Nai River Basin

S/N	Nane	Class	Location	Total area (ha)	Ecoregion	Remarks
1	**Can Gio Mangrove Biosphere Reserve**	**UNESCO Biosphere Reserve**	**Ho Chi Minh**	**Approximately 31,000**	**Indochina Mangrove**	These mangrove forests play a crucial role as the habitat for numerous species, providing shelter, breeding grounds, and a source of food (Nguyen et al. 2016a). Also an IBA (BirdLife International 2023)
2	**Cat Tien**	**National Park**	**Dong Nai**	**Approximately 72,000**	**Southern Indochina Dry Evergreen Forest**	The megafauna include: 105 mammals, 351 Aves, 150 Reptiles & Amphibians, 756 insect species and 159 freshwater fish (Dinh 2022). The flora include: 1615 species of vascular plant belongs to 162 families, among them 47 species in IUCN Red Data Book (Dinh 2022). 5 mains habitat: tropical rainforest, wetland, wood & bamboo mixed forest and bamboo forest (Cat Tien National Park website 2023). Also an IBA (BirdLife International 2023)
	Bau Sau Wetlands and Seasonal Floodplains	**RAMSAR Site**	**Dong Nai**	**13,759**	**Southern Indochina Dry Evergreen Forest (fresh water swam)**	Inside the Cat Tien National Park A freshwater complex and transition zone between the Great Annamite ecoregion and lower Mekong Delta with Vietnam's last remaining lowland semi-evergreen forests representative of the Indo-Chinese region. Bau Sau is a key habitat for 50 very rare IUCN red-listed species like Siamese Crocodile, Asian Arowana, Black-shanked Douc, Asian Elephant, Wild Gaur, Yellow-cheeked Crested Gibbon and Smooth-coated Otter, 131

S/N	Nane	Class	Location	Total area (ha)	Ecoregion	Remarks
						endemic fish and 6 species of turtles, tortoises and terrapins (The Ramsar Sites Information Service 2023)
3	**Dong Nai Nature and Culture Reserve**	**Protected Area**	**Dong Nai**	**100,294**	**Southern Indochina Dry Evergreen Forest**	The Dong Nai Natural and Cultural Reserve has an area of 100,294 ha. This reserve was established with the goal of restoring the biodiversity of the native forest ecosystem in the Dong Nai River basin. It is one of the largest natural reserves in Vietnam and is characterized by the typical forest ecosystem of the Southeastern region. It is home to numerous wild animal species, including many rare ones that are at risk of extinction
4	**Dong Nai Biosphere Reserve**	**UNESCO Biosphere Reserve**	**Dong Nai, Binh Duong, Binh Phuoc**	**966,563**	**Southern Indochina Dry Evergreen Forest**	Consist of Cat Tien National Park, Dong Nai Nature and Culture Reserve and a vast buffer zone
5	**Lo Go - Xa Mat**	**National Park**	**Tay Ninh**	**30,022**	**Southern Indochina Dry Evergreen Forest**	Situated in the transition between Central Highlands, Southern Lowlands, and the Mekong Delta, Lo Go-Xa Mat supports low hills, seasonal inundated grasslands and swamps, natural rivers and streams etc. This combination is very rarely found where else in Vietnam. It is an Important Bird Area due to the presence of a number of globally threatened birds and restricted-range species (Huy, 2008). Also an IBA

S/N	Nane	Class	Location	Total area (ha)	Ecoregion	Remarks
7	**Binh Chau - Phuoc Buu NR**	**Nature Reserve**	**Ba Ria – Vung Tau**	**10,537**	**Southern Vietnam Lowland Dry Forest**	**Binh Chau - Phuoc Buu primary forest, located in the southern part of Xuyen Moc District, Ba Ria - Vung Tau Province, has a natural area of over 10,537 hectares. It is the only relatively intact coastal primary forest remaining in Vietnam (Dang, Potokin, et al., 2020).**

3.2 THREATS AND PROJECTIONS

3.2.1 Hydropower dam and sediment reduction

In the mainstream of Dong Nai River, eight large-scaled hydropower dams have been constructed and operated, while many are being proposed (Vietnam Energy Online 2013). For the La Nga and Song Be tributaries, at least eight other hydropower dams have been operated. All those dams created a “cascading hydropower scheme’, in which a downstream dam is dependent on the discharge from an upstream dam. The assemblages of hydropower dams on Dong Nai River and its tributary, along with other water diversions structures, have heavily reduce the natural flow of this river system, which will eventually lead to sediment reduction (Gugliotta et al. 2020).

Although the reduction of sediment in Sai Gon- Dong Nai River Basin is well recognised (Gugliotta et al. 2020), the actual magnitude of such reduction have been poorly studied. Our literature review found only one publication that have information on the sediment reduction in this region (Gugliotta et al. 2020). According to this paper, the impacts of sediments in the Dong Nai River system have impacts on various benthic species in the Dong Nai River estuary.

For our study area (Dong Nai, Binh Duong, Tay Ninh, Ba Ria-Vung Tau and Ho Chi Minh City), the Tri An hydropower (Dong Nai) and Phuoc Hoa hydropower (Binh Duong province) and Dau Tieng dam/water reservoir plays the key role in modified the natural hydrological regime of the region. A common feature of these dams is their extensive water reservoirs, which also trap sediments that would naturally flow downstream. Quantifying the annual sediment trapped within these reservoirs can provide insight into the volume of sediment withheld from the basin. Regrettably, research on this subject is sparse. Existing studies suggest sedimentation rates within the Tri An reservoir average 0.5 cm/year (Dinh et al. 2013; Mai et al. 2014), and can reach up to 5,24 cm/year in the northern upstream (Dinh et al. 2013). With this data, we can conservatively estimate the sediment reductions in the downstream of Dong Nai River Basin due to hydropower dams would be somewhere between 0.5cm/ year.

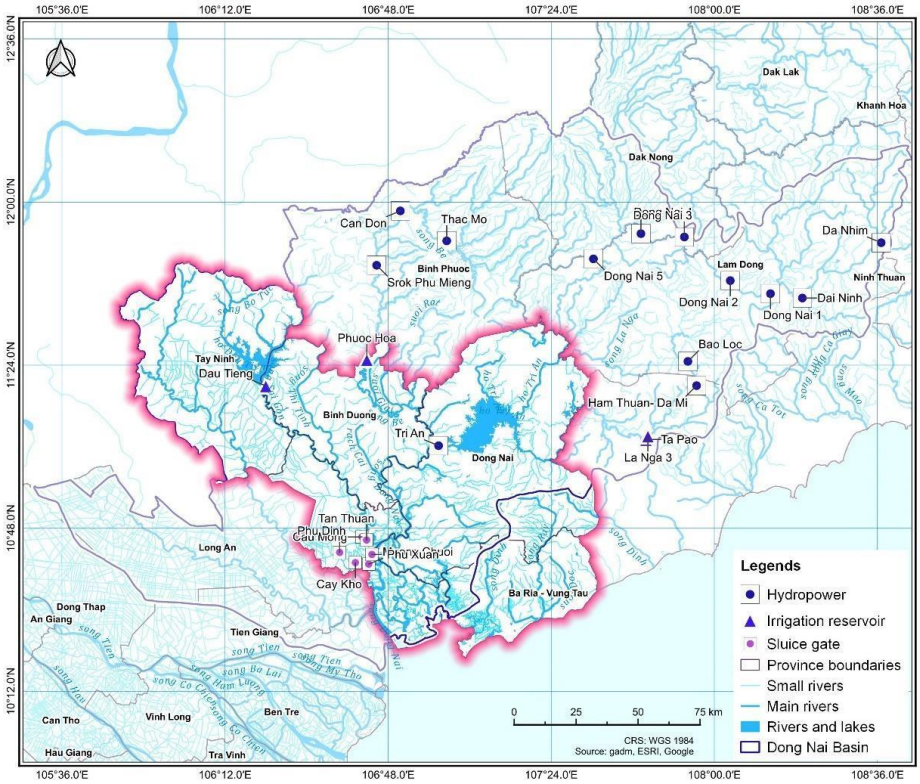

Figure 3-28 Locations of dams for hydropower and irrigation in the Sai Gon- Dong Nai River Basin

3.2.2 Sand mining and its expected impact

While the extent of sand mining research in the Sai Gon-Dong Nai River Basin is limited, the consensus is clear: this activity poses a significant environmental risk to the region. Excessive sand extraction in the Dong Nai River has severely altered the riverbed. This transformation not only modifies the water flow but also leads to extensive riverbank erosion, with large tracts of land collapsing into the river (Vietnam News 2018; Gugliotta et al. 2020). The Lam Đong People's Committee's 2017 report further illustrates the scale of the issue, highlighting that landslides along the Đong Nai riverbanks have impacted over 11.75 hectares in just the Cat Tien District of Lam Dong Province, an area adjacent to Bau Sau Ramsar site and Cat Tien National Park (in Dong Nai Province) (Vietnam News 2018). The Japan International Cooperation Agency (JICA) has also pinpointed sand mining as a critical concern for the region's water environment management (JICA Expert Team 2019)

The implications of these environmental shifts extend far beyond land loss. Biodiversity, particularly within the Cát Tiên district, faces severe threats due to these changing ecosystems. Key habitat areas integral to unique and endangered species are under threat. The altered water flow and sediment distribution patterns may adversely affect the habitats of numerous aquatic species, including fish. The river's modified ecology could impact fish breeding patterns, migration, and overall survival rates. Given the Sai Gon-Dong Nai River Basin's rich biodiversity, any disturbance to its waterways has cascading effects on the intricate web of life it supports, underscoring the pressing need for more comprehensive research and protective measures against unsustainable sand mining practices.

3.2.3 Groundwater extraction and its expected impacts

Various studies have indicated a decline in groundwater levels in the Sai Gon- Dong Nai River Basin since the 1990s, signaling grave concerns for biodiversity and the broader ecosystem (Vuong et al. 2016), Nguyễn et al. 2012, Ngô & Nguyễn 2010). This could be the result of rapid increasing in human population and industrial developments in the catchment. Various cities in this area, such as Ho Chi Minh City, Bien Hoa or Vung Tau, have high populations, which correlate to the high demand of water. Many industrial parks, which also use groundwater for their manufacturing activities, are also located in the area. Amid economic development pressures, the Sai Gon-Dong Nai River Basin has experienced significant alterations in groundwater dynamics (Long & Koontanakulvong 2020). Groundwater pumping surged from 175,000 m³/day in 1995 to 850,000 m³/day in 2017 (Long & Koontanakulvong 2020). This

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intensification disrupted river-groundwater interactions, reducing groundwater discharge to the river upstream, while amplifying Saigon River recharge downstream. The aquifer system has adjusted by releasing less water to the Saigon River to compensate for the increased groundwater abstraction (Long & Koontanakulvong 2020). Further complicating matters, urbanization in Ho Chi Minh City (followed by many other areas in the basin) has substantially reduced groundwater levels, with rapid construction hindering natural groundwater recharge. Changes in built-up areas in the city have directly impacted on this recharge process (Adhikari et al. 2020). Moreover, groundwater quality has been compromised with issues like salinization, acidity, and contamination (Ha et al. 2019). Overall, studies indicate a stark decline in groundwater levels in the Sai Gon River Basin since the 1990s, signaling grave concerns for biodiversity and the broader ecosystem.

The accelerated groundwater extraction in the Sai Gon-Dong Nai River Basin poses severe threats to the region's biodiversity and ecosystem health. As groundwater levels diminish, wetlands and freshwater habitats, crucial for numerous species, can dry up. These habitats serve as breeding grounds, food sources, and refuge for many aquatic species, including fish, amphibians, and invertebrates. A decline in these habitats can lead to a decrease in species populations or even local extinctions. A great example of this issue is the case of Bau Nham Lake (10.546083 Latitude, 107.489794 Longitude) in Binh Chau-Phuoc Buu Nature Reserve (Ba Ria- Vung Tau Province). The increasement of ground water extractions in the reserve's vicinity was identified as the cause of Bau Nham Lake dry up (CBES data based on interview with the reserve's staff).

Commented [20]: Could you identify the coordinates of this problem is on the ground

Commented [21R20]: We cannot identify all areas that have this problem. But we can provide a few examples with coordinates. Please check the text for the example

Furthermore, changes in groundwater-river interactions can destabilize riverbanks and associated riparian habitats, which are vital for many terrestrial and aquatic species. Riparian zones, often characterized by unique plant species adapted to fluctuating water levels, can be disrupted. With groundwater levels dropping, these plants may struggle to access the water they need, leading to habitat degradation. Various examples of this phenomenon can be observed along the Dong Nai River segment running through Cat Tien National Park (e.g. 11.364293496915941 latitude, 107.36075841969699 longitude).

Commented [22]: Could you identify the coordinates of this problem is on the ground

Commented [23R22]: We provided some example

The groundwater quality issues—like salinization and contamination—further compound these ecological challenges. Saline groundwater can infiltrate freshwater systems, rendering them inhospitable for many freshwater species. Acidic and contaminated groundwater can harm aquatic life and propagate through the food chain, impacting larger predators and even humans.

Moreover, groundwater plays a significant role in sustaining the health of forests in the basin. As groundwater levels drop, tree species that depend on these underground reserves during dry periods can experience stress, potentially leading to reduced growth rates, increased susceptibility to diseases, or even large-scale die-offs.

Overall, while the direct consequences of groundwater extraction might seem limited to water levels and quality, the ripple effects on the Sai Gon-Dong Nai River Basin's biodiversity and ecosystem are profound and far-reaching. Immediate action is necessary to prevent irreversible damage to this critical ecosystem.

3.2.4 Land conversion and habitats loss/degradation

Various studies point out that between 1995 and 2020, the Sai Gon- Dong Nai River Basin underwent significant alterations in landscape patterns. There was a pronounced increase in fragmentation and dispersion of natural and semi-natural habitat in this area(Bui & Mucsi 2022) (also see Figure 3-29). Bui & Mucsi (2022) highlight that these changes posed threats to ecological health and sustainable development goals. Truong et al. (2018b) observed a substantial reduction in forest cover from 1994 to 2005 in the upstream area of the basin. This change attributable to population growth and consequent land conversion for agriculture (Truong et al. 2018b). The deforestation in the upstream area accelerated water flow in the Dong Nai River Basin, potentially lead to erosions and localized flooding along the downstream of river. In the lower part of the basin (e.g. Ho Chi Minh City, Binh Duong, Tay Ninh), land conversion lean toward urbanization of agricultural land. This trend towards urbanization is associated with rising temperatures (Le et al. 2021d) and reduced groundwater levels (Luong 2020; Adhikari et al. 2020).

The rampant land conversion observed between 1995 and 2020 in the study area has profound implications for biodiversity and ecosystem health. A primary consequence of this transformation is habitat loss and degradation, which stands as a paramount threat to native species. As forests diminish, replaced by urban or agricultural landscapes, many species face shrinking habitats, leading to a decline in populations and even extinctions.

Commented [24]: Is that possible to visualize the changes of land use between 1995 to 2020?

Commented [25R24]: From the government official sources,we could only acquired data from 2017 to 2020 (visualized in section 3.1.2). For the unofficial source like European Space Agency (ESA) global land cover product only have data up to 2015 for this area. We add that map here, but please note that data from ESA is not considered "official" by Vietnamese government.

Commented [26]: Are there any regulations by the authorities? If you have identified any kinds of "urban development masterplans", please note the environmental challenges

Commented [27R26]: For the whole river basin, there is no unified regulation. However, different provinces have their own master plan. Also, there are master plan for the southeastern region (Binh Duong, Binh Phuoc, Tay Ninh, Dong Nai, Ba Ria Vung Tau, Ho Chi Minh City) during 2021-2030, which aim toward more industrial parks in the area. In those plans, the environmental challenges are very generic

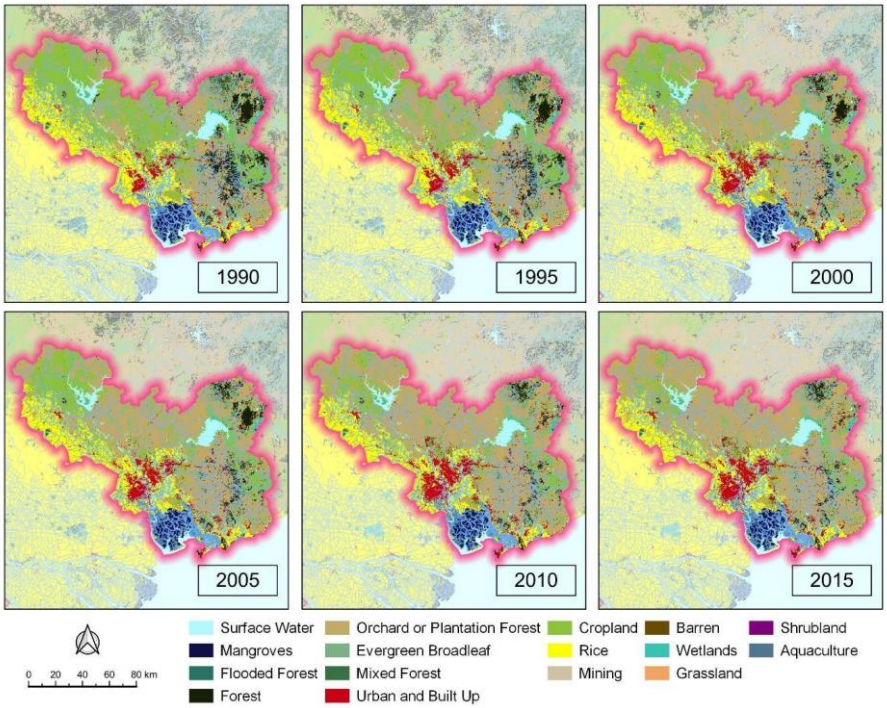

Figure 3-29 Land-use changes from 1990 to 2015 in the Sai Gon- Dong Nai river basin

Source: ESA World Cover at 10m resolution

Fragmentation of natural and semi-natural landscapes disrupts ecological continuity. When habitats are fragmented, wildlife populations can become isolated, leading to reduced genetic diversity and increased vulnerability to threats. These isolated pockets may not be large enough to support viable populations of certain species, resulting in local extinctions.

Furthermore, the degradation of these landscapes alters essential ecosystem functions. Forests, for instance, act as carbon sinks, regulate local climates, and ensure water cycle stability. Their reduction impacts these functions, exacerbating climate change and altering hydrological patterns. The rise in water flow in the Dong Nai River Basin post-deforestation, as observed by Truong et al. (2018b), is a testament to these hydrological shifts.

Changes in land-use patterns also influence soil health. The conversion of forested lands to agriculture often results in soil erosion, loss of essential nutrients, and a decline in soil

biodiversity. This can further result in reduced agricultural yields over time and an increase in vulnerability to pests and diseases.

Moreover, the increased urbanization and the accompanying rise in temperatures, as noted by Le et al. (2021d), create urban heat islands. These can affect local flora and fauna, causing shifts in species distributions and behaviors.

In essence, widespread land conversion, driven largely by socio-economic imperatives, poses severe challenges to biodiversity and ecosystems in the Sai Gon- Dong Nai River Basin. The degradation and loss of habitats stand out as urgent concerns, highlighting the crucial need for more sustainable land management and conservation efforts.

3.2.5 Climate change

Various studies have been conducted to predict the impacts of climate change on the Sai Gon-Dong Nai River Basin. The downstream areas of the basin that lie below sea level faces increasing vulnerability to the impacts of climate change (Tran 2011a). Notably, recent studies have shown a rising sea level in the downstream regions, leading to frequent flooding of cities, particularly Ho Chi Minh city, during flow tides, thus posing significant challenges to socio-economic development (Tran 2011a). Modelling attempts predicted that the Dong Nai River basin will suffer from higher and faster floods during 2020 to 2100 due to climate change (Tran 2011a). Climate change aggravates this by enhancing river discharge through heavy rainfall, leading to broader and deeper inundation zones (Tran 2011a).

Corderi (2011) and Nguyen et al. (2016b) both predicted that climate change will significantly amplify saltwater instruction in the downstream of the basin. Coastal area such as Ho Chi Minh City (Can Gio District) and Ba Ria- Vung Tau area will be most likely to suffer from broader and deeper saltwater instruction in the future. This is the combine effects of sea water raising and the abundance of dams along the Dong Nai River reduced river flows. The increase in salinity levels is predicted to affect agriculture in the basin's downstream areas (Corderi 2011).

Vu et al. (2019) predicted that climate change will also cause reduction in ground water level in the basin region, as it redistribute the rainfall and change water run-off pattern (Vu et al. 2019). The impacts will be most visible in coastal area like Ba Ria- Vung Tau and some parts of Ho Chi Minh City.

The impacts of climate change on the biodiversity and ecosystem of the Sai Gon-Dong Nai River Basin are multi-faceted and far-reaching. Available information suggested that climate change may lead to the following effects:

- Habitat Loss and Degradation: The primary and most pressing concern is habitat loss and degradation. With the increasing occurrences of swift floods, localised flooding in low areas, and prolonged droughts, many terrestrial and aquatic habitats are being disrupted. Such disturbances can lead to:

- Wetland Reduction: Wetlands, which serve as breeding grounds for many aquatic species and are biodiversity hotspots, face contraction or even extinction. As these wetlands recede, the species dependent on them either migrate or face extinction.

- Forest Degradation: The fluctuating water levels, combined with increased temperatures, can stress many plant species in the region's forests. Over time, this can lead to a shift in forest composition, with some trees and plants being replaced by others more tolerant to these new conditions. Such shifts can have cascading effects on the fauna that depend on specific plant species for food and shelter.

- Loss of Aquatic Habitats: The rise in salinity, particularly in the delta region, can make waters uninhabitable for many freshwater species. This salinization can lead to a decline in fish species diversity and abundance, affecting the livelihoods of local fishing communities and the food chain.

- Species Migration and Displacement: As habitats degrade or become inhospitable, many species might attempt to migrate to more favorable conditions. However, not all species have the mobility or adaptability to do so. Those that can't migrate face severe population declines or even extinction.

- Alteration of Ecological Relationships: The changing conditions might break existing ecological relationships. For instance, certain plants and their pollinators might get out of sync if one responds to climate changes differently from the other. Such mismatches can lead to reduced reproduction of the involved species.

- Invasion of Alien Species: As native species face challenges, invasive or alien species, which might be more tolerant to the changing conditions, can establish themselves in the region. These species can outcompete, prey on, or bring diseases affecting native species, further reducing biodiversity.

- Loss of Ecosystem Services: Biodiversity is a key contributor to ecosystem services – the benefits that humans derive from ecosystems. With the degradation of biodiversity in the Sai Gon-Dong Nai River Basin, services like clean water, flood control, and fishery resources might get diminished, impacting human well-being.

In conclusion, the Sai Gon-Dong Nai River Basin, already a sensitive ecological zone, is facing amplified threats due to climate change. The loss and degradation of habitats stand out as a central issue, with ramifications not just for the region's biodiversity but also for the human populations that depend on these ecosystems. Proactive conservation strategies, habitat restoration, and sustainable development practices are crucial for mitigating these impacts.

3.2.6 Water flows shifting

Recent research has brought to light concerning trends in the Dong Nai River system. Multiple studies, including those conducted by Dao et al. (2022), Pham (2021), Nguyen et al. (2021c) and Tran & Tran (2011b), have provided substantial evidence that the Dong Nai River's annual flow rate has seen a marked decline. Several factors appear to be at play, significantly shaping the river's flow patterns.

Primarily, climate change has introduced unpredictable variables to the region, making flow rates in the river system erratic. Moreover, human interventions, such as the construction of dams, have exacerbated the irregularities in water flow. As a result, the Dong Nai River now exhibits extreme fluctuations. During the wet season, the river experiences surges in water discharge, potentially leading to sudden and devastating flash floods. In contrast, the dry season sees the basin's water dry up rapidly. Furthermore, the majority of water reservoirs in the vicinity tend to retain water during the dry season, which further exacerbates the reduction in the overall water flow within the river system. This combination of natural and human-induced factors has made the river's flow patterns not only hard to predict but also a matter of growing environmental concern.

The shifting water flows in the Dong Nai River will impact biodiversity, particularly concerning wetland ecosystems and fish populations. Wetlands, often hailed as biodiversity hotspots, play a pivotal role in offering a habitat for a wide range of species, acting as breeding grounds, and providing essential nutrients for both terrestrial and aquatic ecosystems. The irregularities in water flow can lead to a reduction in wetland areas or, conversely, prolonged inundation, both

of which can alter the natural balance of these ecosystems. Reduced wetland areas might result in the loss of habitat for numerous species. Fishes will be the most vulnerable group to the water flow shifting in the Dong Nai River. Many fish species, especially those that are adapted to specific flow regimes for spawning, migration, and accessing feeding grounds, will be directly impacted. Shifting water flows can disrupt these life cycle events, leading to decreased fish populations due to unsuccessful reproduction and limited food accessibility. Furthermore, the unpredictability of the water flows can lead to a mismatch between fish behaviors and their environment, potentially resulting in the decline or even extinction of certain sensitive species. In the long run, these shifts in aquatic biodiversity can reverberate up the food chain, affecting predators and, ultimately, human communities that rely on the river for sustenance and livelihood.

3.2.7 The effect of dike construction

The literature review found no papers that directly study the effect of dikes construction on the Sai Gon- Dong Nai River Basin. Nonetheless, drawing from related studies and understanding of river dynamics, we can make informed assumptions about the possible repercussions of such activities. Overall, dike constructions in the region were mainly for preventing erosion, controlling floods and irrigating agricultural lands. As a result, dikes will inadvertently disrupt the natural flow regimes and sediment transport of rivers. This alteration can lead to the fragmentation of aquatic habitats, making it challenging for aquatic species, especially migratory fish, to access their breeding or feeding grounds. The change in water flow can also lead to a shift in the composition of aquatic plants and reduce wetland areas, which are critical habitats for numerous species, including birds, amphibians, and invertebrates. The reduction in sediment transport downstream can also impact the replenishment of nutrients in floodplain areas, affecting soil quality and subsequently, the vegetation that relies on these nutrients. Furthermore, dikes can impede the natural inundation patterns of the floodplains, which are essential for certain wetland plant species' lifecycle events. Overall, while dikes may offer immediate socio-economic benefits, their long-term impact on biodiversity in the Sai Gon-Dong Nai River basin can be profound and requires careful consideration and management.

Commented [28]: - Do you have any cases that the dikes are broken or the flooding water overflowed from dikes in recent years?
- Historically, in Japan, levees/dikes have been built to prevent rivers from overflowing, and flood control has been attempt to control within the river areas. In recent years, however, the needs of Nature-based flood management, such like installing wider channels to allow meandering, or allowing flooding in specific areas such like anti-flood ponds. In this context, what is the flood control philosophy of this river or this country, and are there any movements regarding NbS?

Commented [29R28]: We added some example cases in the text.

In Vietnam and in the Dong Nai river basin, there is no unified philosophy for flood managing. Different authorities (e.g. districts or provincials People Committee) do what they see fit for their managed areas. Overall, they use dikes and dam to contain the flood. In some occasion, the dikes and dams redirect flood water into agricultural land for rice farming.

Figure 3-30 Broken dike along Dong Nai River bank

Source and photo: Phuoc Tuan- VNExpress (https://vnexpress.net/bo-ke-song-dong-nai-bi-sat-lo-khi-moi-dua-vao-su-dung-3792378.html)

3.2.8 Related human rights issues

Commented [30]: Please describe any human rights risks that may arise in conservation activities or NbS practices.

Commented [31R30]: Information added

Given the multiple threats facing the Sai Gon-Dong Nai River Basin, from impacts of climate change to fluctuating water flows and dike construction, a range of human rights concerns could manifest in the region:

- Right to Water and Sanitation: Disruptions in natural water flow can lead to water scarcity, affecting residents' access to clean and potable water, with associated health risks. Microplastic in the water is among various long-lasting pollutions occurred in basin (Huynh et al. 2022).
- Right to Food and food security: Changes in water availability, salinity intrusion, and unpredictable floods can hamper agricultural yields, threatening local food security.
- Right to Livelihood: Fishermen and farmers may face economic hardship due to declining fish populations and reduced agricultural yields, impacting their right to work and an adequate standard of living.

- Human-Wildlife Conflict and Safety: As habitats degrade and natural food sources dwindle, wildlife may encroach upon human settlements in search of food and shelter. This can lead to dangerous confrontations between humans and animals. Livestock predation and crop raiding by wildlife can exacerbate food insecurity and economic losses for local communities. Moreover, such conflicts can result in retaliatory actions against wildlife, further threatening biodiversity. This issue was most highlight in the case of elephant-human conflict in Dong Nai Nature and Culture Reserve and Cat Tien National Park (Mowbray 2022; Nguyen et al. 2022d; Humane Society International 2023)

- Right to Health: Reduced access to fresh water can lead to health issues, including water-borne diseases. Flooding could also foster environments conducive to disease vectors, raising health risks.

- Displacement and Right to Adequate Housing: Severe flooding or habitat degradation might force local populations to relocate, challenging their right to adequate housing (Le 2016).

- Rights of Indigenous Peoples and Minority Groups: Indigenous or minority communities could see their traditional way of life and spiritual practices tied to the river disrupted (Pham 2015). The concerned indigenous group in the focused area of the Sai Gon- Dong Nai River Basin include S'tiêng, M'nông, Mạ, Chơro, K'ho, Khmer, Tà Mun.

- Right to Information: Residents have a right to be informed about environmental risks and measures they can take for mitigation.

