



ATLAS

OF MANGROVES, SALT MARSHES
AND SAND DUNES OF THE COASTAL
AREA FROM MALWATHU OYA TO
POONERYN IN THE NORTHWESTERN
COASTAL REGION OF SRI LANKA



SGP The GEF
Small Grants
Programme





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of Mangroves, Salt Marshes and Sand Dunes of the Coastal Area from
Malwathu Oya to Pooneryn in the Northwestern Coastal Region, Sri Lanka

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PREFACE

This atlas was produced in order to provide concise information on the sensitive ecosystems/habitats in one of the remaining largely natural landscapes of Sri Lanka with extensive areas of mangroves, salt marshes and sand dunes. Protection of these ecosystems is vital to poverty alleviation of the people through sustainable development. At a time when the government and NGOs are spending large sums of money annually to increase the mangrove cover in Sri Lanka, protection of the existing mangroves should be given the highest priority. If managed properly, there are many economic and environmental benefits that can be derived from the mangrove ecosystems. Northwestern coastal plain (NWCP) is home to extensive areas of salt marshes. Undisturbed salt marshes will bring migratory birds in large numbers into the area during northern winter attracting large numbers of bird enthusiasts into the area from other parts of Sri Lanka annually. The bird season not only attracts people into the area but also provides an income to local businesses. Potential for the development of nature based tourism in the area is very high but it has not received attention it deserves so far from the tourism sector. Ecotourism will no doubt create employment opportunities to the people in the area.

Landscape is not the only attraction in the area. The Palk Bay seascape is also rich in biodiversity. Rare species of marine mammals are found in the shallow Palk Bay. More research is needed to understand the biological riches of the Palk Bay.

This Atlas is also a source of information for students at various levels in education. The information presented in a graphical manner means no specialized knowledge in Cartography is needed to understand this atlas. As it is said 'A picture is worth a thousand words.' The maps were designed at a large enough scale so the information presented is easy to understand.

It is also our hope that this set of maps will attract sufficient attention from the government institutions in charge of the environment, tourism, development, etc. and will find useful information for the formulation of policies to manage the environment in a sound way. If this atlas helps such efforts even in a small way our labour is not wasted.

This is the first edition of this atlas, and further improvement and timely updating will be necessary. The data we collected and used to create this atlas will become freely available to anyone who needs it. Our only wish is that this will make some contribution to the protection of the environment and sustainable economic development of the area. At a time when data hoarding is the de facto standard of many institutions in the country, all the data that went into preparing this Atlas is available for free without any restrictions.

Avicennia marina and *Sonneratia alba* dominant stand
in Malwathu Oya Islands



ACKNOWLEDGMENTS

This atlas is a product of a field study conducted in the coastal plain of the districts of Mannar and Kilinochchi. The study was funded by a grant awarded to Ecological Association of Sri Lanka (EASL) by UNDP/GEF/SGP to generate information on the sensitive habitats of the area that is vital to achieve sustainable development of the region and to avoid indiscriminate spread of haphazard development activities. Our sincere thanks go to the UNDP/GEF/SGP for funding this study and providing encouragement and help during the course of the study. We also take this opportunity to express our sincere thanks to the members of the National Steering Committee of the Small Grants Programme for supporting our proposal and also for making valuable comments towards setting the goals of the study.

Many individuals, including officers from local government and several government departments, members of the civil society and nongovernmental organizations have supported us during the field survey of the project and also provided information required for the study. First and foremost, we wish to extend our profound gratitude to Professor S. P. Nissanka, Faculty of Agriculture, University of Peradeniya for encouraging us to apply for this grant under GEF 6 program and his continuous guidance throughout the project period. We extend our sincere thanks to former and present Divisional Forest Officers (DFOs) of the District of Mannar, Mr. E.J.M.J.K. Ekanayake and Mr. Nuwan Kekulandara, for providing information on existing and proposed mangrove reserves in the project area. We also wish to extend our gratitude to Dr. Tilak Premakantha, Conservator of Forests (Geo-informatics & Forest Inventory) for sharing the digital maps of the boundaries of forest reserves in the study area. Divisional Secretaries of Nanattan and Manthai West, Mr. Maanikkavaasakar Sriskanthakumar and Mr. Sellaththurai Ketheeshwaran respectively, supported us immensely during the data collection phase of the study and generously shared their knowledge of respective divisions with the research team. This help is greatly appreciated. Mr. Vishnuwardhanan, District Officer of Coast Conservation Department - Jaffna and Mr. Sangarapulle Ravi, Assistant Director of Disaster Management, Jaffna shared valuable information with us and their contributions are greatly appreciated. We would like to extend our sincere thanks to Mr. Packiyathan Rajkumar for assisting the field work in Kautherimunai area in Kilinochchi district and supporting us in many other ways to complete this study. Our special thank goes to all the staff members of the National Herbarium, Royal Botanical Gardens, Peradeniya for their assistance in confirming the identity of fodder grasses and some plant specimens collected from the study locations. We sincerely thank Mr. Anuradha Wickramasinghe, Chairman, Small Fisher Federation, (SUDEESA) Sri Lanka, for granting permission to use the facilities at the Sudeesa – Seacology Regional Center at Pallamadu and assisting to conduct community programs of the project area. Mr. Dominic Thuram and the staff of Sudeesa - Seacology Regional Center at Pallamadu were particularly very helpful in organizing these programs. Support extended to us by Mr. D. Devaneshan for conducting field survey of *Prosopis* and cattle ranching in the project area is gratefully appreciated. Numerous individuals and groups, too many to mention individually, have helped us during the project work and we take this opportunity to express our sincere thanks to all those who assisted us to make this project a success. Our thanks are also due to the Printer, Kandy Offset Printers, for the excellent quality of the Atlas which was printed in a short period of time.



Avicennia marina in Urumale point, Talaimannar

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Palmyra (*Borassus flabellifer*) in Pooneryn Sand dune



Message of the Hon. Minister of Environment

The Northwestern Coastal Plain and the Palk Bay are among the few remaining areas of high ecological value in the lowlands and adjoining seas of Sri Lanka. Preservation of this landscape and seascape while taking steps to raise the standard of living of the people of the area in an environment friendly manner are priority policy areas of the Government. Lack of information on the ecology of this landscape has remained a barrier to proper appreciation of the potential value of this. I believe this Atlas fills the information gap to a considerable degree. It provides valuable information that is required by planners and policy makers, and also acts as a source of information to researchers, students, and the general public. The Atlas covers a large extent along the coastline from Malwathu Oya to the Jaffna lagoon including the Mannar Island and provides detailed information on the fauna and flora of the dominant wetland ecosystems and sand dune areas.

I wish to extend my appreciation to the research team of the Ecological Association of Sri Lanka, with funding from the Global Environment Facility Small Grants Programme which is implemented by the United Nations Development Programme (UNDP), who conducted this study and prepared the Atlas. It is my sincere hope that it would benefit the government authorities to take informed decisions to achieve sustainable economic development goals.

Mahinda Amaraweera M.P.

Minister of Environment Message of the Secretary to the Ministry of Environment

Top image - Black winged Stilt (*Himantopus himantopus*) in Vankalai sanctuary
Bottom image - Black tailed Godwit (*Limosa limosa*) in Vankalai sanctuary





Message of the Secretary to the Ministry of Environment

We are grateful to the Global Environmental Facility Small Grants Programme, which is implemented by the United Nations Development Programme (UNDP), for funding the survey of the coastal landscape from Malwathu Oya (Aruvi Aru) to Jaffna which has made the production of this Atlas possible.

This Atlas surveys the sensitive ecosystems in the Northwestern Coastal Plain and reveals that there are extensive areas of mangroves, salt marshes and sand dunes in the area. The existence of these ecosystems is vital for sustainable development and poverty alleviation among people resident adjacent to these ecosystems. This area provides an excellent habitat for migratory birds during the northern winter since Sri Lanka is the southern end point in the Central Asian Bird flyway.

This area attracts large numbers of local tourists, who come on bird watching tours during the migration season. Developing the tourism infrastructure of the area and other physical infrastructure, along with a well-designed marketing campaign, is likely to attract more tourists to the area and increase the income of the local community who will be able to provide services to this industry.

The Atlas further reveals that the area needs to be protected and conserved for future generations to enjoy the rich biodiversity and natural attractions of the landscape. This Atlas facilitates informed decision making and to regulate human interventions in the area which may threaten to cause environmental degradation and pollution damaging these natural ecosystems.

I wish to thank the Ecological Association of Sri Lanka for conducting this survey and for producing this valuable Atlas which could assist the government, conservationists and NGOs to plan future conservation efforts and sustainable development programmes targeting this area.

Dr. Anil Jasinghe

Secretary

Ministry of Environment



Northern pintail (*Anas acuta*) in Tharapuram area



Message of the Resident Representative of UNDP Sri Lanka

The strain on our planet mirrors the strains facing many of our societies. 2020 is a year in which nature has shown humanity that we have pushed the planet to its boundaries. COVID-19, major wildfires and storms and record heat waves show the catastrophic impacts of climate change and biodiversity collapse. These are harbingers of more to come if we do not change our course. The 2020 UNDP Human Development Report (HDR) explains that we are living in a new geological epoch, the Anthropocene, characterized by human led impacts which risk our collective future.

COVID-19 in particular provides us an opportunity to rethink our relationship with nature, in a way unthinkable even six months ago, on individual, societal, and political norms of business as usual. The moment anthropogenic influences were reduced due to COVID-19, nature bounced back, reminding us to explore innovations that recognize the fundamental role of nature in everything from corporate bottom lines, to human well-being, to the survival of life on Earth.

This first ever Atlas of the Northwestern Coastal Region of Sri Lanka, an initiative of the Small Grants Programme (SGP) funded by the Global Environment Facility (GEF), with UNDP support and the leadership of the Government of Sri Lanka is an example where swift actions can pave the way to creating multiple ripple effects in the realm of nature-based solutions. SGP demonstrates community action can restore the balance between human and nature, as these coastal wetland ecosystems and coastal sand dunes benefit both humans and nature. This prevents coastal hazards such as erosion and flooding, provides habitat for migratory species and breeding grounds for coastal and marine life, and offers livelihood opportunities for local communities.

This initiative is testimony to the fact that the environment plays a fundamental role in determining global economic outputs and human well-being which has led to a range of responses, one of which is the integration of the value of natural capital into policy and decision making. This Atlas will inform biodiversity conservation, climate-smart livelihoods and ecotourism efforts, and will positively influence evidence-based policy making in Sri Lanka. UNDP is keenly supporting the Government of Sri Lanka's shift to a more nature centric investment and policy paradigm with broader alliance of partners, such as the Ecological Association of Sri Lanka. Governments alone cannot close the financing gap in biodiversity investments needs. New research and policy initiatives such as this ATLAS embody transitional collaborations which can shift the paradigm, considering high economic value and financial benefits of biodiversity on one side, and tremendous costs of its loss on the other. Through our continuous collaboration with the Ministry of Environment, civil society, environmental organizations, private sector and other partners, we look forward to ensuring the findings of this Atlas contribute towards a cleaner and greener pathway to the future of Sri Lanka.

Robert Juhkam

Resident Representative – UNDP in Sri Lanka



Indian spot-billed duck (*Anas poecilorhyncha*) in Vankalai sanctuary

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LIST OF ACRONYMS AND ABBREVIATIONS

CCD	Coast Conservation Department
CEA	Central Environmental Authority
CD	Chart Datum
CoS	Conservation Status
CR	Critically Endangered
CZMP	Coastal Zone Management Plan
DD	Data Deficient
DHP	Dissected Highlands Plain
DL	Dry Zone Lowland
DS	Divisional Secretariat
DSD	Divisional Secretariat Division
DWC	Department of Wildlife Conservation
EASL	Ecological Association of Sri Lanka
EN	Endangered
END	Endemic
EX	Exotic
FARA	Fisheries and Aquatic Resources Act
FCO	Forest Conservation Ordinance
FD	Forest Department
FFPO	Flora and Fauna Protection Ordinance
FIM	First Inter Monsoon
GIS	Geographical Information Systems
GN	Grama Niladari
GND	Grama Niladari Division
GoM	Gulf of Mannar
GPS	Global Positioning System
GSS	Grid Substation
HAT	Highest Astronomical Tide
IUCN	International Union for Conservation of Nature
LAT	Lowest Astronomical Tide
LC	Least Concern
LCP	Lower North Western Coastal Plain
MCM	Million Cubic Meters
MHWN	Mean High Water Neap
MHWS	Mean High Water Spring
MLWN	Mean Low Water Neap
MLWS	Mean Low Water Spring
MOE	Ministry of Environment
MSL	Mean Sea Level
NEM	Northeast Monsoon
NCS	National Conservation Status
NGO	Non Governmental Organizations
NT	Near Threatened
NWCP	North Western Coastal Plain
NP	Northern Province
SIM	Second Inter-Monsoon
SRICANSOL	Sri Lanka-Canada Soil Resource Project
SWM	The Southwest Monsoon Period
TL	Transmission Line
VU	Vulnerable



Grey heron (*Ardea cinerea*)



Tidal mud flats at Illuppaikkadavai

1.0 INTRODUCTION

Sri Lanka is a medium size island in the Indian Ocean, located between latitudes 5° to 10° North and longitudes 79° to 82° East. Sri Lanka's latitudinal position gives it an equatorial climate. Its geographic position however brings it under two monsoons, southwest (summer monsoon) and northeast (winter monsoon). The intervening periods between the monsoons are called first inter monsoon (FIM) and second inter monsoon (SIM). The inter monsoon periods display a typical equatorial climate with land-sea exchanges and a convective rainfall.

The areal extent of the main island of Sri Lanka was estimated from 1:50,000 maps at 65,775 km² including inland waterbodies with a maximum width (from East to West) of about 225 km and the maximum length of 433 km (North to South). The coastline of Sri Lanka is about 1,643 km. Some parts of the coastal area, particularly in the Wet Zone, are densely populated. But the population density in the coastal region in the north with the exception of the urban areas, is low. In the northwest, a large part of the area is under forest cover. There are ten forest reserves, one nature reserve and a sanctuary in the Northwestern Coastal Plain (NWCP). Some of these protected areas extend to the interior of the country, while others are confined to the coastal plain.

The Island's proximity to India and its shared geological history are significant factors in the island's ecological make up. The island has had a land connection to India on and off as the sea level fluctuated. During the last ice age, from about 20,000 to 12,000 BP the sea level was much lower than today and the island was connected to India. Geographically the closest part of Sri Lanka to south Indian landmass is the Mannar-Pooneryn coastline. The direct distance from the western tip of the Mannar Island to the Pamban (Rameswaram) island on the Indian side is approximately 25km. This area is also a protected area petrolled by the SL Navy. The observation of common biota of Sri Lanka and the Western Ghats region of India led Wallace (1876) to designate Sri Lanka and Western Ghats as a single biogeographic unit. Later, the Wet Zone of Sri Lanka along with the Western Ghats mountain range of India was designated as one of the biodiversity hotspots of the world for conservation purposes (Myers *et al*, 2000; Brooks *et al.*, 2002; MOE, 2012).

The island is divided into three broad climate zones, Wet Zone, Dry Zone and Intermediate Zone, based on rainfall. The highest rainfall region in the Wet Zone receives up to just over 5,000 mm of mean annual rainfall (Yatiantota, 5,259 mm, Ginigathena 5,086 mm and Watawala 5,024 mm, Survey Department, 2007). The driest parts of Sri Lanka are located on opposite sides of the island, Hambantota in the Southeast and Mannar in the Northwest. Mannar receives less than 1,000 mm of mean annual rainfall (Mannar, 988 mm, average for 1970-2014), while Hambantota receiving just over 1,000 mm.

The climate diversity is one of the major factors contributing to the rich biodiversity of Sri Lanka despite its small land area. Elevation of the island ranges from mean sea level to just over 2,500m. As a result, island's temperature ranges from hot tropical to cooler temperatures at high elevations. The monsoon rainfall is orographic and varies with elevation with the highest rainfall occurring at mid elevations on the windward side during each monsoon. The high elevations of the country are confined to the South Central highlands, while the rest of the country has a low elevation. Northern plain extends from coast to coast and is an undulating terrain with maximum elevation below 500m. Because of this topography, southwest monsoon period is the dry season in the northern plains of Sri Lanka.

Gunathilake *et al.*, (2008) broadly divided ecosystems of Sri Lanka into four major types: (a) the marine and coastal ecosystems, (b) natural forest ecosystems, (c) natural and semi-natural grassland ecosystems, and (d) the inland wetland ecosystems. The vegetation of the study area falls into the first category, the marine and coastal ecosystems. The dominant categories mapped are coastal wetland ecosystems and coastal sand dunes.

The coastal and marine environment of the Northwest can be divided into the seascape of Gulf of Mannar-Palk Bay and the landscape of the Northwestern coastal plain. The latter is the focus of this atlas. Several distinct coastal ecosystems consisting of mangroves, lagoons, estuaries, salt marshes, mudflats and sand dunes were identified in this landscape. The Northern Province as a whole accounts for a large percentage of mangrove cover and salt marshes of Sri Lanka. According to Gunathilake *et al.*, (2008) and Karunathilake (2003) Sri Lanka as a whole has about 12,000-13,000 ha of mangrove. More recent study by Edirisinghe *et al.*, (2012) has estimated the total extent at 15,670 ha. Many government and NGO efforts are directed towards increasing the extent of mangrove cover in Sri Lanka.

Accurate information on coastal ecosystems is not available for the entire country. The landuse legend of the topographic maps of Sri Lanka did not have mangrove and salt marshes until recently. More recent revisions of the 1:50,000 map of Sri Lanka, included mangrove as a separate category, but salt marshes are still not recognized as an important land cover type. Among the vegetation types, salt marshes have received the least attention from researchers. The geographical distribution, ecology and potential uses of salt marshes and associated vegetation types are barely understood up to now. Usually salt marshes are variously described in maps as sandy surfaces, villus, marshes, barren lands, etc. The forest maps prepared by the Forest Department also do not contain salt marshes even though mangrove is mapped as a separate category. As a result, there is no conservation plan specifically devised for salt marshes up to now. Similarly, the sand dunes are also a neglected category and rarely shown on the available maps. Another important void in information is the fauna and flora present in these ecosystems. This atlas is perhaps the first effort towards filling this information gap.

1.1 OBJECTIVES OF THE ATLAS

The main objective of this atlas is to raise awareness among the policy makers, the scientific community and general public of the valuable ecosystems/habitats of an area of Sri Lanka which has up to now remained as an area with low level of human activity. This is mainly due to the low population density and the impact of the civil war (1983-2009). During the postwar period, widespread activities, such as encroachment of natural ecosystems, rapid development activity, influx of population from other areas, etc. can be seen. These activities are carried out with total disregard to the environmental sustainability of the area. Such activities will also deny the benefits of these rich ecological resources to the future generations.

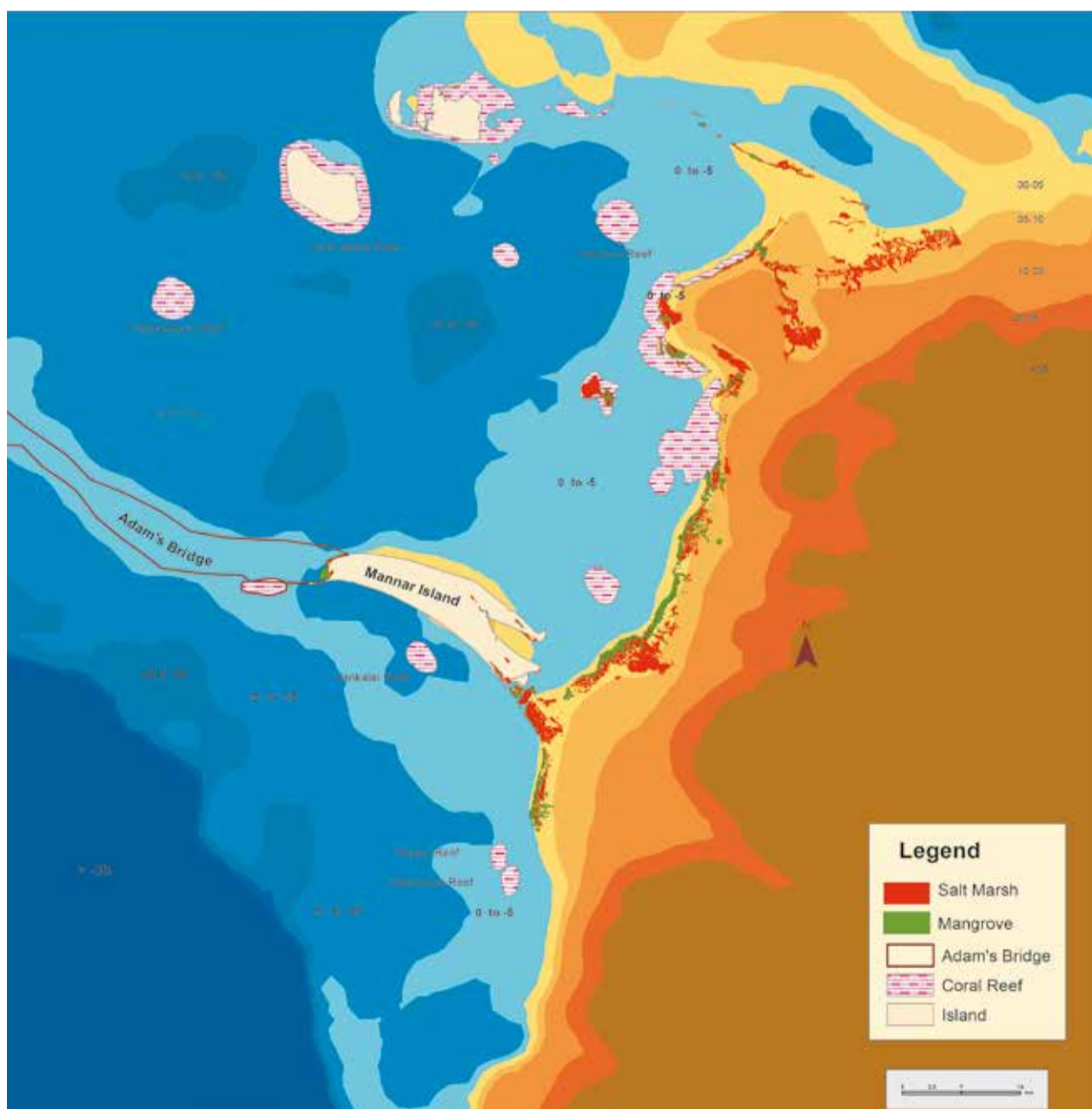
This atlas will share with a wider audience, information on the nature, extent, and spatial distribution of some vital ecosystems that are dominant in the Mannar-Poonaryn landscape. In addition to the maps prepared covering this landscape, the atlas also provides information on the ecological structure, species composition and functional aspects of different ecosystems and the extent of the existing and proposed protected areas. Another aspect covered is cattle farming practices in the area as an important economic activity which is dependent on the salt marshes for fodder during some part of the year.

The atlas will also function as a reference guide for future research and education. An attempt was made for precise inventorying the fauna and flora of the salt marshes, mangroves and sand dunes in this area. A biological threat to salt marshes was found as the spread of an invasive plant, *Prosopis juliflora*, in the salt marshes of Nanattan, Mannar City and Manthai West DS Divisions. Unless remedial measures are taken, it may spread further into the low lying areas of the coastal plain. It is time to take necessary action to control or manage its spread. Although this species is used productively in other countries, in Sri Lanka it is considered a nuisance rather than a resource. This attitude is also contributing to its spread without any control.

It was also intended to be a baseline information source for future ecological studies of the area. If this attempt contributes to generate interest for preservation, improvement and appreciation of the value of these ecosystems, our effort will not be wasted.

1.2 NORTH WESTERN COASTAL PLAIN (NWCP)

The NWCP is bordered on the west by the Palk Bay and the Gulf of Mannar, on the east by the dissected erosional surface. The Jaffna Lagoon marks the northern boundary and the south by the Malawathu Oya (Aruvi Aru). The shallow sea to the west is rich in ecological



resources, such as seagrass beds, coral reefs and rare species of marine mammals especially the dugong (*Dugong dugon*). The sea between Sri Lanka and India is subdivided into two sectors by the Mannar Island. The more sheltered northern part is known as Palk Bay and the southern part, Gulf of Mannar. The Palk Bay is a sheltered sea with low energy waves favoring deposition of sediment brought in by the longshore drift from the south. Similarly, sediment comes from the southeastern shores of India. Eight rivers that cross the coastal plain also provide sediment to the Palk Bay and two rivers to the Jaffna Lagoon. The Malwathu Oya forming the southern boundary of the study area flows into the Gulf of Mannar. As a result, Palk Bay has a large area of tidal mudflats in the intertidal zone off the coastal plain. Except for a few depressions with depths 15-25m, most of the Palk Bay is a shallow sea with a depth less than 15m (Figure 1.1).

Figure 1.1. Seascape and landscape, NW Sri Lanka

The muddy shallow sea bordering the land area is occupied by seagrass beds. Numerous coral reefs are also found in Palk Bay and Gulf of Mannar. They are important fish breeding sites.

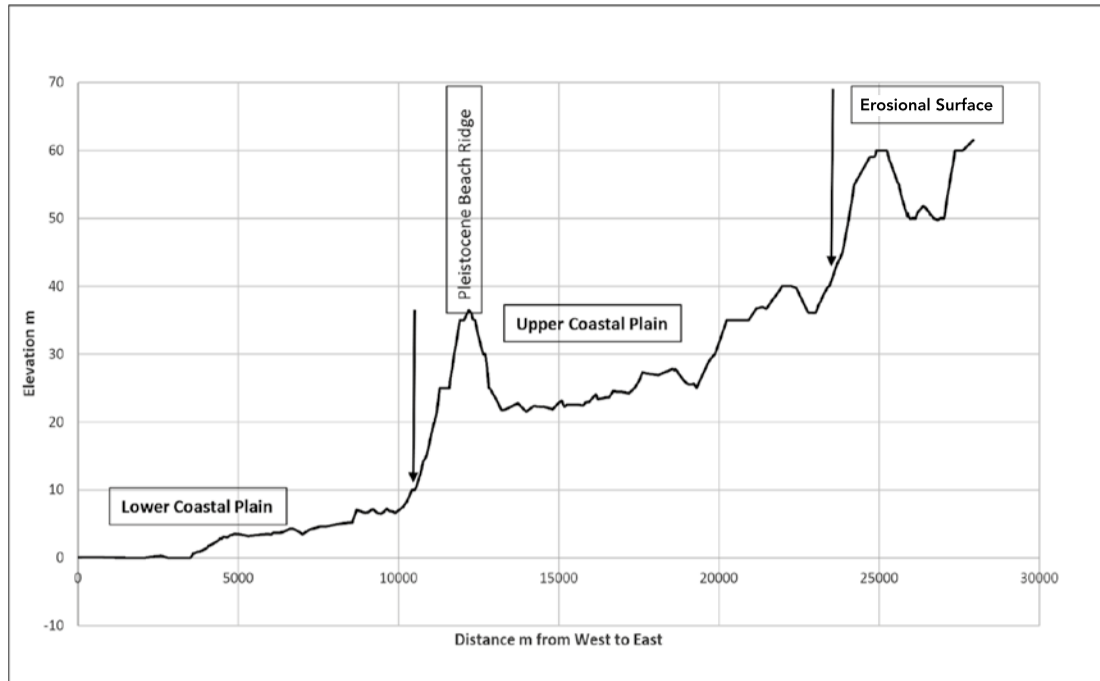


Figure 1.2. Elevation Profile Showing Terrace Levels
(Based on ALOS2 DEM)

The mapped area is confined to the lower coastal plain within the Nanattan, Mannar City, Manthai West DS divisions of Mannar district and Poonakary and Karachchi DS divisions of Kilinochchi District. It extends from the right bank of Malwathu Oya (Aruvi Aru) in the south to Kalawalappu Aru in the north including the Mannar Island and Pooneryn Peninsula. The total area of the NWCP is 1,848 km² but the coastal ecosystems are found in a narrow belt along the coast in an area of about 345 km². There are three terrace levels as Lower Coastal Plain (LCP), Upper Coastal Plain (UCP) and Dissected Interior Plain (DIP). The lower coastal plain (LCP) ends with a topographic break at about 10 m above msl. The UCP ranges in elevation from about 20 to 30m (Figure 1.2). The boundary may vary slightly from place to place.

The coastal plain is predominantly of depositional character with both marine and fluvial sediment overlying the Miocene limestone basement. The depositional processes involved are fluvial, aeolian, and marine. Fluvial deposition is by the rivers crossing the coastal plain and, marine processes are waves, currents and tides. There is evidence of past or present wind action in many parts of the coastal plain but currently wind action is observed in two areas, Mannar Island and Pooneryn Peninsula.

The northwestern coastline is a prograding coastline favoured by the ample sediment inputs from the Indian side as well as from the south of Sri Lanka. The sheltered environment provided to Palk Bay by the Mannar Island and the Southern Indian subcontinent and micro-tidal regime have created a low-energy environment which favours deposition of marine sediment. The sea adjoining the Mannar-Pooneryn Coastal Plain is being filled up with extensive sedimentation creating a micro-environment with seagrass beds, coral reefs, sand islands, etc. with a unique marine habitat zones.

1.3 GEOGRAPHY

The area covered by this Atlas is the coastal plain falling within five coastal DS Divisions of Mannar and Kilinochchi Districts of the Northern Province (Figure 1.3). The coastal plain of three DS Divisions in Mannar District and two in Kilinochchi District are covered by the Atlas.

The NWCP is characterized by low population density (Table 1.1) and extensive ecosystems both terrestrial and wetland are distributed in the area.

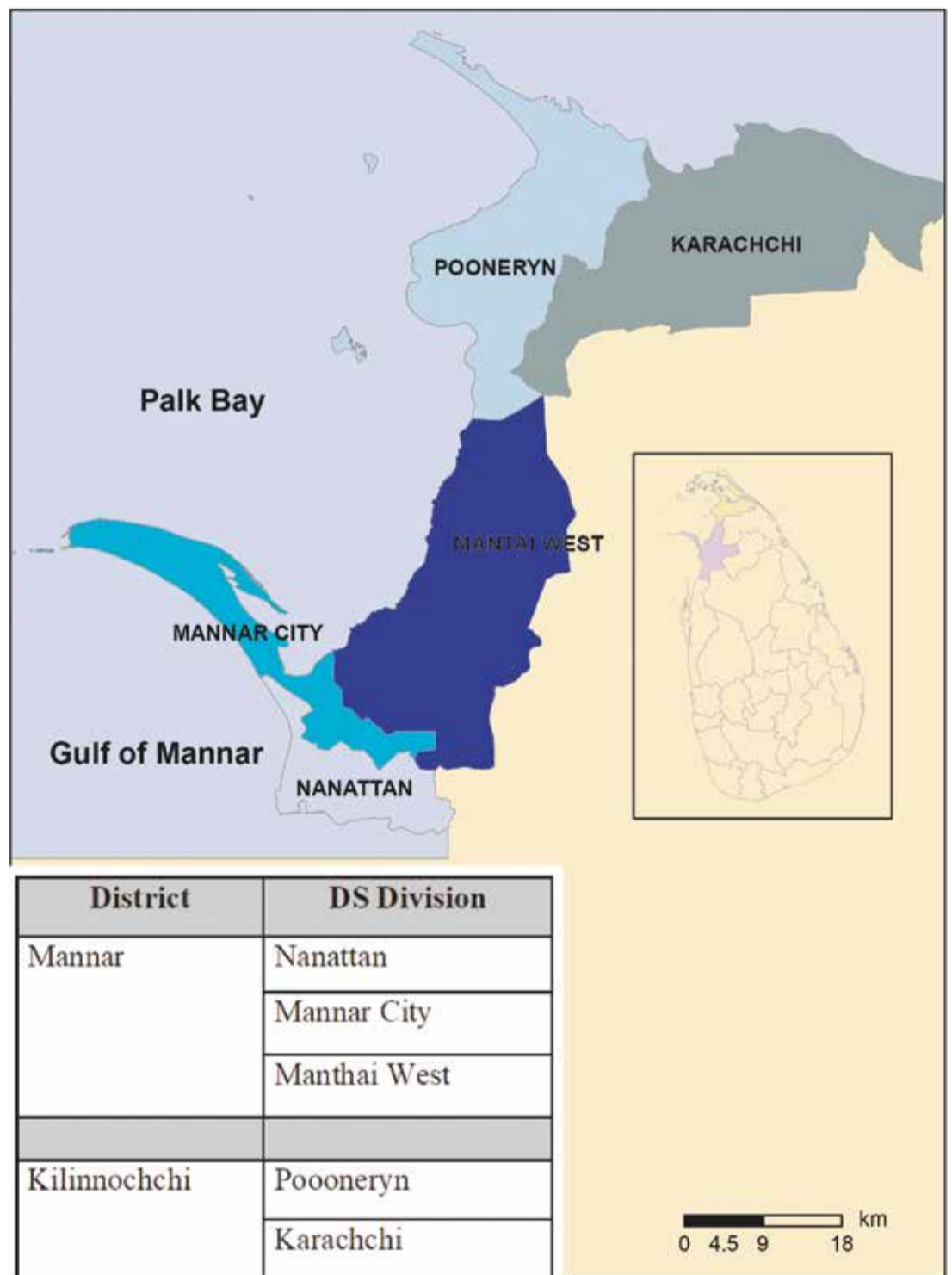


Figure 1.3. The study area

Table 1.1. Area and Population

District	DS Division	Area (km ²)	Population	Population Density Persons per km ²
Mannar	Nanattan	129	21,159	164
	Mannar City	227	68,034	299
	Manthai West	658	24,827	37
Kilinochchi	Poonekary	449	24,870	55
	Karachchi	411	70,840	172

(Data Source: Chief Secretariat Northern Province, 2014)

1.4 CLIMATE

Climatically the NWCP falls into the lowland dry zone. It is subdivided into two agro ecological regions, DL3 and DL4 (Figure 1.4). The 75% rainfall expectancy is less than 889 mm (35 inches) and greater than 584 mm (23 inches). Only second half of January and first half of September are considered wet with respect to 75% rainfall expectancy. The only difference between DL3 and DL4 is the relief and soil type. Region DL3 is undulating to flat and DL4 is flat. The former is bordering the sea and the latter on the land side.

Rainfall

This area is one of the driest regions of Sri Lanka with a mean annual rainfall less than 1,100 mm (Figure 1.5). The rainfall declines towards the West coast of the NWCP. Marichchukkaddi, situated to the south of the study area, has the lowest recorded rainfall in Sri Lanka.

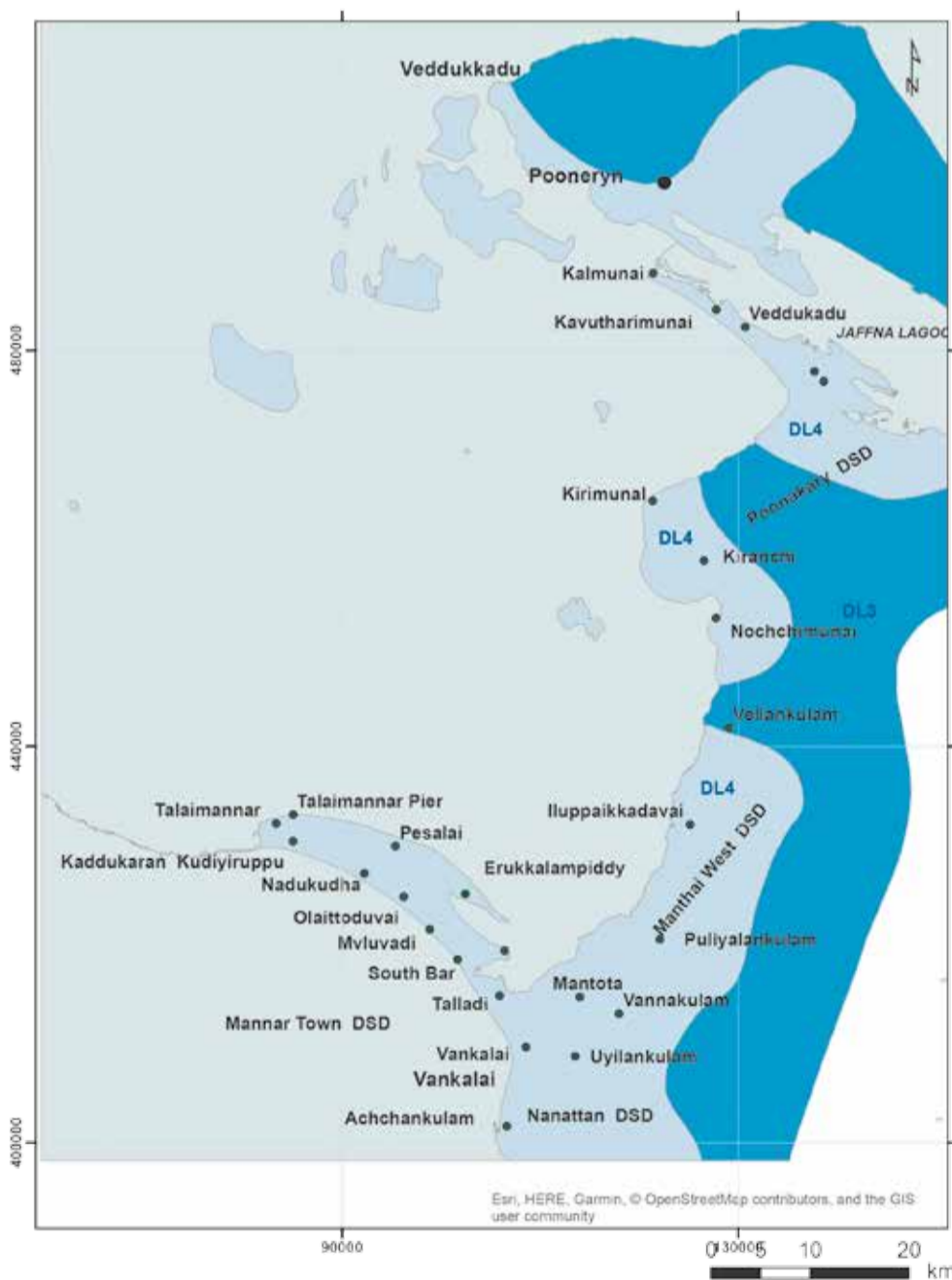


Figure 1.4. Agroclimatic Zoning of the Mannar Coastal Plain

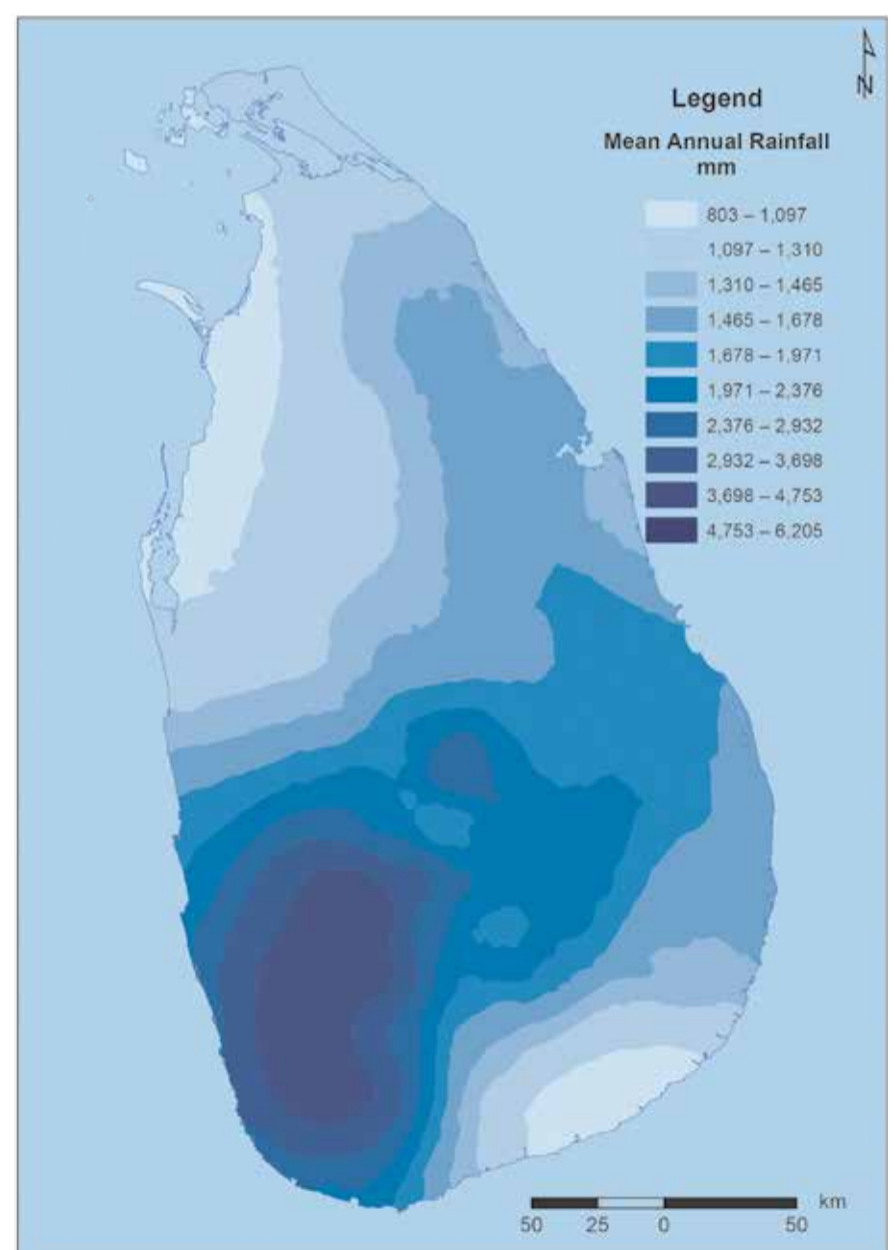


Figure 1.5. Mean Annual Rainfall of Sri Lanka

The seasonal regime of rainfall of Mannar displays a bimodal distribution with one major and one minor peaks (Figure 1.6). The major peak is during the second inter monsoon (SIM - October-November) and Northeast monsoon (NEM), while the minor peak is in the First Inter Monsoon (FIM) period (March and April). The latter is less than half of the first peak. The Southwest monsoon period (SWM - May to September or Pentad 28 to 56) is the driest period. The temperature does not experience large seasonal fluctuations.

During SWM which prevails over about 40% of the year (28th to 56th pentads), Mannar has an extremely low rainfall. This seasonal regime of rainfall has given rise to a severe water shortage in the region during much of the year. The Mannar region is also one of the driest regions of the country and was earlier called the arid zone. This terminology is no-longer used because of the higher mean annual rainfall above the arid or semi-arid category in standard climate classifications. According to aridity indexes no part of Sri Lanka can be designated as arid or semi-arid.

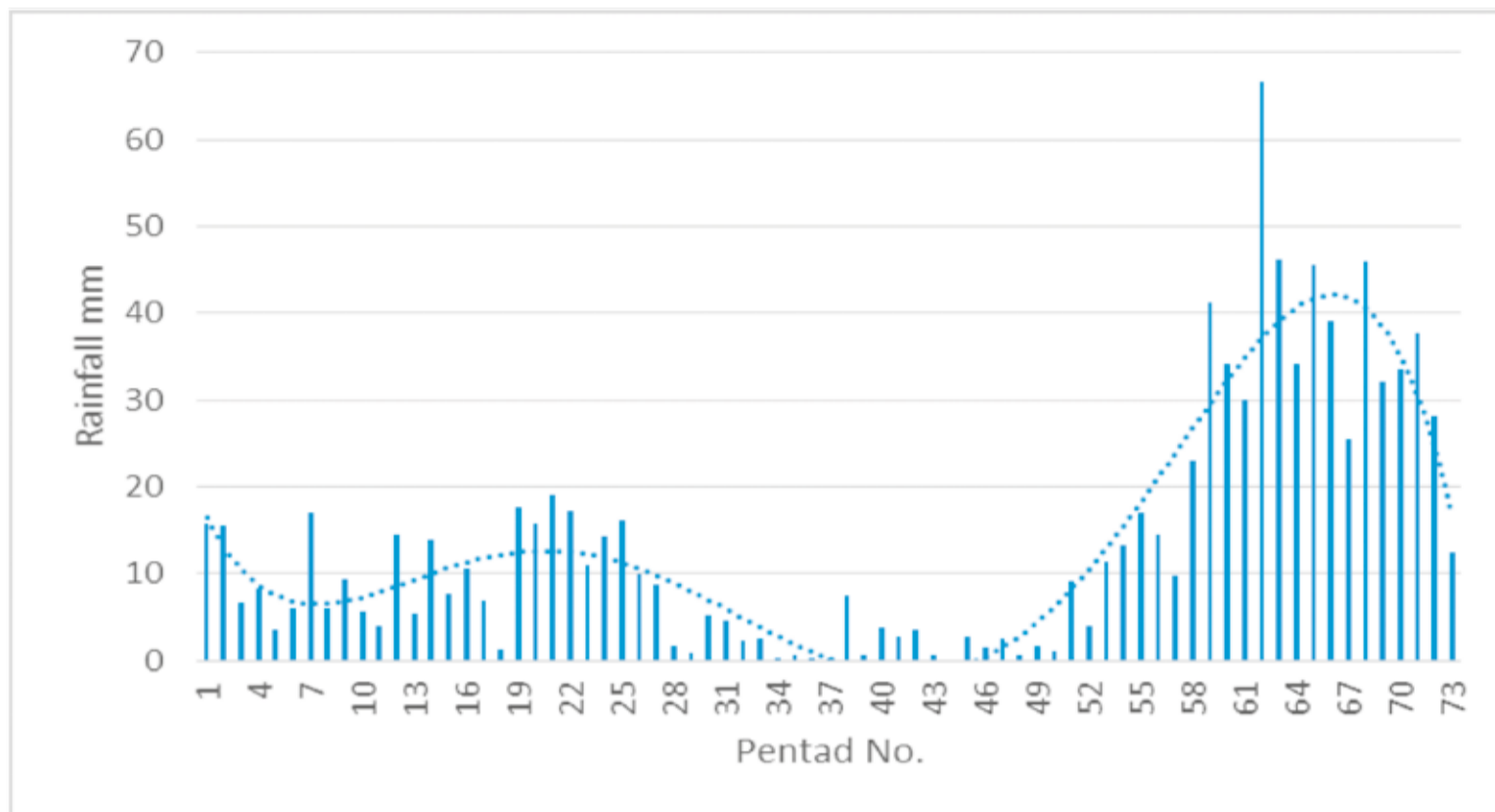


Figure 1.6. Seasonal Regime of Mannar Rainfall

1.5 HYDROLOGY

The main components of hydrology of the region can be described as surface water and groundwater resources. The surface water sources are the rivers and irrigation tanks. The area has a large number of small tanks and a few reservoirs organized into cascade systems. The small tanks are fed by the water stored in larger reservoirs which in turn are fed by the flow from the main rivers of the area. The largest river in the area is the Malwathu Oya or Aruvi Aru which feeds the right bank and left bank irrigation facilities in the Mannar Area. Other rivers are also utilized this way to obtain freshwater for irrigation.