- Right to Participate in Decision-making: Infrastructure projects or policies affecting the river basin should involve local communities, ensuring their voices are considered.

Given the socio-economical context of the Dong Nai river basin area, issues related to Right to Livelihood, Human-Wildlife Conflict and Safety, Rights of Indigenous Peoples and Minority Groups and Right to Participate in Decision-making may arise in conservation activities or Nature-based solution practices. Addressing these potential human rights issues requires a holistic, participatory approach, where local communities are central to decision-making. Proactive measures, including strategies to mitigate human-wildlife conflict, are essential to protect both human rights and biodiversity.

PART 4 VIETNAMESE MEKONG DELTA

4.1 GENERAL INFORMATION

4.1.1 Geography, hydrology, and demographics

4.1.1.1 Geography

The Mekong River Delta, also known as the Vienam Mekong Delta (VNM), is the southernmost region of Vietnam, located to the east of Cambodia. It covers a total area of 40,922.6 km² (General Statistics Office 2022). It consists of one centrally governed city (Can Tho) and twelve provinces namely Long An, Tien Giang, Ben Tre, Vinh Long, Tra Vinh, Hau Giang, Soc Trang, Dong Thap, An Giang, Kien Giang, Bac Lieu, and Ca Mau (General Statistics Office 2022) (see Figure 4.1).

The geography of the Mekong Delta is dominated by the Mekong River, which flows through the region, splitting into various distributaries and forming a dense network of waterways (see Figure 4.2). This intricate water system plays a pivotal role in the region's agricultural activities and transportation. This region is known for its fertile land and is the most densely populated area in Vietnam.

The Mekong Delta are generally flatted as it was formed by the sediment deposition of Mekong River. Therefore, except for some scattered limestone hills in the western part of the delta, the area does not have any tall mountains. The average elevation of the regions is approximately 2m asl (General Statistics Office 2022) (see Figure 4.3). In the context of climate change, rising sea levels pose a significant risk of inundation and saltwater intrusion to a large part of the Mekong Delta due to its low-lying terrain (Eslami et al. 2021)

Even through, the delta area has characteristics of three distinctive ecoregions, namely the Tonle Sap-Mekong Peat Swamp Forest, Tonle Sap Freshwater Swamp Forest and Indochinese Mangrove (Figure 4-3) (Wikaramanayake 2023e, 2023f, 2023b). The delta is also home to numerous swamps, wetlands, and mangrove forests along its extensive coastline. Those habitats are known for high aquatic biodiversity and enormous ecosystem services that had been enjoyed by local communities throughout the history of the area (Chapman & Darby 2016; Minderhoud et al. 2018; Liu et al. 2020; Berchoux et al. 2023).

Figure 4-1 Administrative boundaries of provinces in Vietnam Mekong Delta

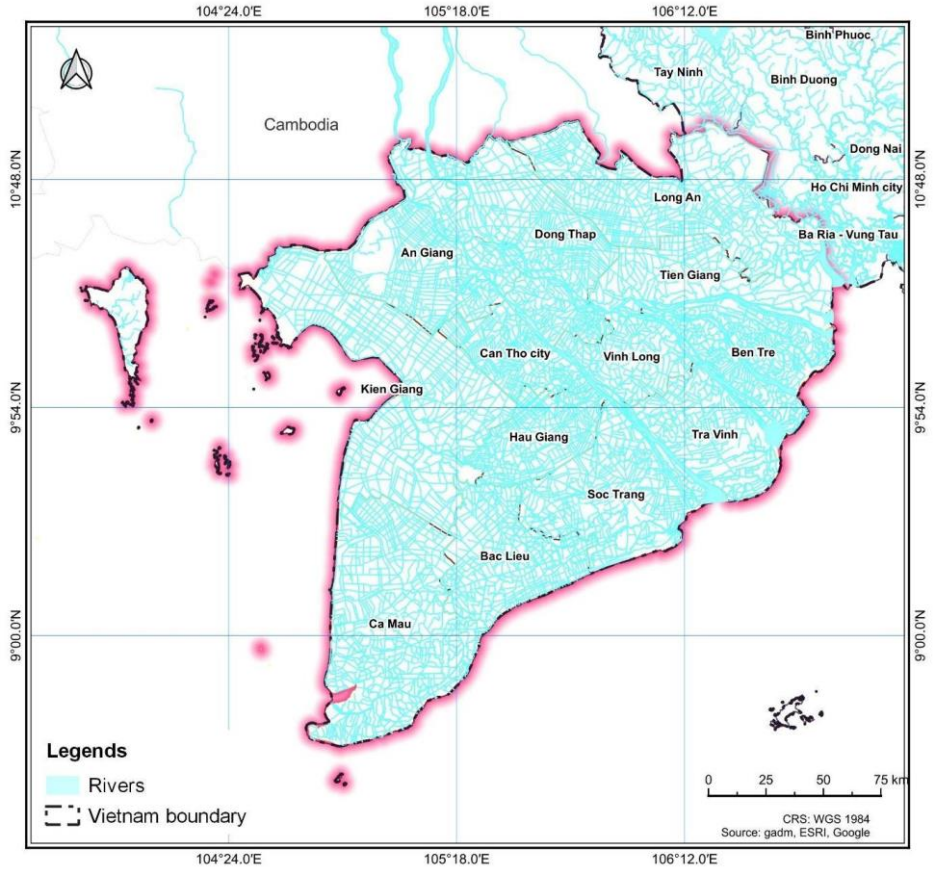

Figure 4-2 River network in Mekong Delta

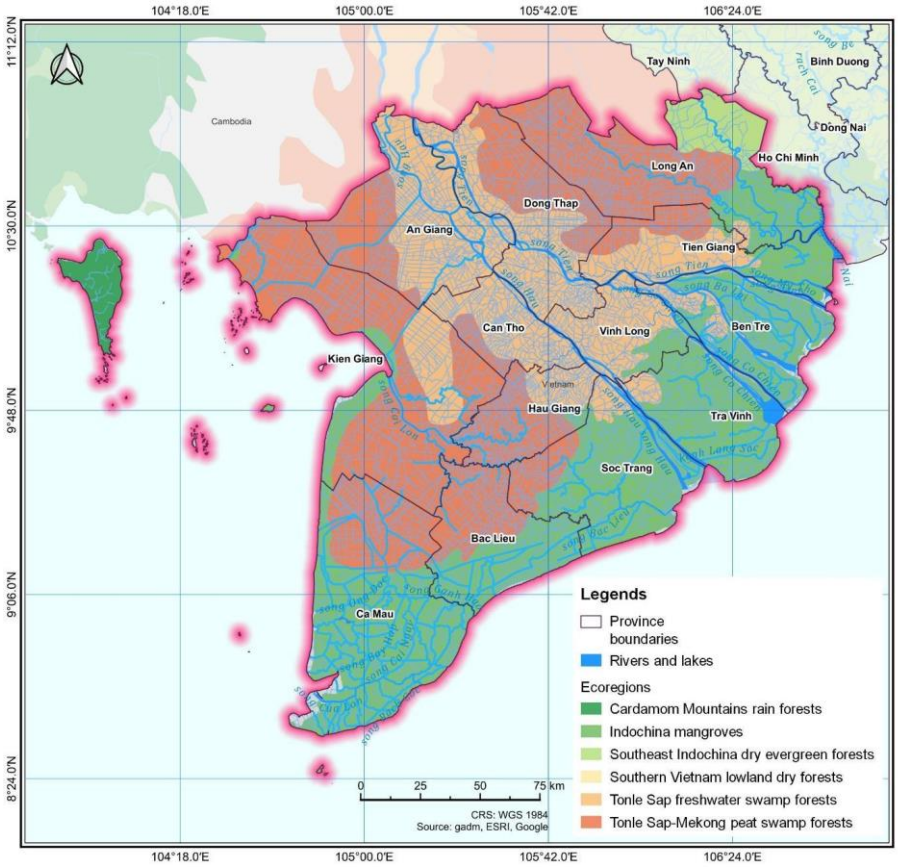

Figure 4-3 **Ecoregions in the Vietnamese Mekong Delta**

Commented [32]: Is that possible to overlay the river network layer and this ecoregions layer?

Commented [33R32]: Yes. Map updated

4.1.1.2 Hydrology

The Mekong River, ranking as the world's 12th longest river, boasts an intricate hydrological system marked by notable inter- and intra-annual fluctuations. The ebb and flow of the Mekong Delta are inextricably tied to the monsoon rains. A significant portion of the river's annual flow originates from tributaries in the Lower Mekong River Basin, with the upstream flow contributing a lesser amount. Nonetheless, the significance of the upstream flow is profound—snowmelt from China during the dry season accounts for over 24% of the river's total annual flow (Mekong River Commission 2023)

In our study region, the Vietnamese Mekong Delta, the hydrology exhibits two prominent seasons: flooding season and dry/drought season (Hung et al. 2012). The flooding season spans May to October, characterized by vigorous water currents and augmented water volume (Shrestha et al. 2016; Thanh et al. 2020; Mekong River Commission 2023). This period promotes the transport of vital sediments and nutrients downstream, enriching the fertile terrain. In contrast, the dry season, extending from November to April, sees diminishing water levels (Unverricht et al. 2013; Shrestha et al. 2016; Vasilopoulos et al. 2021).

Inland provinces like Long An, Dong Thap, An Giang, Can Tho, Vinh Long, and Hau Giang have their hydrological rhythms primarily shaped by the monsoon. Meanwhile, coastal regions of the Mekong Delta, including Tien Giang, Ben Tre, Tra Vinh, Soc Trang, Bac Lieu, Ca Mau, and Kien Giang, experience hydrological patterns influenced both by the monsoon and semi-diurnal tides (Eslami et al. 2021; Loc et al. 2021). In these coastal areas, saltwater intrusion can penetrate far inland, with a record reach of 70km from the sea. To combat this phenomenon, a large number of sluice gates and drainage systems have been built along the coastline of the Mekong Delta and along the banks of its major rivers (Figure 4-4). Those structures have been alternating the hydrological characteristics of the delta.

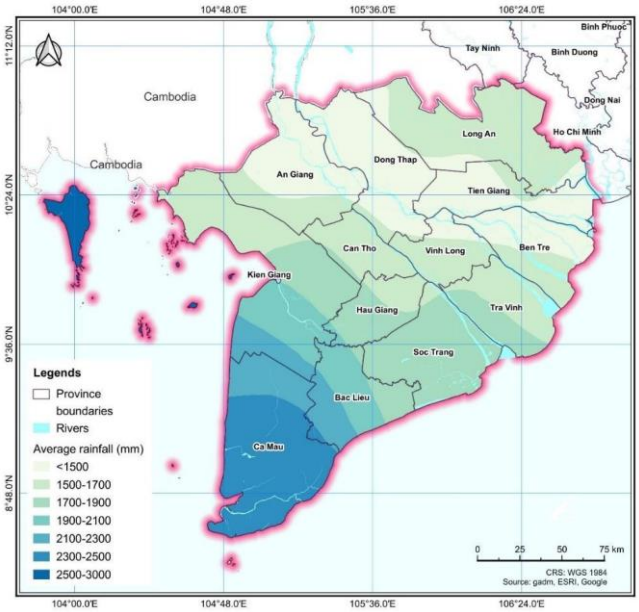

Figure 4-4 Average rainfall in the Mekong Delta

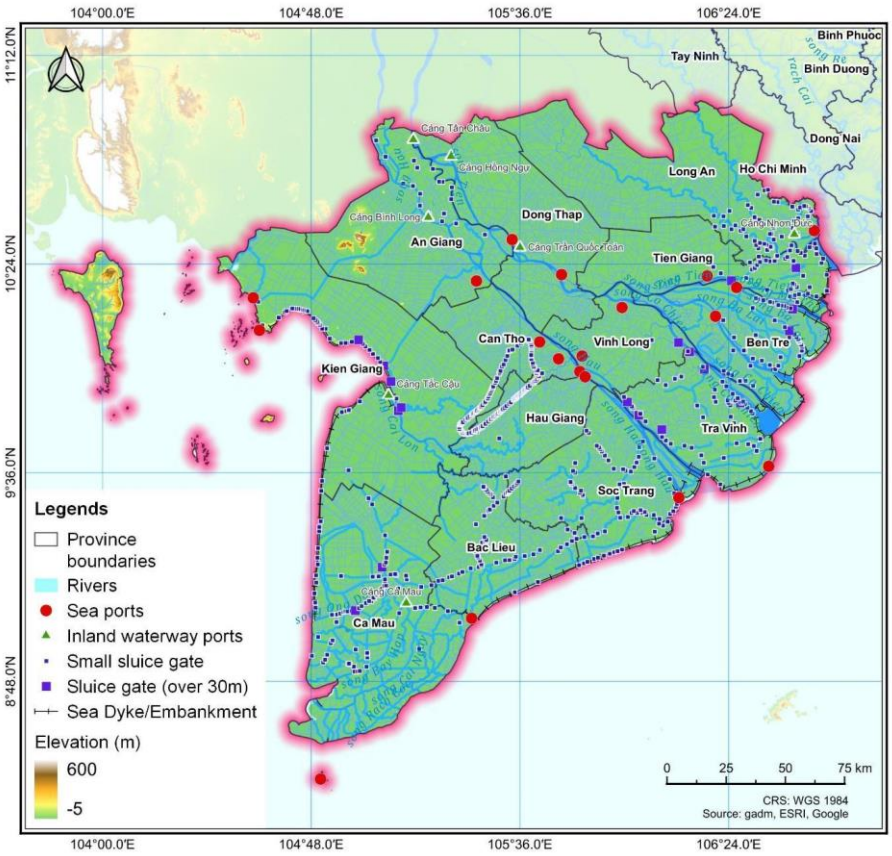

Figure 4-5 Rivers and man-made cannels networks in the Mekong Delta

Commented [34]: Is it possible to overlay the land elevation and this layer?
Is the water outside the sluice gate brackish or seawater? Are there any species depends on the brackish water outside the sluicegate?

Commented [35R34]: Yes, map updated.

The salinity of water outside the sluice gates depend on tide. It can be brackish or very salty, depending on the time.

Yes, there are many fish species that migrate between freshwater and seawater environments. They will be affected by the sluice gats. Please preferred to the fish section below for more detail.

4.1.1.3 Demographic

The total population of the Vietnamese Mekong Delta is approximately 17.431 million people (General Statistics Office 2022). This population is distributed unevenly in the delta (Figure 4-6). An Giang province has the highest population size (approximately 1.9 million people). On the other side of the spectrum, Hau Giang province has the smallest population, with around 733,000 people. Kien Giang, Long An and Tien Giang also have a notably high population. Most people concentrate in the upper part of the delta (An Giang, Long An, Tien Giang, Kien Giang), where the average density may surpassing the 1,300 persons/km² threshold.

Commented [36]: Please add a table of historical dynamics and prediction of the population?

Commented [37R36]: We only have data for the 2022. The data provided by the General Statistic Office are for each province, and we had to do some calculation to have the number presented here.

For the table of historical dynamics and prediction of the population, I don't think we have the correct data to do that.

Contrastingly, four lower coastal provinces Ca Mau, Soc Trang, Bac Lieu, Tra Vinh have lower densities, pointing towards less urbanization.

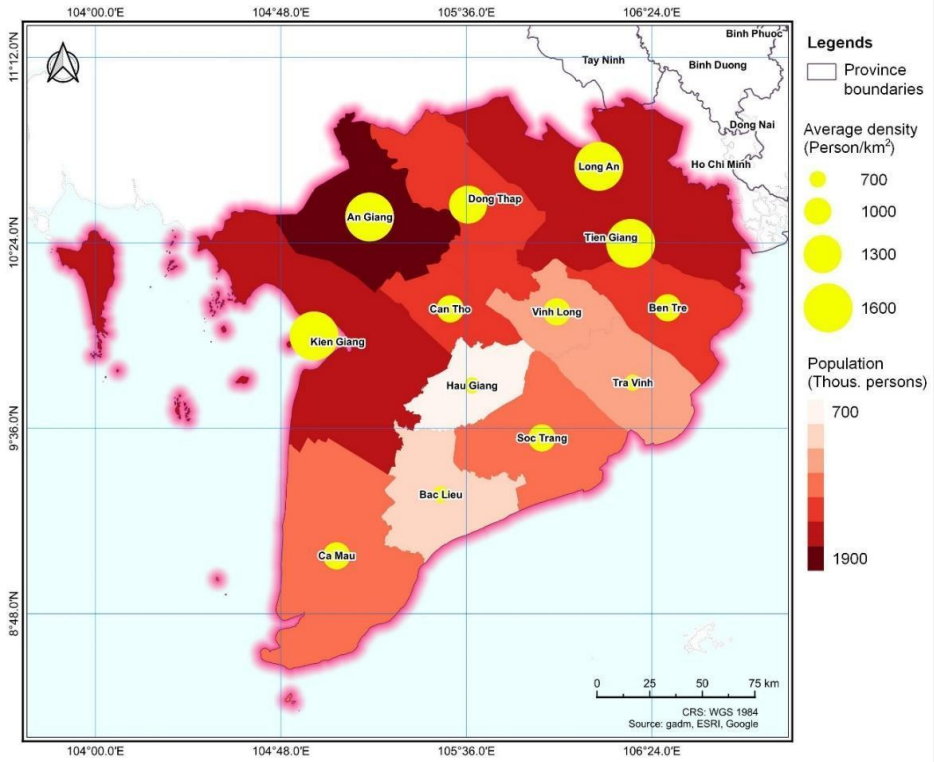

Figure 4-6 Population and average density in Vietnam Mekong Delta

Note: data was calculated from Statistical Yearbook 2022

The Vietnamese Mekong Delta showcases a balance in age demographic. Overall, the population is almost evenly split between working age (which includes those who are above 15 years of age and below retirement age of 60) and non-working age individuals, with 7,953,494 and 9,477,962 people, respectively (Figure 4-7). This demographic suggests a region bustling with potential workforce participants, contributing significantly to the region's socio-economic activities. On the other hand, there's also a considerable segment of the population that belongs to the non-working age category. This segment consists of both the younger generation, likely to enter the workforce in the future, and the older population, many of whom might have retired. The near balance between these two major age groups paints a

picture of a region that has both experience and youthfulness, offering a blend of stability and potential for growth.

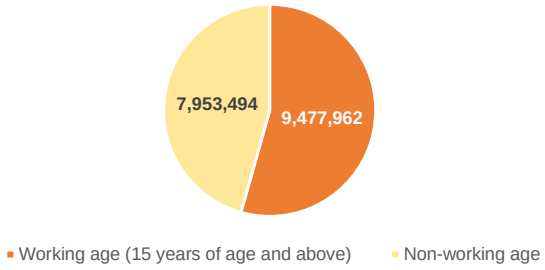

Figure 4-7 Age group in the Vietnamese Mekong Delta

Note: data was calculated from Statistical Yearbook 2022

The age distribution across various provinces in the Mekong Delta varies, yet a few patterns are discernible (Figure 4-8). In provinces such as Long An, Tien Giang, and Can Tho, there is a pronounced concentration of working-age individuals, reflecting a robust and active labor force in these regions. This concentration could be indicative of economic hubs or areas with a multitude of employment opportunities. On the contrary, regions like Tra Vinh, Soc Trang, and Bac Lieu exhibit a closer parity between the working-age and non-working age populations. Such a balance might suggest a mix of urban and rural settings, where both youth and elderly coexist, benefiting from both vigor and wisdom. Provinces like Dong Thap, An Giang, and Ca Mau showcase their own unique distributions, which may be influenced by a blend of socio-economic factors, cultural preferences, and regional opportunities. Across the board, however, the presence of a strong working-age population throughout the delta underscores its significance as a critical economic region within Vietnam.

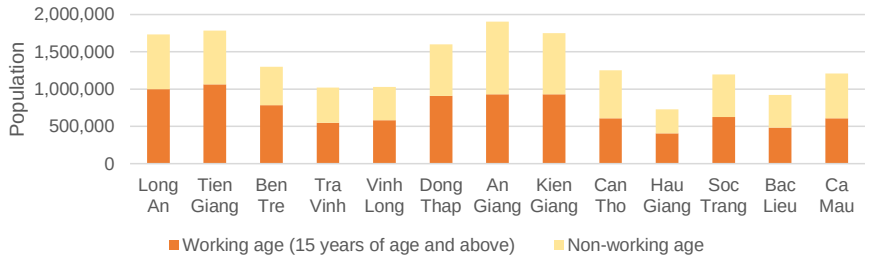

Figure 4-8 Age group by provinces in Vietnamese Mekong Delta

Note: data was calculated from Statistical Yearbook 2022

The Mekong Delta exhibits a distinct leaning towards a predominantly rural population. A broad overview shows that a substantial majority, with over 12.7 million individuals, reside in rural settings, compared to the urban populace of approximately 4.6 million (Figure 4-10). Delving into the provincial data, this rural inclination is consistent across the provinces. For instance, provinces such as Long An, Tien Giang, and Tra Vinh manifest a higher rural population, suggesting vast agricultural landscapes and fewer urbanized centers. Nonetheless, there are regions, like Can Tho, that depict a more balanced distribution, indicating the presence of significant urban areas amidst rural landscapes. Overall, the Mekong Delta's demographic configuration underscores the region's agrarian roots, with urban hubs dispersed amidst a largely rural backdrop.

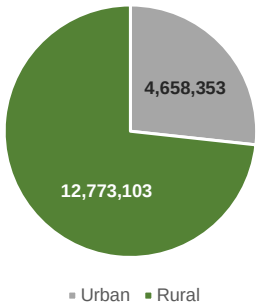

Figure 4-9 Distribution of population between urban and rural in Mekong Delta

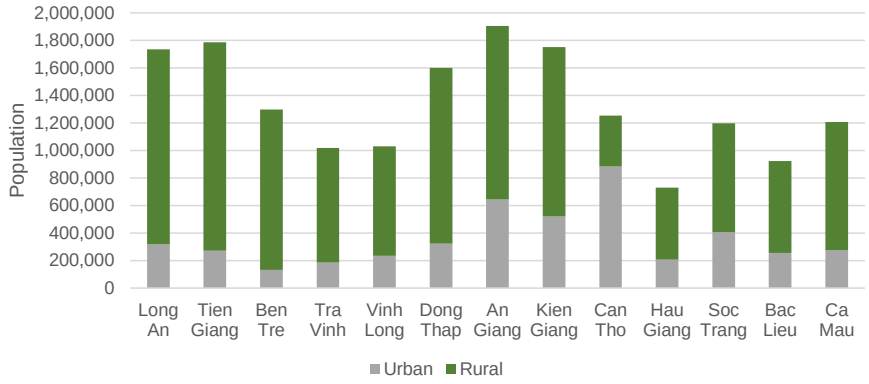

Figure 4-10 Distribution of population between urban and rural in each province in Mekong Delta

4.1.2 Current and projected land use

4.1.2.1 Current land use

The Mekong Delta has total land area of 4092.3 thousand hectares or 40,902km^2 (General Statistics Office of Vietnam 2022). The land use distribution in the Mekong Delta is heavily dominated by agricultural production, accounting for a striking 63.21% (2574.2 thousand hectares) of the total land (Figure 4-11). Aquaculture, another significant land use, covers 12.5% of the area, reflecting the delta's intricate relationship with its water bodies (Figure 4-11). There were only 6.25% of land of Mekong Delta are dedicated to forestry and conservation. Protective forests, crucial for conservation and ecological balance, make up a modest portion of 1.87% the land of the region (Figure 4-11). For a region distinguished by its abundant biodiversity and delicate ecosystems like the Mekong Delta, such conservation effort was minimal. The dominance of agricultural production land and the growing aquaculture sector, while crucial for local economies and food production, do mean that there's been significant transformation and, in some cases, degradation of natural habitats. The limited conservation areas, such as protective and specially used forests, are insufficient to ensure the long-term survival of the delta's unique biodiversity. With only a fraction of land dedicated to conservation, it's challenging to maintain ecological balance, and this might lead to irreversible losses in species and crucial ecosystem services.

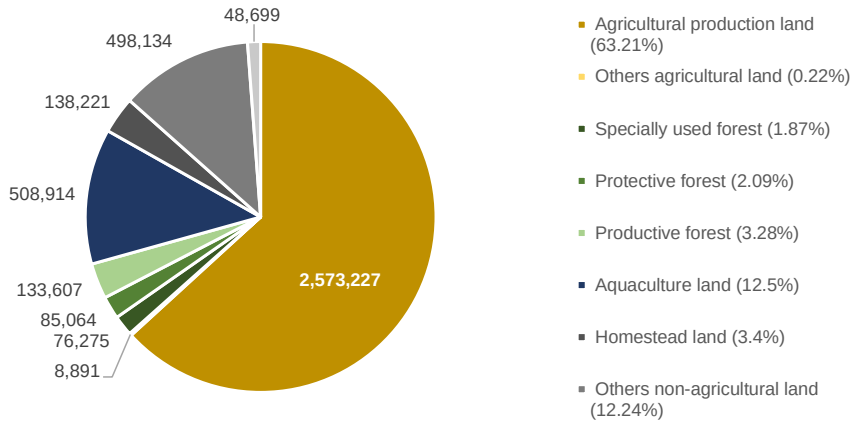

Figure 4-11 Land use statistic for Mekong Delta, year 2022

Note: data was calculated from Statistical Yearbook 2022

Commented [38]: Homestead land means a kind of "urban area"?

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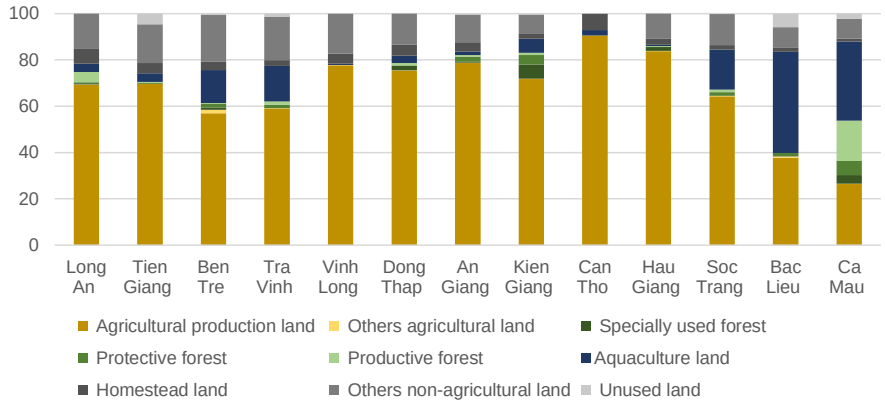

Figure 4-12 Land use in each province in the Mekong Delta, year 2022

Note: data was calculated from Statistical Yearbook 2022

Figure 4-13 Land use in the Vietnamese Mekong Delta in 2020

Note: available at https://quyhoachquocgia.mpi.gov.vn/Pages/default.aspx

Commented [40]: Is it possible to show the historical changes of land use between 1990's to 2020's

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However, there is unofficial source like the ESA World cover data. But for the Mekong Delta, they only have files from 1990 to 2015. Please check the section 4.2.4 below for the land-use change maps from 1990 to 2015

4.1.2.2 Projected land use

According to MONRE data from 2017 to 2021, the land use in the Mekong Delta appears to maintain consistent proportion (Figure 4-14). On the regional scale, there appears to be no notable expansion or reduction in forest areas, which include both protective and productive forests, from 2017 to 2021. However, examining the land use situation in each province shows some localized changes across the area. There has been a distinctive increase in total forest areas, including special-used forest, protective forest, and productive forest in Ca Mau Province. Unfortunately, except for Ca Mau Province, total forest areas were reduced in all other 12 provinces of the Mekong Delta. On the other hand, the total areas used for aquaculture was reduced in Ca Mau Province but increased in all other 12 provinces of the Mekong Delta.

Looking ahead, the persistent dominance of agricultural production in the Mekong Delta will be most likely. Although there has been oscillation in land use in different provinces in the

delta, the agricultural land still accounted for more than 60% at the regional scale. As most of the agricultural production land in the Mekong Delta have been dedicated for monoculture (e.g. rice farming), this can lead to land degradation. The grooming effects of climate change in the Mekong Delta, which may lead to mass droughts, mass floods and saltwater instruction may potentially shift the land use strategy toward non-agricultural uses in the future (Smajgl et al. 2015; MPI 2022; Vu et al. 2022a, 2022b). The increasing of protective forest like what have been observed in Ca Mau Province may become more popular in the Mekong Delta in the near future when the impact of climate become clearer, or when the trade of carbon credits become more popular in Vietnam.

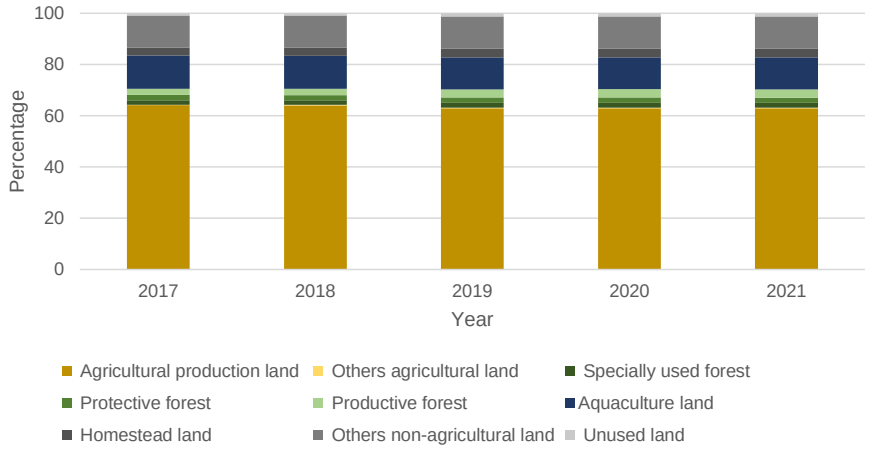

Figure 4-14 Land use proportions from 2017 to 20201 in Mekong Delta

Note: data was calculated from MONRE data

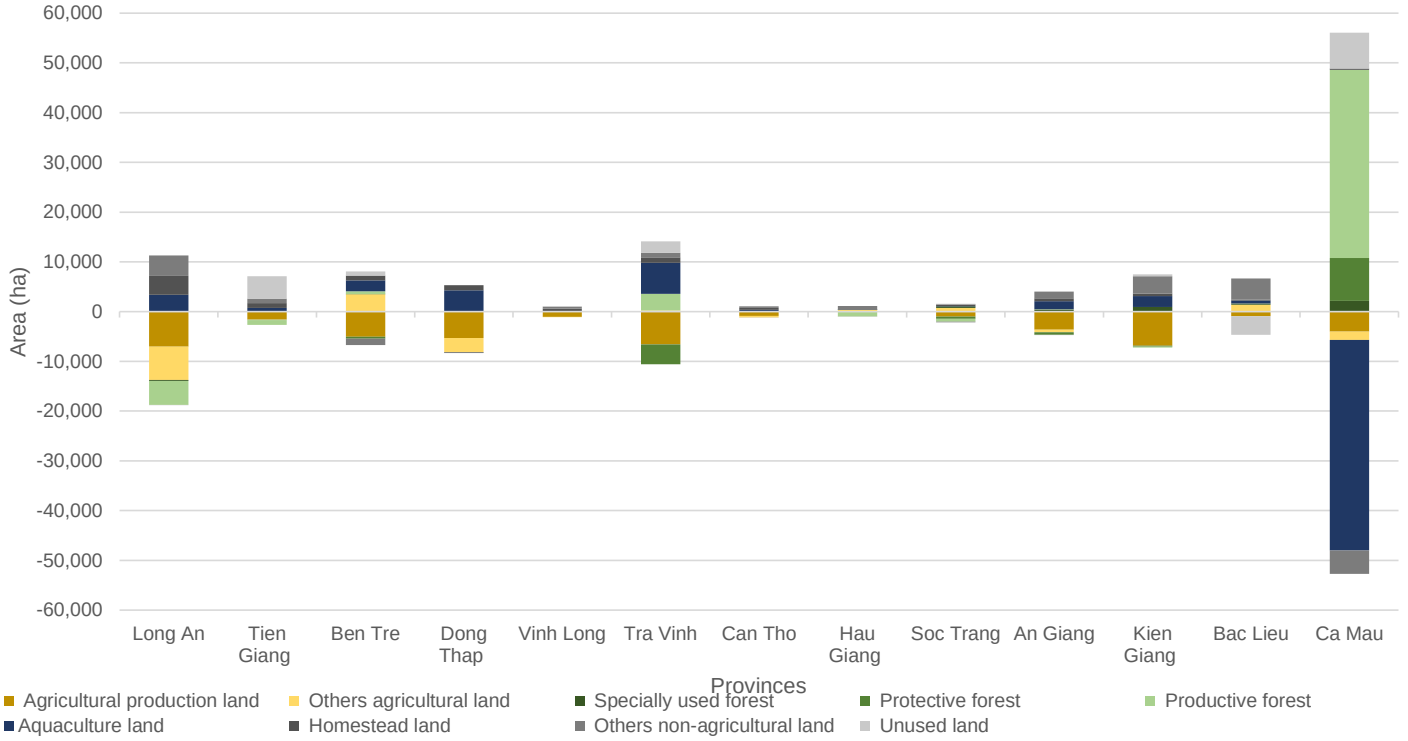

Figure 4-15 Land use changes between 2017 and 2021 in each provinces in Mekong Delta

Note: data was calculated from MONRE data

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4.1.3 Biodiversity

4.1.3.1 Mammals

The Vietnamese Mekong Delta is renowned for its mammalian diversity, much like the Sai Gon - Dong Nai River Basin. The IUCN Red List distribution data highlights that 126 mammal species have overlapping distribution ranges with the Mekong Delta, suggesting potential occurrences in the area. GBIF data, comprising 193 georeferenced historical records from the Mekong Delta, confirms the presence of at least 38 out of the suggested 126 species. Several focused studies and field surveys on mammals have been conducted in the Vietnamese Mekong Delta. A systematic review of the available literature brought to light 18 papers directly relevant to mammalian diversity within this specified region. Appendix 7 provides comprehensive data from both IUCN and GBIF, as well as the literature reviewed. The combined data underscores the rich mammalian diversity of the Mekong Delta. Notably, there are at least 27 mammalian species in the area listed as conservation-concerned by the IUCN Red List 2023 and Vietnamese regulations. These key species are detailed in Table 4-1.

Table 4-1 List of conservation-concerned mammal species in the Mekong Delta

S/N	Species scientific name	English common name	IUCN	VRDB	IUCN Database	GBIF confirmed	Study
1	*Prionailurus viverrinus*	Fishing Cat	**VU**	**EN**	No	Yes	Safford et al. (1998); Hoàng et al. (2008); Nguyễn (2009); Tran (2012); Nguyen et al. (2019a); Hoàng & Nguyễn (2020a)
2	*Aonyx cinereus*	Asian Small-clawed Otter	**VU**	**VU**	Yes	Yes	Safford et al. (1998); Hoàng et al. (2008); Nguyễn (2009); Tran (2012); Tran et al.

S/N	Species scientific name	English common name	IUCN	VRDB	IUCN Database	GBIF confirmed	Study
							(2014); Tran (2015); Willcox et al. (2017); Nguyen et al. (2019a); Hoàng & Nguyễn (2020a)
3	*Arctonyx collaris*	Greater Hog Badger	**VU**	NL	No	Yes	None
4	*Lutra sumatrana*	Hairy-nosed Otter	**EN**	**EN**	No	Yes	Nguyen et al. (2001); Hoàng et al. (2008); Nguyễn (2009); Tran et al. (2014); Tran (2015); Willcox et al. (2017); Hoàng & Nguyễn (2020b)
5	*Lutrogale perspicillata*	Smooth-coated Otter	**VU**	**EN**	No	Yes	(Tran et al. (2014); Willcox et al. (2017); Hoàng & Nguyễn (2020a)
6	*Viverra megaspila*	Large-spotted Civet	**EN**	**VU**	No	Yes	(Hoàng et al. (2008); Nguyễn (2009); Tran (2012); Tran et al. (2014); Hoàng & Nguyễn (2020a)
7	*Rusa unicolor*	Sambar	**VU**	**VU**	No	Yes	Safford et al. (1998); Hoàng & Nguyễn (2020a)
8	*Pteropus lylei*	Lyle's Flying Fox	**VU**	NL	Yes	Yes	(Nguyễn (2009); Nguyen et al. (2010); Vu et al. (2015); Hoàng & Nguyễn (2020a)
9	*Pteropus vampyrus*	Large Flying-fox	**EN**	NL	Yes	Yes	(Nguyễn (2009); Nguyen et al. (2010); Tran (2012); Vu et

S/N	Species scientific name	English common name	IUCN	VRDB	IUCN Database	GBIF confirmed	Study
							al. (2015); Hoàng & Nguyễn (2020a)
10	*Macaca fascicularis*	Long-tailed Macaque	**EN**	LR	Yes	Yes	Safford et al. (1998); Nguyễn (2009); Tran (2012); Hoàng & Nguyễn (2020a)
11	*Macaca leonina*	Northern Pig-tailed Macaque	**VU**	**VU**	Yes	Yes	
12	*Trachypithecus germaini*	Indochinese Silvered Langur	**EN**	**VU**	Yes	Yes	
13	*Macaca arctoides*	Bear Macaque	**VU**	**VU**	No	No	(Tran (2012); Hoàng & Nguyễn (2020a)
14	*Manis javanica*	Sunda Pangolin	**CR**	**EN**	No	Yes	Safford et al. (1998); Nguyễn (2009); Tran (2012); Willcox et al. (2017); Hoàng & Nguyễn (2020a)
15	*Viverra zibetha*	Large Indian Civet	LC	**VU**	Yes	Yes	Hoàng et al. (2008); Tran (2012)
16	*Cynopterus brachyotis*	Lesser Dog-faced Fruit Bat	LC	**VU**	Yes	Yes	Nguyễn (2009)
17	*Rhinolophus thomasi*	Thomas's Horseshoe Bat	LC	**VU**	No	Yes	None
18	*Ratufa bicolor*	Black Giant Squirrel	NT	**VU**	No	Yes	None

Figure 4-16 Smooth-coated Otter in the Mekong Delta

Photo: CBES

Figure 4-17 Indochinese Silvered Langur in Kien Giang

Photo: CBES

4.1.3.2 Birds

The Vietnam Mekong Delta is celebrated for its rich avifauna. Data from BirdLife International indicated that as many as 319 bird species, spanning 78 Families of 20 Orders, have their distribution range overlapping with the Vietnam Mekong Delta. Echoing this, the GBIF database holds 10,323 historical records, documenting 401 bird species in this region. A comprehensive review identified 26 scholarly articles and reports that specifically address the avian species within the Vietnam Mekong Delta. Detailed data and insights from these sources, Birdlife International, and GBIF are collated in Appendix 8 of this report. Drawing from the gathered information, the avian fauna in this area potentially includes up to 400 species. Most of them were waterbirds that associated with aquatic environment. Notably, 30 of these are flagged as conservation-concerned species in various listings, including the IUCN Red List 2023. Table 4-2 offers a list of these conservation-prioritized species that have been verified to inhabit the Vietnam Mekong Delta.

The BirdLife International has recognized the Vietnamese Mekong Delta as a critical region for avian conservation by designating it with 11 IBAs (BirdLife International 2020, 2023e, 2023f, 2023g, 2023h, 2023i, 2023j, 2023k, 2023l, 2023m, 2023n, 2023o) (Table 4-2). The majority of these IBAs have been identified for their importance in the conservation of freshwater birds. Only three of them are noted for their significance to migratory shorebirds, including the Spoon-billed Sandpiper *Calidris pygmaea* (IUCN: CR) or the Spotted Greenshank *Tringa guttifer* (IUCN: EN). The two mentioned species can be found in the Ariake ecoregion in Kyushu, Japan during their journey southward.

Table 4-2 List of IBAs in the Vietnamese Mekong Delta

S/N	Name	Location	Important for	Challenge
1	U Minh Thuong	Kien Giang Province	Freshwater birds (migratory and non-migratory)	This protected area is facing pressures from Illegal hunting, water management and climate change
2	Tram Chim	Dong Thap Province	Freshwater birds (migratory and non-migratory), especially the Sarus Crane	This protected area is facing pressures from water management and climate change

Commented [44]: Please add information of decreasing driver

Commented [45R44]: Okay. Note that for an important bird area, I would say the conservation challenge the area faced, not decreasing driver as there are no measurable decreasing in their importance.

S/N	Name	Location	Important for	Challenge
3	Lang Sen	Long An Province	Freshwater birds (migratory and non-migratory)	This protected area is facing pressures from Illegal hunting, water management and climate change
4	Bac Lieu	Bac Lieu Priovince	Freshwater birds (migratory and non-migratory)	This protected area is facing pressures from Illegal hunting, water management and climate change
5	Kien Luong	Kien Giang Province	Fresh water birds, especially the Sarus Crane	This protected area is facing pressures from development, especially cement factories located around the area
6	Bai Boi	Ca Mau Province	Migratory shorebird	Climate change
7	Tra Cu	Tra Vinh Province	Freshwater birds (migratory and non-migratory)	Illegal hunting, climate change
8	Chua Hang	Tra Vinh Province	Freshwater birds (migratory and non-migratory)	Illegal hunting, climate change
9	Binh Dai	Ben Tre Province	Migratory shorebird, especially the Spoon-billed Sandpiper	Illegal hunting, climate change
10	Ba Tri	Ben Tre Province	Migratory shorebird, especially the Spoon-billed Sandpiper	Illegal hunting, climate change
11	Ha Tien	Kien Giang Province	The Sarus Crane	This protected area is facing pressures from development, especially cement factories located around the area

Figure 4-18 Spotted Greenshank *Tringa guttifer* in Binh Dai

Photo: CBES

Figure 4-19 Spoon-billed Sandpiper *Calidris pygmaea* in Go Cong, Tien Giang

Photo: CBES

Table 4-3 List of conservation-concerned bird species in the Vietnam Mekong Delta

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Migratory	Studies that provided confirmed records	Known drivers for population decreasing	Recorded or potentially occur in Ariake ecoregion in Kyushu, Japan
1	*Clanga clanga*	Greater Spotted Eagle	VU	EN	No	Full Migrant	Tordoff et al. (2002); Tran et al. (2003); Tran (2011, 2015a); Tran & Barzen (2016); Đỗ (2017); Tran & Matusch (2017)	Habitat loss	No
2	*Icthyophaga humilis*	Lesser Fish-eagle	NT	VU	Yes	Not a Migrant		Habitat loss	No
3	*Icthyophaga ichthyaetus*	Grey-headed Fish-eagle	NT	VU	Yes	Not a Migrant	Tordoff et al. (2002); Nguyễn & Đào (2010); Tran (2015a); Tran & Matusch (2017)	Habitat loss	No
4	*Nettapus coromandelianus*	Cotton Pygmy-goose	LC	EN	Yes	Full Migrant	Buckton et al. (1999); Tordoff et al. (2002); Tran (2011); Đỗ et al. (2013)	Habitat loss, hunting	No
5	*Buceros bicornis*	Great Hornbill	VU	VU	Yes	Not a Migrant		Habitat loss, hunting	No

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Migratory	Studies that provided confirmed records	Known drivers for population decreasing	Recorded or potentially occur in Ariake ecoregion in Kyushu, Japan
6	*Anastomus oscitans*	Asian Openbill	LC	VU	Yes	Not a Migrant	Buckton et al. (1999); Tordoff et al. (2002); Buckton & Safford (2004); Nguyễn & Đào (2010); Tran (2011, 2012, 2015a, 2015b); Nguyễn et al. (2013); Đỗ et al. (2013); Lê et al. (2015); Tran & Barzen (2016); Tran & Matusch (2017); Đỗ (2017); Ngô (2019)	Habitat loss, hunting	No
7	*Ciconia episcopus*	Asian Woollyneck	NT	VU	Yes	Not a Migrant	Buckton et al. (1999); Tran et al. (2000, 2003); Tordoff et al. (2002); Buckton & Safford (2004); Nguyễn & Đào (2010)	Habitat loss, hunting	No
8	*Leptoptilos dubius*	Greater Adjutant	EN	DD	Yes	Full Migrant	Tordoff et al. (2002); Tran (2011, 2015b); Tran &	Habitat loss	No

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Migratory	Studies that provided confirmed records	Known drivers for population decreasing	Recorded or potentially occur in Ariake ecoregion in Kyushu, Japan
							Barzen (2016); Đỗ (2017); Ngô (2019)		
9	*Leptoptilos javanicus*	Lesser Adjutant	VU	VU	Yes	Full Migrant	Buckton et al. (1999); Tordoff et al. (2002); Tran et al. (2003); Buckton & Safford (2004); Nguyễn & Đào (2010); Tran (2011); Đỗ et al. (2013); Tran & Barzen (2016); Tran & Matusch (2017); Đỗ (2017); Ngô (2019); BirdLife International (2023e)	Habitat loss	No
10	*Mycteria leucocephala*	Painted Stork	NT	VU	Yes	Not a Migrant	Buckton et al. (1999); Tordoff et al. (2002, 2002); Tran et al. (2003); Buckton & Safford (2004); Nguyễn & Đào (2010); Tran (2011, 2012, 2015a); Đỗ et al. (2013); Tran & Barzen	Habitat loss, hunting	No

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Migratory	Studies that provided confirmed records	Known drivers for population decreasing	Recorded or potentially occur in Ariake ecoregion in Kyushu, Japan
							(2016); Tran & Matusch (2017); Đỗ (2017); Ngô (2019); BirdLife International (2023e)		
11	*Halcyon pileata*	Black-capped Kingfisher	VU	NL	Yes	Full Migrant	Buckton et al. (1999); Tran et al. (2003); Buckton & Safford (2004); Nguyễn & Đào (2010); Tran (2011), 2012; Đỗ et al. (2013); Lê et al. (2015); Đỗ 2015a)	Habitat loss	No
12	*Saundersilarus saundersi*	Saunders's Gull	VU	VU	Yes	Full Migrant		Habitat loss	Yes
13	*Sterna acuticauda*	Black-bellied Tern	EN	NL	Yes	Not a Migrant		Habitat loss	No
14	*Calidris pygmaea*	Spoon-billed Sandpiper	CR	NL	Yes	Full Migrant	Tordoff et al. (2002); Nguyen et al. (2015, 2023a)	Habitat loss	Yes
15	*Calidris tenuirostris*	Great Knot	EN	NL	Yes	Full Migrant	(Nguyen et al. 2023a)	Habitat loss	Yes

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Migratory	Studies that provided confirmed records	Known drivers for population decreasing	Recorded or potentially occur in Ariake ecoregion in Kyushu, Japan
16	*Numenius madagascariensis*	Far Eastern Curlew	EN	NL	Yes	Full Migrant	Buckton et al. (1999); Tordoff et al. (2002); Tran (2012); Nguyen et al. (2019, 2023a)	Habitat loss	Yes
17	*Tringa guttifer*	Spotted Greenshank	EN	EN	Yes	Full Migrant	Tordoff et al. (2002); Nguyen et al. 2019, 2023a)	Habitat loss	Yes
18	*Pavo muticus*	Green Peafowl	EN	EN	Yes	Not a Migrant			No
19	*Grus antigone*	Sarus Crane	VU	VU	Yes	Full Migrant	Buckton et al. (1999); Tran et al. (2000, 2003); Tordoff et al. (2002); Tran (201), 2015b); Đỗ et al. (2013); Tran & Barzen (2016); Đỗ (2017); BirdLife International (2023i, 2023j, 2023f)	Habitat loss	No
20	*Houbaropsis bengalensis*	Bengal Florican	CR	CR	Yes	Full Migrant	Buckton et al. (1999); Tran et al. (2000, 2003); Tordoff et al. (2002); Tran (2011); Đỗ et al. (2013);	Habitat loss	No

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Migratory	Studies that provided confirmed records	Known drivers for population decreasing	Recorded or potentially occur in Ariake ecoregion in Kyushu, Japan
							Tran & Barzen (2016); Đỗ (2017); BirdLife International (2023j)		
21	*Emberiza aureola*	Yellow-breasted Bunting	CR	NL	Yes	Full Migrant	Buckton et al. (1999); Nguyễn & Đào (2010); Tran (2011, 2015a); Đỗ (2017)	Habitat loss, hunting	No
22	*Egretta eulophotes*	Chinese Egret	VU	VU	Yes	Full Migrant	Buckton et al. (1999); Tordoff et al. (2002); Tran (2011, 2012); Đỗ et al. (2013); Đỗ (2015a, 2017)); Nguyen et al. (2019, 2023a)	Habitat loss, hunting	Yes
23	*Pelecanus philippensis*	Spot-billed Pelican	NT	EN	Yes	Full Migrant	Buckton et al. (1999); Tordoff et al. (2002); Tran et al. (2003); Nguyễn & Đào (2010); Tran (2011, 2015a); Đỗ et al. (2013); Lê et al. (2015); Tran & Matusch (2017); Đỗ	Habitat loss, hunting	No

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Migratory	Studies that provided confirmed records	Known drivers for population decreasing	Recorded or potentially occur in Ariake ecoregion in Kyushu, Japan
							(2017); BirdLife International (2023i)		
24	*Platalea minor*	Black-faced Spoonbill	EN	EN	Yes	Full Migrant	Tordoff et al. (2002); Tran (2011); Đỗ et al. (2013); Tran & Barzen (2016); Đỗ (2017)	Habitat loss	Yes
25	*Pseudibis davisoni*	White-shouldered Ibis	CR	CR	Yes	Full Migrant	Buckton et al. (1999); Tordoff et al. (2002); Tran et al. (2003); Ngô et al. (2018); BirdLife International (2023i)	Habitat loss, hunting	No
26	*Threskiornis melanocephalus*	Black-headed Ibis	NT	VU	Yes	Full Migrant	Buckton et al. (1999); Tordoff et al. (2002); Tran et al. (2003); Buckton & Safford (2004); Nguyễn & Đào (2010); Tran (2011, 2015a); Đỗ et al. (2013); Tran & Matusch (2017); Đỗ (2017)	Habitat loss, hunting	No

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Migratory	Studies that provided confirmed records	Known drivers for population decreasing	Recorded or potentially occur in Ariake ecoregion in Kyushu, Japan
27	*Mulleripicus pulverulentus*	Great Slaty Woodpecker	VU	NL	Yes	Not a Migrant		Habitat loss	No
28	*Tyto longimembris*	Eastern Grass-owl	LC	VU	Yes	Not a Migrant	Buckton et al. (1999); Nguyễn & Đào (2010); Tran (2011); Tran & Barzen (2016); Đỗ (2017)	Habitat loss	No
29	*Anhinga melanogaster*	Oriental Darter	NT	VU	Yes	Not a Migrant	Buckton et al. (1999); Tordoff et al. (2002); Buckton & Safford (2004); Nguyễn & Đào (2010); Tran (201), 2015b); Nguyễn et al. (2013); Đỗ et al. (2013); Lê et al. (2015); Đỗ (2015a, 2017); Tran & Barzen (2016); Tran & Matusch (2017); Ngô (2019)	Habitat loss, hunting	No
30	*Phalacrocorax carbo*	Great Cormorant	LC	EN	Yes	Full Migrant	Tran (2011), 2012; Đỗ et al. (2013); Lê et al. (2015); Đỗ	Habitat loss, hunting	Yes

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Commented [47R46]: Okay, added

S/N	Species scientific name	English common name	IUCN	VNRDB	GBIF confirmed	Migratory	Studies that provided confirmed records	Known drivers for population decreasing	Recorded or potentially occur in Ariake ecoregion in Kyushu, Japan
							(2015a, 2017); Ngô (2019)		

4.1.3.3 Herpetofauna

The Vietnam Mekong Delta stands out as a significant hub for herpetofauna diversity, reflecting its ecologically rich environment. Based on data from the IUCN, the Vietnam Mekong Delta serves as a potential habitat for an impressive 134 herpetofauna species, spread across 28 families in five distinct orders. Complementing this data, the GBIF database houses 347 historical records, capturing the presence of 60 unique herpetofauna species within the delta. This consists of a diverse set of reptile and amphibian species that have been identified in this region. Our extensive review unveiled 32 scholarly articles that shed light on the herpetofauna of the Vietnam Mekong Delta, offering deeper insights into the region's herpetological makeup. Readers can refer to Appendix 9 of this report for a more detailed compilation of the mentioned data. In addition to those studies, WWF Vietnam also conducted an eDNA sampling along the Mekong River Delta. It was able to confirm the record of Yellow-headed Temple Turtle *Heosemys annandalii* (IUCN: CR) in the delta (WWF unpublished works 2023).

Pooling together this extensive information, our conservative estimates indicate that the region may be home to approximately 100 herpetofauna species. Of this diverse collection, 45 species have been marked as conservation significant and have had their presence ascertained within the Vietnam Mekong Delta, as detailed in Table 4-3.

Figure 4-20 Yellow-headed Temple Turtle *Heosemys annandalii*

Photo: iNaturalist

Figure 4-21 Southeast Asian Box Turtle *Cuora amboinensis*

Photo: iNaturalist

In the Mekong Delta, snakes and freshwater turtles face considerable threats due to intense hunting and agricultural practices. These reptiles, integral components of the delta's biodiversity, are often targeted for their meat, traditional medicine, and pet trade. The escalating demand has led to rampant hunting, putting numerous species at risk of local extinction. Moreover, the vast expansion of agricultural lands has not only resulted in habitat loss for these reptiles but also increased the chances of them coming in direct contact with humans, thereby heightening the threat of human-induced mortality. Pesticide runoff from farms further contaminates the water sources, adversely affecting the health and survival of aquatic turtles. Without immediate and effective conservation measures, the Mekong Delta might witness a sharp decline in the population and diversity of its snakes and freshwater turtles, disrupting the delicate balance of its ecosystem.

Table 4-4 List of conservation-concerned herpetofauna species in the Mekong Delta

S/N	Taxa	English Name	IUCN 2023	VRDB 2007	GBIF confirm	Endemic in Vietnam	Studies that provided confirmed records	Confirmed by WWF eDNA study (unpublished)
1	*Ichthyophis bannanicus*	Mengla County Caecilian	LC	VU	No	No	Trần & Lê (2007); Nguyễn (2009b); Hoàng & Võ (2013); Hoàng & Hồ (2014); Ngô & Hoàng (2014); Grismer & Smith (2023)	NA
2	*Amyda cartilaginea*	Asiatic Softshell Turtle	VU	VU	Yes	No	Nguyen et al. (2006); Trần & Lê (2007); Chinh et al. (2009); Nguyễn (2009b); Hoàng & Võ (2013); Hoàng & Hồ (2014); Ngô & Hoàng (2014); Ngô (2014); Trần (2014); Nguyễn (2016a); Hoàng & Trương (2022)	NA
3	*Amyda ornata*	Asiatic Softshell Turtle	VU	VU	No	No	Vassilieva et al. (2016); Poyarkov et al. (2023)	NA
4	*Bungarus fasciatus*	Banded Krait	LC	EN	No	No	Trần & Lê (2007); Chinh et al. (2009); Nguyễn (2009b); Hoàng & Võ (2013); Hoàng & Hồ (2014); Ngô & Hoàng (2014); Ngô (2014); Nguyễn (2014); Trần (2014, 2015); Nguyễn (2016a); Hoàng & Trương (2022)	NA

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S/N	Taxa	English Name	IUCN2023	VRDB2007	GBIFconfirm	Endemic in Vietnam	Studies that provided confirmed records	Confirmed by WWF eDNA study (unpublished)
5	*Cnemaspis aurantiacopes*	Hon Dat Rock Gecko	DD	NL	Yes	Yes	Lee Grismer & Van Tri (2007); Nguyễn (2009b, 2014)	NA
6	*Cnemaspis caudanivea*	Hon Tre Island Rock Gecko	VU	NL	Yes	Yes	Lee Grismer & Van Tri (2007); Nguyễn (2009b)	NA
7	*Cnemaspis nuicamensis*	Nui Cam Hill Rock Gecko	VU	NL	Yes	Yes	Lee Grismer & Van Tri (2007)	NA
8	*Cnemaspis psychedelica*	Psychedelic Rock Gecko	EN	NL	No	Yes	Lee Grismer & Van Tri (2007); Poyarkov et al. (2023)	NA
9	*Cnemaspis tucdupensis*	Tuc Dup Hill Rock Gecko	VU	NL	Yes	Yes	Lee Grismer & Van Tri (2007); Poyarkov et al. (2023)	NA
10	*Coelognathus radiatus*	Copper-head Trinket Snake	LC	VU	Yes	No	Nguyen et al. (2006); Trần & Lê (2007); Sang et al. (2008); Chinh et al. (2009); Nguyễn (2009b); Hoàng & Võ (2013); Hoàng & Hồ (2014); Ngô & Hoàng (2014); Trần (2014, 2015); Nguyễn (2016a); Hoàng & Trương (2022)	NA
11	*Crocodylus porosus*	Saltwater Crocodile	LC	EW	No	No	Poyarkov et al. (2023)	NA
12	*Crocodylus siamensis*	Siamese Crocodile	CR	CR	No	No	Hoàng & Võ (2013); Hoàng & Hồ (2014); Ngô & Hoàng (2014); Hoàng & Trương (2022)	NA

S/N	Taxa	English Name	IUCN2023	VRDB2007	GBIFconfirm	Endemic in Vietnam	Studies that provided confirmed records	Confirmed by WWF eDNA study (unpublished)
13	*Cuora amboinensis*	Southeast Asian Box Turtle	EN	VU	Yes	No	Nguyen et al. (2006); Trần & Lê (2007); Chinh et al. (2009); Nguyễn (2009b); Hoàng & Võ (2013); Hoàng & Hồ (2014); Ngô & Hoàng (2014); Ngô (2014); Trần (2014, 2015); Nguyễn (2016a); Hoàng & Trương (2022)	NA
14	*Cyclemys atripons*	Western Black-bridged Leaf Turtle	EN	NL	No	No	Poyarkov et al. (2023)	NA
15	*Cyclemys oldhamii*	Southeast Asian Leaf Turtle	EN	NL	No	No	Nguyễn (2009b)	NA
16	*Cyrtodactylus condorensis*	Pulo Condore Bow-fingered Gecko	LC	NL	Yes	Yes	Ngo & Grismer (2012); Ngo et al. (2022); Grismer & Smith (2023); Poyarkov et al. (2023)	NA
17	*Cyrtodactylus eisenmanae*	Eisenman's Bent-toed Gecko	LC	NL	No	Yes	Grismer & Smith (2023); Poyarkov et al. (2023)	NA
18	*Cyrtodactylus grismeri*	Grismer's Bent-toed Gecko	VU	NL	Yes	Yes	Grismer & Smith (2023); Poyarkov et al. (2023)	NA
19	*Cyrtodactylus hontreensis*	Hon Tre Bent-toed Gecko	LC	NL	No	Yes	Nguyễn (2009b, 2014)	NA