Ground water in the area is of two types (Panabokke and Perera, 2005): shallow aquifers in coastal sand and deep confined aquifers in the limestone basement. The Mannar Island and Pooneryn Pensular have the former. The coastal region in the Mannar mainland extending from Mannar southwards and also the Poonakary and Karachchi DS Divisions have deep confined aquifers in the Miocene limestone terrain. Four deep confined aquifers identified in the coastal area are Kondaichchi Basin, Murukkan basin, Mulankavil Basin and Paranthan basin. These water resources are not yet exploited for agriculture in the area. Towards the interior, groundwater is an important source of potable water. Rainwater harvesting is not widely practiced in this area. Because of the long dry season, its potential is very limited.

1.6 COASTAL RIVER BASINS OF MANNAR-POONERYN AREA

The NWCP is subdivided into nine river basins (Figure 1.7 and Table 1.2). They include from South to North the Malwathu Oya (Aruvi Aru) Nay Aru, Chippi Aru, Parangi Aru, Pali Aru, Pallarayan Kadu, Mendakal Aru, Akkarayan Aru and Kalavalappu Aru. Except for the Malwathu Oya, all the other river basins are small basins and originate in the local area. The Aruvi Aru has the largest catchment area of 3,246 km² which is almost four time larger than the next largest basin (Parangi Aru) and has two and half times more annual discharge. The smallest is the Chippi Aru basin with an area of 66 km². Rivers are important sources of freshwater for domestic, industrial and irrigation purposes.

Table 1.2. River Basins of the Study Area

Basin No	Basin Name	Area	Mean Annual Discharge (MCM)	Discharge as a % of Rainfall	Flows Into
82	Kalawalappu Aru	57	13	18.1	Jaffna Lagoon
83	Akkarayan Aru	194	44	17.7	Jaffna Lagoon
84	Mandekal Aru	300	75	18.6	Palk Bay
P85	Pallarayan Kadu	61	40	15.5	Palk Bay
86	Pali Aru	456	113	18.4	Palk Bay
87	Chippi Aru	67	16	18.0	Palk Bay
88	Parangi Aru	842	225	19.1	Palk Bay
89	Nay Aru	567	123	17.1	Palk Bay
90	Malwathu Oya (Aruvi Aru)	3284	566	12.4	Gulf of Mannar

(Source: Survey Department, 2007)

Most of the rivers crossing the coastal plain originate in the Dry Zone lowlands and therefore have a low discharge and they turn into a trickle during the long dry season. Only river with a mean annual discharge greater than 500 MCM is the Malwathu Oya out of ten rivers in the area (Figure 1.7 and Table 1.2).

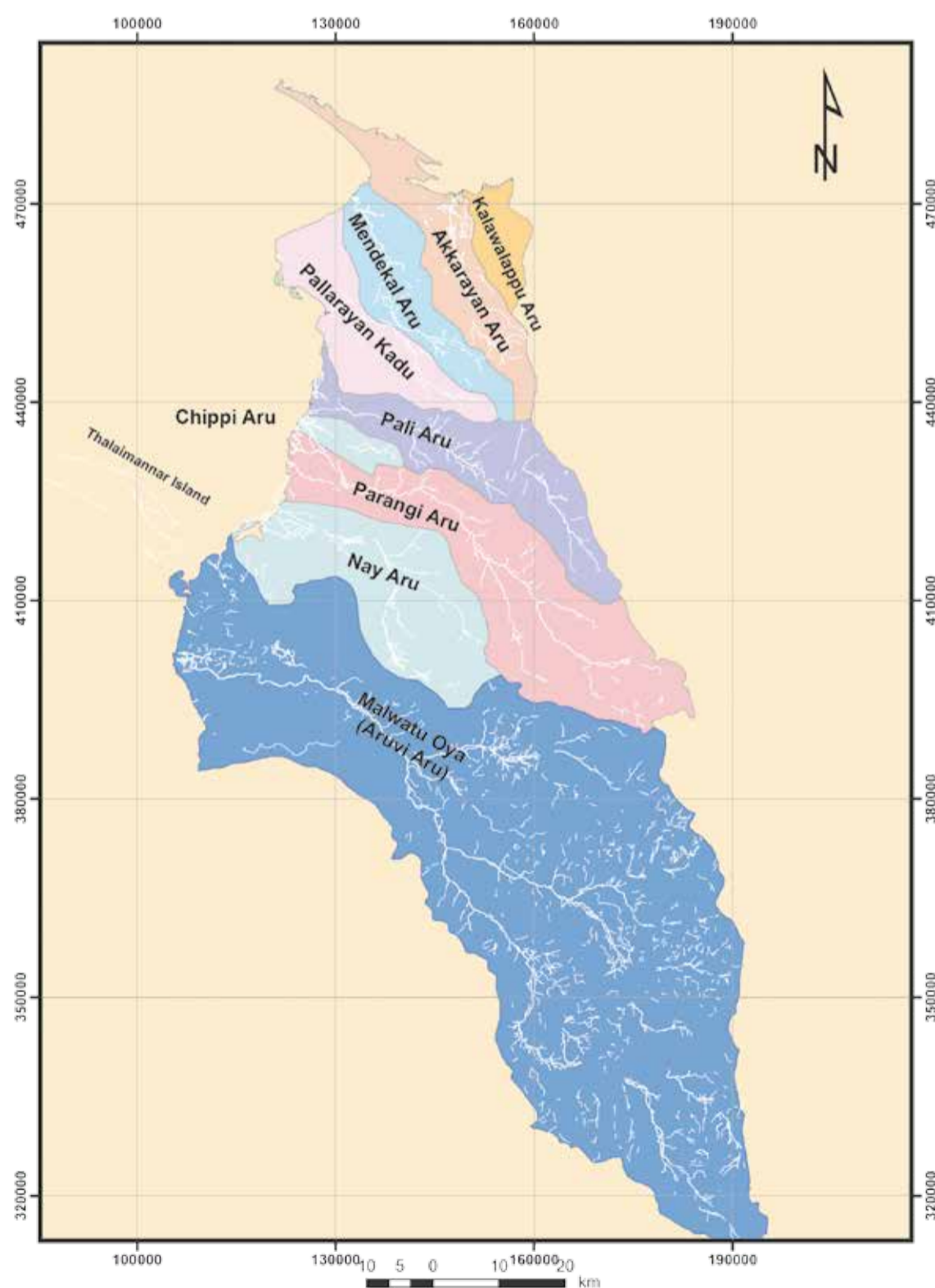


Figure 1.7. River Basins of the Study Area

1.7 SOIL

In the latest available soil map of Sri Lanka (Mapa *et al.*, 2010), the study area has six soil map units (Table 1.3; Figure 1.8). Map units are combinations of soil series as soil associations or complexes. A soil series is generally thought of a soil with similar origin and parent material. It also has similar chemical, physical and morphological characteristics and performs in a similar manner to land use practices. In the USDA (1975) soil taxonomic classification system, a series is a group of soil individuals or pedons. A Pedon is the smallest 3-dimensional unit of soil. A soil series is given the name of the town where a particular soil is described for the first time. For example, some soil series in Mannar coastal plain are given names, like Puttalam series, Negombo series. etc. for the similarity of the soils to those first described in Puttalam and Negombo. Sri Lanka is still lacking detailed soil maps to depict small pockets of different soil series. Therefore a combinations of soil series are used as map units in available maps (known as soil associations and soil complexes). A soil association is two or more soil series occurring in a geographical area that are delineated separately at the scale of mapping. Where that is not possible, two or more soil series make up a soil complex. Among the map units delineated in this area, there are four soil associations and one soil complex. No specific soil series is identified in Map Unit 40 and the Map Unit 45 can be described as non-soil (recent alluvium and rock outcrops).

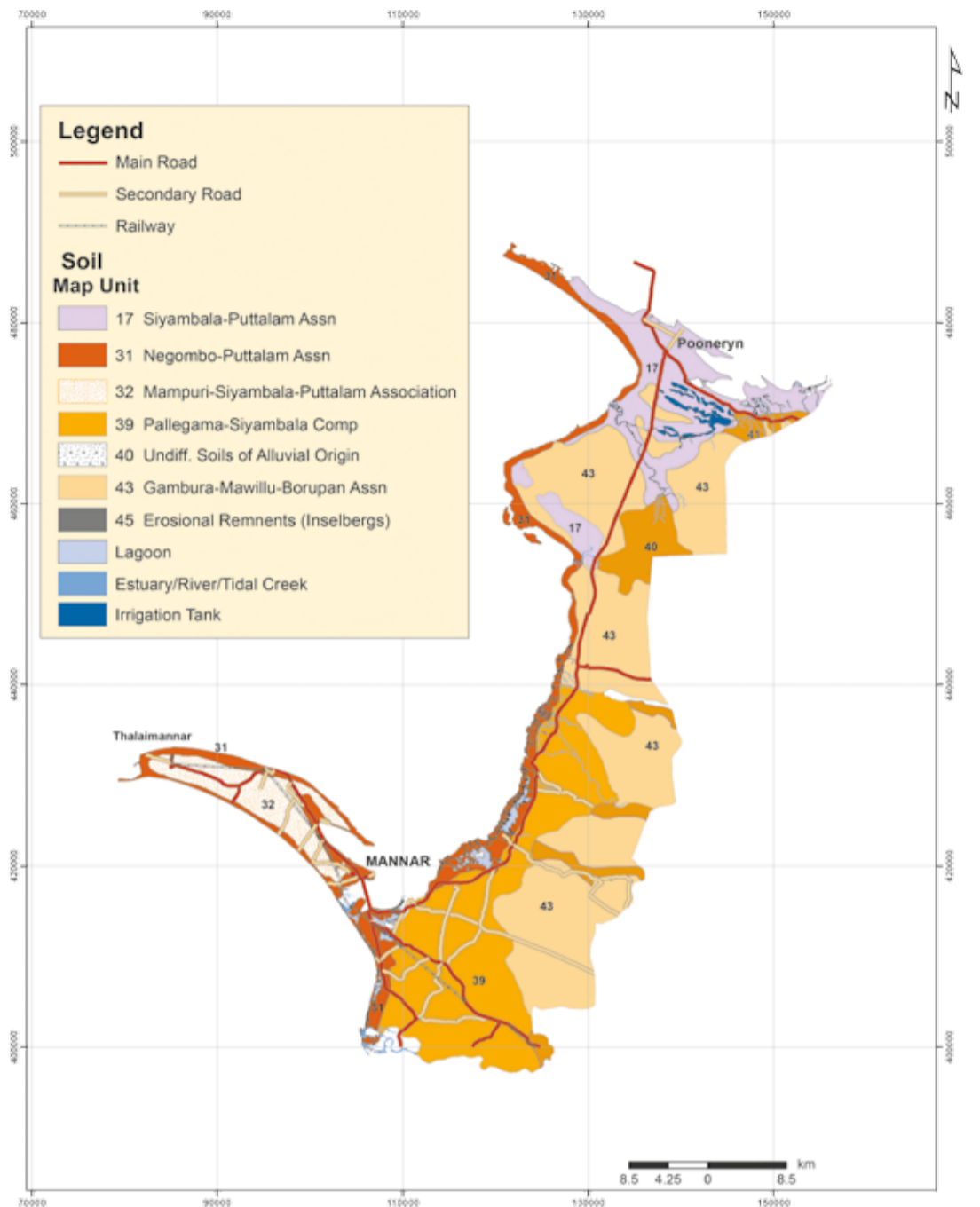


Figure 1.8. Soil map NWCP

Table 1.3. Soil map units of the Northwestern coastal plain

Map Unit No.	Map Unit Name	Included Soil Series	Great Group
17	Siyambala-Puttalam Association	Siyambala Series Puttalam Series	Solodized Solonetz Solodized Solonetz
31	Negombo-Puttalam Association	Negombo Series Puttalam Series	Regosols Solodized Solonetz
32	Mampuri-Siyambala-Puttalam Association	Mampuri Series Siyambala Series Puttalam Series	Regosol Solodized Solonetz Solodized Solonetz
39	Pallagama-Siyambala Complex	Pallegama Series Siyambala Series	Grumusols Solodized Solonetz
40	Undifferentiated Soils of Alluvial Origin	-- Gambura Series	-- Red Latosols
43	Gambura-Mavillu-Borupan Association	Mavillu Series Siyambala Series	Yellow Latosols Solodized Solonetz
45	Erosional Remnants (Inselbergs)	Non-Soil	--

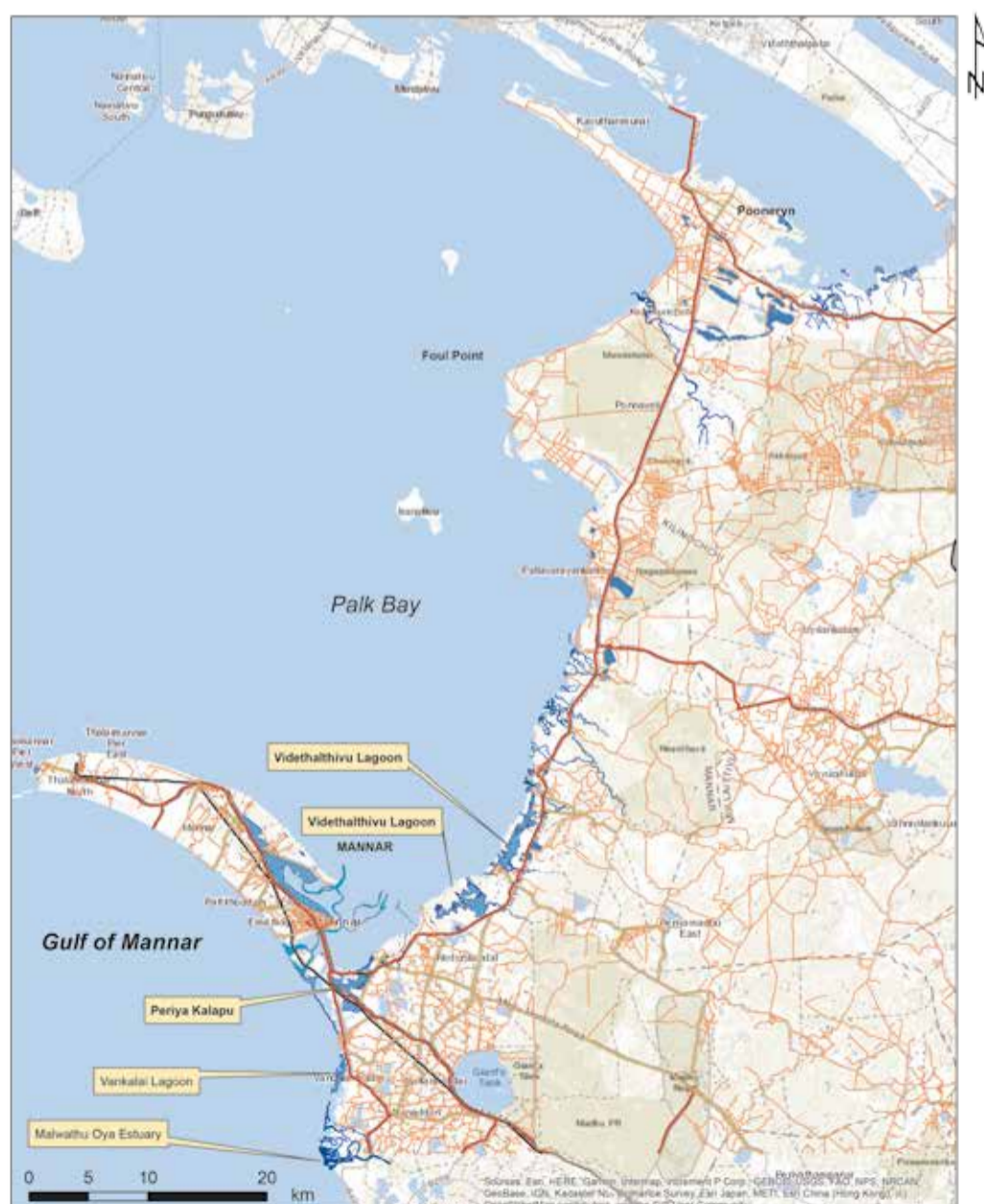
The parent materials of these soils are tidal flat deposits, beach deposits, lagoonal deposits, alluvium, and wind-blown sand. All these types of parent material are of recent origin. SRICANSOL Project has mapped the soils of this area mostly based on earlier data and descriptions by Hunting Survey (1963). The soil series identified in this area are grouped into Great Groups as given in Table 1.3. The Great Soil Groups identified in the area are Solodized Solonetz, Regosols, Grumusols, Red Latosols and Yellow Latosols. The soil, solodized solonetz was first defined in the Russian pedological literature is a sodic soil (salt affected soil). Moormann and Panabokke (1961) described this soil as having a "bleached A horizon as well as a low content of free salts." Furthermore it also has a B (textural B) horizon which has "high exchangeable sodium and may contain free salts." These soils are found in Sri Lanka near the coastline in all districts. Mangroves and salt marshes are mostly found in this soil. Regosols derived from recent parent material lacks profile development. Negombo series is the only soil series of the Regosols great group and it is combined with Puttalam series (Solodized Solonetz) into a single map unit. Regosols are of recent origin and differentiated from Alluvial Soils Great Group by the presence of an A1 horizon. In Mannar the Regosols belong to Sandy Regosols subgroup which has developed in elevated beaches and sand dunes (Map Unit 31). Pallegama series belongs to Grumusols Great Group and it is combined with Siyambala series to form the map unit 39. Grumusols are usually found in depressions behind map unit 31. The parent material is monitmorillonitic and is of fluvial origin. Red and Yellow Latosols are two Great Groups that are found towards the interior.

Erosional Remnants or inselbergs are what is left after eroding away of the weathered material in the surrounding area. They represent terrain features that are resistant to erosion. That means the feature is often rock surface rising above the surrounding terrain. Such surfaces do not contain soil. In the study area, they have been mapped in several locations. Inselbergs are wide spread in the interior of the northern plain as remnants of subaerial erosion. USDA (1975) Classification designate these features as Lithosols.

1.8 TIDAL CHARACTERISTICS

Tides are an important element in the morphodynamics of the Northwestern Coastal Plain. The two main characteristics of the tides are the tidal range and type. Sri Lanka has a mixed semidiurnal tidal regime. The landward penetration of tidal inflows occurs during high tides along the river valleys, tidal creeks, lagoons and the coastal depressions connected to the sea. The tidal range is the determinant of the altitudinal limit of the salt marshes. The mean spring and neap tidal ranges in Colombo are 0.56m and 0.13m respectively (Wijeratne, 2003). The tidal range around Sri Lanka declines towards north (Wijeratne, 2003). Thus Sri Lanka has a micro-tidal regime. As a result the coastal belt that is inundated by the sea water is very limited.

1.9 COASTAL BRACKISH WATER BODIES



1.9. Coastal Brackish Water Bodies

There are several fresh and brackish water bodies in the NWCP. The brackish water bodies are the tidal creeks, lagoons and estuaries. The main lagoons are the Vankalai lagoon, Wedithalathive Lagoon, Periya Kalapu and Thalaimannar lagoon. The lagoons have been formed by the development of barrier islands parallel to the coastline. The Periya Kalapu receives sea water through several channels in the sand barrier and its major connection to the sea is at the northern end of the lagoon. Freshwater from the land drainage enters the lagoon from the east. Some of the barrier islands have joined the mainland, while others remain detached from the coastline. The freshwater bodies are mostly man-made tanks built for irrigation purposes.

The total length of the coastline of the study area is approximately 318 km (Table 1.4, Figure 1.9). But the entire coastline does not have coastal marshes. For example, the western coastline of Poonekary DS Division up to about Poonekary is dominated by Dry Monsoon Forests. Mobile coastal dunes are found only in parts of Mannar Island and Poonekary Peninsula. The length of the coastline of the mapped area by DS Division is listed in Table 1.4.

Table 1.4. Length of the coastline by DS division

District	DS Division	Length of Coastline (km)
Mannar	Nanattan	17.8
	Mannar City	106.8
	Manthai West	39.6
Kilinochchi	Poonkary	140.3
	Karachchi (Mapped Section only)	13.5
Total Length		318.0

The longest coastline is in the Poonekary Division, while the second longest is in the Mannar City Division. These two divisions are characterized by two Southeast-Northwest trending narrow islands, one connected to the mainland, and other separated from the mainland by narrow channels. Both of these land areas are characterized by the presence of sand dunes, but they have only a limited extent of coastal marshes. The shortest coastline is in the Manthai West DS division most of which is covered by mangroves. Only part of the Karachchi Division was mapped in this study and the coastline shown in Table 1.4.

2.0 COASTAL WETLANDS AND SAND DUNES OF MANNAR-POONERYN LANDSCAPE

The coastal plain is a transitional environment between the land and sea. This transitional character is reflected in the ecology of this environment. Sea water and freshwater mix to varying ratios to determine the soil salinity. Sea salt enters the soil as salt spray carried landwards by onshore winds, through saline ground water and tides. The salt tolerant plants are mostly found near the sea, while moderately salt tolerant plants tend to grow behind them. There is also an altitudinal gradient from just below the mean sea level to about 10-15m. The areas that are below sea level receive sea water with the tides. In a micro-tidal coast the tidal inundation regime plays a critical role on the landward extent of the coastal wetlands. Coastal plains in general have a shallow water table with a freshwater lens floating on a seawater layer. As the dry season progresses, the freshwater lens becomes thinner or disappears completely. High evaporation rates bring salt from the groundwater to the soil layer increasing soil salinity. Some of the marshes dry up completely during the dry season and salt crystals are visible on the ground surface. Coastal marshes have developed in this harsh environment, where plant communities have adapted to different levels of salinity. Coastal habitats are confined to a narrow belt along the coastline in all five coastal DS divisions, Nanattan, Mannar City, Manthai West (Mannar District), Poonekary and Western part of Karachchi (Kilinochchi District). The northwestern coastal landscape and seascape when taken together, have a high habitat diversity. This study is however limited to the inland habitats and intertidal habits on the coastal plain.

Eleven major coastal habitat types with a total extent of 34,791 ha were mapped and described in the NWCP. Their extents by DS Division are given in Table 2.1 and Figures 2.1 and 2.2. The major wetland habitats and sand dunes mapped in the Northwestern Coastal Plain (NWCP) are tidal flats (mudflats), mangroves, salt marshes, freshwater marshes, dune systems, and maritime grasslands (Table 2.1). There are also mixed habitats, where two or more habitat types exist in close association in a repetitive manner. These natural habitats are colonized by a salt tolerant alien invasive species, *Prosopis juliflora*, which occupies elevated sites in the coastal marshes as well as highlands.