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S/N	Taxa	English Name	IUCN2023	VRDB2007	GBIFconfirm	Endemic in Vietnam	Studies that provided confirmed records	Confirmed by WWF eDNA study (unpublished)
20	*Cyrtodactylus phuquocensis*	Phu Quoc Bent–toed Gecko	EN	NL	No	Yes	Nguyễn (2009b)	NA
21	*Cyrtodactylus septimontium*	Bảy Núi Bent-toed Gecko	NL	NL	Yes	Yes	Ngo et al. (2022b); Poyarkov et al. (2023)	NA
22	*Elaphe taeniura*	Cave Racer	VU	NL	No	No	Bain & Hurley (2011); Poyarkov et al. (2023)	NA
23	*Gekko badenii*		EN	NL	No	Yes	Bain & Hurley (2011); Thomas et al. (2015); Poyarkov et al. (2023)	NA
24	*Gekko gecko*	Tokay Gecko	LC	VU	Yes	No	Trần & Lê (2007); Sang et al. (2008); Nguyễn (2009b); Hoàng & Võ (2013); Ngô & Hoàng (2014); Ngô (2014); Nguyễn (2014); Trần (2014), 2015; Nguyễn (2016a); Grismer & Smith (2023)	NA
25	*Gekko vietnamensis*	Vietnam Gecko	VU	NL	Yes	Yes	Bain & Hurley (2011); Grismer & Smith (2023); Poyarkov et al. (2023)	NA
26	*Heosemys annandalii*	Yellow-headed Temple Turtle	CR	EN	No	No	Chinh et al. (2009); Nguyễn (2009b); Hoàng & Võ (2013); Ngô (2014); Trần (2015); Nguyễn (2016a); Hoàng & Trương (2022)	Confirmed
27	*Heosemys grandis*	Giant Asian Pond Turtle	CR	VU	Yes	No	Nguyễn (2009b); Hoàng & Hồ (2014); Ngô & Hoàng (2014); Trần (2015); Nguyễn (2016a)	NA

S/N	Taxa	English Name	IUCN2023	VRDB2007	GBIFconfirm	Endemic in Vietnam	Studies that provided confirmed records	Confirmed by WWF eDNA study (unpublished)
28	*Indotestudo elongata*	Elongated Tortoise	CR	EN	Yes	No	Bain & Hurley (2011); Ngô & Hoàng 2012; Nguyễn (2014); Poyarkov et al. (2023)	NA
29	*Malayemys subtrijuga*	Mekong Snail-eating Turtle	NT	VU	Yes	No	Trần & Lê (2007); Chinh et al. (2009); Krohn (2009a); Nguyễn (2009b); Hoàng & Võ (2013); Hoàng & Hồ (2014); Ngô & Hoàng (2014); Ngô (2014); Trần (2014), 2015; Nguyễn (2016a); Hoàng & Trương (2022)	NA
30	*Malayopython reticulatus*	Reticulated Python	LC	CR	No	No	Chinh et al. (2009); Nguyễn (2009b); Hoàng & Võ (2013); Hoàng & Hồ (2014); Nguyễn (2014); Trần (2015); Nguyễn (2016a); Grismer & Smith (2023)	NA
31	*Naja siamensis*	Black And White Spitting Cobra	VU	NL	No	No	Trần & Lê (2007); Nguyễn (2009b, 2016); Ngô (2014); Ngô & Hoàng (2014); Trần (2014, 2015)	NA
32	*Ophiophagus hannah*	King Cobra	VU	CR	No	No	Chinh et al. (2009); Nguyễn (2009b); Ngô & Hoàng (2014); Trần (2015); Nguyễn (2016a)	NA
33	*Oreocryptophis porphyraceus*	Black-banded Trinket Snake	LC	VU	No	No	Poyarkov et al. (2023)	NA
34	*Palea steindachneri*	Wattle-necked Softshell Turtle	CR	VU	No	No	Trần & Lê (2007)	NA

S/N	Taxa	English Name	IUCN2023	VRDB2007	GBIFconfirm	Endemic in Vietnam	Studies that provided confirmed records	Confirmed by WWF eDNA study (unpublished)
35	*Pelochelys cantorii*	Asian Giant Softshell Turtle	CR	EN	No	No	Bain & Hurley (2011)	NA
36	*Pelodiscus sinensis*	Chinese Softshell Turtle	VU	NL	Yes	No	(Hoàng & Võ (2013); Hoàng & Hồ (2014); Ngô & Hoàng (2014); Trần (2014); Nguyễn (2016a); Hoàng & Trương (2022)	NA
37	*Physignathus cocincinus*	Chinese Water Dragon	VU	VU	No	No	Bain & Hurley (2011); Ngô & Hoàng 2012; Poyarkov et al. (2023)	NA
38	*Ptyas korros*	Javan Rat Snake	NT	EN	Yes	No	Trần & Lê (2007); Sang et al. (2008); Chinh et al. (2009); Nguyễn (2009b, 2016b, 2016a); Bain & Hurley (2011); Hoàng (2013); Hoàng & Võ (2013); Hoàng & Hồ (2014); Ngô (2014); Ngô & Hoàng (2014); Trần (2014, 2015); Lê (2020); Tran & Lam (2020); Poyarkov et al. (2023)	NA
39	*Ptyas mucosa*	Oriental Ratsnake	LC	EN	Yes	No	Trần & Lê (2007); Sang et al. (2008); Chinh et al. (2009); Nguyễn (2009b), 2016b, 2016a; Bain & Hurley (2011); Hoàng (2013); Hoàng & Võ (2013); Hoàng & Hồ (2014); Ngô (2014); Ngô & Hoàng (2014); Trần (2014), 2015; Lê (2020); Tran & Lam (2020); Poyarkov et al. (2023)	NA
40	*Python bivittatus*	Burmese Python	VU	CR	No	No	Bryan (2004); Nguyen et al. (2006); Trần & Lê (2007); Chinh et al. (2009); Krohn (2009a, 2009b);	NA

S/N	Taxa	English Name	IUCN2023	VRDB2007	GBIFconfirm	Endemic in Vietnam	Studies that provided confirmed records	Confirmed by WWF eDNA study (unpublished)
							Hoàng (2013); Hoàng & Hồ (2014); Trần (2014), 2015; Tran & Lam (2020); Poyarkov et al. (2023)	
41	*Siebenrockiella crassicollis*	Black Marsh Turtle	EN	NL	No	No	Bryan (2004); Nguyễn (2009b); Ngo & Hoang (2011); Ngô & Hoàng (2012)	NA
42	*Trimeresurus honsonensis*	Hon Son Pit Viper	VU	NL	No	Yes	(Nguyễn (2009b); Bain & Hurley (2011); Grismer & Smith (2023)	NA
43	*Varanus nebulosus*		LC	EN	No	No	Chinh et al. (2009); Hoàng & Hồ (2014); Ngô (2014); Nguyễn (2014, 2016b); Trần (2015); Poyarkov et al. (2023)	NA
44	*Varanus salvator*	Common Water Monitor	LC	EN	No	No	Chinh et al. (2009); Nguyễn (2009b, 2016b, 2016a); Hoàng & Võ (2013); Hoàng & Hồ (2014); Ngô (2014); Ngô & Hoàng (2014); Ngo et al. (2022a); Grismer & Smith (2023); Poyarkov et al. (2023)	NA

WWF eDNA report There is one ASAP that has been found in the rainy season, which is yellow-headed temple turtle (*Heosemys annandalii* - Critically Endangered). Yellow-headed Temple Turtle *Heosemys annandalii* (Boulenger 1903) is the endemic south-east Asian. It inhabits swamp, pond and slow-moving river in forested, and agricultural lowlands (Das 2015; Timms et al. 2021; Hawkeswood & Talsap 2021). This species is active mainly during the day and semiquatic, they diet is aquatic vergetation, fruit (Das 2015; Vassilieva et al. 2016). The range of *Heosemys annandalii* icludes Cambodia, The Mekong lowlands of Lao PRD, northern Malaysia, central and southern Thailand, southern VietNam. In Viet Nam, the range of *Heosemys annandalii* includes Mekong Delta and Southeast VietNam (Vassilieva et al. 2016; Douglas et al. 2022; Poyarkov et al. 2023). The main threats to this species are harvest and habitat loss throughout its range (Timms et al. 2021). In Viet Nam, *Heosemys annandalii* is included in CITES Appendix II, listed at Vietnam Red Data book 2007 (**EN**) and Appendix IIB in the Decree Number 06/2019/ND-CP" On the management o.f endangered, rare, and valuable forestry flora and fauna and the practicing of the Convention on International Trade in Endangered Species of Wild Fauna and Flora" Trading and hunting are limited. Currently, there are no published research and conservation actions for this species in Vietnam

4.1.3.4 Fishes

he Vietnamese Mekong Delta, given its complex hydrological, emerges as a significant center for freshwater fish diversity. Preliminary data sourced from the IUCN Red List posits that as many as 364 freshwater fish species, distributed across 70 families within 19 distinct orders, could be native to the Mekong Delta. In line with this, the GBIF database sheds light on the region's ichthyological diversity with 1,411 historical records pinpointing 286 distinct fish species. Our systematic review of the literature found 35 scholarly articles emphasizing the ichthyofauna of the Vietnamese Mekong Delta. This comprehensive data, which deepens our grasp of the region's fish diversity, can be accessed in Appendix 10 of this report. Additionally, the WWF Vietnam had also conducted an eDNA survey in the delta to record endangered fish species (WWF unpublished work). Drawing from these diverse information streams, we conservatively estimate the Vietnamese Mekong Delta to harbour around 330 fish species[4].

[4] Marine fish species are not included in the data scanning and data extraction. However, various amphidromous species that migrate between freshwater and marine environment were included.

Alarmingly, 34 of these species are earmarked for conservation attention as highlighted in Table 4-4.

Among the 34 conservation-concerned fish species found in the Mekong Delta, at least 20 species are migrators (Table 4-4). The Mekong Giant Catfish *Pangasianodon gigas* (IUCN: CR) and the Giant Barb *Catlocarpio siamensis* (IUCN: CR) sand out as the most charismatic fish species for the area. Due to their large size when reach adulthood and their complex potamodromous migratory patterns. Unfortunately, the most recent eDNA survey conducted by WWF Vietnam did not find any trait of those two species in the Mekong Delta (WWF unpublished work). This implied that those two species have become extremely rare in the region and actions are needed to rewild the Vietnamese Mekong.

Figure 4-22 Mekong Giant Catfish *Pangasianodon gigas*

Photo: iNaturalist

Table 4-5 List of conservation-concerned fish species in the Vietnamese Mekong Delta

S/N	Scientific name	IUCN	VRDB	GBIF confirmed	Studies that provided confirmed records	Confirmed by WWF eDNA study (unpublished)	Migrant behaviours
1	*Ambastaia nigrolineata*	**VU**	NL	Yes	Hoàng et al. (2022)		No-Migrant
2	*Ambastaia sidthimunki*	**EN**	NL	Yes			No-Migrant
3	*Bagarius lica*	**VU**	NL	No	Hoàng et al. (2022)		No-Migrant
4	*Bagarius vegrandis*	**VU**	NL	No	Hoàng et al. (2022)		No-Migrant
5	*Carcharhinus leucas*	**VU**	NL	Yes			Amphidromous
6	*Catlocarpio siamensis*	**CR**	**EN**	Yes	Nguyễn (2007); Thái et al. (2009); Phạm (2011)		Potamodromous
7	*Cirrhinus microlepis*	**VU**	**VU**	Yes	Đinh et al. (2009, 2019); Nguyễn et al. (2020); Vu et al. (2020); Dinh et al. (2020); Hoàng et al. (2022)	Recorded	Potamodromous

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S/N	Scientific name	IUCN	VRDB	GBIF confirmed	Studies that provided confirmed records	Confirmed by WWF eDNA study (unpublished)	Migrant behaviours
8	*Coilia mystus*	**EN**	NL	No	Nguyễn & Nguyễn (2021)	Recorded	Amphidromous
9	*Cyprinus carpio*	**VU**	NL	No	Đinh et al. (2009, 2019); Nguyễn et al. (2020); Vu et al. (2020); Dinh et al. (2020)		No-Migrant
10	*Datnioides undecimradiatus*	**VU**	NL	No	Hoàng et al. (2022)		Potamodromous
11	*Hemitrygon laosensis*	**EN**	NL	No	Hoàng et al. (2022)		Potamodromous
12	*Hypsibarbus lagleri*	**VU**	NL	No	Hoàng et al. (2022)		Potamodromous
13	*Incislabeo behri*	**VU**	NL	No	Hoàng et al. (2022)		No-Migrant
14	*Labeo pierrei*	**VU**	NL	Yes	Hoàng et al. (2022)		No-Migrant
15	*Mystus bocourti*	**VU**	NL	No	Hoàng et al. (2022)		Potamodromous
16	*Nemacheilus banar*	**VU**	NL	No	Hoàng et al. (2022)		No-Migrant

S/N	Scientific name	IUCN	VRDB	GBIF confirmed	Studies that provided confirmed records	Confirmed by WWF eDNA study (unpublished)	Migrant behaviours
17	*Oreochromis mossambicus*	**VU**	NL	No	Cao et al. (2014); Hà (2019); Mai (2019); Nguyễn & Nguyễn (2019); Lê & Nguyễn (2020); Nguyễn et al. (2020); Vu et al. (2020)	Recorded	Amphidromous
18	*Osphronemus exodon*	**VU**	NL	No	Hoàng et al. (2022)		Potamodromous
19	*Oxygaster pointoni*	**VU**	NL	No	Hoàng et al. (2022)		No-Migrant
20	*Pangasianodon gigas*	**CR**	**VU**	No	Nguyễn (2007); Thái et al. (2009)		Potamodromous
21	*Pangasianodon hypophthalmus*	**EN**	NL	Yes	(Đinh (2008); Le et al. (2018); Mai (2019); Đinh et al. (2019); Hoàng et al. (2022)	Recorded	Potamodromous

S/N	Scientific name	IUCN	VRDB	GBIF confirmed	Studies that provided confirmed records	Confirmed by WWF eDNA study (unpublished)	Migrant behaviours
22	*Pangasius krempfi*	**VU**	NL	Yes	Nguyễn (2008); Nguyễn et al. (2020); Trần et al. (2020); Vu et al. (2020); Nguyễn & Nguyễn (2021)		Potamodromous
23	*Pangasius sanitwongsei*	**CR**	NL	No	-		Potamodromous
24	*Poropuntius deauratus*	**EN**	NL	No	Hoàng et al. (2022)		Potamodromous
25	*Probarbus jullieni*	**CR**	**VU**	No	Lê & Nguyễn (2020); Nguyễn et al. (2020); Hoàng et al. (2022)		Potamodromous
26	*Pterocryptis inusitata*	**EN**	NL	No	Hoàng et al. (2022)		No-Migrant
27	*Rasbora lateristriata*	**VU**	NL	Yes			No-Migrant
28	*Scaphognathops bandanensis*	**VU**	NL	No	Hoàng et al. (2022)		Potamodromous
29	*Schistura kontumensis*	**VU**	NL	No	Hoàng et al. (2022)		No-Migrant
30	*Scleropages formosus*	**EN**	**EN**	No	Phạm (2011)		No-Migrant

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S/N	Scientific name	IUCN	VRDB	GBIF confirmed	Studies that provided confirmed records	Confirmed by WWF eDNA study (unpublished)	Migrant behaviours
31	*Tenualosa thibaudeaui*	**VU**	NL	No	Hoàng et al. (2022)		Potamodromous
32	*Urogymnus polylepis*	**EN**	NL	No	Hoàng et al. (2022)		Potamodromous
33	*Wallago attu*	**VU**	NL	No	Trần et al. (2020); Vu et al. (2020); Hoàng et al. (2022)	Recorded	Potamodromous
34	***Epinephelus fuscoguttatus***	**VU**	NL	No	None	Recorded	No-Migrant

4.1.3.5 Insects

Within the Vietnamese Mekong Delta, the amassed data on insects presents a slightly fragmented picture. The IUCN Red List, typically a primary source for species distribution data, does not specifically cater to insects, creating a gap in our understanding of this fauna group in the area. However, a deep dive into the GBIF databases helps bridge this gap, revealing 1,392 historical insect records which collectively represent an impressive 589 species. These species span 161 families across 15 orders, accentuating the region's ecological richness. Our exhaustive literature survey yielded 15 pivotal academic articles and reports that focus on the insect fauna of the Mekong Delta. All of that information were included in Appendix 11 of this report. It is noticed that the eDNA study conducted by WWF Vietnam also recorded several insect species in the region. Collating the available information, we extrapolate that the Vietnamese Mekong Delta may be home to close to 600 insect species. Of significant concern, six of these insect species have been earmarked as conservation critical, as delineated in Table 3-6

Table 4-6 List of conservation-concerned insect species in the Vietnamese Mekong Delta

S/N	Scientific name	English name	IUCN2023	VNRB2007	GBIF confirmed	Study	WWF eDNA study
1	*Harvengia vietnamita*		EN		No	Deharveng et al. (2023)	
2	*Eustra honchongensis*		EN		No	Deharveng et al. (2023)	
3	*Troides aeacus*	Golden Birdwing	LC	VU	Yes	Tô et al. (2015)	
4	*Euphaea cyanopogo*		EN		Yes	None	Recorded

5	*Amphicnemis valentini*		EN		Yes	None	Recorded
6	*Podolestes coomansi*		VU		Yes	None	Recorded

4.1.3.6 Flora

The Vietnamese Mekong Delta, characterized by its flat landscape devoid of notable topographical features such as tall mountains, presents an intriguing contrast to areas typically rich in plant diversity. The uniformity of its soil, primarily a result of sedimentation from the Mekong River, suggests that one might not anticipate a vast array of plant species. However, this delta region remarkably integrates the characteristics of three distinctive ecoregions: the Tonle Sap-Mekong Peat Swamp Forest, the Tonle Sap Freshwater Swamp Forest, and the Indochinese Mangrove. The GBIF database shines a light on the botanical fabric of the delta, documenting the presence of 535 plant species. These species, distributed across 141 families and spanning 54 orders, underscore the botanical significance of the area, despite its topographical uniformity. Our dedicated literature survey on the Mekong Delta's flora unveiled 30 seminal research articles and reports. Appendix 12 of this report stands as a detailed compendium for those seeking a deeper dive. Notably, within this botanical ensemble, 38 species have been identified as conservation priorities, as catalogued in Table 4-7.

Table 4-7 List of conservation-concerned flora species in the Vietnamese Mekong Delta

S/N	Taxa	English name	IUCN 2023	VRDB 2007	GBIF confirm	Study
1	*Actinostemma tenerum*		NL	VU	No	Lê et al. (2022)
2	*Adonidia merrillii*	Manila Palm	VU	NL	Yes	
3	*Aeginetia indica*		LC	VU	No	Nguyễn et al. (2018)
4	*Aglaia spectabilis*		LC	VU	No	Đặng et al. (2016); Nguyen et al. (2017); Đặng et al. (2016)
5	*Aquilaria crassna*	Agarwood	CR	EN	No	Nguyễn et al. (2018); Lê et al. (2022); Ngô et al. (2021); Phùng et al. (2018) ; Nguyễn et al. (2018); Lê et al. (2017) Nguyễn (2009)
6	*Coffea arabica*	Arabica Coffee	EN	NL	Yes	

7	*Curculigo orchioides*		NL	EN	No	Nguyễn et al. (2018)
8	*Dalbergia cochinchinensis*	Siamese Rosewood	CR	EN	No	Phạm (2018)
9	*Dioscorea zingiberensis*		NL	VU	No	Nguyễn et al. (2018); Nguyễn (2009)
10	*Dipterocarpus costatus*		VU	NL	Yes	
11	*Drynaria bonii*		NL	VU	No	Nguyễn et al. (2018); Lê et al. (2017); Nguyễn (2009)
12	*Drynaria fortunei*		NL	EN	No	Phùng et al. (2018) ; Phạm (2017)
13	*Elaeocarpus hygrophilus*		NL	VU	No	Nguyễn et al. (2022) ;Đặng et al. (2022); Trần et al. (2021); Trần et al. (2020); Phạm (2020); Dang et al. (2020); Phạm (2018); Dang et al. (2020); Phạm (2017) Lê et al. (2014); Nguyễn (2009)
14	*Euphorbia atoto*		VU	NL	Yes	
15	*Fernandoa adenophylla*	Katsagon	NL	VU	Yes	
16	*Hemisorghum mekongense*		NL	VU	No	Nguyễn et al. (2022)
17	*Homalomena pierreana*		NL	VU	No	Lê et al. (2022); Ngô et al. (2021)
18	*Hopea ferrea*		EN	NL	No	Nguyễn et al. (2018); Nguyễn (2009)
19	*Hopea odorata*		VU	NL	No	Phạm (2020); Nguyen et al. (2017)
20	*Hopea pierrei*		VU	EN	Yes	
21	*Lithocarpus harmandii*		NL	EN	Yes	
22	*Lithocarpus vestitus*		NL	EN	Yes	
23	*Lumnitzera littorea*		LC	VU	No	Lê et al. (2022); Ngô et al. (2021); Nguyễn (2009)
24	*Millingtonia hortensis*	Indian Cork Tree	NL	VU	Yes	Lê et al. (2017)
25	*Murraya glabra*		NL	VU	No	Lê et al. (2022); Ngô et al. (2021); Nguyễn (2009)
26	*Nothaphoebe condensa*		VU	NL	Yes	
27	*Ornithoboea emarginata*		CR	NL	Yes	
28	*Oryza rufipogon*	Red Rice	LC	VU	No	Nguyễn et al. (2022) ; Dang et al. (2020) Phạm (2017); Nguyễn & Nguyễn (2017); Lê et al. (2014)

29	*Pterocarpus indicus*	Burmese Rosewood	EN	NL	No	Lê et al. (2017)
30	*Pterocarpus macrocarpus*	Burma Padauk	EN	NL	No	Phùng et al. (2018) ; Nguyễn et al. (2018) ; Nguyễn (2009)
31	*Rauvolfia micrantha*		NL	VU	No	Nguyễn (2009)
32	*Rauvolfia verticillata*		NL	VU	No	Nguyễn (2009)
33	*Sarcostemma acidum*		NL	EN	No	Lê et al. (2022); Ngô et al. (2021)
34	*Shorea hypochra*	White Meranti	EN	NL	Yes	
35	*Shorea roxburghii*	White Meranti	VU	NL	Yes	
36	*Sindora siamensis*		LC	EN	No	Lê et al. (2017)
37	*Sonneratia griffithii*		CR	NL	Yes	
38	*Tacca palmata*		NL	VU	No	Lê et al. (2022); Ngô et al. (2021); Nguyễn et al. (2018)

4.1.4 Ecological or Biological Significant Areas in Vietnamese Mekong Delta

The Mekong Delta stands as a beacon of ecological significance, marked by its incorporation of three unique ecoregions: the Tonle Sap-Mekong Peat Swamp Forest, Tonle Sap Freshwater Swamp Forest, and Indochinese Mangrove. This region is characterized by an expansive tapestry of swamps, wetlands, and mangrove forests along its extensive coastline, which serve as hotspots for aquatic biodiversity and offer invaluable ecosystem services cherished by local communities for generations. The delta's prominence on the international conservation stage is evident through its four RAMSAR sites, including the globally recognized U Minh Thuong and Tram Chim National Parks, Lang Sen Protected Area, and Mui Ca Mau National Park. Moreover, 11 Important Bird Areas (IBAs) in the region underscore the importance of its fragmented landscapes for avian conservation. Notably, mangrove forests in areas like Mui Ca Mau, Thanh Phu, and Cu Lao Dung play dual roles in biodiversity preservation and offering ecosystem services such as storm protection and carbon sequestration. Furthermore, the Ha Tien - Kien Luong region, nestling in Vietnam's extreme southwest near Cambodia, showcases an array of geological wonders, from flat plains and limestone mountains to diverse water bodies. Particularly, the limestone formations in the Hon Chong - Kien Lương vicinity are teeming with biodiversity, being home to species like the Silvered Langur and other recent discoveries. This dynamic confluence of habitats and conservation landmarks firmly establishes the Mekong Delta as a vital ecological and biological treasure trove.

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Table 4-8 offers a comprehensive summary of the EBSAs within the Sai Gon-Dong Nai River Basin. This table collates vital details, presenting a clear overview of each EBSA's characteristics, the ecoregion it belong to and key information on its biodiversity.

Table 4-8 Summarized Information on ecologically or biologically important areas in Vietnamese Mekong Delta

S/N	Name	Class	Location	Area (ha)	Ecoregion	Remark
1	U Minh Thuong	National Park Ramsar Site Important Bird Area	Kien Giang Province	22,918	Tonle Sap-Mekong Peat Swamp Forest	The landscape in the core area of U Minh Thuong National Park consists of vast wetlands, large swamps, and narrow artificial channels with rich vegetation cover. (Goodall & Faithfull 2010). U Minh Thuong is the habitat for several wildlife species in the flooded forest region such as the Hairy-nosed Otter *Lutra sumatrana* (IUCN: EN) and the Javan Pangolin *Manis javanica (*IUCN: **CR**). It is also home to several important bird species that require conservation efforts (Sterling, et al., 2008). This area is a part of the Kien Giang Biosphere Reserve
2	U Minh Ha	National Park	Ca Mau Province	8,527	Tonle Sap-Mekong Peat Swamp Forest	U Minh Ha National Park covers a total area of 8,527 hectares and is characterized by its unique aquatic ecosystem on peat soil, formed over time by the accumulation of plant remains (Thi Thanh et al. 2020). The melaleuca forest in U Minh Ha is one of the last remaining carbon and peat reserves in Vietnam. This region is not only highly diverse with many endangered species but also plays a crucial role as a carbon reservoir for climate change mitigation (Thi Thanh et al. 2020).
3	Tram Chim	National Park Ramsar site Important Bird Area	Dong Thap Province	7,313	Tonle Sap Freshwater Swamp Forest	Tram Chim National Park is a seasonal flooded wetland, and regularly inundated areas. The biodiversity here is exceptionally diverse, especially concerning fish and birds (Tran & Barzen 2016b). Tram Chim is a crucial location for migratory birds and one of the most important wintering grounds for the Sarus Crane (*Grus antigone*

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S/N	Name	Class	Location	Area (ha)	Ecoregion	Remark
						sharpii), a species classified as Vulnerable (VU) by the IUCN, within the Mekong Delta (Thanh, et al., 2020).
4	Lang Sen	Wetland Reserve Ramsar Site Important Bird Area	Long An Province	5,030	Tonle Sap-Mekong Peat Swamp Forest	Lang Sen wetland conservation area. The habitat within this conservation area, characterized by seasonally inundated wetlands, is directly influenced by the hydrological regime of the Mekong River. It experiences annual flooding as a result (Hong Quan, et al., 2017).
5	Mui Ca Mau	National Park Important Bird Area Biosphere Reserve	Ca Mau Province	41,862	Indochinese Mangrove	Mui Ca Mau National Park is a vast mangrove forest grown on sedimentation soil. The ecosystem in this area is highly diverse, comprising mangrove forests, melaleuca swamps, mudflats, and coastal ecosystems, providing habitats for various aquatic and marine species. Additionally, the mudflats, seasonal wetlands, and brackish water ecosystems, as well as the marine environment, harbor rich biological and geological resources. Therefore, it holds significant conservation value and requires attention and protection from nature conservation organizations (as stated by the Head of the Ca Mau Geographic Information Department on camau.gov.vn). The area is recognised as UNESCO Biosphere Reserve A mudflat in the Mui Ca Mau National park is recognised as IBAs
6	Bac Lieu	Bird Sanctuary Important Bird Area	Bac Lieu Priovince	385	Indochinese Mangrove	Bac Lieu Bird Sanctuary covers an area of 385 hectares and represents one of the remaining patches of what used to be a large mangrove forest. Within this area, there are 19 hectares of pristine mangrove forest (Ngo & Truong 2017). As an IBA, this area is particularly important for bird conservation.

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S/N	Name	Class	Location	Area (ha)	Ecoregion	Remark
						The sanctuary hosts 109 wild bird species. Among these, several bird species are endangered, such as the Painted Stork, Oriental Darter, and Spot-billed Pelican… (Ngo & Truong 2017).
7	Lung Ngoc Hoang	Nature Reserve	Hau Giang Province	2,800	Tonle Sap-Mekong Peat Swamp Forest	Lung Ngoc Hoang is wetland ecosystem that have high biodiversity value (An, Tuan, 2021).
9	Ha Tien – Kien Luong (Kien Luong proposed nature reserve)	Important Bird Area Proposed nature reserve	Kien Giang Province		Tonle Sap-Mekong Peat Swamp Forest	The Ha Tien - Kien Luong region, located in the extreme southwest of Vietnam, adjacent to Cambodia, exhibits a diversity of geological features, including flat plains, hills, mountains, rivers, lakes, coastal areas, and various geological formations. The limestone mountains in the Hòn Chông - Kiên Lương area contain a highly diverse biological resource. This area is home to numerous rare animal and plant species, including the Silvered Langur, and some newly discovered species (Kiên Giang Provincial Department of Natural Resources and Environment). This area is a part of the Kien Giang Biosphere Reserve This area include the Ha Tien IBA and Kien Luong IBA
10	Thanh Phu	Nature Reserve	Ben Tre Province		Indochinese Mangrove	Thanh Phu is an area mangrove forest situated along the coastline of the Vietnamese East Sea, experiencing strong influences from erosion and sediment deposition. The intertidal mudflats in this area are vital habitats for various shorebird species. However, the bird species recorded in Thạnh Phú are common and widely distributed, including birds like Grey Plover

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S/N	Name	Class	Location	Area (ha)	Ecoregion	Remark
						(*Pluvialis squatarola*), Common Greenshank (*Tringa nebularia*), and Sanderling (*Calidris alba*) (Buckton, et al., 1999).
11	Cu Lao Dung	Nature Reserve	Soc Trang Province		Indochinese Mangrove	The mangrove forest of Cu Lao Dung, located along the coast of Soc Trang province, plays a vital role in providing food, shelter, and breeding grounds for various species of fish, shrimp, crustaceans, as well as birds and mammals (Liên, et al. 2013). This area is an important roosting site for various Flying foxes *(Pteropus* sp.) colonies (Vu et al. 2015a).
12	Dong Thap Muoi	Habitat Reserve	Tien Giang Province		Tonle Sap Freshwater Swamp Forest	The Dong Thap Muoi region features a diverse ecosystem with 291 plant species belonging to 214 genera and 80 families from two plant branches: Polypodiophyta (ferns) and Magnoliophyta (flowering plants). Among these species, 212 serve various purposes and can be categorized into five primary groups: medicinal plants (131 species), edible plants (42 species), ornamental plants (15 species), timber sources (12 species), and domestic use (12 species). Furthermore, research has identified three species in need of protection based on the Red Data Book of Vietnam (2007), which includes *Elaeocarpus hygrophilus*-VU (Cà na), *Oryza rufipogon* (Lúa ma), and *Hemisorghum mekongense* (Lau vôi) (Duy, Trường, et al. 2023).
13	Kien Giang	UNESCO Biosphere Reserve	Kien Giang Province	more than 1.1 million	Tonle Sap-Mekong Peat Swamp Forest and	A vast area includes the U Minh Thuong National Park, Ha Tien-Kien Luong area and

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S/N	Name	Class	Location	Area (ha)	Ecoregion	Remark
					Indochinese Mangrove	

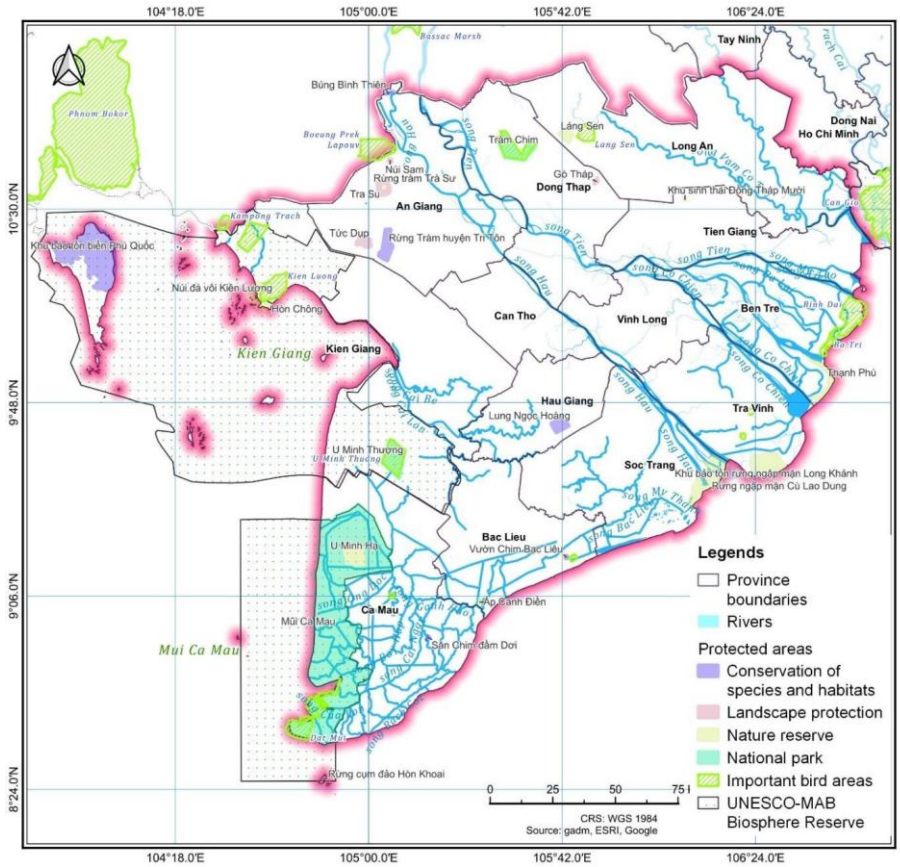

Figure 4-23 Location of Ecological or Biological Important Areas in Vietnamese Mekong Delta

4.2 THREATS AND PROTECTION

4.2.1 Upstream hydropower dams and sediment reduction

The Vietnamese Mekong Delta, a crucial hub for biodiversity, food production, and local livelihoods, faces profound challenges due to sediment reduction arising from upstream hydropower activities. As of recent data, 13 hydropower dams are operational along the Mekong's main course, with a majority located in its upper regions, and an additional 20 dams

are slated for future development. The situation is further intensified by hundreds of dams active on its tributaries (MRC 2018, 2019, 2022, 2023a, 2023b).

Scholars have extensively studied the sediment decrement trend in the Mekong Delta, with the Mekong River Commission spearheading many such investigations. Notably, sediment loads at the Tan Chau station plummeted fourfold in a span of 35 years, from 159 million tons in 1980 to a mere 38 million tons by 2015 (Nguyen et al. 2022b). Historically, the delta annually received 140-160 million metric tons of sediment from the Mekong basin, a figure now halved due to reservoir sediment trapping activities. Dam constructions on the upsteam Mekong, both existing and planned, threaten to withhold up to 97% of this sediment from reaching the Vietnamese Mekong Delta (Kondolf et al. 2014, 2022; Shrestha et al. 2016; Thanapon & Manish 2017)

The sediment's ecological role is multifaceted: annually, approximately 150 million tons of alluvium, primarily delivered during flood seasons, replenish the Mekong Delta, furnishing crucial nutrients for the Mekong Downstream Basin. Disrupting this sediment transport not only destabilizes the Mekong Delta but also jeopardizes nutrient carriage vital for the region's soil fertility (Le et al. 2021). A decline in sediment and nutrient transport, instigated by upstream dams, could critically impede rice production, fish yields (MRC 2019; MRC 2018), and overall biodiversity, bringing forth ecosystem service losses and heightened food security concerns (Soukhaphon et al. 2021).

Various coastal areas in the Mekong Delta, like the Ca Mau peninsula and the Kien Giang coastline, might endure a 60% sediment load drop over the upcoming two decades (Peter & Michael 2011). Off the river outlets, a balance once existed between deposition and erosion, which is now disrupted, particularly south of the delta. The sediment dearth, coupled with powerful coastal currents, is accelerating erosion (Hein et al. 2013). This will lead the loss or degradation of habitats in this region.

In summary, upstream hydropower dams on the Mekong River and its tributaries signify an impending ecological predicament, marked by a sharp decline in sediment transport and alterations to the region's natural hydro-ecological rhythms (Jeremy et al. 2010). As the sediment's multifarious ecological benefits become increasingly evident, the sustainable coexistence of hydropower development and ecological preservation in the Mekong Delta is undeniably a matter of utmost priority.

4.2.2 Sand mining and its expected impacts

Due to its development needs, sand mining, particularly dredging sand from riverbeds, are common practice in the Vietnamese Mekong Delta. Therefore, sand mining is an economic sector in this region. In 2018 alone, a staggering 17.7 million m^3 of sand was dredged from the Mekong River system, positioning sand mining as a prominent economic sector in the region (Jordan et al. 2019; Hackney et al. 2020; Tran et al. 2023). Such large volume of sand extracted leads to various severe impacts on biodiversity, habitats and environment in the region.

This sand extraction imperils the Mekong Delta in multiple dimensions. Mechanized operations inherent to the mining process substantially eradicate benthic fauna and destroy the habitat of aquatic species. This can impact the whole river ecosystem and eventually the associated ecosystem services (Koehnken & Rintoul 2018; Tran et al. 2023, 2023)

Sand mining also mobilizes sediment, engendering deeper river channels which, in turn, undermine riverbank stability and augment susceptibility to erosion. This phenomenon paves the way for accelerated tidal influx, compromising critical spawning sites and inundating deep pools, which function as vital habitats for endangered fish species.

Under the impacts of upstream hydropower dams, the sediment contribution from the Mekong's upper reaches remains insufficient to counteract the sediment loss instigated by rampant sand mining (Jordan et al. 2019). This could jeopardize expansive intertidal mudflats, sand dunes, and mangrove systems. Various key biodiversity areas that aim to protect mangrove ecosystems and their natural expansion characteristic will be vulnerable to these impacts. The system of intertidal sandbars and mudflats, important habitats for a large amount of migratory shorebirds and waterbirds will also subjected to the severe impacts of sand mining.

Furthermore, from a socio-economic vantage point, sand mining-induced modifications in sediment transport dynamics imperil the very existence of the Mekong Delta. Such geomorphological alterations could translate into staggering economic downturns. The livelihoods of millions residing in the VMD, predominantly engaged in agriculture—a mainstay of the national GDP—are precariously balanced on this environmental fulcrum (Park et al. 2020). Augmenting these challenges, sand mining operations also inflict tangible transformations on channel morphology and local hydrodynamics, threatening infrastructure stability, from housing and road networks to bridges, while simultaneously diminishing wildlife habitats and agricultural land (Hackney et al. 2020).

4.2.3 Groundwater extraction and expected impacts

In the Mekong Delta, groundwater plays an integral role, supporting aquaculture and catering to domestic and industrial needs. Recent findings indicated an abstraction of approximately 350,000 m^3/day across the region (Wagner et al. 2012). Human activities, compounded by climate changes, exert profound pressures on groundwater reserves (Xiao et al. 2021). The challenges faced in the Mekong Delta concerning groundwater can be distilled into two primary issues:

- Groundwater Level Decline: Parts of the delta are experiencing a drop in groundwater levels. This decline stems from excessive drainage, overexploitation, and interception of recharge waters. Numerous areas, especially those adjacent to the Tien and Hau tributaries of the Mekong River, have documented this decline, including regions like Can Tho, Tra Vinh, Soc Trang, Bac Lieu, and Ca Mau. Predictive models suggest that groundwater levels might diminish by 0.3 to 0.5 m annually (Erban et al. 2014; Bui et al. 2015, 2017; Danh 2019; Minderhoud 2019; Van & Koontanakulvong 2019). Given that most of the lower Mekong Delta lies less than 2 meters above sea level, such reductions will have dire implications for biodiversity, ecosystems, and human populations.

- Groundwater Quality Decline: Contamination from urban, industrial, and rural sources, along with the concentration of natural contaminants and saltwater intrusion due to excessive groundwater extraction, is rampant.

    - In areas like An Giang and Dong Thap, water testing indicates $NO3^-$ pollution, possibly originating from excessive fertilization, wastewater, and agricultural runoff (Giao et al. 2023).

    - Coastal regions, such as Soc Trang, have documented $NH4^+$, Cl^-, Fe, total coliform, and E. coli, with local geology and human activities being significant factors (Giao et al. 2022, Tran et al. 2020a).

    - Heavy metal pollution is a serious issue for ground water in Long An, Dong Thap, An Giang and Kien Giang. Tran (2019) reported an elevated iron concentrations in ground water samples from those province (Tran 2019). Notably, a staggering 50% of groundwater samples from An Giang and Dong Thap were polluted with arsenic, posing a potential health risk to nearly two million residents (Huang et al. 2016, Tran 2019). Arsenic concentrations displayed

strong correlations with proximity to the Mekong River and well depths (Tran 2019).

- Municipal wastewater and urban runoff also present a health concern, with areas like Can Tho showing high total coliform levels (Tran 2019).
- Moreover, increasing salinity is observed in Tra Vinh's groundwater (Van & Koontanakulvong 2019). Such contaminants could have cascading effects on food webs, severely impacting biodiversity, ecosystems, and human health.

In sum, while groundwater remains vital for the Mekong Delta, a suite of challenges, ranging from volume reduction to quality degradation, underscores the need for sustainable management and intervention.

4.2.4 Land conversion and habitats loss/degradation

The Mekong Delta, a crucial ecological region, has undergone profound land use alterations, severely impacting its biodiversity and ecosystems. Distinct land conversion patterns were observed: the upper delta witnessed a 90% wetland loss to cropland, the middle delta saw a diverse conversion of wetlands and croplands to aquaculture, permanent crops, and infrastructure, while the coastal zone predominantly converted to aquaculture (Nguyen et al. 2022a).

Agriculture, particularly rice farming, had been the main driver for land conversion in the Mekong Delta during 1960-1990s (Nguyen et al. 2017a, Nguyen et al. 2018). Until now, one of the dominant land use categories throughout these years is agricultural production land, account for 60% the total area of the region (MONRE 2023). This dominance underscores the region's reliance on agriculture, with rice farming being the primary agricultural activity. The Delta's fertile alluvial soils and abundant water sources make it the "rice bowl" of Vietnam, supporting the livelihoods of millions and producing a significant portion of the country's rice exports. However, the downside of such reliance is evident in the associated environmental challenges. The expansion of agricultural land, particularly for rice cultivation, can lead to habitat fragmentation, degradation of soil quality, and alteration of water flow patterns. Under the impact of climate change and the availability of alternative livelihood, agriculture, particularly rice farming, keep becoming less attractive to the local communities in the Mekong Delta.

Aquaculture, particularly shrimp farming, is a formidable driving forces for the land conversion in the Mekong Delta. The enticing profits from shrimp and aquaculture farms have resulted in the widespread destruction of the mangrove belt in numerous parts of the delta, eliminating the coast's protective buffer against storm surges and high tides (Hua et al. 2023). Historical data reflects the extent of this trend: in 1993, Ca Mau province lost 53,969 hectares of mangroves to shrimp farming (Bùi & Huỳnh 2008), while Tra Vinh experienced a 50% decline in mangrove forests from 1965 to 2001 due to shrimp farm developments (Phan & Populus 2007). From 1990 to 2019, this conversion trend slowed down (Nguyen et al. 2022a). Even though mangrove forests recovered slightly by 58 km^2 from 2005 to 2019, there was an overall loss of 740 km^2 over the 1990-2019 period (Nguyen et al. 2022a).

Construction (which is linked to the socioeconomical development of the whole area) is another driver of land conversation in the Mekong Delta. Land conversation for mega-scale constructions started from the French colonial era in the 1920s, marked the construction of a complex irrigation system with canals, sluice gate and agricultural expansions (Huu Nguyen et al. 2016). There were a records of subsequent dredging and conversion of wetlands, leading to an annual loss of approximately 5,000 hectares of forest from 1880 to 1910 (Huu Nguyen et al. 2016). Between 1998 and 2017, the region's built-up areas, including residential zones and road systems, expanded massively from 3,780 ha to over 23,126 ha, resulting in a decline of vegetation land (Nguyen et al. 2018). In the coastal area, a significant area of mangrove was loss, primarily due to sea dike construction (Phan et al. 2015).

Natural disasters, which may or may not be related to climate change, may also influence the land conversion situation in the Mekong Delta. For example, erosion along the Mekong's eastern and southeastern coast can sometimes reduce to mere 100m strips, effectively convert mangrove into water surface or baren (Phan et al. 2015). Sometime, the threat from natural disasters and climate changes motivates the attempt of reforestation. For example, there has been a a distinctive increase in total mangrove areas, including special-used forest, protective forest, and productive forest in Ca Mau Province from 2017 to 2021 (MONRE 2023).

Overall, the large-scale land conversation in the Vietnamese Mekong Delta have started from the early of 20th century. The overall trend was the conversion of nature habitat such as wetlands, grasslands and mangroves into either agricultural, aquacultural or built-up land. The main driver of land conversation in this region has been strongly linked with the socioeconomic developments that take place in Mekong Delta and Vietnam. Regardless the drivers, conversing natural habitats into man-made habitats have been caused adverse and long-lasting impacts for biodiversity and ecosystem in this region.

From a scientific perspective, the conversion of natural habitats into man-made environments in various regions poses severe threats to both biodiversity and the integrity of ecosystems. Natural habitats, evolved over millennia, are intricate webs of relationships between myriad species, from the smallest microorganisms to apex predators. These habitats provide essential resources, shelter, and breeding grounds that sustain diverse species. When these habitats are altered or replaced by man-made structures or monocultures, the balance is disrupted. This disruption often leads to a decline in native species due to the loss of food sources, shelter, or increased vulnerability to predators. Additionally, these transformations can alter the nutrient cycles, water flow, and soil structure, further jeopardizing the ecosystem's health. Over time, the cascading effects of these changes can lead to decreased ecosystem resilience, making these areas more susceptible to invasive species, diseases, and the consequences of climate change. The long-term ramifications are not just confined to the immediate area of conversion but can ripple throughout interconnected ecosystems, illustrating the profound and enduring impact human interventions can have on the natural world.

4.2.5 Climate change

In the Mekong Delta, the ramifications of climate change on biodiversity and ecosystems are becoming increasingly evident, presenting multifaceted challenges to both the natural world and local communities. One primary consequence is the pervasive saltwater intrusion into freshwater habitats and agricultural lands, which not only alters the salinity balance but also jeopardizes the vitality of several species dependent on freshwater ecosystems (Hồ et al. 2011). Moreover, a forecasted increase in the flood-prone areas due to climate change is anticipated to transform the ecosystem and landscape drastically (Ho et al. 2023).

A detailed study carried out in Lung Ngoc Hoang Nature Reserve reveals the susceptibility of protected habitats and species to various climate change-induced stressors (Nguyen et al. 2022c). Here, habitats, especially the Melaleuca forest, are threatened by saltwater intrusion, prolonged droughts, high temperatures, and persistent inundation. This combined pressure increases the risk of forest fires and diminishes the extent and quality of open water habitats. Notably, the Melaleuca forest faces severe threats from drought, high temperatures, and extended flooding, which disrupt the life cycles and growth of resident species. Additionally, these habitats are vulnerable to extreme climatic events, like storms, leading to extensive tree damage (Nguyen et al. 2022c).

Sea level rise, driven by global climate change, poses significant risks to coastal ecosystems, subsequently affecting the ecosystem services these habitats provide. A modeling study by Dang et al. (2021) suggested the Mekong Delta mangroves can be reduced by 33% by 2027 in extreme scenarios. This change has profound implications for the coastal communities,

particularly low-income groups that heavily rely on mangrove ecosystem services, making them especially vulnerable (Linh & Huan 2022).

Additionally, the Mekong Delta's aquatic ecosystems are witnessing shifts in species composition due to rising average temperatures. Such climatic alterations, combined with sea level rise, have been identified as the principal drivers leading to the decline of wetland species in the region. Moreover, heightened temperatures facilitate the proliferation of vector-borne and water-borne diseases among wildlife, and farmed animals, which could potentially escalate disease transmissions between humans and animals (Dang et al. 2021, Espagne et al. 2021).

In summary, the intricate interplay of rising sea levels, increased saltwater intrusion, temperature fluctuations, and intensified weather events has severely impacted its biodiversity and ecosystems in the Vietnamese Mekong Delta. Habitats, ranging from freshwater reserves to coastal areas, are undergoing transformative changes, with several species facing existential threats. The profound shifts in aquatic ecosystems, combined with heightened risks of diseases, further underscore the Delta's vulnerability. In essence, climate change is reshaping the ecological tapestry of the Vietnamese Mekong Delta, highlighting an urgent need for adaptive and protective measures to safeguard its rich biodiversity and ensure the resilience of its ecosystems.

4.2.6 Water flow shifting

The Mekong Delta has a natural water flow rhythm, often called the "seasonal rhythm of the delta" (Hung et al. 2012) Wildlife, ecosystems, and communities have adapted to this consistent flow over time. However, this established rhythm is now under threat due to human activities, like the construction of hydropower dams upstream, and the effects of climate change. Dams in areas such as Se San and Sre Pok have reduced the amount of water that reaches the Vietnamese Mekong Delta (MRC 2022). There are plans for even more dams by countries like Thailand, Lao PDR, and Cambodia, which might further reduce the water flow by 0.5 to 3.6% (Kantoush et al. 2017). Many of these dams, designed primarily for power production, hold back water during dry seasons, exacerbating water scarcity in the delta. Conversely, during heavy rains, they may discharge excessive water, leading to intensified flooding, disrupting the natural rhythm that the region's biodiversity has adapted to over millions of years.

Climate change also alters the water flow in the Mekong River Basin. Historically, the delta's water flow varied according to season and proximity to main rivers, with flow velocity generally

decreasing as one moved further from these rivers (Le et al. 2022). However, climate change has begun to modify these seasonal patterns, resulting in diminished flows during dry seasons and shifts in the timing of peak tidal levels Research indicates that the average tidal peak over the past decade has risen by 2–6 cm compared to previous years (Nguyen et al. 2021a). A notably shifting the timing of peak water flows, which affects both wildlife and human activities, was also report (Mondal et al. 2022).

The Mekong Delta's water flow is undergoing significant shifts, which pose imminent threats to its rich biodiversity, particularly the wetland tidal flat ecosystems. Recognized as biodiversity reservoirs, wetlands in the delta serve multifaceted roles—from housing diverse species and facilitating reproduction to being a source of essential nutrients for both land and water-based ecosystems. The intertidal flats along the coast of Mekong Delta are recognized habitats for numerous shorebirds species, which being attracted there by the abundance of food sources (such as benthic organisms and juvenile fishes). However, the inconsistency in water flow threatens to diminish these ecosystems, upsetting the ecological equilibrium of the region. The prolonged flooding due to water flow shift could jeopardize the habitats of numerous native species. There are 4 RAMSAR sites in the Vietnamese Mekong Delta are vulnerable to this water flow shifting.

Commented [48]: How about the tidal flat areas?

Commented [49R48]: added

Fish, which play an integral part in the Mekong Delta's ecosystem, stand at a heightened risk due to these altered water patterns. Specific fish species have evolved over time, aligning their spawning, migratory patterns, and feeding habits with the delta's natural water flows. Any deviation in these flows can obstruct their natural life processes, resulting in reduced fish numbers due to reproductive challenges and food shortages. Moreover, the unpredictable water patterns might cause behavioral and environmental misalignments for the fish, potentially pushing some sensitive species towards decline or even extinction. Over time, these aquatic changes can cascade up the food chain, impacting larger predators and, more critically, human communities that depend on the river's bounty for both food and their livelihood.

4.2.7 Dikes and other barriers and flooding season

The establishment of dikes in the Mekong Delta profoundly influences flood dynamics, including peak flood levels, floodwater retention capabilities, and the region's water equilibrium. Erecting high dikes amplifies the potential for flooding, a situation further exacerbated by other environmental stressors such as the escalation in sea levels, land subsidence, and heightened rainfall patterns induced by climate change (Duc Tran et al. 2018a).

Commented [50]: Is it possible to show the artificial dykes/ embankment in the delta

Commented [51R50]: Yes, it was showed in figure 4.5 above

Observational data from the upstream region in An Giang province provides compelling evidence of the dike's impact. Notably, between the intervals 1997–2004 and 2007–2010, there was a marked elevation in flood levels. By the year 2011, a substantial 69% of the province's total expanse was under the governance of the dike system, segregating the region into 15% semi-dike areas and 54% full dike territories. Concurrently, recorded flood heights in two designated monitoring zones around An Giang soared by 76.6% and 60.7%, respectively (Xuan et al. 2022a). These alarming trends are not isolated to An Giang but are anticipated to manifest in other dike-constructed zones throughout the Mekong Delta (Duc Tran et al. 2018a).

Furthermore, dike constructions can directly destroy critical natural habitats, including mangroves, intertidal sandbars, and mudflats (Phan et al. 2015; Minh et al. 2019; Dinh et al. 2020; Vu et al. 2022a; Xuan et al. 2022b). Those habitats area crucial for biodiversity, which in turn contributed to the ecosystem integrity and its associated services. The degradation of these habitats' risks destabilizing the intricate balance of the Mekong Delta's ecosystem. For example, areas like mangroves often act as nurseries for juvenile fish. As dikes destroy or alter these habitats, there's a decline in spaces safe for young fish to grow, leading to reduced fish populations.

Dikes can alter sediment deposition patterns (Duc Tran et al. 2018b; Minh et al. 2019; Xuan et al. 2022b). The Mekong Delta is historically replenished by nutrient-rich sediment from the Mekong River. However, dikes can hinder this natural sedimentation process, leading to erosion in some areas and unwanted sediment build-up in others. Such changes can impact the fertility of wetlands and other habitats.

4.2.8 Related human right issues

The Vietnamese Mekong Delta, with its rich biodiversity and ecosystems, has undergone significant changes due to factors like dike construction, alterations in water flow, and climate change. These changes, while ecological at their core, have deep-seated ramifications on human rights (Võ & Nguyễn 2014). Based on the current socioeconomical aspects of the regions and projected environmental issues, we raise concerns on the following human right issues:

- Right to Water and Sanitation: Disruptions in natural water flow can lead to water scarcity, affecting residents' access to clean and potable water, with associated health risks (Minderhoud 2019).
- Right to Livelihood: The Mekong Delta is a vital source of income for millions. The alterations in water flow, heightened flood risks due to dike constructions, and destruction of habitats like mangroves and mudflats can jeopardize the livelihoods of local communities. Many residents rely on the delta's resources for fishing, agriculture,

Commented [52]: Please describe if there are some risks when we start nature-based solutions or conservation works

Commented [53R52]: Okay, done

Commented [54]: Just want to know current regulation for the development works , climate change related policies and development plans by the authorities

Commented [55R54]: There are no specific regulation for the development works here. National laws such as the Environment Protection Law and Biodiversity Law applied here when it come to developments.

or tourism. The decline in fish populations or reduced agricultural yields due to ecological changes can lead to economic hardships and unemployment.

- Right to Food and food security: The Mekong Delta is Vietnam's rice bowl, producing a significant portion of the country's rice. Disruptions caused by changes in water flow, sedimentation, and dike construction can impact rice yields. Moreover, the decline in fish populations can also affect the availability of protein-rich food sources. This poses a threat to the food security of not only the local residents but also the broader Vietnamese population.

- Human-Wildlife Conflict and Safety: As habitats degrade and natural food sources dwindle, wildlife may encroach upon human settlements in search of food and shelter. This can lead to conflict between human and wildlife conservation. The case of the Sarus Crane displaced from their habitats due to human activities is the good example of this unsolved conflict (Tran 2005; Zalinge et al. 2010; Van Zalinge et al. 2023).

- Right to Health: The destruction of natural habitats and changes in water flows can lead to increased risks of water-borne diseases. Stagnation of water behind dikes and reduced flow can create breeding grounds for disease vectors like mosquitoes. Furthermore, prolonged inundation and increased flooding can contaminate drinking water sources, leading to health issues.

- Displacement and Right to Adequate Housing: The heightened flood risks due to dike construction and climate change factors like rising sea levels and increased rainfall can threaten the safety of homes in the delta. The unpredictability of flood events, combined with infrastructural challenges, can displace families and disrupt communities (Lê et al. 2014, Võ & Nguyễn 2014, Nguyen 2022, Mai & Ngô 2016).

- Right of Indigenous Peoples: The Mekong Delta has a rich cultural heritage, with traditions and practices deeply connected to the river and its rhythm. The two main indigenous groups in this region were the Khmer and Cham people. Ecological changes can threaten this cultural connection, eroding traditional practices, rituals, and ways of life that have been passed down through generations.

- Gender equality issue: Women, who often bear the primary responsibility for household sustenance and caregiving, find themselves disproportionately affected. Their limited access to resources, decision-making forums, and climate-resilient skills amplifies their vulnerabilities. Furthermore, as climate-induced migration increases, women left behind in the delta face increased workloads and potential security threats.

Thus, climate change in the Mekong Delta not only threatens its ecosystem but also deepens existing gender disparities, underscoring the need for inclusive adaptation strategies (Mai et al. 2018).

- Right to Information and Participation: The construction of infrastructures like sluice gates, dikes or dams often involves decisions made at higher administrative levels. If local communities are not adequately informed, consulted, or involved in these decisions, it can infringe upon their right to participate in decisions that directly impact their lives.

- Right to a Healthy Environment: The rapid ecological changes in the Mekong Delta, be it due to dike construction or climate change, can deprive the local communities of their right to a healthy and sustainable environment. The loss of biodiversity, alteration of habitats, and changes in water quality can all impact the overall well-being of residents.

Given the socio-economical context of the Mekong Delta area, issues related to Right to Livelihood, Human-Wildlife Conflict and Safety, Rights of Indigenous Peoples and Minority Groups and • Right to Information and Participation may arise in conservation activities or Nature-based solution practices. In conclusion, the ecological transformations in the Vietnamese Mekong Delta, while having direct environmental implications, also cast a shadow on various human rights. Addressing these intertwined issues requires a holistic approach that considers both ecological preservation and human rights protection.

PART 5 CONNECTIONS BETWEEN JAPANESE INVESTMENT WITH ENVIRONMENTAL ISSUES IN THE SAI GON- DONG NAI RIVER BASIN AND THE MEKONG DELTA

5.1 JAPANESE INVESTMENT IN SAI GON- DONG NAI RIVER BASIN

5.1.1 Supply chains

The Sai Gon-Dong Nai River Basin, strategically located and rich in resources, stands as a pivotal hub for Vietnam's trade activities with Japan. Historically rooted in the exchange of agricultural produce, the trade portfolio has diversified over the years to include electronics, textiles, and other manufactured goods.