Table 2.1. Extents (ha) of coastal habitat types by DS Division

Map Unit	Habitats	Mannar District			Killinochchi District		Total
		Nanattan	Mannar City	Manthai West	Poonekary	Karachchi	
1	Freshwater Marsh	40.03	-	26.35	0.11	5.19	71.68
2	Grasslands with <i>Prosopis</i>	-	-	275.87	-	-	275.87
3	Grasslands with Scrub	8.2	57.85	2,691.57	90.73	-	2,848.36
4	Mangrove	396.69	206.7	1,703.22	702.36	10.87	3,019.84
5	<i>Prosopis</i>	293.2	657.08	737.27	-	-	1,687.55
6	Salt Marsh	1,124.53	746.95	2,394.93	4,832.08	1,416.67	10,515.16
7	Salt Marsh Encroached	-	-	148.13	-	-	148.13
8	Salt Marsh with Scattered Grassland, Scrub and <i>Prosopis</i>	11.62	49.76	66.13	60.09	-	187.60
9	Salt Marsh with Scattered Mangroves	3.67	22.1	135.25	39.48	-	200.49
10	Sand Dune	-	5,707.24	-	808.11	-	6,515.35
11	Tidal Mudflats	-	4,330.81	1,323.90	3,666.14	-	9,320.84
Total		1,877.95	11,778.49	9,502.62	10,199.10	1432.73	34,790.88

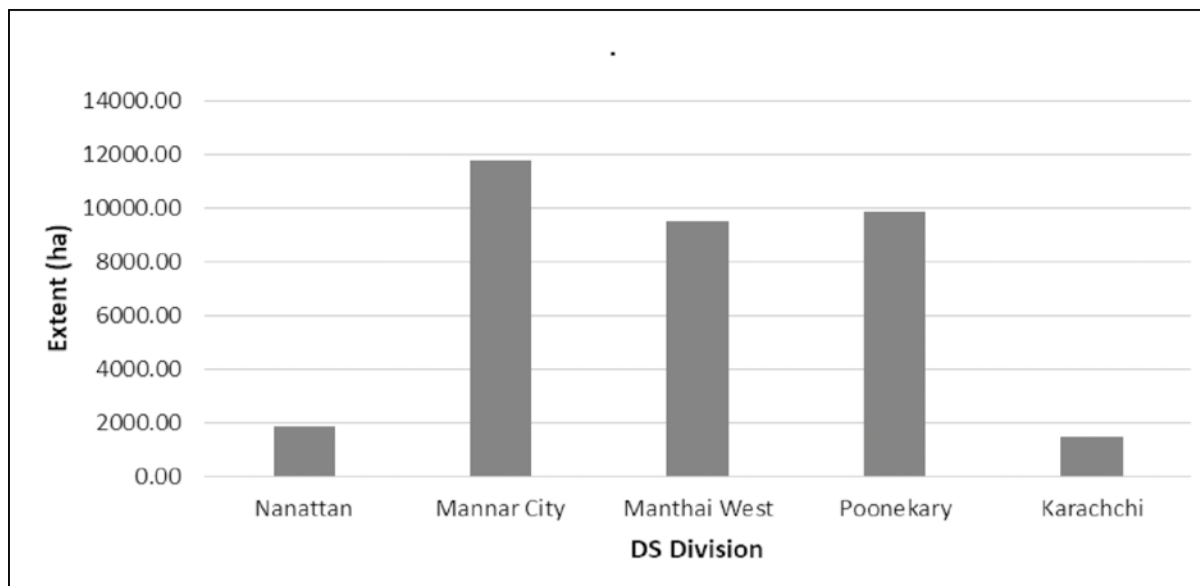


Figure 2.1. Extents of coastal ecosystems by DS divisions

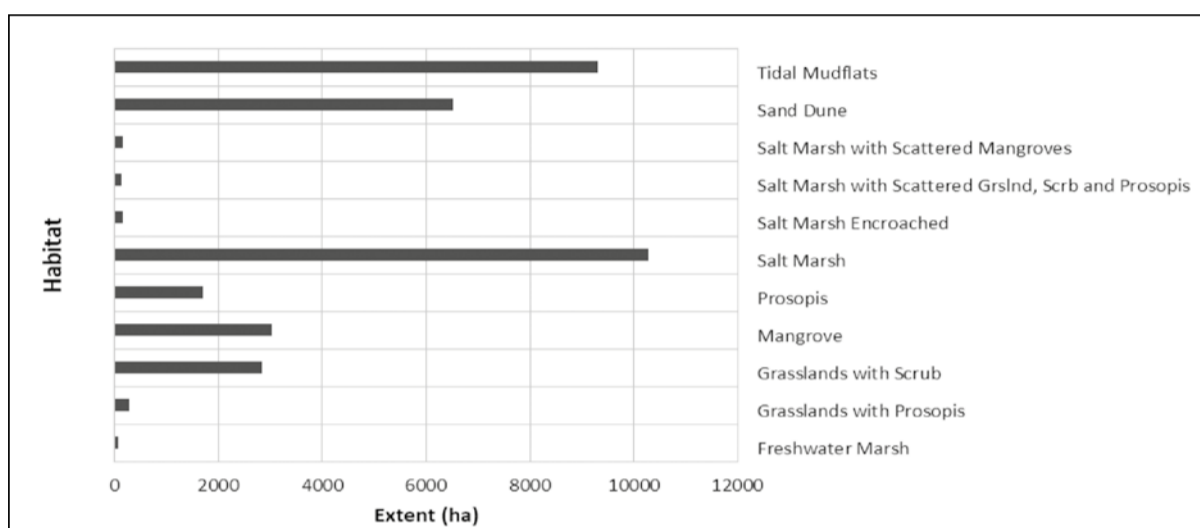


Figure 2.2. Extents of coastal habitats

The largest area of the mapped habitats is in Mannar City DS Division, while the Poonekary division accounts for the second largest area. Manthai West comes close third. The total areas of the mapped habitat types in the Nanattan and Karachchi divisions are significantly lower. Thus Mannar City, Poonekary and Manthai West form one cluster with high extents and Nanattan and Karachchi the second cluster with much lower extents.

The dominant coastal habitat is salt marshes which were mapped in all five DS divisions. The largest area of salt marshes was found in the Poonekary DS Division and the second largest in Manthai West Division. The DS Divisions of Nanattan, Mannar City and Karachchi also contain extensive areas of salt marshes. Tidal Mudflats cover the second largest area. They are a common feature in the inter-tidal zone of Mannar City, Manthai West and Poonekary DS Divisions on the west coast. The map unit, sand dunes, has the third largest area but they are confined to two geographic areas, Mannar Island (Mannar City DSD) and Pooneryn Peninsular (Poonekary DSD). A total extent

of 3,020 ha of mangrove was mapped in all divisions, but the largest areas were found in Manthai West and Poonekary Divisions. Two other divisions with large areas of mangrove are Nanattan and Mannar City. Only a small area of mangrove was mapped in Karachchi Division. On the flat terrain where soil salinity is low, maritime grasslands are found. These grasslands provide fodder to the cattle as well as other animals such as wild ponies (*Equus caballus*) and feral donkeys (*Equus africanus*). The grasslands exist interspersed with other plant communities, such as scrub, salt marshes, and *Prosopis*. *Prosopis juliflora* covers an extensive area of the coastal plain towards southern part of the NWCP. The total extent of land under *Prosopis* cover is about 1,688 ha. *Prosopis* is confined to Nanattan, Mannar City (mainland area) and Manthai West DS Divisions. Poonekary and Karachchi divisions and Mannar Island are still free of this alien invasive species. In the easternmost area of the Mannar Island, a few trees or small patches were found, but the extent was not large enough to map. Sandy areas in the Mannar Island are colonized by two species of acacia namely, *Acacia planifrons* and *Acacia eburnea*.

In addition to the major habitat types, there are also mixed habitats where two or more habitat types exist in a single system. They are named according to the major and minor habitat types. Some examples are mangrove with scattered salt marsh, salt marsh with scattered mangrove, etc.

Large extents of coastal wetland habitats are found within the existing or proposed protected areas. For example, a large proportion of coastal habitats in the Nanattan, Mannar City and Manthai West Divisions are within the Vankalai Sanctuary and Wedithalathive Nature Reserve. But coastal marsh habitats outside these protected areas are under increasing threat. Various development projects have come into the area after the end of the civil war and the development work seems to be taking place in a haphazard manner with scant attention to the environmental protection or sustainability of the development activities.

2.1 MANGROVES

Mangrove is the marine tidal forest that includes trees, shrubs, palms, epiphytes and ferns (Tomlinson, 1986). They are the only forests situated at the confluence of the land and sea (Alongi, 2002). The term 'mangrove' is commonly used in two ways. It is used to describe a community of trees or shrubs which grow in the intertidal zone or it may be applied to any plant which belongs to this community (Macnae, 1968). The mangrove environment is characterized by high salinity, extreme tidal fluctuations, strong winds, high temperature and muddy, anaerobic soils. Mangroves are the only group of plants which have highly developed morphological, anatomical and physiological adaptations for such extreme environmental conditions (Kathiresan and Bingham, 2001). Climate of Sri Lanka provides conditions suitable for the growth of mangrove ecosystems.

Twenty-one true mangrove species have been recorded from Sri Lanka by 2012 (MOE, 2012). The National Red List 2012 of Sri Lanka (MOE, 2012) recognized two mangrove species, namely *Lumnitzera littorea* and *Ceriops decandra* as critically endangered species while grouping 11 others into threatened category. *Rhizophora mucronata*, *Rhizophora apiculata*, *Lumnitzera racemosa*, *Avicennia marina* and *Excoecaria agallocha* are most dominant, widely distributed and more common true mangrove species in the country (Jayathissa *et al.*, 2002). De Silva and De Silva (1998) recognized two main mangrove communities in Sri Lanka, namely “Low Saline” and “High Saline”. Low saline mangrove communities are present in river estuaries where salinity is less than 10 ppt. In these communities the prominent species are *Nypa fruticosa*, *Bruguiera sexangula*, *Sonneratia caseolaris* and *Heritiera littoralis*. High saline mangrove communities are usually present in shores of lagoons, Islands within lagoons and in estuaries where salinity exceeds 25 ppt. *Avicennia marina*, *Rhizophora mucronata*, *Sonneratia alba* and *Pemphis acidula* are prominent mangrove species in these communities. According to the Forest Department of Sri Lanka, approximately 15,670 ha of mangroves are reported in the country in 2010 (Edirisinghe *et al.*, 2012). Most mangrove areas in Sri Lanka are confined to the coastal areas in the dry and intermediate zones. Jaffna district possesses the largest extent of mangroves in the island with 2,505 hectares. The other five districts with more than 1000 hectares of mangroves are Trincomalee, Batticaloa, Puttalam, Kilinochchi and Mannar. The distribution of mangrove areas by district in relation to the total forest cover is given in Table 2.2. The primary reason for low mangrove cover in the country is the low tidal range which limits the marine action to a narrow elevation range.

Table 2.2. The distribution of mangroves and total forest areas in coastal districts

District	Mangrove Area (ha)	Total Forest Area (ha)	% of Total Forest
Ampara	618	151,109	0.4
Batticaloa	2,071	50,467	4.1
Colombo	-	2,012	0
Galle	406	21,310	1.9
Gampaha	634	2,231	28.4
Hambanthota	692	57,894	1.2
Jaffna	2,505	4,847	51.7
Kaluthara	75	17,587	0.4
Kilinochchi	1,885	38,060	4.9
Mannar	1,351	126,108	1.1
Mathara	39	19,994	0.2
Puttalam	1,958	84,178	2.3
Trincomalee	2,395	126,674	1.9
Total	15,670.00	1,951,473	0.8

(Source: Edirisinghe *et al.*, 2012).

2.1.1 MANGROVE FLORA

The NWCP is noted for the existence of extensive areas of mangrove (Figure 2.3). They are found as pure stands or as mixed mangroves. The total extent of mangrove pure stands in the study area is over 3,035 ha or about 19% of the total extent of 15,670 ha of mangroves reported in previous estimates in Sri Lanka (Edirisinghe *et al.*, 2012).

The mixed mangrove stands are mapped as salt marshes with scattered mangrove. The mixed habitats were named by using the dominant type first. The total area with the mixed mangrove is 161 ha of which the largest area is in Salt Marshes with Scattered Mangroves. The most extensive areas of mangrove are found in the Manthai West DS Division (Figure 2.3). Nine true mangrove species and five mangrove associate species were recorded during the survey in NWCP (Table 2.3 and Appendix I). This includes two endangered species (*Bruguiera cylindrica* and *Sonneratia alba*), one vulnerable species (*Scyphiphora hydrophyllacea*) (Plate 2.1) and two near-threatened species (*Lumnitzera racemosa* and *Pemphis acidula*).

Table 2.3. True mangrove species recorded in the project area

Family	Species	Sinhala name	Life form	Conservation status
Acanthaceae	<i>Avicennia marina</i>	Manda, Manda Gas	Tree	LC
Combretaceae	<i>Lumnitzera racemosa</i>	Beraliya, Beriya	Tree	NT
Euphorbiaceae	<i>Excoecaria agallocha</i>	Talakiriya, Tela kiriya	Tree	LC
Lythraceae	<i>Pemphis acidula</i>	Muhudu wara	Shrub	NT
Lythraceae	<i>Sonneratia alba</i>	Kirilla / Kirala	Tree	EN
Primulaceae	<i>Aegiceras corniculata</i>	Hin-Kadol, Avari Kadol	Shrub	LC
Rhizophoraceae	<i>Bruguiera cylindrica</i>	Heen Mal Kadol	Tree	EN
Rhizophoraceae	<i>Rhizophora mucronata</i>	Kadol, Maha Kadol	Tree	LC
Rubiaceae	<i>Scyphiphora hydrophyllacea</i>	Kalu-kadol	Tree	VU

Conservation status - based on The National Red List 2012 of Sri Lanka (MOE 2012)

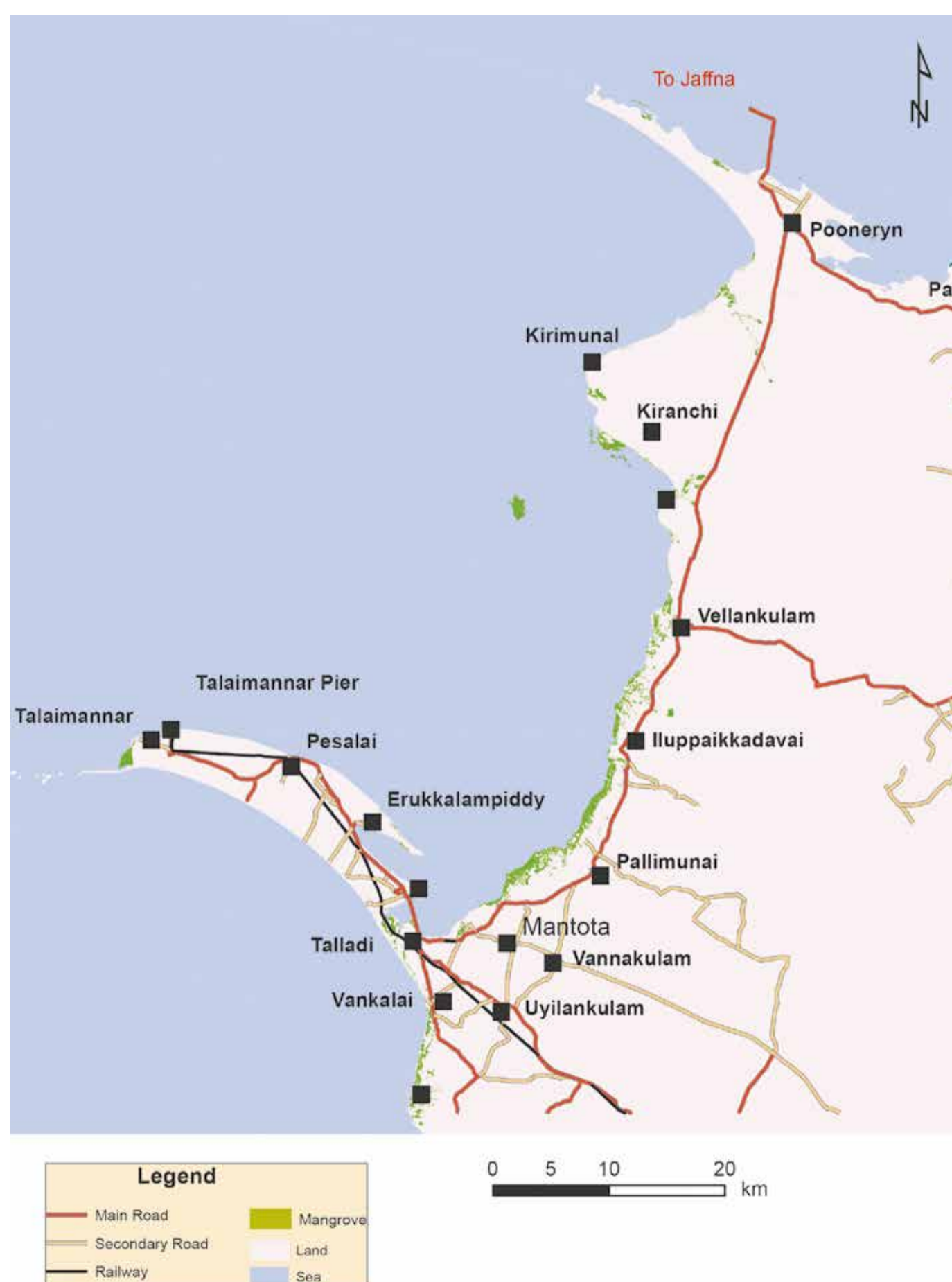


Figure 2.3. Distribution of mangroves in the project area



(a) *Bruguiera cylindrica* (EN)



(b) *Sonneratia alba* (EN)



(c) *Scyphiphora hydrophyllacea* (VU)

Plate 2.1. Threatened mangrove species recorded in the project area

All the true mangrove species are not located across the entire landscape. They were found scattered in different mangrove communities in the project area.

Based on floristic assemblage type, six mangrove sub-communities could be observed in the project area. They include:

a. *Rhizophora mucronata* dominant stands: The tallest type of mangrove community reaching up to 12m and often with dense mono species stands (Plate 2.2.)

b. *Avicennia marina* dominant stands: Dense stands are widespread in the project area where tidal influence is moderate. Height is highly variable between 0.25m to 8m and dwarf trees are common in heavily browsed sites. In some sites, mono species growth of *Avicennia marina* could be seen (Plate 2.3). This type is widely distributed over in-shore areas. Generally, in vertical stratification there is only one forest layer going up to 4m to 5m height, and the closed canopy layer does not allow much light penetration to the ground layer. Ground is muddy and occupied by a thick layer of pneumatophores (breathing roots) of *Avicenna marina*. Inside the forest, much of the space between ground and canopy is empty and well-spaced stems of trees can be seen.

c. *Lumnitzera racemosa* dominant stands: Impenetrable thickets attain 4m to 8m height (Plate 2.4)



Plate 2.2. *Rhizophora mucronata* dominant stand (Malwathu Oya delta)



Plate 2.3. *Avicennia marina* dominant stand



Plate 2.4. *Lumnitzera racemosa* dominant stand (near Pampedi Forest Reserve)

d. *Sonneratia alba* dominant stands: The community is usually 3m-6m in height and confined to southern part of Mannar district, mainly in the Malwathu Oya delta (Plate 2.5). Trees are gnarled and stunted due to strong winds. Such large *Sonneratia alba* patches are found nowhere else in Sri Lanka. Only some isolated trees of this species were reported previously in Sri Lanka and that is also from this part of the country (northwestern dry zone coastal region). Occurrence of these endangered and rare mangrove species also displays a firm association with a river delta.

e. *Excoecaria agallocha* dominant stands: Muddy areas with occasional tidal influence are often occupied by this mangrove species. Several other mangrove associates and salt tolerant dry zone species occur as subordinate companion species. Generally, the community is 2m-4m high and has low and dense spread (Plate 2.6).

f. Mixed mangrove stands: There are certain locations where there is no domination by a single species and instead there is an assemblage of both true mangrove species and mangrove associate species. The stand density in these mangals is also highly variable (Plate 2.7).



Plate 2.5. *Sonneratia alba* dominant stand
(Malwathu Oya delta)



Plate 2.6. *Excoecaria agallocha*
dominant stand



Plate 2.7. Mixed mangrove stand (consisting of *Avicennia marina*, *Rhizophora mucronata*, *Excoecaria agallocha* and *Lumnitzera racemosa*)

2.1.2 MANGROVE SITES AND SPECIES OF SPECIAL CONSERVATION INTEREST

Apart from the above mentioned floristically differentiated groups of mangrove communities, there is a structurally distinct community of mangrove that can be termed as 'Dwarf Mangrove' on account of characteristically low vertical structure rarely exceeding 2m-3m height (Plate 2.8). Such dwarf mangrove patches consisting of *Sonneratia alba* and *Avicennia marina* growing on a purely sandy substratum was recorded in the Malwathu Oya delta (Plate 2.8). Perhaps, this may be the first time in Sri Lanka, a dwarf mangrove patch was identified. It is therefore of high conservation and scientific value. Hence Malwathu Oya Delta covered with mangrove (Figure 2.4) must be declared as a protected area. This area could be first included in the Forest Department's proposed mangrove protected area list until proper steps are taken for the declaration of the Malwathu Oya Delta as a protected area.



Plate 2.8. Dwarf *Avicennia marina* patch at Malwathu Oya delta

Malwathu Oya (Aruvi Aru) Delta

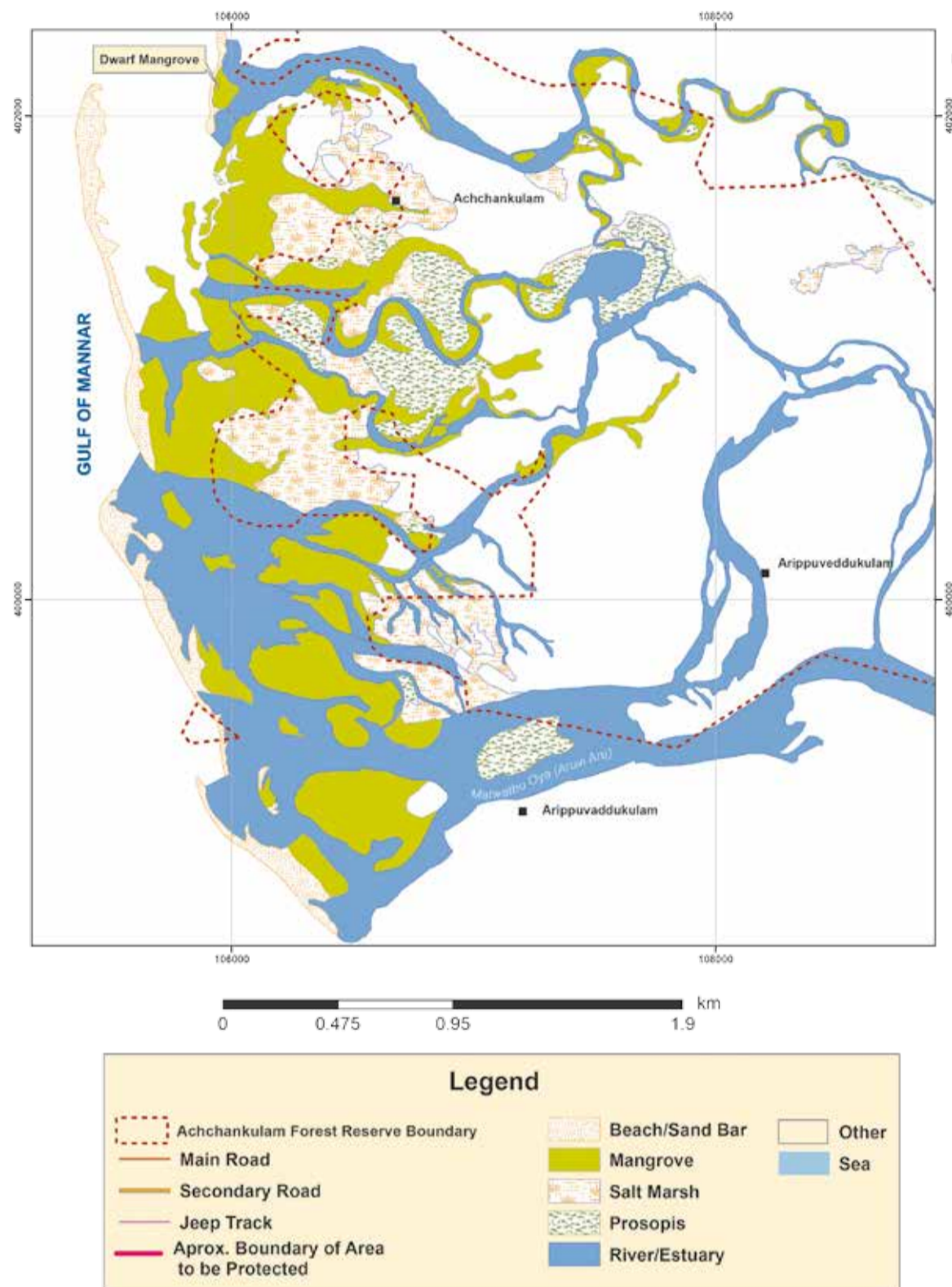


Figure 2.4. Mangroves in Malwathu Oya delta

2.1.3 MANGROVE FAUNA

The mangrove substratum is rich in organic matter which provides an ideal habitat for some brackish water mollusk and crab species. During the survey, four species of gastropod mollusks and two species of fiddler crabs (Plate 2.9) were recorded from the mangrove substratum (Table 2.4).

Table 2.4. Fauna recorded from mangrove substratum

Phylum	Class	Family	Species	English name
Mollusca	Gastropoda	Potamididae	<i>Telescopium telescopium</i>	Horn snail
			<i>Terebralia palustris</i>	Giant mangrove whelk
			<i>Cerithidea cingulata</i>	Girdled horn snail
		Pachychilidae	<i>Faunus ater</i>	Black devil snail
Arthropoda	Malacostraca	Ocypodidae	<i>Uca (Austruca) annulipes</i>	Ring-legged fiddler crab
			<i>Uca (Gelasimus) vocans</i>	Orange fiddler crab



(a) *Terebralia palustris* common gastropod mollusk in mangroves



(b) Orange fiddler crab *Uca (Gelasimus) vocans* in exposed mangrove substratum

Plate 2.9. Gastropod Mollusks and Orange Fiddler Crabs

Furthermore, 44 terrestrial faunal species in 25 families were also recorded in the mangroves (Table 2.5 and Appendix II). Terrestrial faunal component in the mangroves is dominated by birds. Of the 27 bird species recorded from mangrove areas, 11 are water birds (Appendix II).

Table 2.5. Summary of fauna recorded in mangroves

Faunal group	Families	Species	Endemics	Conservation Status				
				Threatened				
				CR	EN	VU	NT	LC
Land Snails	1	1	-	1	-	-	-	-
Dragonflies	1	3	-	-	-	-	-	3
Butterflies	3	7	-	-	-	-	-	7
Fishes	2	2	-	-	-	-	-	1
Reptiles	1	2	1	-	-	-	-	2
Birds	15	27	-	-	-	1	-	17
Mammals	2	2	-	-	-	-	-	-
TOTAL	25	44	1	1	-	1	-	30

Conservation Status - based on 'The National Red List 2012 of Sri Lanka' (MOE, 2012)

CR - Critically Endangered, EN - Endangered, VU - Vulnerable, NT - Near threatened, LC - Least concerned

Mangrove habitats support large numbers of prey species of water birds, such as fish, mollusks, other invertebrates, and plankton. The phytoplankton contributes to a major portion of the primary production in these lagoons. This provides the basis for the food chain. High densities of prey species support large populations of water bird species. The study region also has some of the most seriously threatened wetlands in Asia (Scott, 1989).

In overall assessment, it is appropriate to conserve maximum possible area of mangroves for their ecological services and products. Ecological values of mangroves are well known and they are many and varied. They help in soil formation by trapping debris, stabilize loose soil and detritus, act as a filter for land runoff, prevent sea erosion and protect the hinterland from tidal surges, cyclonic impacts, provide appropriate ecosystem conditions and refuge for fish, marine invertebrates, mollusks and birds. The products and services provided by mangroves are indispensable for socio-economic sustainability of the area. Mangroves also provide various economically valuable plant materials needed for the community (e.g. firewood, light timber, "Mas Athu" for prawn fishery and bark tannin), etc. Fishery industry is highly dependent on the ecosystem services of mangroves.

2.2 SALT MARSHES

The term salt marsh generally refers to a mosaic of coastal wetland vegetation types that occupy low energy coastal areas with intermittent tidal inundation. Typically, these are associated with bays, inlets and estuaries, and sheltered soft substratum foreshores, often occurring behind the mangroves (Creighton *et al.*, 2017). In Sri Lanka, salt marshes occur mainly in the north, northwest, northeast and south-eastern coastal areas where the climate is characterized by a long dry season. In the north, salt marshes occur mainly on exposed tidal flats and in the south mainly in depressions between sand dunes. Salt marsh vegetation in most areas occur as sparse, short growths interspersed with other types of vegetation (NARESA, 1991).

Salt marshes occur in land patches that experience occasional tidal inflows (seasonally inundated coastal areas). They become extremely dry during the prolonged dry season and excessive evaporation enhances soil salinity. Often crystallized free salt can be seen on the soil surface and on dry plants. Salt marsh vegetation is a plant community dominated by herbs (up to 1m).

The distribution of salt marshes in the NWCP is shown in Figure 2.5. The total extent is over 10,700 ha (all types) or about 45% of the total extent (23,819 ha) of salt marshes in Sri Lanka as estimated by CCD (1997).

2.2.1 SALT MARSH FLORA

Seven true salt marsh species (Table 2.6) and 18 salt marsh associate species (Patro *et al.*, 2017) have been recorded during the survey (Appendix III). Typical salt marsh species such as *Suaeda maritima*, *Suaeda vermiculata*, *Sesuium portulacastrum*, *Halosarcia indica* and *Salicornia branchiata* cover the ground surface. They are perennial herbs/small shrubs with prostrate and upright shoots. Usually, the ground is 50% bare soil and associate species like *Cyperus stoloniferus*, *Indigofera oblongifolia* and *Zoysia matrella* occur intermixed. Environmentally extreme conditions such as dry desiccating winds with salt spray, soil salinity, perennially high temperature, excessive evaporation do not attract other plant species to such locations.



Figure 2.5. Distribution of salt marshes in the project area

Table 2.6. True salt marsh species recorded in the Mannar landscape

Family	Species	Common name	Life form	Conservation states
Aizoaceae	<i>Sesuvium portulacastrum</i>	Maha sarana	Herb	NT
Amaranthaceae	<i>Halosarcia indica</i>		Herb	NT
Amaranthaceae	<i>Salicornia branchiata</i>		Herb	NT
Amaranthaceae	<i>Suaeda maritima</i>	Umiri	Herb	NT
Amaranthaceae	<i>Suaeda monoica</i>		Shrub	NT
Amaranthaceae	<i>Suaeda vermiculata</i>	Wormleaf saltwort	Herb	NT
Connvolvulaceae	<i>Cressa cretica</i>		Herb	LC

Conservation states - based on The National Red List 2012 of Sri Lanka (MOE, 2012)

Five major sub floristic assemblages of salt marshes found in the NWCP are:

- Chenopod succulent dominant salt marsh communities
- Sedge dominant salt marsh communities
- Grass dominant salt marsh communities
- Forb dominant salt marsh communities and
- Mixed salt marsh communities

a. Chenopod succulent dominant salt marsh communities

Several species of true salt marsh plants which are grouped as Chenopod succulents; *Halosarcia indica*, *Salicornia branchiata*, *Suaeda maritima*, *Suaeda monoica* and *Suaeda vermiculata* dominate some well-developed natural salt marsh areas as a mosaic in the landscape. Often, separate stands of *Halosarcia indica*, *Salicornia branchiata*, *Suaeda maritima*, *Suaeda monoica* and *Suaeda vermiculata* are found as thick growths on sandy and muddy saline areas. Among them, *Suaeda monoica* (Plate 2.10) is a shrub with succulent leaves growing up to 2m, while the rest of the plants are herbaceous species, often below 50cm height, with little or no woody parts.



Plate 2.10. *Suaeda monoica* (true salt marsh succulent) dominant patch of salt marsh

Halosarcia indica (Plate 2.11) and *Suaeda maritima* (Plate 2.12) serve as fodder plants especially during peak dry season as both cattle and donkeys feed on these plants.



Plate 2.11. *Halosarcia indica*
(a common low growing salt marsh succulent)



Plate 2.12. *Suaeda maritima*

b. Sedge dominant salt marsh communities

Assemblages of Cyperaceae species growing often up to 40cm are located covering marshy substrate in depressions and bordering stagnant pools. Thick mat of vegetation is formed by *Eleocharis geniculata*, *Cyperus arenarius*, *Cyperus rotundus* and few other Cyperaceae species (Plate 2.13). In addition to sedges, sparse growth of several other graminoid species such as *Leersia hexandra*, *Panicum repens*, *Panicum sumatrense* and *Sporobolus diander* are often associated with those sedge dominant salt marsh communities. *Typha agustifolia* (about 2m) is an invasive plant growing by displacing some pockets of natural sedge dominant salt marsh communities. The vegetation is an effective filter that can trap soil nutrients and sediment in surface runoff. Feeding value of available sedge communities are at moderate level as per grazing use of such sites by cattle, wild ponies, donkeys and buffaloes.



Plate 2.13. Sedge (*Fimbristylis triflora*) dominant salt marsh

c. Grass dominant salt marsh communities

On relatively higher ground, vast expanses of turf grass dominated salt marshes are common sites in Mannar area (Plate 2.14). Salt tolerant grasses, namely, *Cynodon dactylon* and *Zoysia matrella* are the most abundant species while *Aeluropus lagopoides*, *Cyperus rotundus*, *Eragrostis* spp, *Fimbristylis pubisquama*, *Panicum repens*, *Suaeda maritima* and *Suaeda vermiculata* occur as scattered populations (Plate 2.15). The plant community is a low growing (5cm-20cm) thick grass cover with high grazing value. The structure and floristic composition of the grassland system is highly influenced by grazing pressure, trampling, salinity and drought. Turf grass dominant salt marsh communities are indispensable with regard to the role they play in sustaining cattle and wild herbivores in the area and therefore referred to as 'arid pastures' by some researchers (Pemadasa, 1990). Similar to other open vegetation types, turf grass dominant salt marsh communities act as ground stabilizer - the vegetation cover and the root mat are highly effective against erosion. They are also effective in filtering sediment from runoff.



Plate 2.14. Turf grass dominant salt marsh



Plate 2.15. A patch of turf grass *Zoysia matrella*

d. Forbs dominant salt marsh communities

Patches of low growing broad leaf herbaceous plants (forbs) dominant salt marsh communities (less than 30cm in height) are located randomly in the flat landscape among other graminoid and chenopod salt marsh communities (Plate 2.16).

Common salt tolerant broad leaf herbaceous species include *Atriplex repens*, *Enicostema axillare*, *Epaltes divaricata*, *Euphorbia indica* and *Heliotropium curassavicum* (Plate 2.17). Semi-woody broad leaf *Indigofera oblongifolia* is a low shrub (1m) occupying the edges of salt marshes. Generally, grazing value of this community is low but several companion herb species of high grazing preferences, such as *Alysicarpus ovalifolius*, *Commelina spp.*, *Cyanotis burmanniana*, *Desmodium triflorum* and *Hybanthus enneaspermus*, add value to local economy.



Plate 2.16. A patch of forb dominant salt marsh



Plate 2.17. Common salt marsh forbs
(broad leaf herbs - *Epaltes divaricata* and *Euphorbia indica*)

e. Mixed salt marsh communities

In sites where micro environmental conditions are highly heterogeneous, the composition and structure of salt marsh communities become variable depending upon the successional stage and physical circumstances of the sites in which they occur. Disturbances, variation of micro topography, ground water regimes and salinity levels are governing factors as exhibited by plant life. Pockets of depressions are occupied by sedge communities while higher ground or mounds are covered with either salt tolerant grasses or broad leaf plants (Plate 2.18). Often, sparse growth of isolated mangroves and Chenopod succulents at close distance are not uncommon. Hence these mixed salt marsh communities display heterogeneous nature of horizontal as well as vertical structure. Height may vary from 5 cm to 2 m and the community does not fit into any kind of clearly noticeable floristic alliance.



Plate 2.18. Mixed salt marsh community

The total flora represented in all above salt marsh plant communities included 91 species belonging to 26 families (Appendix III). Plants belonging to threatened category include *Sonneratia alba* (EN), *Cyanotis burmanniana* (VU), *Aristida adscensionis* (VU) and *Indigofera oblongifolia* (VU). Different life forms were represented by herbs (72), shrubs (8), trees (10) and a vine (1).

2.2.2 SALT MARSH FAUNA

A total of 157 fauna species were recorded in the salt marshes in the project area during the survey from October 2018 to February 2020. Vast majority of the species recorded (98) are birds, while butterflies were the second most abundant faunal group (Table 2.7). Of the bird species recorded, Jungle fowl (*Gallus lafayetii*) and Sri Lanka Swallow (*Cecropis hyperythra*) are endemics. The only endemic butterfly species recorded from the study area (Sri Lanka Lesser Albatross *Appias galena*) was found in the salt marsh and sand dune habitats. Because of the harsh environmental conditions in the salt marshes, the other faunal groups are poorly represented (Table 2.7 and Appendix II).

Table 2.7. Summary of fauna recorded in salt marshes

Faunal group	Families	Species	Endemics	Conservation Status				
				Threatened				
				CR	EN	VU	NT	LC
Land Snails	1	1	-	-	-	-	-	-
Dragonflies	3	12	-	-	-	-	1+	10
Butterflies	4	30	1	-	-	-	-	30
Fishes	3	3	-	-	-	-	-	1
Amphibians	1	4	-	-	-	-	-	4
Reptiles	2	3	1	-	-	-	-	2
Birds	32	98	3	-	-	2	3+	48
Mammals	9	9	-	-	-	-	-	5
TOTAL	54	159	5	-	-	2	4	100

Conservation Status - based on 'The National Red List 2012 of Sri Lanka' (MOE, 2012)

CR - Critically Endangered, EN - Endangered, VU - Vulnerable, NT - Near threatened, LC - Least concerned

Salt marshes serve as important wintering sites for migratory water birds. During the survey (2018-2020), 39 migratory water bird species were recorded in the salt marshes especially in Vankalai and Wedithalathive areas. Furthermore, five bird species having migratory and resident populations and 13 resident water bird species were also recorded (Appendix IV). Of the water birds recorded, two species, Little Ringed Plover (*Charadrius dubius*) (Plate 2.19) and Kentish Plover (*Charadrius alexandrinus*) (Plate 2.20) have resident and migratory populations. They are listed as vulnerable in the National Red List 2012 of Sri Lanka (MOE, 2012) while three other resident water bird species namely, Painted Stork (*Mycteria leucocephala*) (Plate 2.21), spot-billed Pelican (*Pelecanus philippensis*) (Plate 2.22) and Black-headed Ibis (*Threskiornis melanocephalus*) (Plate 2.23) are considered as Near Threatened (NT) globally (MOE, 2012).



Plate 2.19. Little ringed plover
(© P. Rajkumar)



Plate 2.20. Kentish plover
(© P. Rajkumar)



Plate 2.21. Painted stork (Vankalai sanctuary)



Plate 2.22. Spot-billed pelican (Vankalai Sanctuary)



Plate 2.23. Black-headed Ibis (Wedithalathive saltmarshes)

2.2.3 IMPORTANCE OF SALT MARSHES

The salt marshes are the habitats for migratory birds which arrive in the area during October-December major rainy period. The water filled salt marshes become feeding grounds for the migratory birds. During the study period, about 200 pintail ducks and 2000 Garganey ducks were counted in Vankalai sanctuary during the months of January and March, 2019. Vankalai area did not receive its normal rainfall during 2019/2020 bird migratory season. As a result, the sanctuary (lagoon and salt marshes) was not filled with water and hence it has not attracted migratory water birds in large numbers. However, according to Ceylon Birds Club notes (2011 - 2017), more than 200,000 ducks were seen in Vankalai Sanctuary in 2011. In 2014 it was estimated to be 200,000 to 250,000. During the survey, we have recorded about 500 pintail ducks every month from January to March in freshwater marshes in Tharapuram area along Mannar - Thalaimannar road.

The reason why this region is so rich in water birds may be because it lies at an end point of the major Central Asian flyway. Each year as the winter approaches, hundreds of thousands of waterbirds in the Northern hemisphere migrate along this flyway and end their journey in Sri Lanka. Most of them make landfall in Jaffna or Mannar. Furthermore, most of these birds remain in these areas throughout the migratory season (Wijesundara *et al.*, 2017). Shorebirds, ducks, gulls, and terns in very large numbers feed and rest in, and fly among, the many wetlands within the Jaffna and Mannar regions, and intermittently fly between these two regions, throughout the migratory season. Water birds prefer sites less altered by humans (Wijesundara *et al.*, 2017).

During the rainy season, an algal mat consisting mainly of nitrogen fixing microorganisms occurs on the water surface of salt marshes. This provides habitats for many larval and juvenile stages of aquatic organisms. For example, in Mannar and Puttalam areas they are sites for the collection of milkfish fry (*Chanos chanos*) for brackish water aquaculture (Arulpragasam, 2000).

Mannar has an unexploited tourism potential during the bird migratory season. Already bird enthusiasts from other parts of Sri Lanka converge in Mannar during this season. But foreign tourists are still not a common site. This is because of lack of tourism infrastructure in the area and major tour operators have still not understood the ecotourism potential of the area.

Mannar Island is home to a free ranging donkey (*Equus africanus*) population. They are now considered as a symbol of Mannar. The donkey was introduced into Sri Lanka many centuries ago, probably from north-eastern Africa by Arab traders, and became a conspicuous member of the herbivore fauna of the north-western coastal areas of the island (Santiapillai et al., 1999). In Sri Lanka, the animal was used extensively in the north-western coastal areas of the island as a draft animal by some communities, a practice that continued well into the 20th century. By 1900 the animal had become feral (Santiapillai et al., 1999) and well-established feral populations are now found in Kalpitiya, Puttalam, and Mannar areas. Within the Mannar city area, the donkeys feed on grasses and household garbage including discarded vegetables and fruits. However, donkeys living in mainland Mannar especially in Vankalai sanctuary and Talladi area, feed on some salt marsh plants and salt tolerant grasses in salt marshes. Salt marshes in Mannar area now serve as feeding grounds for donkeys and therefore help sustain the donkey population (Plate 2.24).



Plate 2.24. Donkey feeding on salt marsh succulent *Halosarcia indica* in Vankalai sanctuary

Donkeys in Mannar area are now becoming an important asset as they provide therapeutic assistance to differently abled children. As such, a few donkey-assisted therapy centres are in operation in Mannar area now (Plate 2.25)



Plate 2.25. Donkey assisted therapy centre (at Murrugan)

Mangrove and salt marshes are the most important habitats of conservation value mapped and documented by this study. They are found in varying extents in the entire area of the NWCP. Government and NGOs spend large sums of money annually to extend the mangrove cover in Sri Lanka, but protection of existing mangrove coverage is not done properly. This is particularly the case outside the protected areas. Mangrove has a tremendous value as an ecological resource. It also plays a significant role in coastal protection. The study area has extensive mangrove cover (3,196 ha). Among coastal ecosystems, Mangrove has received most attention from researchers as well as environmental organizations

and the government, but same attention has not been paid to the salt marshes of Sri Lanka. Their existence is known only to a few scientists. This undervalued resource faces destruction particularly from the emerging aquaculture industry. Already close to 2,000 ha of land, mostly from salt marshes have been allocated for aquaculture. Even the salt marshes in the protected areas (Forest and Nature Reserves) have been allocated for aquaculture projects. Degazetting of these areas is under consideration by the government. Dumping of waste in sensitive sites was noted in salt marsh and mangrove areas and therefore a proper waste management in coastal areas is a must. Often, salt marshes are identified as wastelands. This has led to misuse such areas both by local authorities and villagers. Salt marshes contain plants which can be exploited as a source of nutrition for the local people. At present this use is not very common. For example, *Suaeda maritima* (Omari / Sea Blight) is a wild edible plant that is very common in salt marshes in Mannar landscape. Young leaves of sea blight can be used either as an uncooked fresh vegetable in salads or as cooked dishes. This can be promoted as 'sea vegetable' for tourism industry and other high end food industries assisting sustainable livelihoods.

2.3 *Prosopis juliflora*

Europeans introduced *Prosopis* around the world during the past 200 years, as they were very useful drought resistant species. Fast growth, drought resistance and the remarkable coppicing power makes *Prosopis* an ideal source of fuel wood. *P. juliflora* has been cultivated in arid areas of tropical and subtropical regions in Africa and Asia under the afforestation programs (Gunawardane et al., 2014).

Native to Mexico, South America and the Caribbean, *Prosopis* was introduced to Africa by 1822, and to Asia and Australia before 1900 (Pasicznik et al., 2001). *Prosopis* was introduced by the British to Sri Lanka in 1880 and to India in 1877 (Perera et al., 2005).

The alien invasive plant, *Prosopis juliflora* locally known as Kalapu-Andara (in Sinhala) / Karuvelam (in Tamil) / Mesquite (in English), was introduced to Hambantota District in the Southern province of Sri Lanka during the early 1950's to rehabilitate salt affected soils and for firewood. Within a very short period of time, this species got naturalized and started to show an aggressive growing pattern;

currently it covers almost all areas of the Bundala National Park suppressing regeneration of native plant species (Gunawardena et al., 2014). Although, *Prosopis* has some well-established and naturalized populations in the Puttalam and Mannar districts in the west coast, there are no records to ascertain the reasons and the time period of its introduction to this area. *Prosopis* was either intentionally introduced to infertile saline soils in the western coast for the same reasons that they were introduced to Hambantota area, or it arrived accidentally with livestock or through other local routes. Gunawardane et al., (2014) have stated that as an island, Sri Lanka has a large number of lagoons and coastal areas which are ideal ecosystems to the spread *P. juliflora*. Among them, Puttalam to Mannar coastal area of Sri Lanka is highly vulnerable to the spread of this species.

The plant is a thorny evergreen tree with a large flat-topped crown; it can grow up to 4 m to 8 m in height. Salt marshes are most vulnerable to the spread of *Prosopis* (Plate 2.26). It is viewed by some as the number one biological trouble maker in Mannar district. Impacts are many and varied including loss of valuable grazing lands, disappearance of large areas of salt tolerant native biodiversity and its products, health impacts on people and livestock, vanishing tourist attractions, etc. In Mannar district *Prosopis* is growing on high grounds just above the water logged areas with saline and sandy soils (Plate 2.26). According to density estimations made during the study, it was found that tree density is variable between 500-800 trees per hectare. People are reluctant to handle *Prosopis* because of its thorny nature. A survey was conducted to evaluate the villagers' attitudes towards *Prosopis* from January to March 2019 using 50 respondents in Manthai West and Nanattan Divisional Secretariat Divisions where *Prosopis* invasion is severe (Table 2.8).

Table 2.8. Survey of *Prosopis* by DS divisions

DSD	No of GN divisions	No. of Respondents
Nanattan	9	17
Manthai West	11	33

Almost all respondents indicated that *Prosopis* is affecting their livelihoods by reducing the amount of fodder for their animals due to invasion of natural grazing lands and thorny branches causing injuries to both humans and animals. The villagers are of the view that *Prosopis* is responsible for the loss of agricultural lands in areas where the invasion is severe. It was also widely held belief that *Prosopis* change hydrology of the area by blocking water ways and reducing irrigation water in the area. The survey also found that *Prosopis* alter the village infrastructure and reduce the aesthetic value of the land and thereby reducing the land/property value. Even though awareness about the potential uses this species is comparatively low, the majority of the respondents identified high heat capacity as a favorable energy property of *P. juliflora* firewood. The respondents viewed *Prosopis* as a difficult plant to harvest



Plate 2.26. *Prosopis* spreading in a salt marsh

because of its thorny nature and the hard stem. Similar findings have been reported in Bundala area of Hambantota district by Udadini and Bandara (2016). Despite this general view, it was observed that some villagers have learnt to harvest *Prosopis* trees and use them as fence poles. However, they are reluctant to clear large extents of *Prosopis* lands as they are growing in state lands. Because it is growing naturally, society still feels that *Prosopis* is a useless weed (Perera et al., 2005).