Garments, clothing, and footwear have been the main trade items produced from the region, which contributes a significant portion to the 90% primary products exported (Nhung et al. 2018). Between 2001 and 2017, the export turnover of Vietnamese wood products consistently surged, boasting an annual growth rate of 11.4%. The Sai Gon- Dong Nai River Basin stand out in this furniture supply chain as a material area, a processing zone, and a logistic hub (Nhung et al. 2018).

The trade of electrical products between Japan and Vietnam has seen notable growth over recent years, with both nations capitalizing on their respective technological and manufacturing strengths (Michida & Nabeshima 2012). Various international corporates from Japan found value in collaborating with Vietnamese partners, sourcing high-quality components and even final electrical products to cater to international market. Japanese electrical and tech innovations often find their way to Vietnam, assisting local industries in enhancing production quality and efficiency. This bilateral trade synergy isn't just limited to end products; it extends to machinery, production techniques, and knowledge transfer, amplifying the entire electrical ecosystem. Central to this evolving supply chain is Ho Chi Minh City and its satellite towns in the Sai Gon-Dong Nai River Basin. As one of Vietnam's economic powerhouses, Ho Chi Minh City serves as a pivotal hub for both the import of Japanese electrical components and the export of finished products. The city's strategic location, bolstered by the logistical advantages of the Sai Gon-Dong Nai River Basin, facilitates seamless transportation and distribution (Vind & Fold 2010).

As bilateral trade between Japan and Vietnam grows, logistical infrastructure become critical. The Sai Gon-Dong Nai River Basin, with its network of waterways and international ports,

provides an essential transport route, reducing lead times and ensuring that products move efficiently between manufacturing sites, ports, and onward to Japan. The river basin's infrastructure, complemented by Ho Chi Minh City's growing technological base, reinforces the region's stature as an indispensable node in the electrical products supply chain between Japan and Vietnam (Vind & Fold 2010).

5.1.2 Non-trade related investments

Non-trade related investments by Japanese companies in the Sai Gon-Dong Nai River Basin typically revolve around long-term strategic projects that aim to foster economic growth, improve infrastructure, or enhance the quality of life in these regions, rather than directly promoting the exchange of goods. Based on JETRO data, the major non-trade investments by Japanese companies in the Sai Gon-Dong Nai River Basin are:

- Infrastructure Development: Japanese firms, often in collaboration with governmental agencies (e.g. JICA), have been involved in the development of infrastructure projects, such as roads, bridges, ports, and airports. The Metro project (rapid transit by electric train) in Ho Chi Minh City is a good example of this development. These projects may not directly involve trade but facilitate smoother operations for businesses and improve accessibility. The hotspot for Japan related Infrastructure Development were in Ho Chi Minh City and in Binh Duong (Lê et al. 2022b).

- Urban Planning and Development: Companies might invest in housing projects, commercial spaces, and smart city initiatives in rapidly urbanizing areas, especially around Ho Chi Minh City in the Sai Gon-Dong Nai River Basin.

- Environmental Initiatives: Given the environmental challenges in the Sai Gon-Dong Nai River Basin, Japanese firms may invest in sustainable and environmental projects. This includes water management, flood control initiatives, or reforestation efforts.

- Research and Development (R&D) Centers: Japanese companies might establish R&D centers to innovate and develop new products or solutions tailored for the Vietnamese market and Southeast Asia. Most of Japanese R&D centers were found in Ho Chi Minh City of the Sai Gon-Dong Nai River Basin.

- Training and Education: Investments in educational institutions, vocational training centers, or collaborative projects with local universities to nurture talent, develop skills, and improve the quality of the workforce.

- Tourism and Hospitality: While not directly related to trade, Japanese investments in hotels, resorts, or tourist attractions can boost local economies and improve the region's appeal to international tourists. Most of Japanese hotels and restaurants are located in Ho Chi Minh City.
- Healthcare: Investments in hospitals, clinics, and other healthcare facilities to provide quality medical care and services.
- Energy and Power: Investments in renewable energy projects, power plants, or energy management systems to meet the growing demands of these regions.

While these investments might not be directly related to the exchange of goods, they play a significant role in shaping the economic and social landscape of the Sai Gon-Dong Nai River Basin. Such non-trade related investments indicate a deep-rooted commitment of Japanese companies to the long-term development and prosperity of these regions.

5.1.3 Development project funded by Japanese Government

The Japanese government, through its Official Development Assistance (ODA), has been instrumental in driving sustainable development projects within the Sai Gon-Dong Nai River Basin. A systematic search on JICA database and news articles in Vietnam highlights four primary areas of investment, namely water management, transportation, energy, health care and training.

Recognizing the basin's issues linked to urbanization, industry and climate change, Japan government has directed its ODA toward multiple water treatment projects in this region. ODA funds have been directed towards establishing and operating a network of water management and treatment projects across Ho Chi Minh City(JICA 2020a, 2020b, 2021), Dong Nai (JICA 2011, 2017a; JICA Expert Team 2019), Binh Duong (JICA 2013a), and Ba Ria-Vung Tau (Inazawa 2016). This intervention is crucial, especially given the basin's pivotal role in supply chains, ensuring that the region's water resources remain uncontaminated and sustainable for both trade and daily life.

In transportation, with the basin being a central node for trade, especially in sectors like electronics, garments, and furniture, the Japanese-backed highways, expressways and international port projects play a quintessential role. These infrastructural upgrades are not just about easing commuter travel but are strategically designed to expedite the movement of goods, fostering a more robust trade ecosystem between Vietnam and Japan, among other global partners. The notable ODA transportation projects in the regions are Metro project in

Ho Chi Minh City (JICA 2012; Phạm 2015), the North-South Expressway Construction Project (Ben Luc - Long Thanh Section) (JICA 2018) and the Cai Mep- Thi Vai International Port project (Keishi 2018)

In the energy sector, the Phu My Thermal Power Plant in Ba Ria-Vung Tau, built with the aid of Japan's ODA (JICA 1999). This power plant not only reinforces the region's energy matrix but also ensures a steady power supply, critical for sustaining the burgeoning industries and trade activities of the basin.

In a bid to enhance the healthcare infrastructure, Japanese ODA have also been directed towards Cho Ray hospital in Ho Chi Minh City (Định 2023), in Ho Chi Minh City, bolstering its capacity and capability to deliver advanced medical care to the region's inhabitants. As trade and commerce intensify and the region becomes more urbanized, the demand for advanced healthcare services surges. By bolstering the Cho Ray hospital's facilities, Japan's ODA ensures that the local and transient population within the basin has access to better medical care.

Lastly, cognizant of the human capital's significance, Japan's ODA has been instrumental in providing capacity-building programs, training officers and workers in the basin (JICA 2014, 2017b). These programs are designed to upskill the local workforce, ensuring they are well-equipped to handle the technological and managerial challenges of the modern trade environment.

5.1.4 The connections between Japanese investments and the environment issues in the Sai Gon- Dong Nai River Basin

The Sai Gon-Dong Nai River Basin has experienced significant Japanese investments across various sectors, intricately tying the region's environmental and economic dynamics. According to JETRO data (2023), there are 431 Japanese companies and/or projects that take place in the Sai Gon- Dong Nai River Basin. Among those, manufacturing stands out as the predominant sector, with a staggering 329 Japanese-related companies and projects, underscoring its significant role in the basin's industrial activities. This dominance is followed by the textile industry, which comprises 41 entities. Agriculture, another vital sector for the basin, boasts 38 Japanese-affiliated initiatives. The construction and ICT sectors also play essential roles, with 15 and 6 projects respectively, while energy has a notably limited Japanese footprint with only 2 entities, despite its vast potential implications for the region. These investments, while fostering economic growth, can have multifaceted environmental implications, especially when considering sectors like textile, agriculture, construction, and

Commented [56]: Please show a map of distribution of those companies and their water risks

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energy. The sheer volume of manufacturing-related endeavors highlights the need for sustainable practices to mitigate potential environmental impacts in this vital watershed area. Figure 5-1 provide an overview of the Japanese investment and business landscape in the region of Sai Gon- Dong Nai River Basin.

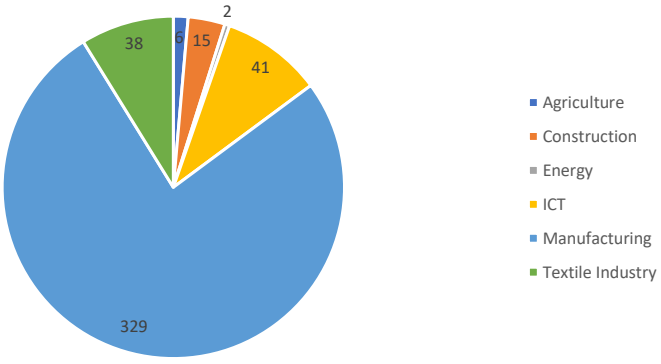

Figure 5-1 Number of projects/companies by each sector In Sain Gon- Dong Nai River Basin

The data from JETRO (with some verification from JICA website) allowed to estimate the location of those 431 companies/projects (Figure 5-2). Mapping those entities on a map together with the main Sai Gon-Dong Nai River and EBSA would allow inferring their potential impacts on environment and biodiversity in this region (Figure 5-2). It's apparent that there's a considerable concentration of diverse sectors — particularly manufacturing, agriculture, and the textile industry — located proximate to the water systems and in close vicinity to ecologically sensitive zones, particularly the Can Gio Mangrove Biosphere Reserve. The dense clustering of manufacturing units near Dong Nai and to the south of Ho Chi Minh City, adjacent to the river, poses risks of water pollution due to effluents, potentially threatening both aquatic life and the quality of water for human consumption. Similarly, the textile units, known for their intensive water use and chemical discharge, are situated close to waterways, further intensifying the potential for water contamination. Agricultural activities, evident mainly to the northwest, could result in nutrient run-off into the water systems, especially when they're positioned near tributaries and river confluences. This can lead to algal blooms and harm aquatic ecosystems.

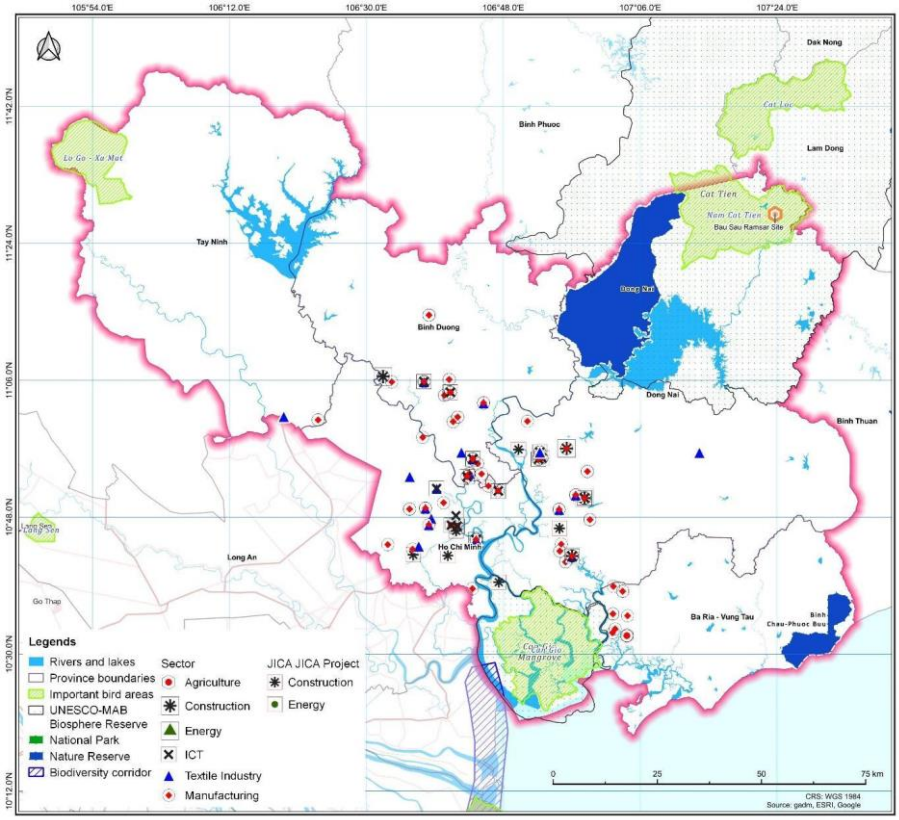

Figure 5-2 Locations of Japanese investment (companies or projects) in the Sai Gon- Dong Nai River Basin

Drawing from comprehensive data regarding the biogeography, ecology, and environmental characteristics of the Sai Gon-Dong Nai River Basin, coupled with our best understanding of the pertinent sectors, we delve into the potential environmental implications of Japanese investments in the region, as detailed in Table 5-1

Table 5-1 Connections between Japanese investment to environmental issues in Sai Gon- Dong Nai River Basin

Sector	Number of companies/ projects	Potential impacts	Vulnerable to
Agriculture	6	**Water Pollution**: Overuse of pesticides and fertilizers can lead to nutrient run-off, causing algal blooms and dead zones in aquatic systems. **Habitat Destruction:** Expanding agricultural areas might necessitate clearing natural habitats. **Land-use Change:** Conversion of forests or wetlands to farmland affects biodiversity and ecosystem services. **Water Over-extraction:** Irrigation might lead to lowered groundwater levels if not managed sustainably.	Flooding, saltwater instruction, water pollution
Construction	15	**Habitat Destruction:** Construction projects, especially infrastructure, can fragment habitats and disrupt local ecosystems. **Land-use Change:** Construction often requires changing land use, which can affect local biodiversity. **Resource Depletion:** Construction activities can strain local resources, especially materials like sand, gravel, and water. This can worsen the sand mining situation in this region and surrounding areas.	Flooding, Societal and Governance Issues

Sector	Number of companies/ projects	Potential impacts	Vulnerable to
Energy	2	**Air Pollution:** Phu My Thermal Power Plant burn fossil fuels to produce energy. The process emits greenhouse gases and other pollutants. **Habitat Destruction:** Infrastructure for energy, especially large installations like hydropower plants, can disrupt local habitats.	Societal and Governance Issues, Interdependence of Sectors
ICT	41	**Electronic Waste**: Improper disposal of electronic waste can lead to soil and water contamination due to the leaching of hazardous materials. **Energy Consumption:** Data centers and other ICT infrastructures can be energy-intensive, leading to increased greenhouse gas emissions if powered by non-renewable sources.	Societal and Governance Issues, Interdependence of Sectors
Manufacturing	329	**Water Pollution:** Effluents from manufacturing units can contain chemicals, heavy metals, and other pollutants. If not treated appropriately, they can severely degrade water quality in the basin. **Air Pollution:** Emissions from factories might include greenhouse gases and other harmful pollutants that affect air quality. **Habitat Destruction:** Large-scale manufacturing units can lead to habitat fragmentation and displacement of local flora and fauna.	Flooding, Water pollution, Societal and Governance Issues

Commented [58]: Want to know in detail, is this a serious problem in this region?

Commented [59R58]: Yes, it is serious, as may high-tech companies are located in Ho Chi Minh City in this area. Also, the comsumerism ideology are strong in major city like Ho Chi Minh city. People will throw away their old smartphone to get the new one just for trend. This creates many electronic wastes

Sector	Number of companies/ projects	Potential impacts	Vulnerable to
		Resource Depletion: High demand for resources, such as water and raw materials, can strain local supplies.	
Textile Industry	38	**Water Pollution:** The textile industry is known for its high water use and the release of harmful chemicals and dyes into waterways. **Land Degradation**: Disposal of untreated waste can affect soil quality. **Resource Depletion:** The textile industry often demands vast amounts of water, leading to potential over-extraction.	Societal and Governance Issues, Interdependence of Sectors

5.1.5 Vulnerabilities for Japanese investments in the Sai Gon- Dong Nai River Basin

The Japanese investments in the Sai Gon-Dong Nai River Basin face a set of vulnerabilities due to various factors, primarily climate changes and other intertwined environmental and social issues:

- Climate Change-Induced Risks (Water-related risk):

    - Flooding: With increasing climate variability, the Basin is prone to more frequent and severe flooding. Infrastructure, such as manufacturing plants and transportation links funded by Japanese investments, may be disrupted or damaged due to these unpredictable flood events.

    - Rising Sea Levels:Coastal areas, particularly near the Ba Ria-Vung Tau province, face threats from sea-level rise. This can jeopardize port operations, coastal infrastructure, and other facilities vital for trade and logistics.

    - Salinization: Climatic changes increase the risk of saline water intrusion into freshwater sources. This poses a significant threat to agriculture investments, as it affects crop yield and quality.

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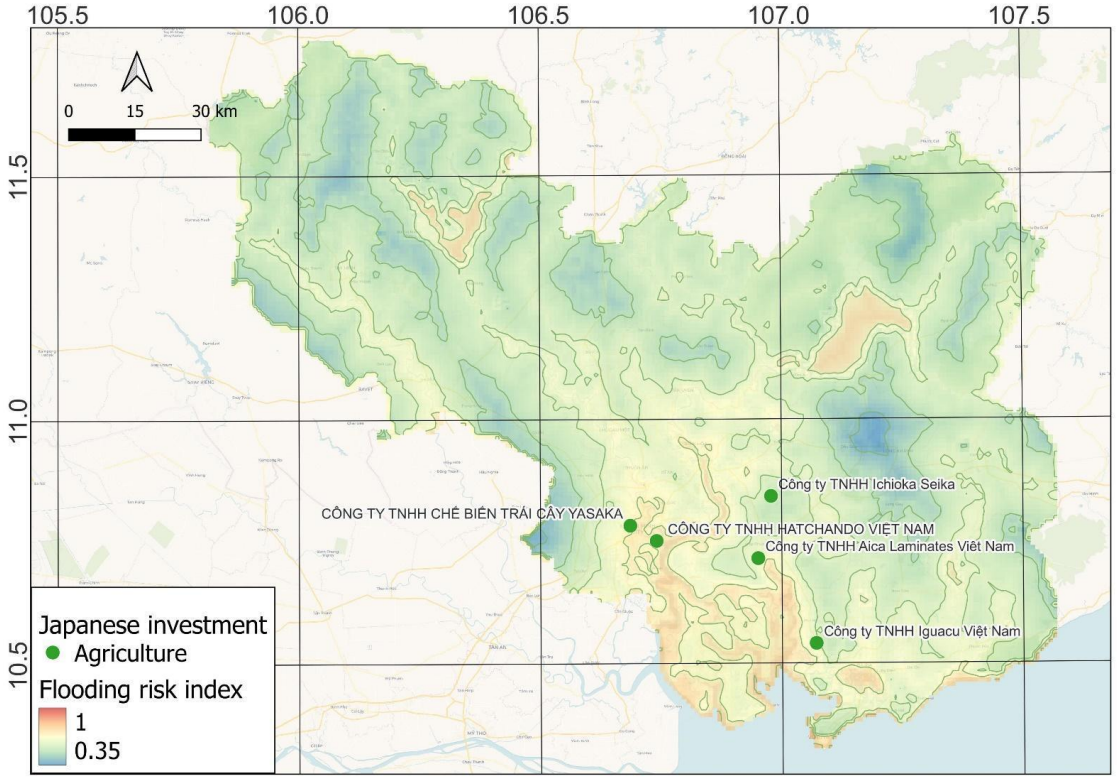

Figure 5-3 Japanese investments in agricultural field and flood risk in Sai Gon- Dong Nai River Basin

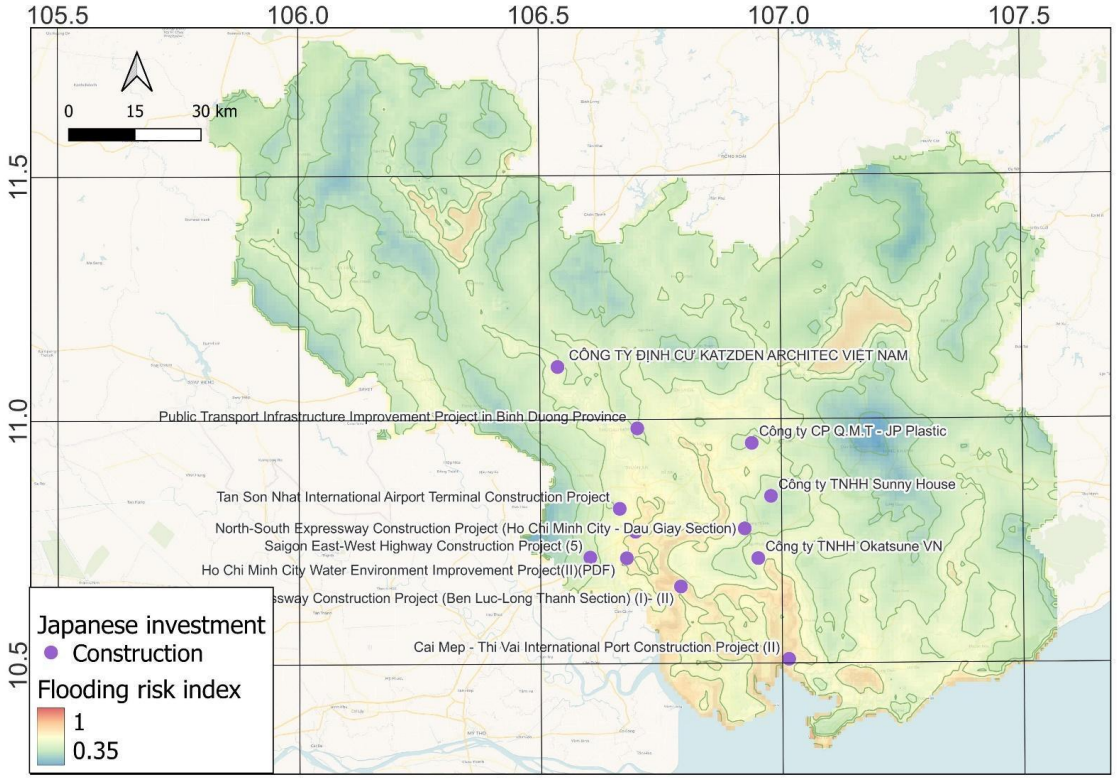

Figure 5-4 Japanese investment in construction field and flood risk in Sai Gon- Dong Nai River Basin

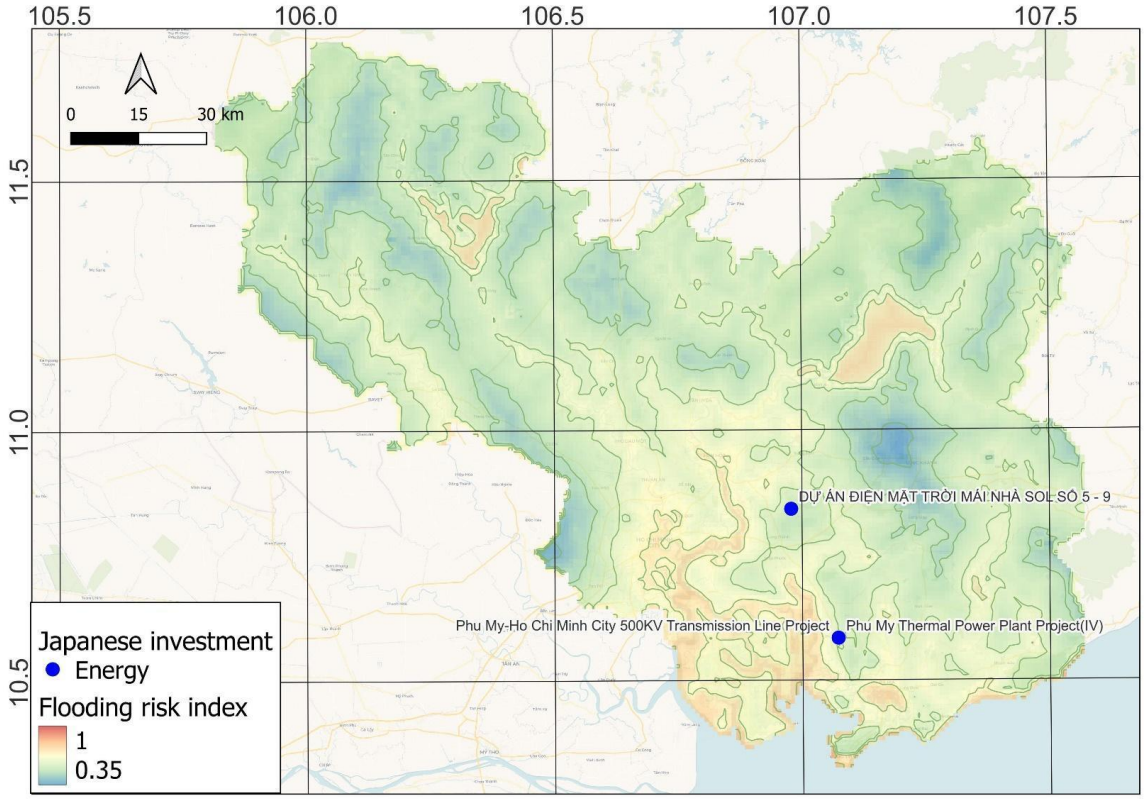

Figure 5-5 Japanese investments in energy field and flood risk in Sai Gon- Dong Nai River Basin

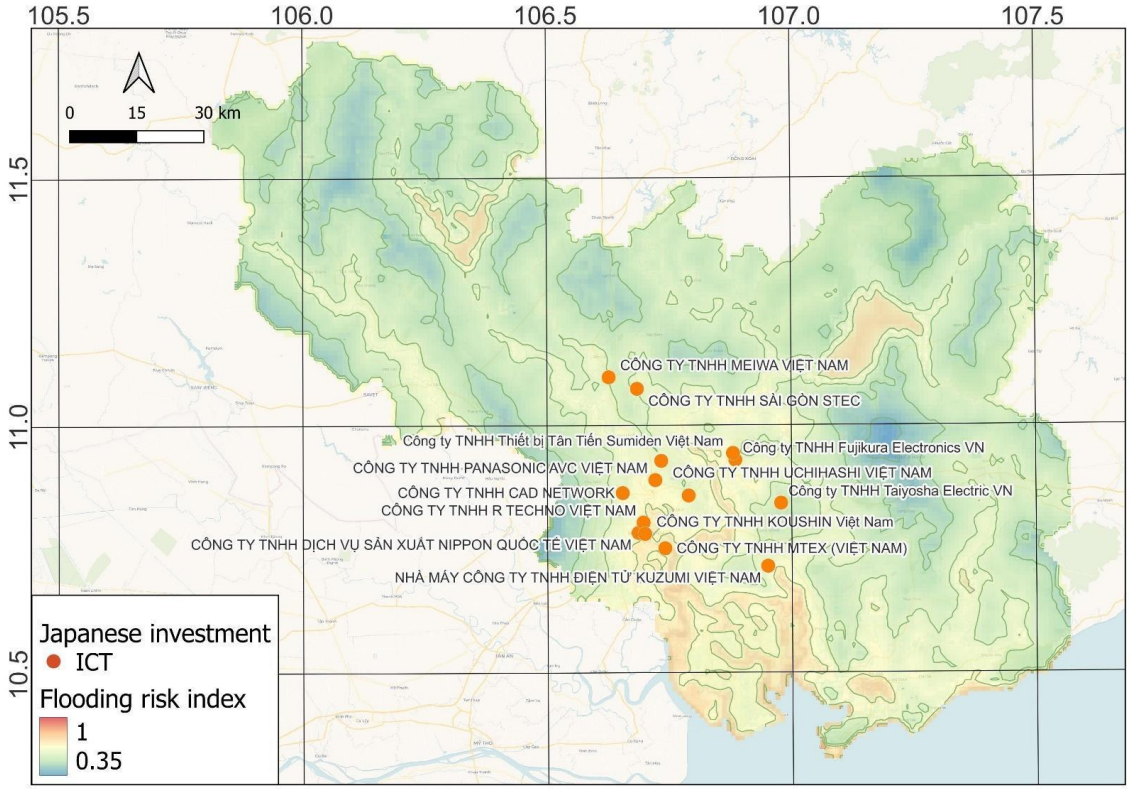

Figure 5-6 Japanese investments in ICT and flood risk in Sai Gon- Dong Nai River Basin