In some countries *Prosopis* is considered as a 'wonderful' multipurpose tree, with such uses as high energy fuel wood, fodder for livestock, green manure, bee keeping, and many other uses. Therefore, every effort must be taken to 'tame' this multipurpose tree and to put it into use to improve the livelihoods of the rural poor (Perera et al., 2005). Naturally growing *Prosopis* could be managed as wood lots by removing the lower branches allowing a space between trees (Plate 2.27a & b).



Plate 2.27a. Unmanaged *Prosopis* stand



Plate 2.27b. Managed *Prosopis* stand

This will allow enough space between trees facilitating free movements of livestock within a *Prosopis* wood lot. This will also allow light penetration to the ground so that grass cover on the ground could be improved/re-established thereby improving the grazing lands in the area.

Although, most of the saline areas of Mannar district are under *Prosopis* invasion, no attempt has yet been made to estimate the distribution and extents of this invasive species in the Mannar landscape. GIS based mapping (Figure 2.6) and documenting program of socio-ecological aspects of *Prosopis* in Mannar by EASL was the first comprehensive study on *Prosopis*. Clear understanding of the baseline status of *Prosopis* has several advantages:

- Location specific detailed information for decision making for managing *Prosopis*.
- Providing a baseline for change detection in future. Time series geographical changes can be easily detected and impacts on people and ecosystems determined.
- Helping plan future course of action in order to sustain ecosystems and livelihoods.



Figure 2.6. Distribution of *Prosopis juliflora* in the project area

We have estimated that land completely covered with *Prosopis* in three DSD's, namely Nanattan, Mannar City and Manthai West in the Mannar district to be about 1,756 ha. Further, about 276 ha of *Prosopis* was found discontinuously distributed in dry grasslands in the project area (Table 2.1). Thus, *Prosopis juliflora* has already replaced about 1,963 ha of productive saline ecosystems in Mannar region (Figure 2.6). The other two DSD's sampled in the Kilinochchi district namely, Poonekary and Karachchi did not have land under *Prosopis* cover (Table 2.1). The rapid botanical survey enabled recording 76 plant species in 34 families associated with *Prosopis* stands (Appendix V).

The rapidly spreading *Prosopis juliflora* is a biological threat to the salt marshes. Eradication of this plant needs a considerable investment and sustained effort. It is therefore imperative that less costly management strategies are adopted. There are lessons that can be learned from the way this plant is used in other countries for the benefit of the people. Informal discussions we had with people reveal that there are many misconceptions about *Prosopis* due to its thorny nature. But the wood is known to contain high energy value and can be used as firewood. It also can be trained to be a shade tree. Exploitation of the plant might be a good strategy to control its rapid spread.

2.3.1 FAUNA in *Prosopis* STANDS

Prosopis stands have a poor faunal species composition (Table 2.9 and Appendix II), except butterflies and birds. Twelve species of butterflies and 20 species of birds were recorded in *Prosopis* stands during the survey. Not a single endemic species was recorded from *Prosopis* stands. A near threatened bird species, Grey Francolin (*Francolinus pondicerianus*, Plate 2.28), which is restricted to northern avifaunal zone (Wijesundara *et al.*, 2017) was recorded in abundance in dry areas of saltmarshes and vegetated areas underneath *Prosopis* stands.



Plate 2.28. Flock of Grey francolin

Table 2.9. Summary of fauna recorded in areas covered with *Prosopis julifera*

Faunal group	Families	Species	Endemics	Conservation Status				
				Threatened			NT	LC
				CR	EN	VU		
LAND SNAILS	2	2	-	-	-	-	-	1
DRAGONFLIES	2	2	-	-	-	-	-	2
BUTTERFLIES	4	19	-	-	-	1	-	18
FISHES	-	-	-	-	-	-	-	-
AMPHIBIANS	-	-	-	-	-	-	-	-
REPTILES	1	1	-	-	-	-	-	1
BIRDS	14	20	-	-	-	-	1	18
MAMMALS	6	6	-	-	-	-	-	1
TOTAL	29	49	-	-	-	-	1	41

Conservation Status - based on 'The National Red List 2012 of Sri Lanka' (MOE, 2012)

CR - Critically Endangered, EN - Endangered, VU - Vulnerable, NT - Near threatened, LC - Least concerned

2.4 SAND DUNES

2.4.1 MORPHOLOGY

Dunes are windblown accumulations of sand that remain unstable unless covered by vegetation. A series of mounds/hills/ridges are formed by continuous landward pushing of the sand by onshore winds.

In Sri Lanka coastal dunes are found mostly in the driest regions of the country's northwestern, north-eastern, south-eastern coasts. Coastal dunes are also present in wetter regions like Negombo between the Negombo lagoon and the sea (Swan, 1983). Extensive dune systems have developed between Mullaitivu and Point Pedro, between Elephant Pass and Chavakachcheri, across Mannar Island, between Ambakandawila and Kalpitiya, and between Kirinda and Sangamukande point (NARESA, 1991).

Namboorthi (2008) describes south Indian sand dunes which are similar to those occurring in northwest of Sri Lanka as coastal sand dunes. The morphology of the dunes varies substantially depending on the wind direction. Most kinds of dunes have long gentle slope on the windward side where the sand is pushed up the dune slope, and a shorter 'slip face' in the leeward side. The trough between dunes is called 'slack' which has greater levels of moisture and supports vegetation. Formation of dunes is through sand accretion. Sand that is brought in by the wind gets trapped by such obstacles as shrubs, creepers, trees and other obstacles. This accumulated sand forms mounds of sand that keep growing over time to form large dunes (Plate 2.29)

Dunes are broadly classified into

1. Transgressive: Those dunes that are mobile and covered with Vegetation (Plate 2.30)
2. Retentive: This type of dunes are comparatively more vegetated and static (Plate 2.31)



Plate 2.29. General view of sand dune ecosystem (Pooneryn)



Plate 2.30. Highly mobile sand dune with expanding leeward side



Plate 2.31. Vegetated static sand dune area

2.4.2 GEOGRAPHICAL DISTRIBUTION

Coastal dunes are found in all climates in all latitudinal zones provided there is an ample sand supply and persistent winds. Both these conditions exist in the Pooneryn Peninsula and Mannar Island. Sand accumulations on the beaches dry out quickly under sunny weather and onshore winds carry sand particles inland. Well-developed sand dunes are about 5m-18m in height. It is important to note that occurrence of sand dunes in the study area coincides with locations where average daily total solar irradiation level is high (5.6 kWh/m²; World Bank, 2019) and also have a higher average wind speed of 7m-8m/s measured at 50m height (Elliot *et al.*,2003).

Of the five DSD's surveyed, sand dunes are occurring mainly in Mannar Island (Mannar City DSD of Mannar District) and Pooneryn Peninsula (Poonakary DSD of Kilinochchi District). The extent of dunes in the two areas is given in Table 2.1. Sand dunes mapped in two areas, (a) Pooneryn Peninsular and (b) Mannar Island are shown in Figures 2.7 a & 2.7 b. The former is less disturbed by human activities and also well established. In both places dunes are mobile indicating that they are of more recent origin. The other DSD's namely Nanattan, Manthai West and Karachchi (western part) do not have mobile dunes, except some low beach dunes and old stabilized dunes (Swan, 1983).

In the Mannar City DSD, sand dunes extend over 5,700 ha while in the Poonakary DSD sand dunes cover about 808 ha. In the Pooneryn Peninsular, the highest dunes (up to about 18m above msl) are found toward the Kautherimunai area (Plate 2.32). On the Mannar Island the maximum height of dunes is not more than 11m above msl and such heights are confined to a few areas. They are also mostly concentrated towards the western tip of the island (Plate 2.32). The largest area of dunes is found in the elevation range of 2m to 11m above msl. On the whole, the dunes in Mannar Island can be described as low dunes compared to those in the Pooneryn Peninsula which are more spectacular and extensive. In the mainland we did not observe any mobile dunes. According to Cooray (1984) sand dunes in the mainland are much older and well stabilized (Cooray, 1983; Swan, 1984). Such windblown sand layers are wide spread in the northwestern coastal plain and these deposits are called red earths and brown earths due to the colour of the soil.



Figure 2.7a. Sand dunes in Pooneryn Peninsular

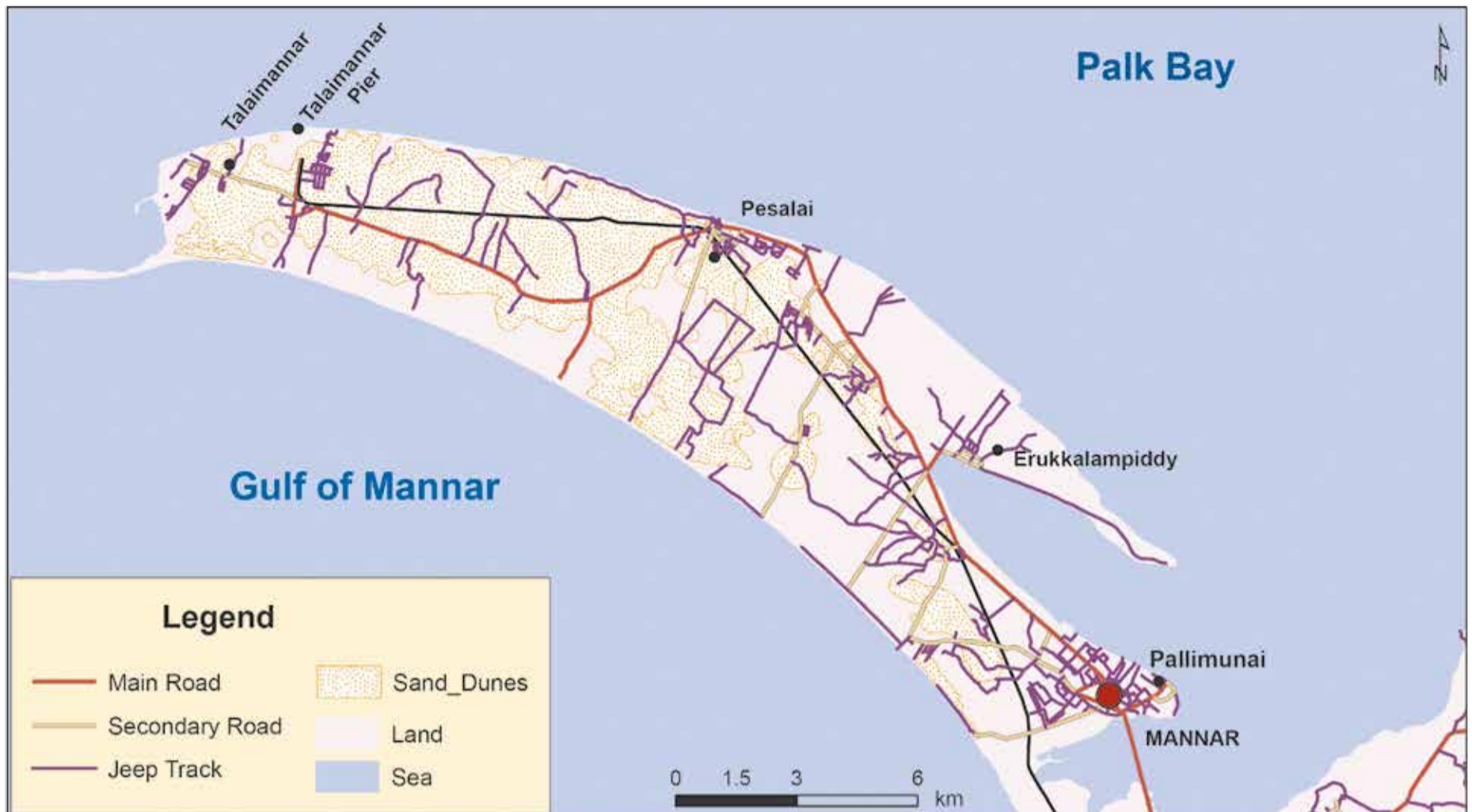


Figure 2.7b. Sand dunes in Mannar island



(a) Kautherimunei (Pooneryn Peninsula)



(b) Thalaimannar

Plate 2.32. High dunes

2.4.3 SAND DUNE FLORA

Distinctive communities of plants characterize the coastal dune system. This vegetation promotes accretion, binds the sand grains, and provides moderate protection by acting as barriers against coastal erosion, and help prevent the transport of sand by wind. Sand dunes also provide an important habitat for a number of plants and animals and have environmental, social and economic significance. The dune environment is highly sensitive and vulnerable even to a slight environmental stress (Arulpragasam, 2000).

Sand dunes are found as low dunes near the southern beach and high dunes towards north. Since both areas of dunes (Mannar Island and Pooneryn Peninsular) are narrow strips of land from south to north and elongated in the east-west direction, dunes gain height from south to north in line with the dominant wind direction (Southwest to Northeast). In some places dune fields stretch up to the northern shoreline. The low dunes near the southern beach are often covered with strand vegetation, mainly by *Spinifex littoreus* (Plate 2.33) and this strand vegetation could extend up to the ridge of the dune (Plate 2.34).



Plate 2.33. *Spinifex littoreus* - the most common strand plant in near beach dunes



Plate 2.34. Near coast sand dune with strand plants

This is basically salinity affected vegetation facing salt breeze and growing in saline sand. Strand plant cover holds the sand above the high tide mark. Salt-tolerant shrubs (small woody plants) and low-growing woody plants are on the beach berm (beach crest). They break the wind velocity and filter salt spray. This companion vegetation community of sand dune landscape is sometimes called littoral (seashore) shrubland. *Scaevola taccada* is very common in such sites. Taller plants that can tolerate salt spray grow up to 4m-6m high on the back beach. Their roots hold the sand mass. *Pandanus odorifer* is a characteristic plant in this saline sand. Larger trees are found further inland. Undulating landscape of heaps of wind-blown fine sand of yellow-brown color is the prominent feature of these hot and sunny inland areas. Scattered trees (mainly Palmyrah - *Borassus flabellifer*) (Plate 2.35), shrubs and herbs are established on this less stable sandy substrate (Plate 2.36).



Plate 2.35. Interior sand dune dominated by *Borassus flabellifer* (Palmyrah)



2.36. Legume *Indigofera aspalathoides* - common low growing shrub-herb in interior sand dunes

This process over a long period of time has created dunes as high as 18 m from the mean sea level. Small whirlwinds formed by heated air mass carry fine sand particles in this dry landscape. One can observe wind-blown sand moving up the gentle upwind side of the dune and accumulates at the brink, the top of the slip face. When the buildup of sand at the brink increases the leeward slope of the dune towards angle of repose a small avalanche occurs over the slip face and little by little the dune moves on.

Wind deposited sand occurs as sand sheets, ripples, and dunes (Plate 2.37). Sand forms ripples on the surface with crests and troughs whose long axes are perpendicular to the wind direction. Some dry organic matter gets accumulated among ripples. Dunes have gentle upwind slopes on the windward side. The downwind portion of the dune (the lee slope) is commonly a zone of expanding area. Dunes may have more than one slip face. As the sand avalanching continues in the slip face, the dune moves in the direction of the wind and presently at Pooneryn some stretches of roads are covered by moving dunes blocking the roads (2.38).



Plate 2.37. Sand ripples in wind facing side



Plate 2.38. Mobile sand dune blocking road

The rapid botanical survey enabled recording 104 plant species associated with sand dune ecosystem (Appendix VI) and among them six species namely *Salacia oblonga* (EN), *Hypserpa nitida* (EN), *Crinum zeylanicum* (VU), *Indigofera oblongifolia* (VU), *Aristida adscensionis* (VU) and *Manilkara hexandra* (VU) are under threatened category. No endemic plants were recorded among them. The flora is a selection of better adapted dry zone species of Sri Lanka and there are no obligatory or true sand dune plant species. Extreme heat, sandy substrate, water deficit environment, frequent dry winds, sunny conditions and many types of biological pressures have given rise to a unique floral assemblage in this ecosystem. The plant life of sand dunes is composed of two types of plants; ephemerals (herbs) and perennials (mostly woody plants). Ephemerals are active only in wet season and covers their life cycle opportunistically, e.g. *Amorphophallus sylvaticus*. They have shallow seated roots while perennials exploit the sub soil where some moisture is preserved throughout the year.

The perennial plant cover forms the permanent framework of the vegetation and is the best indicator of site conditions. The plant cover is organized as a mosaic patterns of patches belonging to different community types. Abundance of Palmyrah - *Borassus flabellifer* palm, 15m-20m tall is a prominent feature of sand dune areas. They occur as scattered individuals or as isolated closely growing clumps forming a patch work of landscape. Clumps of Palmyrah (*Borassus flabellifer*) growth have many companion species forming forest refugia in this harsh environment supporting an array of plants and animals. Often, all key life forms of plants are well represented in these mini forest plots; trees, shrubs, herbs, climbers, lianas and epiphytes (Plate 2.39 and 2.40).



Plate 2.39. *Ficus benghalensis* (Nuga) often grows as an epiphyte on *Borassus flabellifer* (Palmyrah) in sand dunes



Plate 2.40. *Cymbidium* sp. (orchid) growing on Palmyrah tree trunk

Two *Acacia* species namely, *Acacia planifrons* and *Acacia eburnea* have established well in the dunes in Talaimannar area on the Mannar Island (Plate 2.41). However, these species are not very common in Pooneryn dunes.



Plate 2.41. *Acacia* dominant sand dune vegetation in Talaimannar area

Variations of plant assemblages are noted in line with diversity of landscape features of sand dunes; saline areas, land depressions, flat lands and sandy hills. According to Namboorthi (2008), coastal sand dune ecosystems have conditions quite similar to those of desert dunes with shifting sand, extreme conditions of exposure to air and the sun, and poor moisture retention that inhibit plant growth. In addition, dune systems have several physical and chemical parameters typical of the ecosystem, which limit the distribution of flora and fauna. Such parameters include poor nutrient levels, soil salinity, salt spray, changes in organic matter and pH.

Many plants in sand dunes have specific adaptations that enable them to establish successfully in this harsh environment. A few of the observed floral adaptations are as follows:

- Reducing leaves and branches during peak drought (woody perennials) e.g. *Dodonaea viscosa* and *Crateva adansonii*
- Storing of moisture in enlarged leaves or stems (succulents) e.g. *Euphorbia indica*, *Pedaliium murex* and *Scaevola taccada*
- Dieback of above ground parts to allow underground parts to survive until better times e.g. *Coccinia grandis*
- Covering with waxy layer to prevent evaporation as well as provide extra support e.g. *Borassus flabellifer* and *Phoenix pusilla*
- Covering with fine white hair to reflect sunlight and reduce evaporation e.g. *Spermacoce hispida* and *Polycarpha corymbosa*
- Long central root system to reach deep aquifers. e.g. *Crateva adansonii*
- Extended superficial root system to profit from dew at night times e.g. *Indigofera aspalathoides*
- Shallow root system combined with a short growing and reproductive season (ephimerals) e.g. *Amorphophallus sylvaticus*, *Cleome chelidonii* and *Cyanotis cristata*
- Sharp spines or impalatability to protect themselves from being grazed or browsed e.g. *Scutia myrtina* and *Zizyphus oenopila*

2.4.4 SAND DUNE FAUNA

Sand dunes are characterized by having a poor faunal composition (Table 2.10 and Appendix II). Unlike in the other habitats studied, land snails and dragon flies were conspicuously absent in the sand dunes in both Mannar island and the Pooneryn peninsula.

Table 2.10. Summary of fauna recorded in sand dunes

Faunal group	Families	Species	Endemics	Conservation status				
				Threatened			NT	LC
				CR	EN	VU		
Butterflies	4	11	1	-	-	-	-	11
Amphibians	1	2	-	-	-	-	-	2
Reptiles	2	3	1	-	-	1	-	1
Birds	11	12	-	-	-	-	1	9
Mammals	1	1	-	-	-	-	-	1
TOTAL	19	29	2	-	-	-	1	24

Conservation Status - based on 'The National Red List 2012 of Sri Lanka' (MOE, 2012)

CR - Critically Endangered, EN - Endangered, VU - Vulnerable, NT - Near threatened, LC - Least concerned

Fauna in the sand dunes are dominated by butterflies (11 species) and birds (12 species). However, the numbers of species recorded in these faunal groups are much smaller than in the other habitats sampled. Only two amphibian species, three reptile species and a single mammal species were recorded from sand dunes. Semiaquatic Jerdon's bullfrog (*Hoplobatrachus crassus*) (Plate 2.42) which is commonly found in rivers, reservoirs and marshes (<https://amphibiaweb.org/species/4711>) was recorded in the banks of natural water pools in Pooneryn sand dunes (Plate 2.43). This indicates that the natural water pools in the Pooneryn sand dunes are accumulation of freshwater mainly due to rain. But this species has the ability to tolerate salinity to some extent. They tolerate 25% natural sea-water but do not live for more than a week when the salinity goes up to 35% natural sea-water (Chakko, 1968). Saw scaled viper (*Echis carinatus*) (Plate 2.44) which is distributed in the dry and sandy coastal areas of Sri Lanka was recorded from the sand dune areas of Mannar and Pooneryn. Further, *Sitana devakai* (Plate 2.45) an endemic lizard species restricted to drier coastal areas in the north and northwestern parts of Sri Lanka were also recorded from Poonaryn sand dunes and some dry salt marsh habitats in the Mannar area.



Plate 2.42. Jerdon's bullfrog (*Hoplobatrachus crassus*)



Plate 2.43. Natural ponding areas of sand dunes serving as sinks for rainwater and supporting wildlife in Pooneryn dune area



Plate 2.44. Saw scaled viper (*Echis carinatus*)



Plate 2.45. *Sitana devakai*

Active sand dunes in the project area was found only in two geographic regions, Mannar Island and Pooneryn Peninsula. The dunes in Pooneryn is more spectacular than those in the Mannar Island. Although no fauna and flora specific to the dunes were found, the landscape with dunes has a high value for ecotourism development. Disturbance to the dunes by human activity runs the risk of their destruction. Dunes are highly sensitive systems that needs protection for their aesthetic and scientific value. A well planned strategy is needed for the protection of at least some selected sites with prominent dunes. Mobile dunes pose a threat to other ecosystems and human habitats as well. Migration of dunes across farm land is a common site and it can be further aggravated when the dunes are disturbed by human activity. This can get intense during times of drought. Letting dunes to stabilize by colonizing vegetation this risk can be reduced.

The coastal landscape has very high potential for ecotourism, with area specific bird life, scenic resources, trekking in sand dunes, charismatic species like feral donkeys and wild ponies. However, there is no adequate infrastructure available for dissemination of this information and implementing responsible ecotourism at ground level. There is lack of an interpretation center or signboards, hoardings etc. to educate people about the presence of such resources. The area does not receive much tourists, except a few bird enthusiasts once in a while. The reasons is lack of information to tourists, inaccessibility to some areas, absence of quality accommodation facilities to stay and educated guides to take tourists for different sites etc. This nature based tourism should be viewed as a key development thrust in the area.

3.0 PROTECTED AREAS

The Mannar-Pooneryn landscape supports a number of protected areas. Some are declared by the Department of Wildlife Conservation (DWC) while some other areas by the Forest Department. Recently some more areas have been declared as protected areas and the gazette notifications to this effect are in print at the time of the preparation of this Atlas.

3.1 VANKALAI SANCTUARY

Vankalai tidal wetland (4,839 ha) was declared as a sanctuary on 21st August 2008 under the Fauna and Flora Protection Ordinance (Gazette Extraordinary No.1566/3 of 08.09.2008) and now under the jurisdiction of the Department of Wildlife Conservation. This wetland is designated by the Government of Sri Lanka as its 4th Wetland of International Importance. Vankalai Sanctuary is now recognized as a Ramsar Wetland (Ramsar Convention, 2013).