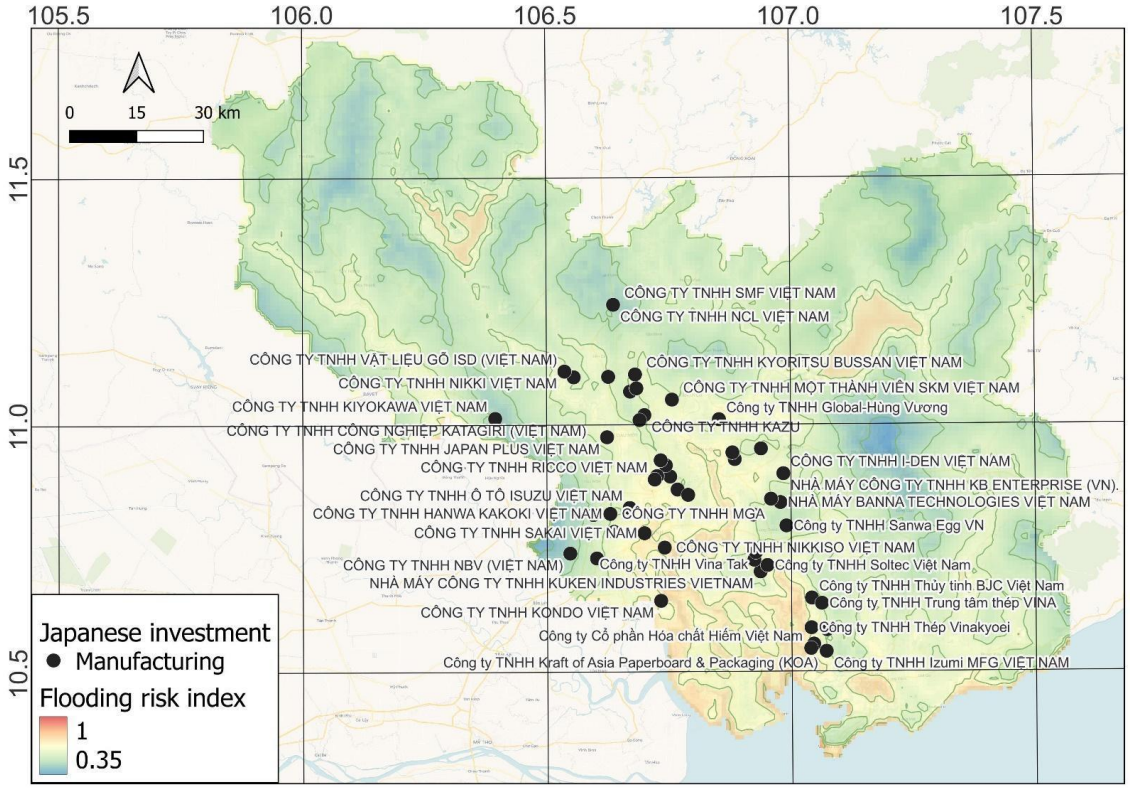

Figure 5-7 Japanese investment in manufacturing and flood risk in Sai Gon- Dong Nai River Basin

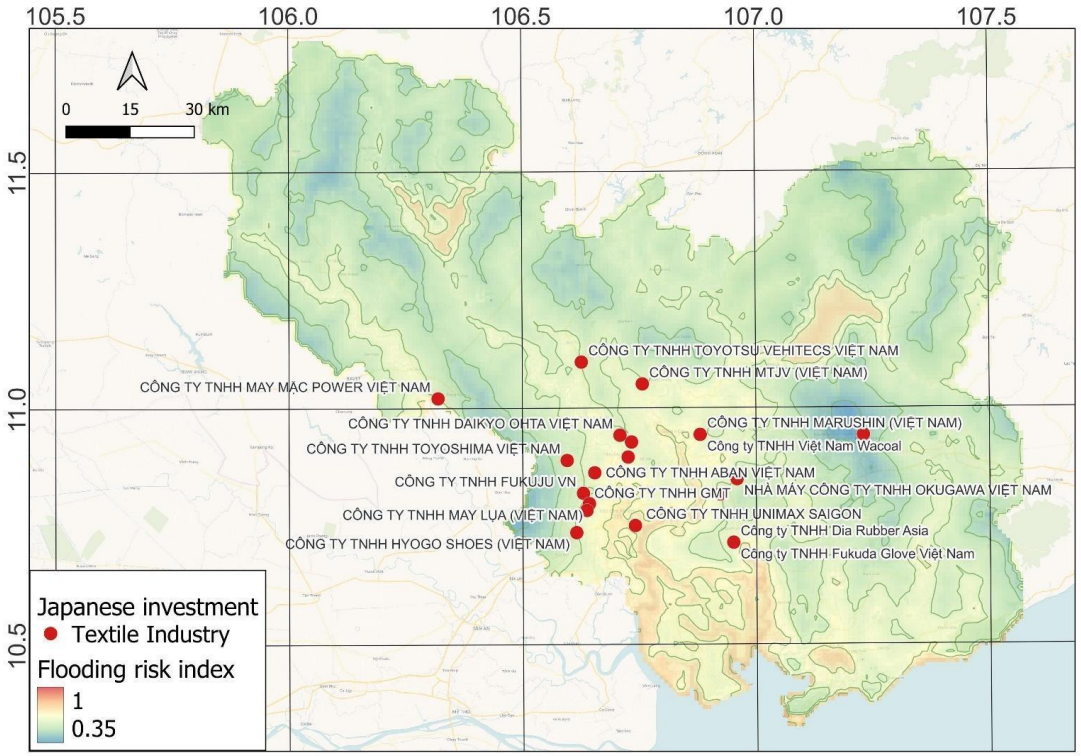

Figure 5-8 Japanese investment in textile field and flood risk in Sai Gon- Dong Nai River Basin

- Environmental Vulnerabilities:
    - Water Pollution: The high concentration of industries, particularly in the textile and manufacturing sectors, might lead to increased pollution if not properly managed. This can affect water sources, posing a risk to operations reliant on clean water.
    - Deforestation & Habitat Loss: As investments grow, there might be pressures leading to deforestation or habitat destruction, which could exacerbate flooding, reduce biodiversity, and damage ecosystems that many local communities depend on.
- Societal and Governance Issues:
    - Land Disputes: As investments often require land acquisition, it can lead to potential conflicts with local communities if not conducted transparently and ethically.
    - Labor Issues: The region has seen labor strikes and disputes in the past. Ensuring fair wages, good working conditions, and upholding workers' rights become paramount for smooth operations.
    - Local Governance and Regulations: Fluctuating or inconsistent environmental regulations might pose challenges to Japanese investments if they are not in line with international standards or if they change unpredictably.
- Interdependence of Sectors: Given the interconnected nature of the sectors, a disruption in one (e.g., a failure in the energy sector or transportation infrastructure) can have cascading effects on others, such as manufacturing or ICT.

In essence, while the Sai Gon-Dong Nai River Basin presents numerous opportunities for Japanese investments, a holistic understanding of its vulnerabilities, coupled with proactive measures, is essential for sustainable and resilient growth

5.2 JAPANESE INVESTMENT IN VIETNAMESE MEKONG DELTA

5.2.1 Supply chains

The Mekong Delta, often referred to as Vietnam's "rice bowl", is an indispensable part of the trade relationship between Vietnam and Japan. This region, teeming with biodiversity, boasts fertile lands and abundant waters, making it a pivotal hub for the production of seafood, especially shrimp (Le et al. 2019), tropical fruits (Vo & Smith 2014), and other vital agricultural products. However, the supply chain encompassing these products faces several challenges. A pronounced lack of storage and advanced logistics facilities often compromises the quality of the products (Vo & Smith 2014). The existing quality control standards, not always aligned with international benchmarks, sometimes fall short in ensuring consistent product quality (Le et al. 2019). Additionally, many processing units in the region still rely on outdated technology, which hampers efficiency and can affect the overall product quality (Tran et al. 2013).

Due to the limitations of processing technologies and logistic facility, the Mekong Delta are somewhat dependent on the adjacent Sai Gon- Dong Nai River Basin, particularly Ho Chi Minh City to export their products. Goods harvested from the Mekong Delta often travel through the intricate network to various facilities in the Sai Gon-Dong Nai River Basin before moving elsewhere. Ho Chi Minh City's ports, storage facilities, and transportation infrastructure play a pivotal role in processing, packaging, and exporting products sourced from the Delta. The city also provides advanced technological solutions and market insights, enhancing the value of goods from the Mekong Delta.

5.2.2 Non-trade related investments connected to Japanese companies

Non-trade related investments by Japanese companies in the Vietnamese Mekong Delta typically revolve around long-term strategic projects that aim to foster economic growth, improve infrastructure, or enhance the quality of life in these regions, rather than directly promoting the exchange of goods. Based on JETRO data, the major non-trade investments by Japanese companies in the Mekong Delta are:

- Infrastructure Development: Japanese firms, often in collaboration with governmental agencies, have been involved in the development of infrastructure projects, such as roads, bridges, ports, and airports. These projects may not directly involve trade but facilitate smoother operations for businesses and improve accessibility. The Can Tho Bridge is one great example of this type of investment.

- Research and Development (R&D) Centers: Japanese companies might establish R&D centers to innovate and develop new products or solutions tailored for the Vietnamese market and Southeast Asia. In the Mekong Delta, those types of investment usually related to a university (e.g. Can Tho University).
- Training and Education: Investments in educational institutions, vocational training centers, or collaborative projects with local universities to nurture talent, develop skills, and improve the quality of the workforce.
- Environmental Initiatives: Given the vulnerability of the Mekong Delta to climate change and the environmental challenges, Japanese have invested in sustainable and environmental projects. This includes water management, flood control initiatives, or reforestation efforts.
- Tourism and Hospitality: Japanese investments in hotels, resorts, or tourist attractions can boost local economies and improve the region's appeal to international tourists.
- Healthcare: Investments in hospitals, clinics, and other healthcare facilities to provide quality medical care and services.
- Agricultural Technology: Given the Mekong Delta's agricultural significance, Japanese firms might invest in advanced agricultural technologies, research centers, or initiatives that promote sustainable farming practices.
- Energy and Power: Investments in renewable energy projects, power plants, or energy management systems to meet the growing demands of these regions.

While these investments might not be directly related to the exchange of goods, they play a significant role in shaping the economic and social landscape of the Mekong Delta. Such non-trade related investments indicate a deep-rooted commitment of Japanese companies to the long-term development and prosperity of these regions.

5.2.3 Development project funded by Japan Government

The Japanese government's ODA has played a pivotal role in bolstering sustainable growth and fortifying local infrastructure in the Vietnamese Mekong Delta (Ohno 2019)

A testament to Japan's commitment towards the region's future, various water management projects, especially in Ben Tre province, have been launched to combat saltwater intrusion—a pressing issue stemming from climate change in this region (JICA 2010, 2013b). Those

projects aim to ensure equitable water distribution among communities, safeguarding both livelihoods and the fragile ecosystem.

Complementing these efforts, the ODA has made strides in nurturing the region's intellectual capital, with significant investments channeled towards Can Tho University (JICA 2019; Trieu 2022). Such support amplifies the quality of education and fosters research opportunities, laying the foundation for future innovation in the delta (JICA 2019; Trieu 2022)

Additionally, the heart of the Mekong Delta lies in its agriculture, and recognizing this, Japanese ODA projects are keenly focused on elevating the quality of agricultural products. By introducing advanced techniques and promoting rural development, these projects are set on ensuring that the delta's produce remains competitive and resilient in global markets (JICA 2013a, 2013c).

In essence, Japan's multifaceted development approach promises a harmonious blend of education, agriculture, and water conservation for the Mekong Delta's vibrant future.

5.2.4 The connections between Japanese investments and the environment issues in the Mekong Delta

Compared to Sai Gon- Dong Nai River Basin, Mekong Delta had fewer significant Japanese investments. According to JETRO data (2023), there were only 108 Japanese companies and/or projects that take place in the delta. Among those, manufacturing accounted for majority of the investment, with 71 Japanese-related companies and projects. This dominance was followed by the textile industry, which comprises 16 entities. Most of those investment concentrated in Tien Giang Province, particularly the area adjacent to Ho Chi Minh City. Agriculture, another vital sector for the basin, had only 4 Japanese-affiliated initiatives. Parallelly, the number of Japanese-affiliated initiatives that related to fishery (farmed fishes or wild capture fishes) were 4. Interestingly, there have been a significant investment from Japan on the energy sector in the Mekong Delta. Those investments included thermal power (Song Hau 2 Thermal Power Plant, O Mon 1 & 2 Thermal Power Plants, O Mon gas pipeline) and renewable energy (An Hao Solar Power Plant, Duyen Hai Wind Power Company Limited, Hau Giang solar power plant in Hoa An commune, Hau Giang Biomass Power Plant). The ICT and construction sectors have a notably limited Japanese footprint with only 3 and 1 entities, respectively. These investments, while fostering economic growth, can have multifaceted environmental implications, especially when considering sectors like textile, agriculture, construction, and energy. The sheer volume of manufacturing-related endeavors highlights

the need for sustainable practices to mitigate potential environmental impacts in this vital watershed area. Figure 5-3 provide an overview of the Japanese investment and business landscape in the region of Sai Gon- Dong Nai River Basin.

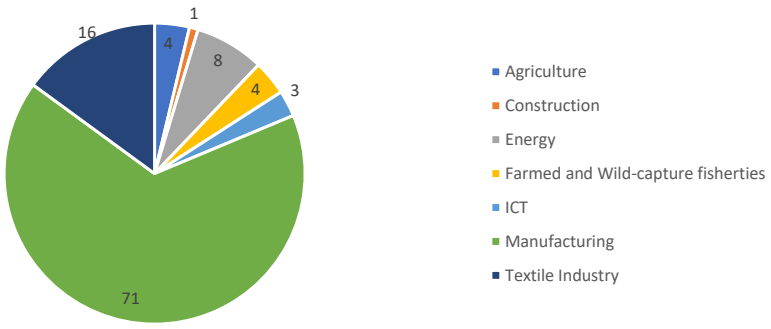

Figure 5-9 Number of projects/companies by each sector in Mekong Delta

The data from JETRO (with some verification from JICA website) allowed to estimate the location of those 108 companies/projects (Figure 5-4). Mapping those entities on a map together with the Mekong Delta and its EBSAs would allow inferring their potential impacts on environment and biodiversity in this region (Figure 5-4). Again, it's apparent that there's a considerable concentration of diverse sectors — particularly manufacturing, agriculture, and the textile industry near the Can Gio Mangrove Biosphere Reserve (not in Mekong Delta). This poses a risks of water pollution due to effluents, potentially threatening both aquatic life and the quality of water for human consumption. Similarly, the textile units, known for their intensive water use and chemical discharge, are situated close to waterways, further intensifying the potential for water contamination.

Commented [62]: Want to see the characteristics of those companies, such as sector, relation with water (water-consuming/ water-wasting/ vulnerable to the hazards etc..)

Commented [63R62]: Sure, we made several maps that separate companies of different sectors and the flooding hazard below.

To calculate which sectors/companies have high water-consuming, I think we need to do a in-depth survey in the field. For a desktop study like this one, we were unable to get such data

Commented [64]: Please overlay the location of the firms and water-related risks

Commented [65R64]: Sure, we added some maps below in section 5.2.5

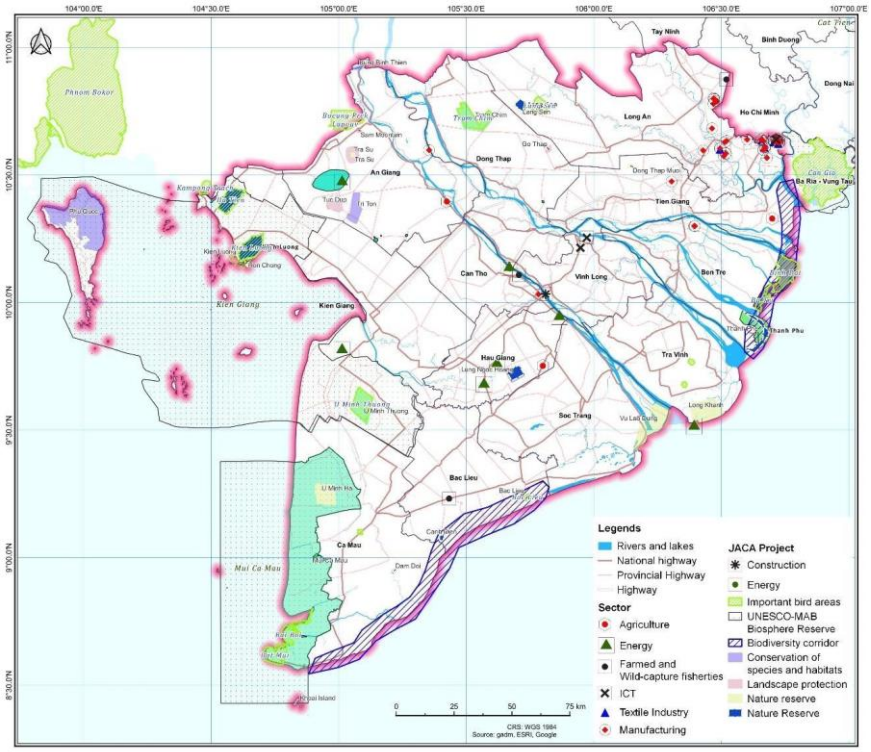

Figure 5-10 Locations of Japanese investment (companies or projects) in the Mekong Delta

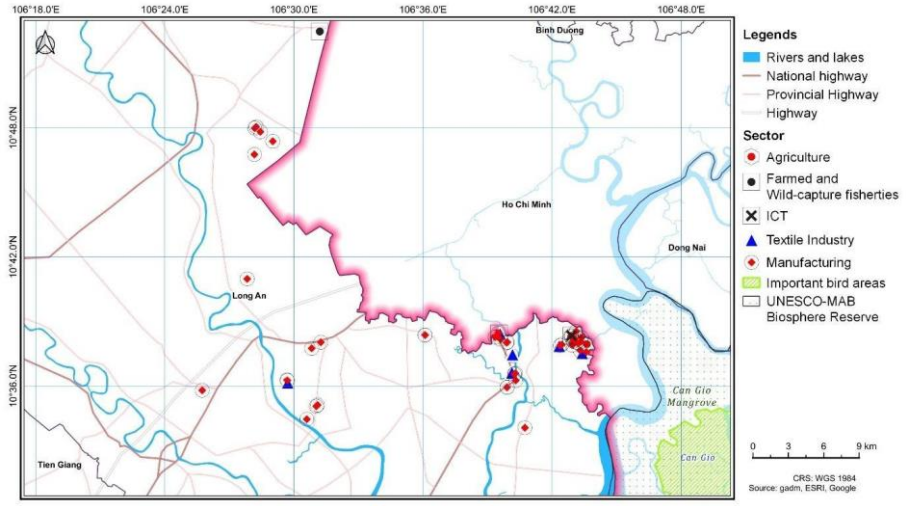

Figure 5-11 Locations of Japanese investment (companies or projects) in Tien Giang area

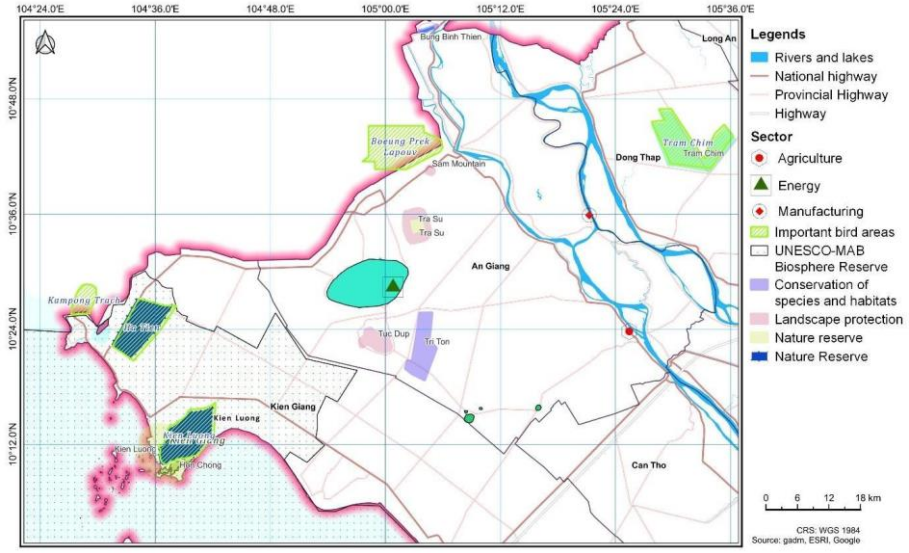

Figure 5-12 Locations of Japanese investment (companies or projects) in the An Giang- Can Tho area

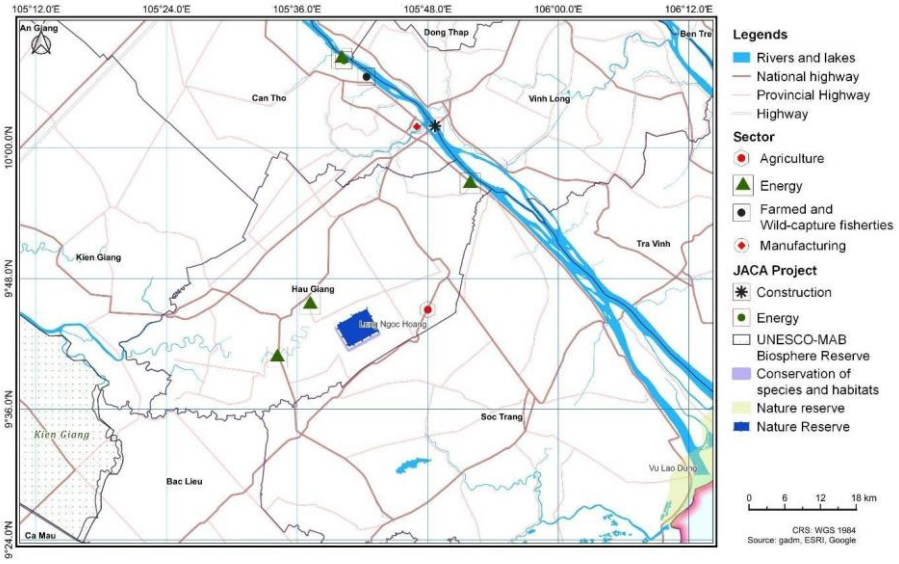

Figure 5-13 Locations of Japanese investment (companies or projects) in the Can Tho- Soc Trang area

Drawing from comprehensive data regarding the biogeography, ecology, and environmental characteristics of the Mekong, coupled with our best understanding of the pertinent sectors, we delve into the potential environmental implications of Japanese investments in the region, as detailed in Table 5-2 below.

Table 5-2 Connections between Japanese investment to environmental issues in Mekong Delta

Sector	Number of companies/ projects	Potential impacts	Vulnerable to
Agriculture	6	**Water Pollution:** Overuse of pesticides and fertilizers can lead to nutrient run-off, causing algal blooms and dead zones in aquatic systems. **Habitat Destruction:** Expanding agricultural areas might necessitate clearing natural habitats. **Land-use Change:** Conversion of mangrove or wetlands to farmland affects biodiversity and ecosystem services. **Water Over-extraction:** Irrigation might lead to lowered groundwater levels if not managed sustainably.	Flooding, saltwater instruction, water pollution
Construction	15	**Habitat Destruction:** Construction projects, especially infrastructure, can fragment habitats and disrupt local ecosystems. **Land-use Change:** Construction often requires changing land use, which can affect local biodiversity. **Resource Depletion:** Construction activities can strain local resources, especially materials like sand, gravel, and water.	Flooding, Societal and Governance Issues

Sector	Number of companies/ projects	Potential impacts	Vulnerable to
Energy	2	**Air Pollution:** thermal power projects involve fossil fuels, they can emit greenhouse gases and other pollutants. **Habitat Destruction:** Infrastructure for energy can disrupt local habitats. **Collision between migratory birds and bats with wind turbines:** Only applicable for Duyen Hai Wind Power Project.	Societal and Governance Issues, Interdependence of Sectors
Farmed and wild-capture fisheries	4	**Habitat Destruction:** The expansion of aquaculture, especially shrimp and catfish farming, often results in mangrove deforestation, leading to reduced natural breeding grounds and disrupting the ecological balance. **Pollution:** Aquaculture can result in nutrient pollution from feed waste, feces, and chemicals. This impacts water quality, harming both farmed species and wild populations. **Overfishing:** The wild-capture fisheries of the Mekong face severe pressure from overfishing. This depletes stocks, leading to reduced catches and affecting fishers' livelihoods.	Flooding, saltwater instruction, water pollution, temperature fluctuations, disease outbreaks, dams and hydropower projects upstream

Sector	Number of companies/ projects	Potential impacts	Vulnerable to
ICT	1	**Electronic Waste:** Improper disposal of electronic waste can lead to soil and water contamination due to the leaching of hazardous materials. **Energy Consumption:** Data centers and other ICT infrastructures can be energy-intensive, leading to increased greenhouse gas emissions if powered by non-renewable sources.	Societal and Governance Issues, Interdependence of Sectors
Manufacturing	8	**Water Pollution:** Effluents from manufacturing units can contain chemicals, heavy metals, and other pollutants. If not treated appropriately, they can severely degrade water quality in the basin. **Air Pollution:** Emissions from factories might include greenhouse gases and other harmful pollutants that affect air quality. **Habitat Destruction:** Large-scale manufacturing units can lead to habitat fragmentation and displacement of local flora and fauna. **Resource Depletion:** High demand for resources, such as water and raw materials, can strain local supplies.	Flooding, Water pollution, Societal and Governance Issues

Sector	Number of companies/ projects	Potential impacts	Vulnerable to
Textile Industry	4	Water Pollution: The textile industry is known for its high water use and the release of harmful chemicals and dyes into waterways. Land Degradation: Disposal of untreated waste can affect soil quality. Resource Depletion: The textile industry often demands vast amounts of water, leading to potential over-extraction.	Societal and Governance Issues, Interdependence of Sectors

Commented [66]: Keen to know the reality in this region, can you put locations of dying factories?

Commented [67R66]: Yes, please see Figure 5.18 for Textile Industry in section 5.2.5

5.2.5 Vulnerabilities for Japanese investments in the Mekong Delta

The Mekong Delta, a vital region encompassing a significant portion of Southeast Asia, is inherently susceptible to the effects of climate change and various socio-environmental issues. The vulnerabilities faced by Japanese investments in the Mekong Delta are multi-faceted:

- Climate Change-Induced Risks (Water-related risks):
    - Flooding: The Mekong Delta is increasingly prone to floods due to heavier rainfall and changing upstream water flow patterns. This situation jeopardizes infrastructure and can disrupt industries and transport systems vital to Japanese investments.
    - Rising Sea Levels and Coastal Erosion: Being a low-lying coastal region, the Delta is highly vulnerable to sea-level rise. Coastal erosion threatens infrastructure, particularly ports and transport facilities, essential for trade operations.
    - Salinization: Climate change magnifies saline intrusion risks in freshwater sources. Agriculture, a significant sector in the Mekong Delta, is profoundly affected by increased salinity, harming fishery resources and rice cultivation.

Commented [68]: Could you summarize current damages caused by flooding

Commented [69R68]: We could not access this data (especially the damage for Japanese investment in this area).

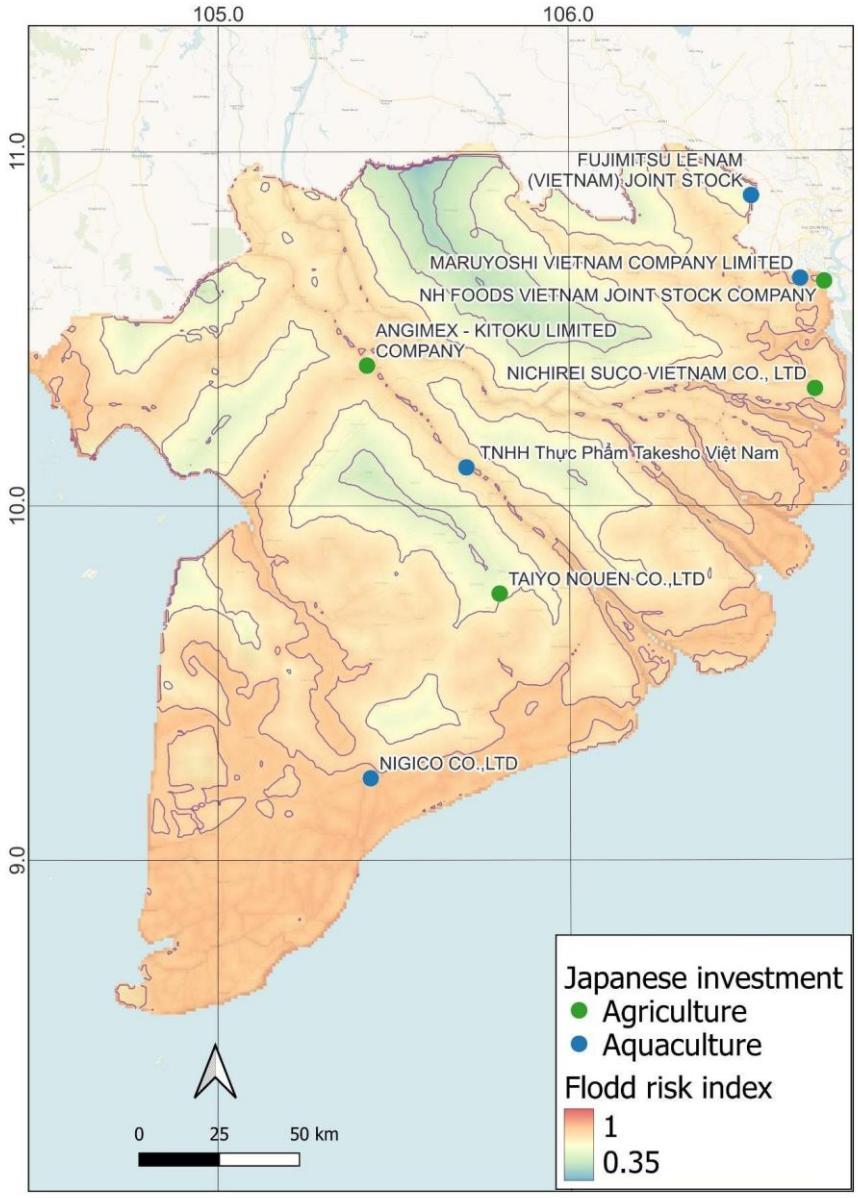

Figure 5-14 Japanese investment in Agriculture and Aquaculture and flood risk in Mekong Delta

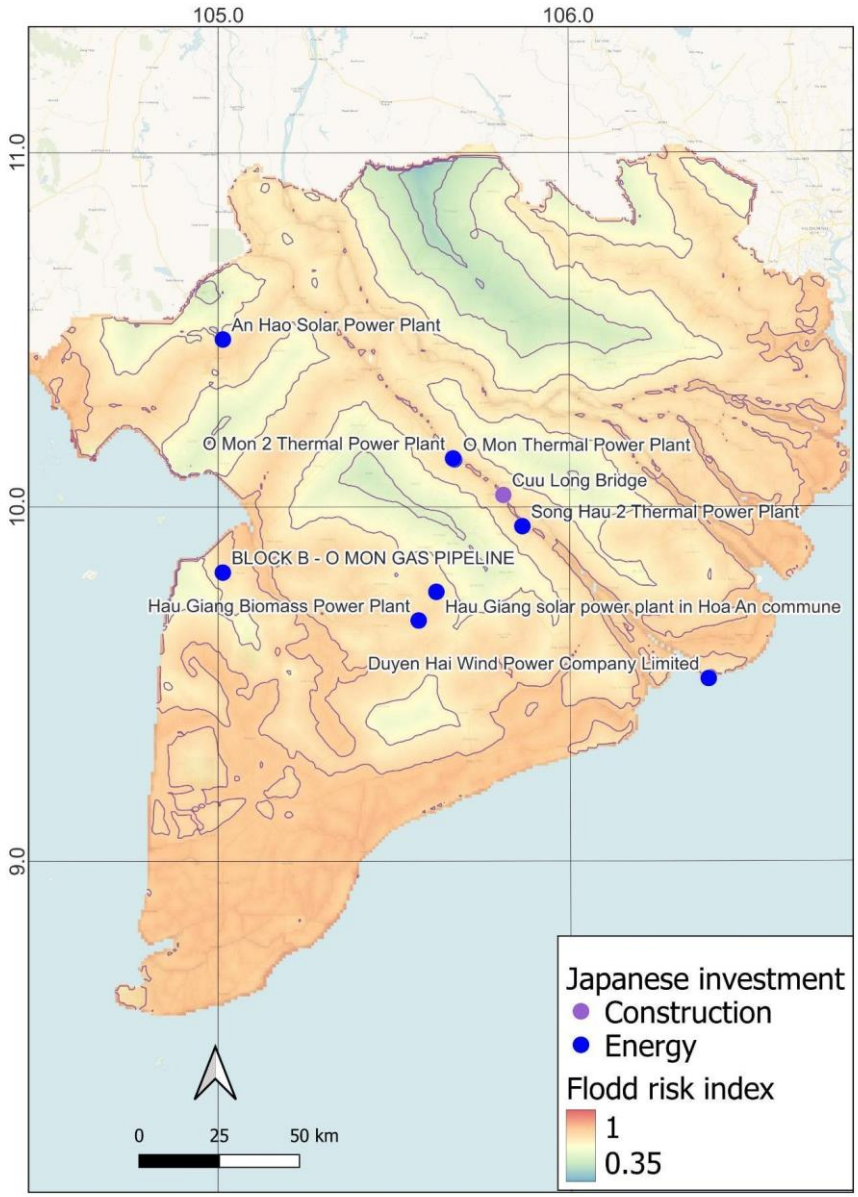

Figure 5-15 Japanese investment in construction and energy and flood risk in Mekong Delta

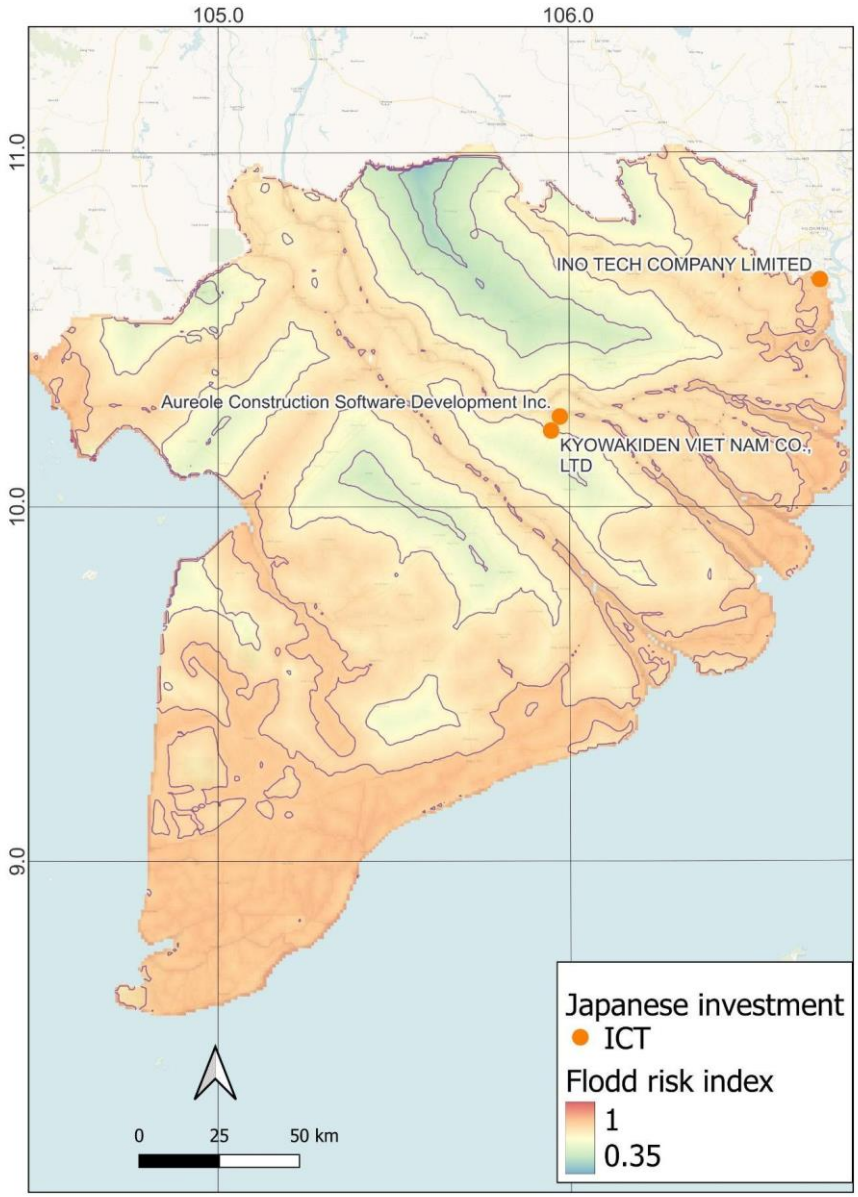

Figure 5-16 Japanese investment in ICT and flood risk in Mekong Delta

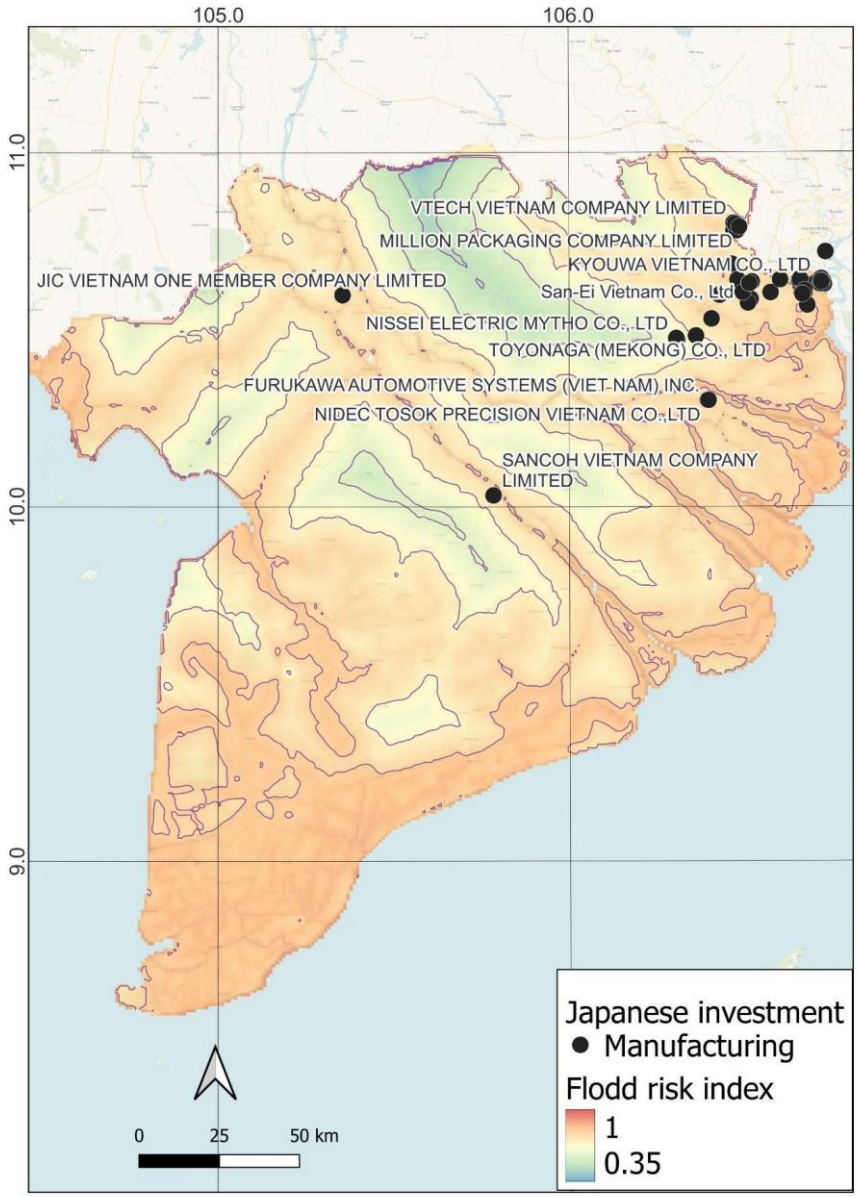

Figure 5-17 Japanese investment in manufacturing and flood risk in Mekong Delta

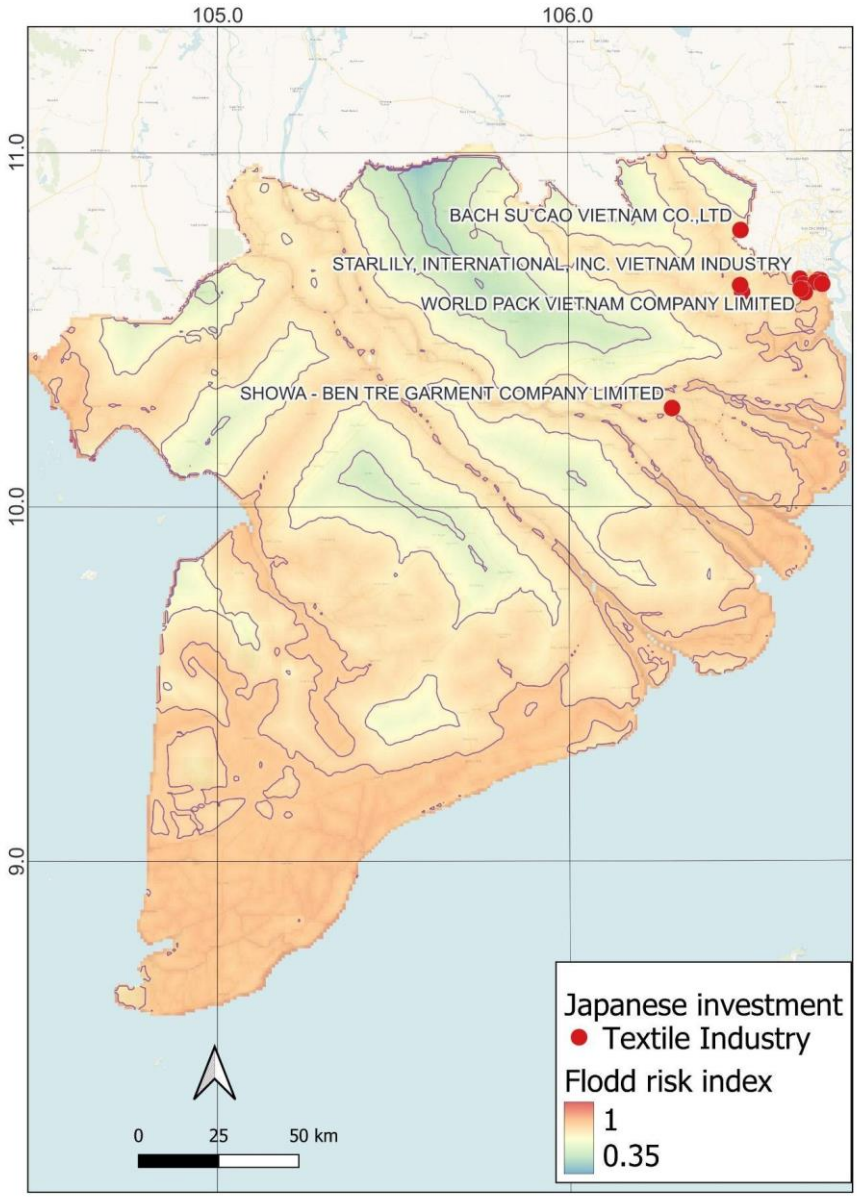

Figure 5-18 Japanese investment in textile industry and flood risk in Mekong Delta

- Environmental Concerns:
    - Loss of Biodiversity: The Delta's rich biodiversity is at risk from habitat loss due to industrial expansion and infrastructure development, potentially jeopardizing sectors like tourism and fisheries.
    - Water Scarcity and Pollution: With expanding industries and agriculture, there's an augmented strain on water resources. Japanese ventures, particularly in manufacturing and agriculture/aquaculture, might related to water pollution and reducing water availability. However, this issue is poorly studied in the Mekong Delta.
    - Land Subsidence: Over-extraction of groundwater has led to noticeable land subsidence in parts of the Delta, a risk for infrastructure projects.
- Societal and Governance Challenges:
    - Land Rights and Resettlement: Land acquisition for investments might clash with local communities' rights and interests. Resettlement and compensation issues can lead to conflicts and potential project delays.
    - Labor Challenges: Assuring ethical labor practices becomes pivotal in the region known for periodic labor strikes and disputes. Japanese investments need to focus on guaranteeing suitable wages and safe working conditions.
    - Regulatory Hurdles: The Delta encompasses multiple countries, leading to diverse and sometimes fluctuating environmental and trade regulations. Navigating this regulatory landscape can pose challenges for foreign investments.
- Regional Interactions and Dependencies: The Mekong Delta spans across several countries. As such, actions or policies in one country, such as dam construction upstream, can have downstream effects, potentially impacting sectors Japanese investors are involved in.

Considering these vulnerabilities, Japanese investments in the Mekong Delta need to adopt a foresight-driven and adaptive approach, balancing economic goals with environmental conservation and social responsibility to ensure sustainability and resilience.

Commented [70]: Could you identify locations affected by the infrastructure development?

Commented [71R70]: Information added

PART 6 POTENTIAL COLLABORATING ON CONSERVATION

Commented [72]: Please make a location map of your conservation activities in this region

Commented [73R72]: Need WWF Vietnam imput for this.

The World Wildlife Fund (WWF), renowned globally for its conservation efforts, operates with local nuances through its various national entities, each tailored to the specific challenges and opportunities of their region. WWF-Vietnam, deeply rooted in the ecological and socio-economic fabric of the nation, focuses on initiatives that cater to Vietnam's unique biodiversity and the threats posed by rapid industrialization and urbanization. On the other hand, WWF-Japan, emanating from one of the world's most technologically advanced nations, has a rich history of championing environmental causes and influencing policy frameworks both domestically and overseas. Given the intertwining dynamics of socio-economic growth and environmental conservation between Vietnam and Japan, especially with the latter's significant investment footprint in the former, the collaboration between WWF-Vietnam and WWF-Japan holds vast potential to address shared environmental concerns.

6.1 POTENTIAL COLLABORATIONS FOR SAI GON- DONG NAI RIVER BASIN

In this region, the WWF Vietnam and WWF Japan can consider those following potential collaborations to address complex conservation challenges:

6.1.1 Sustainable Development Advocacy

Given the rapid industrial and agricultural development in the region, there's an urgent need to advocate for and implement sustainable practices. WWF-Viet Nam and WWF-Japan can jointly develop guidelines and promote them among industries, especially those with Japanese investments. These activities should focus on the manufacturing sector, which dominate the Japanese investment landscape in the region.

6.1.2 Research and monitoring biodiversity, with focus on endangered species

There is still a gap of information regarding the biodiversity in the region. Collaborate on research, monitoring of endangered species and their habitats in the Sai Gon- Dong Nai River Basin hold the key to further protect and restore this river system.

6.1.3 Waste Management and Pollution Control

Implement projects to reduce industrial pollution, focusing on sectors like manufacturing, ICT, and energy. Encourage the adoption of cleaner technologies and waste management practices.

6.1.4 Community Engagement and Education

Develop community-based programs to raise awareness about the importance of the river basin's ecology. Engage local communities in conservation activities and sustainable livelihood initiatives.

6.1.5 Climate Resilience

Develop strategies to make the region's industries and communities more resilient to climate change, especially with the increased risk of flooding and other extreme weather events.

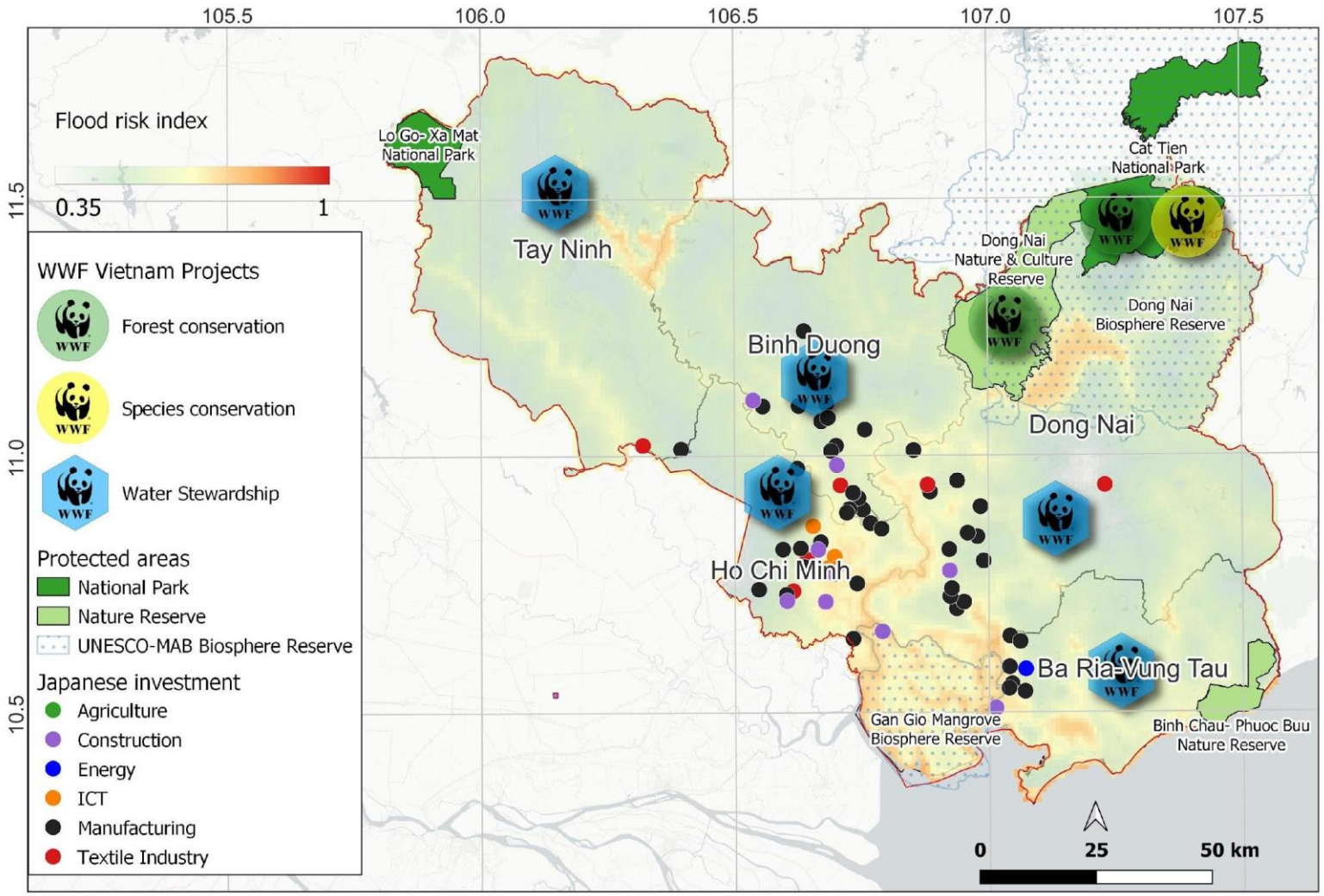
105.5
106.0
106.5
107.0
107.5
11.5
11.0
10.5
Flood risk index
0.35
1
WWF Vietnam Projects
Forest conservation
Species conservation
Water Stewardship
Protected areas
National Park
Nature Reserve
UNESCO-MAB Biosphere Reserve
Japanese investment
Agriculture
Construction
Energy
ICT
Manufacturing
Textile Industry
Lo Go- Xa Mat National Park
Tay Ninh
Cat Tien National Park
Dong Nai Nature & Culture Reserve
Dong Nai Biosphere Reserve
Binh Duong
Dong Nai
Ho Chi Minh
Ba Ria-Vung Tau
Gan Gio Mangrove Biosphere Reserve
Binh Chau- Phuoc Buu Nature Reserve
0
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Figure 6-1 On-going projects of WWF Vietnam in the Sai Gon- Dong Nai River Basin

6.2 POTENTIAL COLLABORATIONS FOR MEKONG DELTA

In this region, the WWF Vietnam and WWF Japan can consider those following potential collaborations to address complex conservation challenges:

6.2.1 Sustainable Fisheries Management

Given the significant impacts and vulnerabilities of both farmed and wild-capture fisheries, a collaboration can focus on promoting sustainable fishing practices, aquaculture methods, and stock management.

6.2.2 Habitat Restoration

Work on restoring mangrove forests and other crucial habitats degraded by aquaculture expansion. Mangroves act as natural barriers against sea-level rise and storm surges, crucial for the delta's future.

6.2.3 Climate Change Adaptation

With the Mekong Delta being a hotspot for climate change impacts, there's a need to develop and implement adaptation strategies. This could involve building community resilience, promoting salt-tolerant crops, and creating early warning systems for extreme weather events.

6.2.4 Water Management and Upstream Collaboration

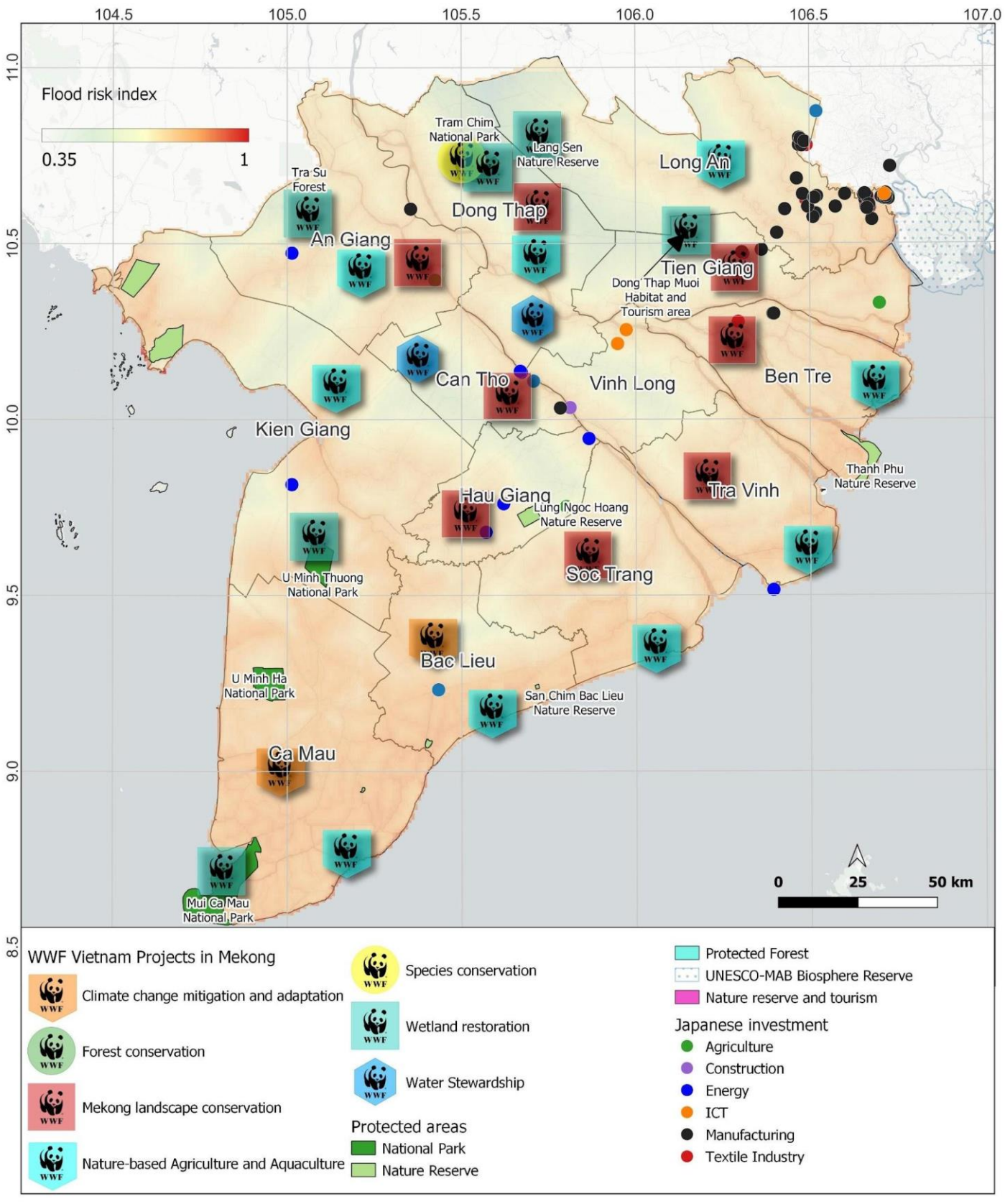
Advocate for and work on sustainable water management practices, considering the delta's vulnerability to upstream developments like dams. Collaborate with stakeholders across the Mekong region to ensure water and sediment flow continuity.

6.2.5 Socio-economic Initiatives

Given the socio-political issues around fisheries, there's potential for projects focusing on alternative livelihoods, community-based resource management, and conflict resolution.

6.2.6 Education and Outreach

Launch campaigns to educate the public and stakeholders on the ecological and economic significance of the Mekong Delta, promoting conservation and sustainable practices.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Flood risk index
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Tram Chim National Park
Lang Sen Nature Reserve
Long An
Tra Su Forest
Dong Thap
An Giang
Tien Giang
Dong Thap Muoi Habitat and Tourism area
Can Tho
Vinh Long
Ben Tre
Kien Giang
Thanh Phu Nature Reserve
Tra Vinh
Hau Giang
Lung Ngoc Hoang Nature Reserve
Soc Trang
U Minh Thuong National Park
Bac Lieu
U Minh Ha National Park
San Chim Bac Lieu Nature Reserve
Ca Mau
Mui Ca Mau National Park
0
25
50 km
WWF Vietnam Projects in Mekong
Climate change mitigation and adaptation
Forest conservation
Mekong landscape conservation
Nature-based Agriculture and Aquaculture
Species conservation
Wetland restoration
Water Stewardship
Protected areas
National Park
Nature Reserve
Protected Forest
UNESCO-MAB Biosphere Reserve
Nature reserve and tourism
Japanese investment
Agriculture
Construction
Energy
ICT
Manufacturing
Textile Industry

Figure 6-2 On-going projects of WWF Vietnam in the Mekong Delta

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- ## APPENDIX 1: EXTRACTED DATA ON MAMMALS IN SAI GON- DONG NAI RIVER BASIN

(Sent in separate file)

- ## APPENDIX 2: EXTRACTED DATA ON BIRDS IN SAI GON- DONG NAI RIVER BASIN

(Sent in separate file)

- ## APPENDIX 3: EXTRACTED DATA ON HERPETOFAUNA IN SAI GON- DONG NAI RIVER BASIN

(Sent in separate file)

- ## APPENDIX 4: EXTRACTED DATA ON FISHES IN SAI GON- DONG NAI RIVER BASIN

(Sent in separate file)

- ## APPENDIX 5: EXTRACTED DATA ON INSECT IN SAI GON- DONG NAI RIVER BASIN

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- ## APPENDIX 6: EXTRACTED DATA ON FLORA IN SAI GON- DONG NAI RIVER BASIN

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● APPENDIX 7: EXTRACTED DATA ON MAMMALS IN MEKONG DELTA

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● APPENDIX 8: EXTRACTED DATA ON BIRDS IN MEKONG DELTA

(Sent in separate file)

- ## APPENDIX 9: EXTRACTED DATA ON HERPETOFAUNA IN MEKONG DELTA

(Sent in separate file)

APPENDIX 10: EXTRACTED DATA ON FISHES IN MEKONG DELTA

(Sent in separate file)

- ## APPENDIX 11: EXTRACTED DATA ON INSECT IN MEKONG DELTA

(Sent in separate file)

- ## APPENDIX 12: EXTRACTED DATA ON FLORA IN MEKONG DELTA

(Sent in separate file)