This shallow tidal wetland consists of several ecosystems ranging from thorn scrublands, maritime grasslands, mangroves, salt marshes, lagoons, and extensive tidal mudflats. There are also sea grass beds (not mapped) and shallow marine areas (Figure 3.1 and Table 3.1). Salt marshes form the second largest area after the tidal mudflats. Due to the integrated nature of shallow wetland and terrestrial coastal habitats, this sanctuary is a highly productive coastal ecosystem supporting high ecosystem and species diversity. The site provides excellent feeding and living habitats for a large number of water bird species, including annual migrants, which also use this area on their arrival and also during their exit from Sri Lanka (Wijesundara et al., 2017)

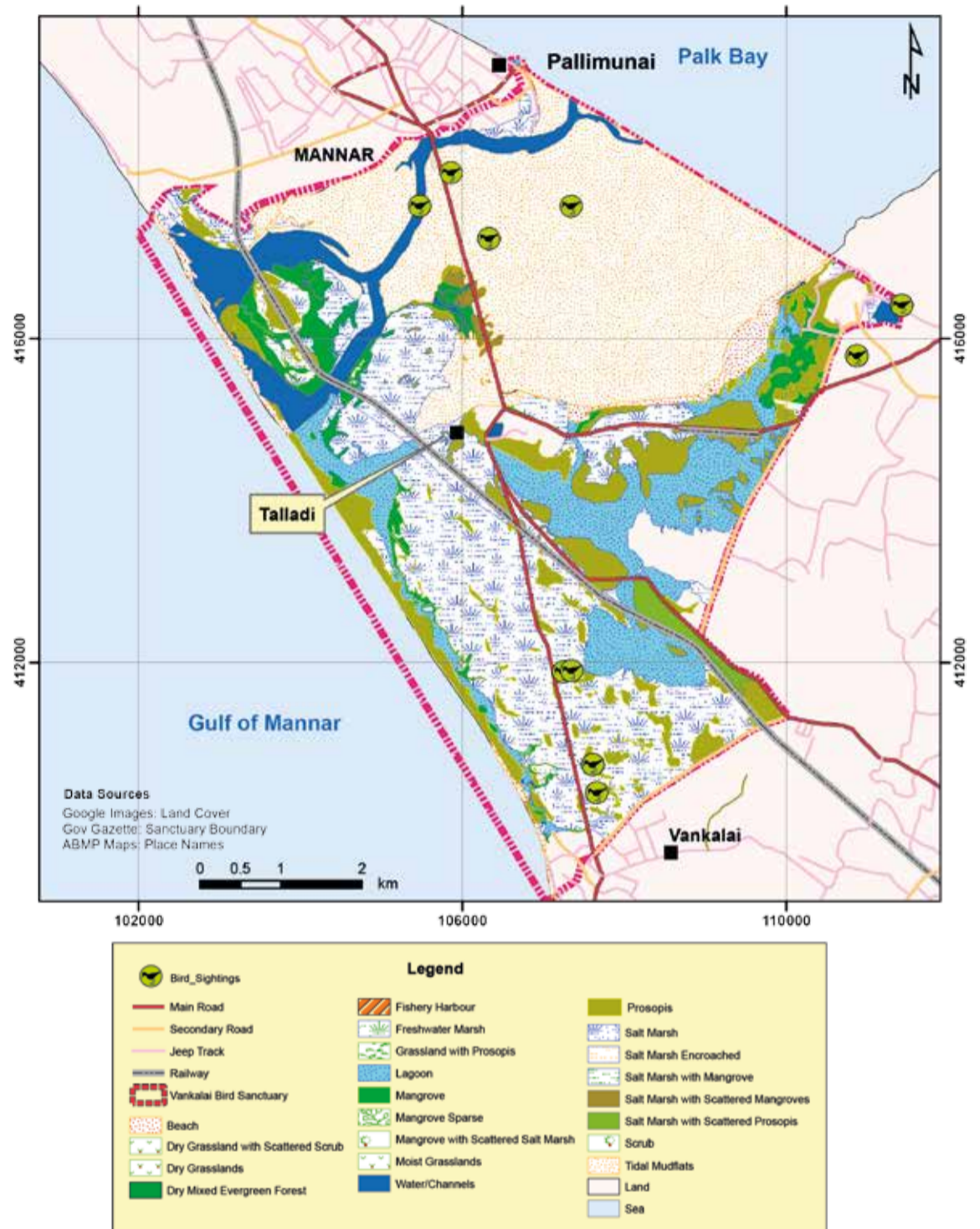


Figure 3.1. Map of Vankalai sanctuary

Table 3.1. Habitat types in Vankalai Sanctuary

Land Cover	Extent (ha)	Percent cover
Beach	109.14	1.36
Canal/Tidal Channel	542.12	6.73
Dry Grasslands	3.19	0.04
Lagoon	1,433.39	17.80
Mangrove	203.89	2.53
Other	102.40	1.27
Pond/Pool/Water body	2.47	0.03
<i>Prosopis</i>	673.89	8.37
<i>Prosopis</i> with Scattered Maritime Grasslands	7.05	0.09
Salt Marsh	1,356.89	16.85
Salt Marsh with Scattered Mangroves	22.10	0.27
Salt Marsh with Scattered <i>Prosopis</i>	45.03	0.56
Saltern	98.16	1.22
Tank	33.44	0.42
Tidal Creek	2.76	0.03
Tidal Mudflats	3,416.72	42.43
Total Extent	8,052.66	100.00

3.2 WEDITHALATHIVE FOREST RESERVE AND WEDITHALATHIVE NATURE RESERVE

Wedithalathive Forest Reserve was the first to be declared in the Manthai West DS Division mainly to protect mangrove vegetation in the area. An area of 525 ha was declared as a forest reserve in 2013 by the minister in-charge-of the subject of Environment (Gazette No 1834/13 of 28/10/2013) under the Forest Ordinance. This forest reserve comes under the jurisdiction of the Forest Department. The entire forest reserve falls within the Manthai West DS Division. Subsequently, a much larger area inclusive of the Wedithalathive Forest Reserve was declared as a Nature Reserve under the Fauna and Flora Ordinance by the Gazette Extraordinary No. 1956/13 of 1/03/2016. This newly declared reserve comes under the jurisdiction of the Department of Wildlife Conservation. This covers a total area of 29,180 ha falling within the Mannar City and Manthai West DS Divisions (Table 3.2).

Table 3.2. The land cover types and extents in the Wedithalathive Nature Reserve

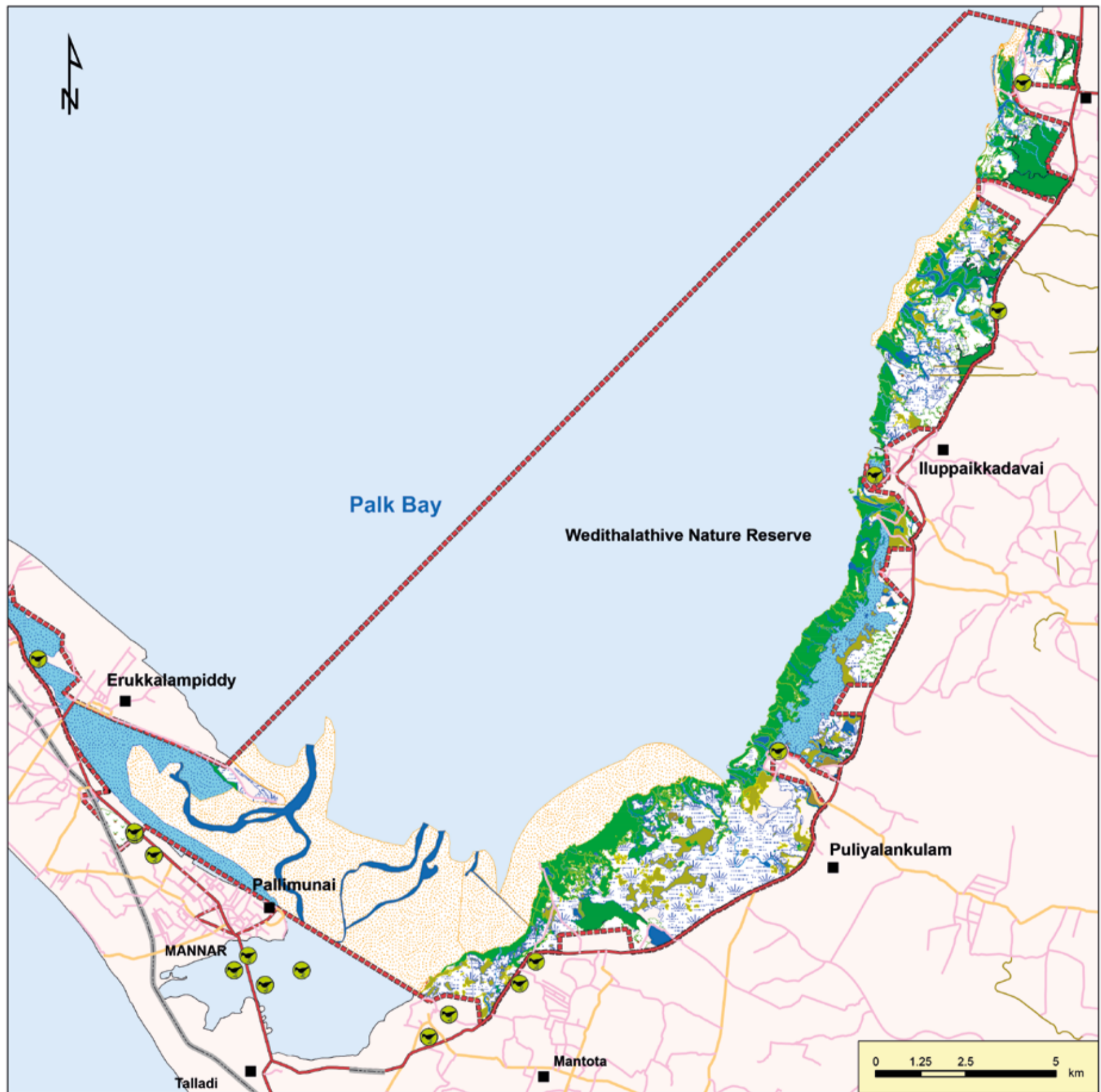
Land Cover Type	Extent (ha)	Percent cover
Beach	20.36	0.17
Canal/Tidal Channel	310.04	2.58
Dry Grassland with Scattered Scrub	47.99	0.4
Dry Grasslands	58.04	0.48
Dry Mixed Evergreen Forest	482.67	4.01
Fishery Harbour	0.19	0
Freshwater Marsh	1.39	0.01
Grassland with <i>Prosopis</i>	87.13	0.72
Lagoon	1,332.48	11.08
Mangrove	1,594.29	13.25
Mangrove Sparse	14.67	0.12
Mangrove with Scattered Salt Marsh	4.23	0.04
Moist Grasslands	0.32	0
Other	283.99	2.36
Pond/Pool/Waterbody	17.82	0.15
<i>Prosopis</i>	609.87	5.07
River	198.03	1.65
Riverine Forest	17.25	0.14
Salt Marsh	2,239.76	18.62
Salt Marsh Encroached	87.59	0.73
Salt Marsh with Scattered Mangroves	38.43	0.32
Salt Marsh with Scattered <i>Prosopis</i>	4.32	0.04
Scrub	512.75	4.26
Tank	54.72	0.45
Tidal Creek	105.72	0.88
Tidal Mudflats	3,906.37	32.47
Total	12,030.43	100

3.2.1 MAJOR ECOSYSTEMS IN WEDITHALATHIVE NATURE RESERVE

The Wedithalathive Nature Reserve covers the government land of the entire coastal and pelagic strip from the 97th km post on A14 main road at Erukkalampiddy (on Mannar Island) to the 29th km post on A32 highway Just north of Vellankulam tank in the north. The southern boundary of the Nature Reserve merges with the Vankalai Sanctuary. The Nature Reserve is placed under the jurisdiction of Department of Wildlife Conservation. This has created some confusion about who is responsible for the management of the entire area. This conflict needs to be sorted out by the relevant authorities. The total area protected is listed in the gazette as 29,180 ha.

This land area of the Nature Reserve has extensive pure mangrove stands (1,594 ha) occupying the area between the lagoon and the sea. There is hardly any beach along the entire length of the mangrove fringed coastline. The mangroves occupy barrier island(s) which separate the lagoon from the sea. In addition, sparse mangrove areas and mangrove with scattered salt marshes cover further 19 ha. The nature reserve has 2,370 ha of salt marshes and mixed salt marshes with other habitat types. The salt marshes with houses were designated as 'salt marshes encroached' but the legal ownership of these areas cannot be established. Houses and other forms of human activity in salt marshes can be considered as environmentally unsustainable activities. Some of these areas get flooded during the rainy season and the environment is highly unsuitable for human habitation. There is also a large area of *Prosopis* within the reserve (610 ha). The density of *Prosopis* is highly variable. In some areas dense coverage was found while in other areas *Prosopis* co-exist with other plant species. It is most common in recently disturbed areas. Southern parts of the nature reserve include extensive areas of tidal mudflats (Figure 3.2).

This Nature Reserve and the nearby marshes are used by very large numbers of migrant birds each year. All of these marshes in the northwestern coastal area of Sri Lanka are important for the survival of avian species which are major attractions in the northern region, such as Crab Plover and Indian Courser (Wijesundara, 2017). In 2010, at least a million shorebirds were seen at the Wedithalathive lagoon in the Mannar region, and it has been claimed as possibly the most important shorebird site in the Central Asian Flyway (Sirivardana and Hettige 2010; Warakagoda et al., 2012). Mannar region (from Adam's Bridge in the west to Giant's Tank Sanctuary in the east and Iluppaikadavai in the north to Silavaturai in the south) has been identified as one of the four richest water bird regions in Sri Lanka (Wijesundara, 2017).



Data Sources

Google Images: Land Cover
 Gov Gazette: Sanctuary Boundary
 ABMP Maps: Place Names



2020

Figure 3.2. Map of Wedithalathive nature reserve

3.3 PROPOSED FOREST RESERVES IN NWCP

Forest Department has taken steps to declare some more mangrove sites (approximately 6,500 ha in extent) within the study area as forest reserves (Table 3.3). According to the Forest Department sources all these reserves in the Northwestern coastal zone consist of mangrove and salt marsh vegetation. With the exception of Erukampetti all others fall within the existing protected areas according to the coordinates available.

Table 3.3. Details of proposed mangrove forests reserves in Mannar District

District	Forest Name	Forest Category	Surveyed Extent (ha)	Remarks
Mannar	Achchankulam	Proposed Reserve	1,405.79	Draft gazette
Mannar	Thiruketheeswaram	Proposed Reserve	328.01	notifications
Mannar	Erukampetti	Proposed Reserve	166.28	received from
Mannar	Thewampiddi	Proposed Reserve	801.00	FD HO ⁺ to be
				published at
				relevant DS offices
Mannar	Mudrampiddi	Proposed Reserve	593.00	Proposed
				boundary
				schedules sent to
				FD HO
Mannar	Kalliadi	Proposed Reserve	2,258.00	Falls within
				Wildlife Sanctuary
				boundaries
Mannar	Illupukadawei	Proposed Reserve	947.00	Still processing

⁺Forest Department Head Office

(Source: Divisional Forest Officer (DFO) – Mannar District)

The Mannar and Killinochchi districts have a fair share of protected areas, and further increase is coming under criticism from the public. Future selection of land to be protected has to be done very carefully without causing undue hardship to the population living in the area. In addition to the Wedithalative Nature Reserve and the Vankalai Sanctuary, a large part (>1069 km²) of the NWCP is already within a Forest Reserve (Figure 3.3).

Land Use plan prepared for Kilinochchi district has identified Kautharimunai sand dunes as an environmentally sensitive area that should be protected (Land Use Policy Planning Department, 2016). Although the Kautharimunai sand dunes extend over a much larger area (808 ha) only 9.8ha of land has been identified by Kilinochchi Land Use Plan (2016) to be declared as an environmentally sensitive area. The mangrove area of Kautharimunai is already a forest reserve covering an area of about 72 ha (Figure 3.3). The sand dunes are to the south of the forest reserve.

The Northern Province in general has a large extent of protected areas. They have been declared under various Acts/Ordinances by the Central Government. They are administered mainly by the Forest Department and Department of Wildlife Conservation. However, there is a confusion about the jurisdiction over some protected areas in the NWCP. The same area has been declared as protected area of one sort or another under different Acts/Ordinances by different authorities. The boundaries of the existing reserve areas are also not clearly marked on the ground everywhere making room for encroachment. There is also lack of clarity about the land ownership in the region. During the war period, the official documents were either lost or misplaced and sorting out land ownership seems to be a formidable task.

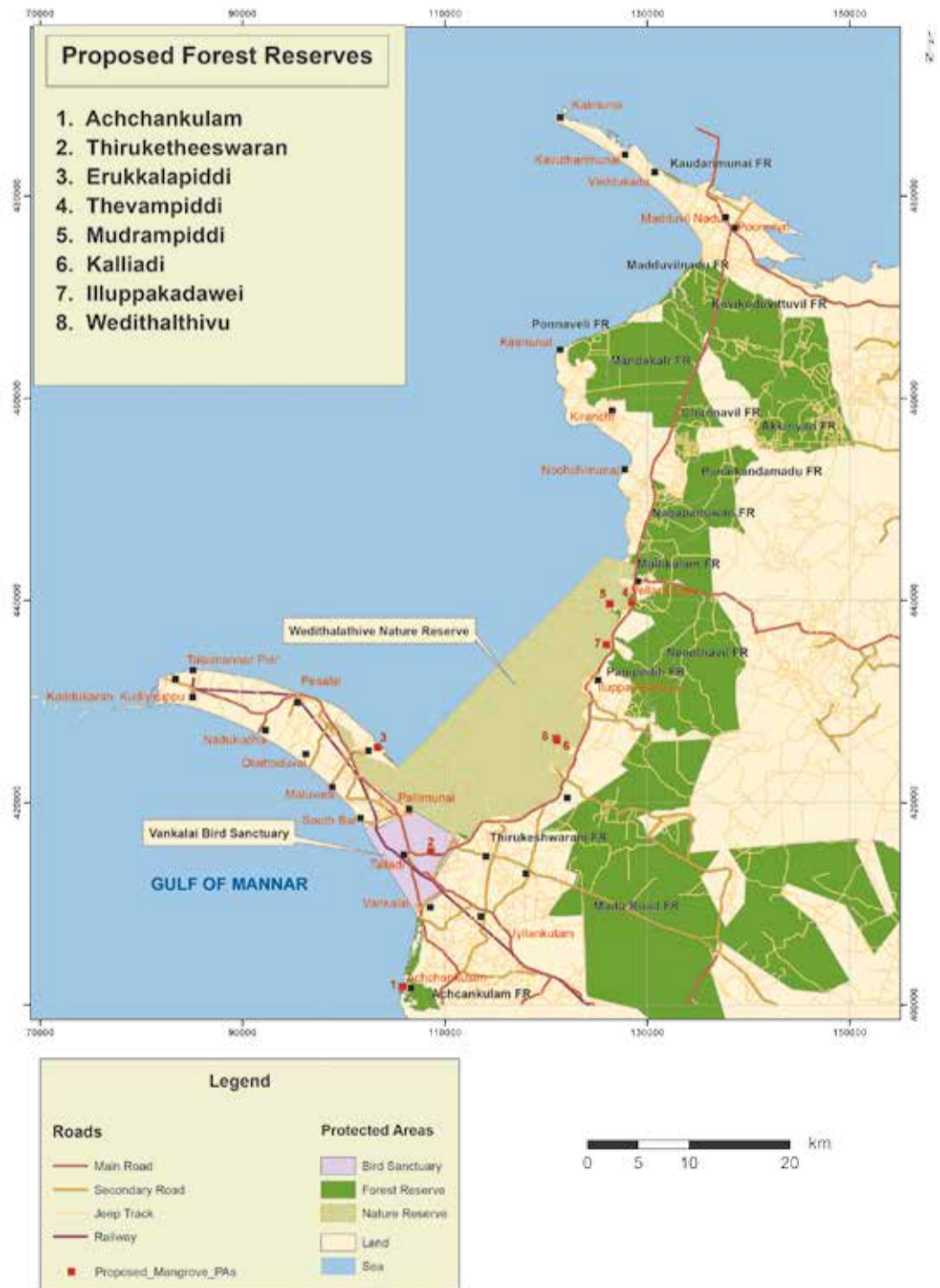


Figure 3.3. Existing and proposed forest reserves in the Project area

3.4 HUMAN INTERVENTIONS

Human interference in all coastal habitats takes many forms. Some of the extensive activities can be described as long established, newly started and proposed. These activities, if not performed with due care to the environment, many of the existing ecosystems may be irreparably harmed in the long run. A proper management strategy is therefore imperative and urgent for the sustainability of economic development of the area.

3.4.1 AQUACULTURE

In the Mannar and Kilinochchi districts, 14 sites with a combined area of about 900 ha have been identified for coastal aquaculture/mariculture development (Table 3.4) (Gazette extraordinary No. 2009/20 of 08.03.2017). Ten of them are in Kilinochchi district and four in the Mannar District. The extent of land allocated varies from 4 ha to 150 ha. The land identified as suitable for aquaculture/Mariculture in the Mannar district is located within the Mannar City DS Division and all the sites in Kilinochchi district are in the Poonekary DS Division (Table 3.4)

Table 3.4. Sites identified as suitable for water based Coastal/ Mariculture Projects

District	DS Division	Water Resource	Approximate Extent (ha)	Google Coordinates
Kilinochchi	Poonakary	Eramaitivu Site	100	9° 20' 55.28" N 80° 3' 36.97" E
		Nachimunai	100	9° 17' 13.61" N 80° 7' 1.98" E
		Valaipadu	100	9° 21' 32.99" N 80° 3' 43.38" E
		Brindawan	100	9° 18' 42.84" N 80° 6' 35.11" E
		Iranaitivu	5	9° 28' 91" 7N 79° 99' 54" E
		Kiranchi	5	9° 30' 54" 3 N 80° 11' 00" E
		Mulangawil	5	9° 25' 29" 19 N 80° 1' 16" 25 E
		Iraneimatha Nagar	4	9° 32' 7205 N 80° 0' 6780 E
		Nachchikuda	7	9° 30' 7301 N 80° 1' 1050 E
		Kiranchi	5	9° 31' 6110 N 80° 0' 9762 E
Mannar	Mannar Town	Talaimannar	65	09° 05' 45.69" N 79° 40' 56.29" E
		Pesalai	150	09° 05' 41.22" N 79° 51' 02.09" E
		Thevanpitty	100	09° 11' 40.02" N 80° 06' 37.9" E
		Illupaikadavai	150	09° 09' 04.16" N 80° 05' 44.82" E
Total Extent (ha)			900	

Another 1,828 ha of land in Mannar and Kilinochchi districts have been identified as sites suitable for coastal aquaculture projects (Gazette extraordinary No. 2009/20 of 08.03.2017). A largest extent of land (ie.1,782 ha) identified is within the Mannar district (Table 3.5). The allocated land is mostly covered by salt marshes or a mixture of saltmarshes and mangroves. For instance, the largest aquaculture site identified (1,300 ha) is located inside the Wedithalathive Nature Reserve. Aquaculture projects are to be implemented by private sector.

Table 3.5. Sites earmarked for land based coastal aquaculture projects

District	DS Division	Land Name	Approximate Extent (Ha.)	Coordinates
Kilinochchi	Poonakary	Sambuwalu Site	100	9° 19' 1.89" N
				80° 8' 34.39" E
Mannar	Nanattan	Naruvilikulam	100	8° 51' 51.12" N
				79° 56' 4.56" E
	Musali	Kadikkuli 1	40	8° 41' 14.38" N
				79° 57' 20.97" E
	Musali	Kadikkuli 2	97	8° 40' 09.26" N
				79° 57' 13.05" E
Manthai West	Vaddayamurippu	22	08° 57' 59.96" N	
Manthai West	Wedithalathive (Naayaru) site	1,300	79° 53' 28.76" E	
Manthai West	Illupaikadavai	169	8° 58' 32.68" N	
			80° 1' 20.74" E	
Manthai West				9° 2' 21.91" N
				80° 4' 30.30" E
Total Extent (ha)			1,828	

3.4.2 MANNAR WIND PARK

A 100 MW wind energy park comprising up to 39 wind turbines is being developed by Ceylon Electricity Board (CEB) on Mannar Island. The power generated by this wind park will be transmitted to the national grid through by 29.1 km-long 220 kV overhead power transmission line between Mannar Island and the mainland, starting from the Nadukuda grid substation (GSS), and ending in Mannar GSS - referred to as the Mannar-Nadukuda Transmission Line (TL). Out of the 29.1 km-long transmission line, about 7.5 km will traverse through the Vankalai Sanctuary.

3.4.3 UNSUSTAINABLE USE OF MANGROVE VEGETATION

Most of the mangroves in the project area is under the Forest Department protection now. However, some sites are not accessible by land and therefore are vulnerable to human disturbance. One such site is the mangroves of Malwathu Oya delta. Lack of roads, law enforcement in this area is difficult. Fishermen are engaged in removing branches of mangrove trees for various fishing activities.

Threats to *Avicennia marina* trees in the delta are very severe as they are being continuously removed to setup traps to catch squids. Adult squids are attracted to floating fish traps prepared using bundles of *Avicennia marina* branches to lay eggs among the branches (Plate 3.1). Once a large number of squids aggregate around the branch bundle to deposit their egg masses, the fishermen collect all the adult squids using nets. This fishing practice is destructive in many ways as it involves collecting of adult squids that are ready to lay eggs and destroying their egg masses as well as uncontrolled removal of *Avicennia marina* branches. Most of the *A.marina* trees in the Malwathu Oya delta are stunted probably due to the repeated removal of branches (Plate 3.2)



Plate 3.1. Squid trap prepared using *Avicennia marina* branches



Plate 3.2. Stunted *Avicennia marina* trees in the Malwathu Oya delta

3.4.4 DISTURBANCE TO SAND DUNES

Sand removal from the dunes in Kautherimunei was observed during the field survey (Plate 3.3). Although the people engaged in these activities claimed that they are permitted to collect two tractor loads for house construction/repair, this was denied by the Divisional Secretary's Office. However, this illegal activity is going on in the area threatening the sensitive environment. These activities disturb the colonization of dunes by vegetation.

Villagers also claim ownership of sand dunes and have erected fences in certain segments of the sand dunes (Plate 3.4). This activity was noticed in sand dunes in Thalaimannar area as well as in Kautherimunei.



Plate 3.3. Sand removal from Kautherimunei dunes



(a) Mannar dunes



(b) Kautherimunei dunes

Plate 3.4. Fencing of sand dunes

4.0 SUSTAINABLE USE POTENTIAL OF SALT MARSHES

Salt marshes are unique coastal wetland ecosystems providing numerous ecosystem services. They serve as storm water storage and nutrient traps in the coastal systems. Nutrient trapped by the salt marshes are slowly released to the nearby coastal sea and thereby increasing the primary production. Salt marshes in Mannar-Pooneryn landscape in Sri Lanka serve as important wintering sites for migratory birds. Unfortunately, ecological and economic importance of salt marshes is hardly recognized at local or national level in Sri Lanka. Therefore, a survey was conducted to evaluate the potential for sustainable use of salt marshes.

Cattle grazing in salt marshes

During the initial survey, it was noted that in areas where salt marsh is a prominent feature of the landscape, villagers use salt marshes as grazing lands for their livestock (mainly cattle). Since cattle rearing is an important livelihood practice in Mannar district, a survey was carried out in selected coastal DS Divisions in order to determine the extent to which this livelihood practice is prevalent in the coastal areas of the district and to estimate the number of people involved. Further, our intension was to determine the fodder resources of the area including the potential of salt marshes as a source of cattle feed. During the field survey it was observed that after the harvest (fallow period) the paddy fields become feeding grounds for cattle in the area (Plate 4.1) During the *maha* cultivation season (October – January) there seems to be a shortage of cattle feeding grounds in the area and therefore, the herders send their cattle to salt marshes (Plate 4.2) and forest reserves inland. This practice is deemed to have a detrimental effect on the forests, particularly in the Madu Sanctuary and Madu Forest Reserve. The Mannar District has four coastal DS divisions, namely Musali, Nanattan, Mannar City and Manthai West. The cattle survey was carried out in three divisions (excluding Musali DSD) from December 2018 to February 2019. During the survey, 73 cattle herders who send their cattle to salt marshes for grazing were interviewed in Nanattan, Mannar City and Manthai West DSD's. Of the cattle herders, four of them were females and the rest (69) were males. They are residents of 31 Grama Niladari Divisions (GND's).



Plate 4.1. Cattle grazing in paddy fields during fallow period



Plate 4.2. Cattle grazing in a salt marsh

The largest cattle herd that was recorded from Pallakamam GN division in Nanattan DSD was 250 animals and the total number of cattle occupying the area during the survey period was about 3,540 animals. The distribution of cattle by DSD is shown in Figure 4.1. The largest number comes from Manthai West and the second largest from Nanattan DSD.

Although cattle herding was recorded in 31 GN Divisions, only ten had numbers greater or equal to 150 (Figure 4.2). The other divisions had much lower numbers. It is also clear that there is a concentration of cattle herds in the southern parts of Mannar District (Figure 4.3).

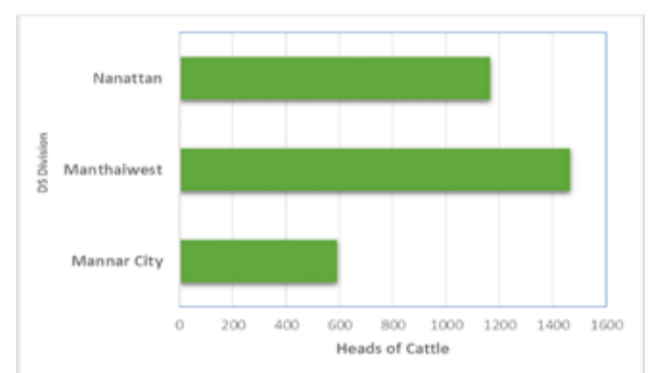


Figure 4.1. Number of cattle grazing in salt marshes in three DSD's

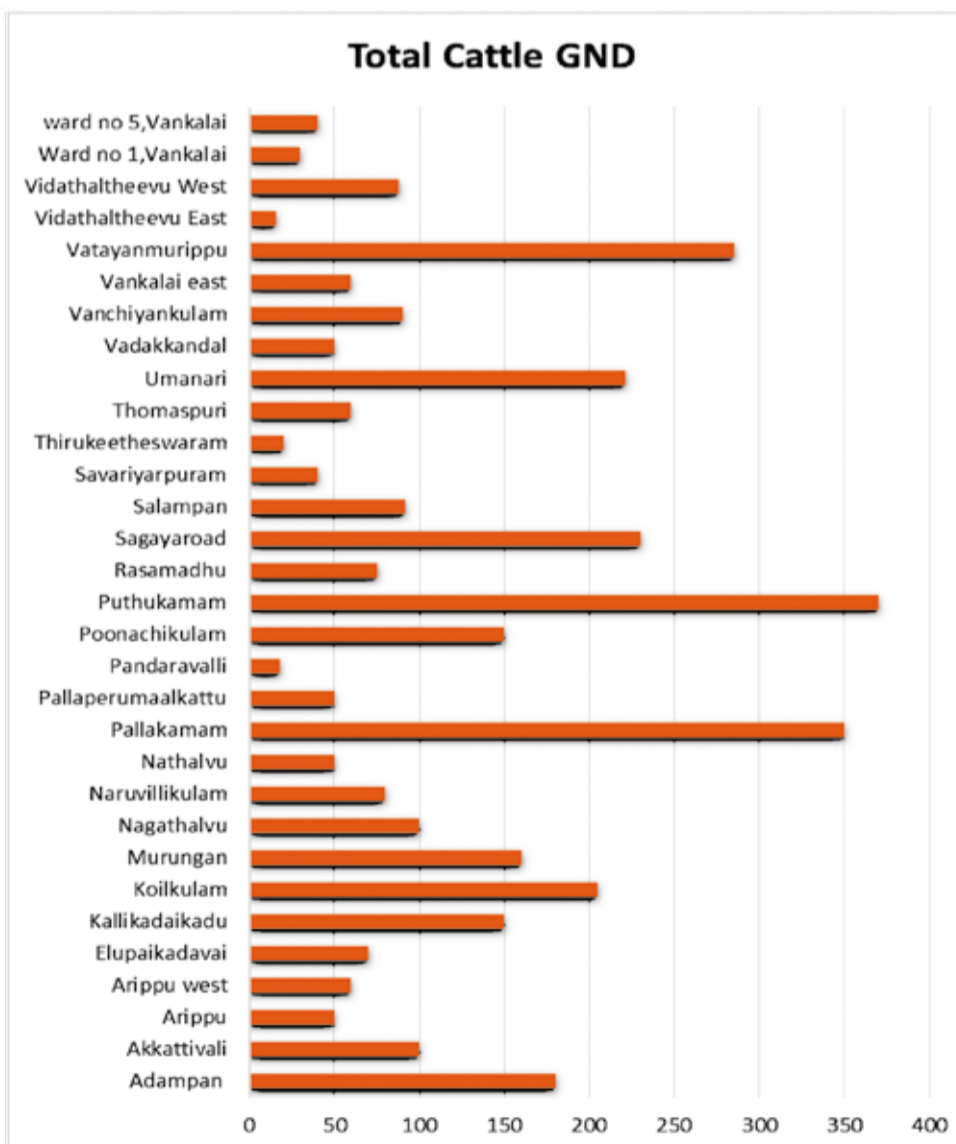


Figure 4.2. The distribution of cattle in three DSD's in the project area by Grama Niladhari Divisions in Mannar District

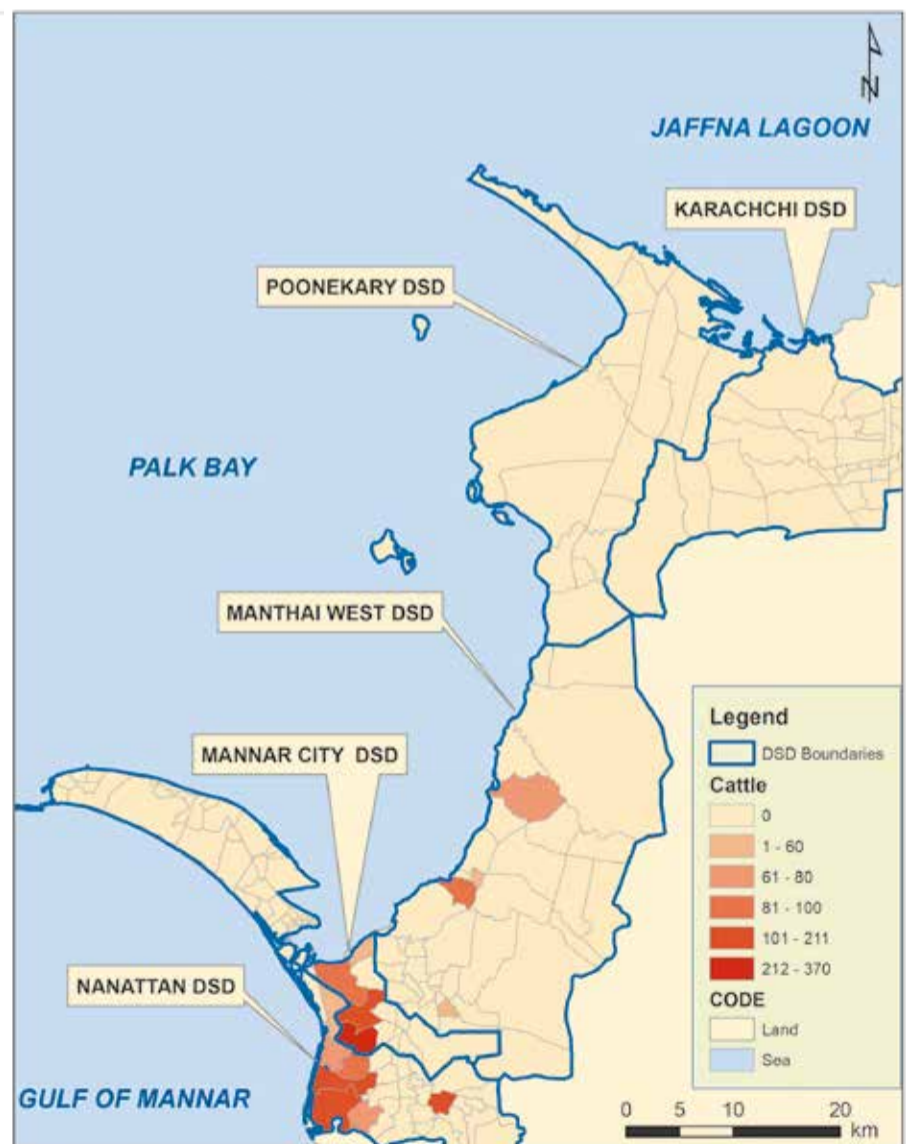


Figure 4.3. Spatial distribution of cattle in the area surveyed

The cattle population in the Mannar District shows the phenotypical features of indigenous cattle which is locally called "Batu Harak" and they are a cross with Indian cattle hybrid. All the cattle in the area are free ranging and the herders send their cattle to different grazing lands during different seasons of the year. The cattle are allowed to graze in paddy fields during the fallow period (Plate 4.1). Cattle herds varying from 10 to 200 individuals are taken to salt marshes for grazing and browsing (Plate 4.2) during paddy cultivating season and harvesting periods (Maha season from October to March in the following year). These cattle owners employ herdsmen who follow the herd from morning till evening and guard them during the night in their resting places. The herdsmen are provided with temporary shelters closer to cattle grazing grounds. The cattle are not fed with cut grass or foliage during any time of the year unlike intensive and semi-intensive management systems used for high producing imported cattle or cross breeds for dairy purposes. Even under harsh climatic conditions these cattle will be released to the field for grazing. During the dry season herdsmen prepare water holes in the salt marshes to fulfil the drinking water requirement of cattle. In the dry season the diet of the cattle mainly satisfied by salt tolerant grasses, such as *Cynodon dactylon* and *Zoysia matrella* (Plates 4.3 and 4.4), the salt marsh species such as *Halocarsia indica* and *Suaeda maritima* (Plate 4.5) and young leaves of mangrove species *Avicennia marina* (Plate 4.6).



Plate 4.3. *Cynodon dactylon*



Plate 4.4. *Zoysia matrella*



Plate 4.5. Cattle feeding on *Suaeda maritima*



Plate 4.6. Cattle feeding on young *Avicennia marina* leaves

Compared to the European and Indian hybrids, most of the cattle that we found in Mannar salt marshes are small and carry less meat in their body. Under these body performances their milk production is limited to 1-2 litres during the peak lactation period. Middle men (collectors) pay Rs.60.00 per litre of milk and if the milk is brought to a chilling centre of a recognized company, header can get Rs.70.00 per litre of milk.

Also, breeding of these cows is beyond the herdsmen's control. Pregnant cows also move with the herd. Calving takes place during the daytime in the grazing grounds or at night in their resting places enclosed by a fence. Milking is done inside the enclosure or out of the enclosure before they are sent for grazing. The cattle owner's main income is from the sale of live cattle for meat. Cattle

buyers come to the owner to negotiate their purchase. There is no proper scientific or standard method for branding or prizing of beef cattle. Cattle are sold after visual examination and negotiation between the buyer and the owner. Small herd owners usually sell these cattle for meat when they need money for a special purpose. The young and adult bulls are generally sold as beef cattle; occasionally bull calves are also sold for meat as veal, which is a delicacy for certain communities. However, island wide it is considered as under produced beef type. Middle man (collector) pays Rs.600.00/kg of meat, who in turn sells the bulls to the slaughter house for Rs.800.00/kg of meat.

These free ranging cattle add fertilizer to the paddy fields and salt marshes by their dung and urine. They will be providing nitrogen to the soil in paddy fields to reduce the nitrogen containing fertilizer need. The cattle also help control weeds in agricultural fields due to high grazing pressure in fallow lands. Since large number of cattle herds use the area as their pasture land, growth of salt marsh plants could be inhibited due to grazing and trampling.

The field observations reveal that the coastal ecosystems, particularly salt marshes and *Avicennia marina* stands, are currently under pressure due to increasing cattle population of the area. Unmanaged high stocking density and excessive grazing have led to degradation of coastal ecosystems through reduction in vegetation cover/biomass, scarring of landscape due to trampling, increased risk of soil erosion, poor recovery of vegetation, stunting of *Avicennia marina* stands, abundance of unpalatable species and invasive plants (e.g. *Dyschoriste erecta*, *Opuntia dillenii*, *Prosopis juliflora*, *Spermacoce hispida*, *Stachytarpheta indica* and *Typha agustifolia*) and the spread of viable *Prosopis* seeds through cattle dung. Therefore, it is important to introduce appropriate grazing management methods based on sound science for sustainability of both ecosystems and local livelihoods.

Salt marsh plants as leafy vegetable

Salt marshes contain plants which can be exploited as a source of nutrition for the local people. At present this use is not very common. For example, *Suaeda maritima* (Omari / Sea Blight) is a wild edible plant that is very common in salt marshes in Mannar landscape. It is a yellowish-green or reddish-green herb with fleshy leaves and a green flower (Plate 4.7a & b). They grow as scrubby bushes to a height of 30 - 40 cm and spread in large areas. Young leaves of sea blight can be used either as an uncooked fresh vegetable in salads or as cooked vegetable (Pal et al., 2018). Due to the high salt content in the succulent leaves of this species, the prepared dish is quite salty and hence, it is cooked with other types of vegetables to reduce the salty taste. In areas bordering Indian Sundarbans samosa (potato) and kachuri (Sattu) are prepared with variable proportions of semi-dried leaves of *Suaeda* species with other ingredients (Pal et al., 2018).



a.



b.

Plate 4.7. Color variations of *Suaeda maritima* (a. Yellowish-green, b. Reddish-green)

During our study it was found that *Suaeda maritima* based food products could be used as natural sources of protein, carbohydrate and minerals (Plates 4.8 a,b,c,d). Considering the underutilization of salt marsh land in coastal habitats, farming of this species can be promoted. Currently this has not been seriously explored due to lack of knowledge about its commercial importance (Pal et al.,2018).



a. Knowledge sharing on food preparation



b. Omelet prepared using *Saueda maritima*



c. Dhal - *Saueda maritima* mixed curry



d. *Saueda maritima* salad

Plate 4.8. Preparation of vegetable dishes using *Saueda maritima*

5.0 WAY FORWARD

Currently general awareness on important coastal ecosystems is at very low level both among general public and administrative agencies. This has led to unsustainable extractive practices both through legal and illegal means, e.g. sand mining, removal of pole wood, cutting of mangroves, etc. These practices might have been sustainable a few decades back, but with increasing population and commercialization, such practices have become detrimental. The communities in and around the area are not much aware of conservation laws and the value of ecosystems. Thus there is a need to spread awareness on these aspects among the residents of the surrounding villages and relevant administrative agencies.

Physical demarcation of conservation zones needs to be undertaken by construction and placement of pillars, and a map of the area. Zonation of core and buffer areas can be proposed through habitat analysis and appropriate site specific management prescriptions could be made. Habitat improvement or restoration can be undertaken where habitats are degraded due to human pressures of resource extraction, particularly mangroves and salt marshes. Management of invasive *Prosopis* can be a leading activity. Encroached areas which have been cleared are now degraded and would need planting of suitable species. Once a degraded area is identified habitat restoration could be initiated based on assisted natural regeneration and planting for gap filling.

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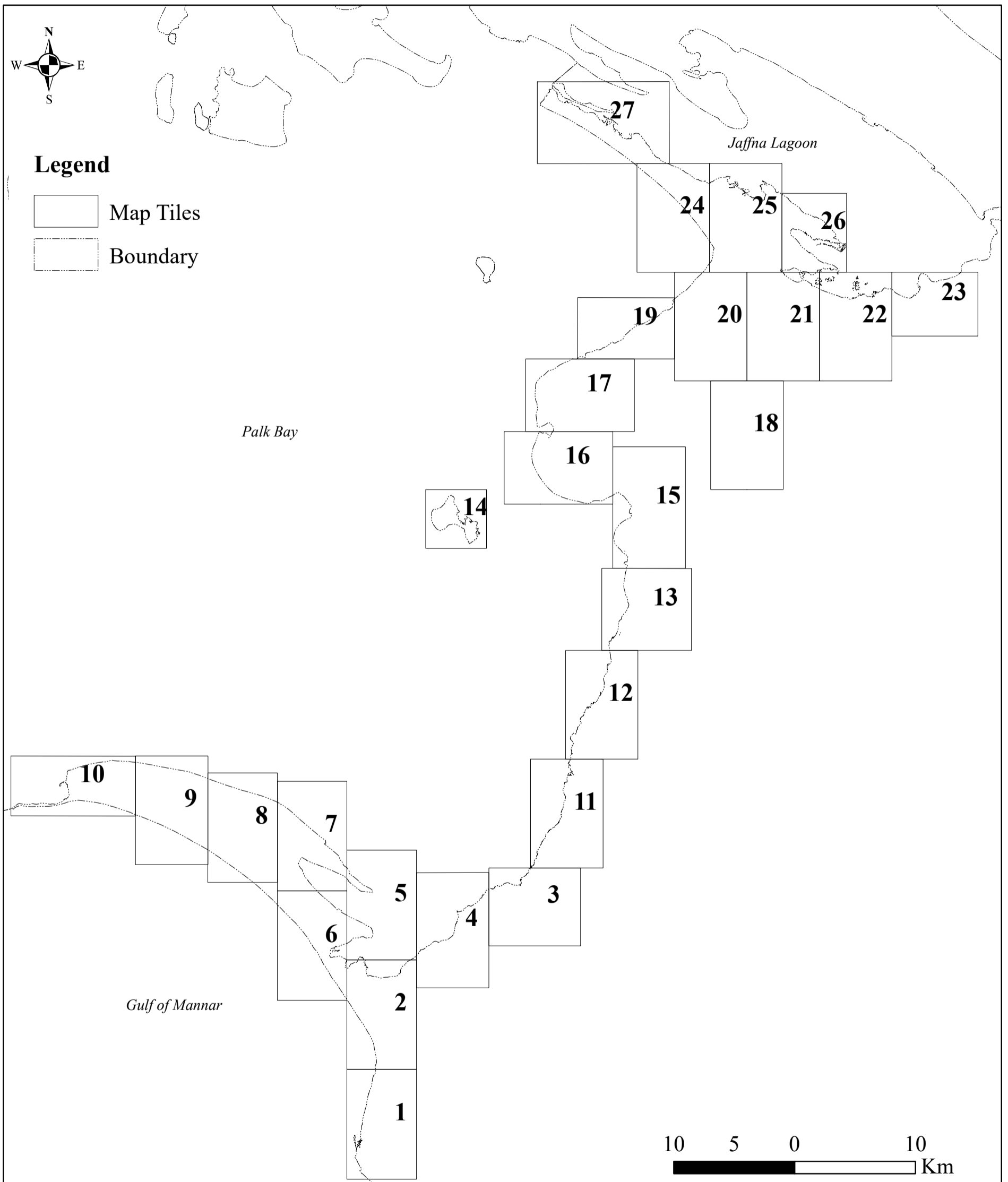
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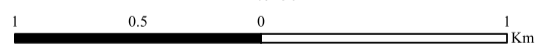
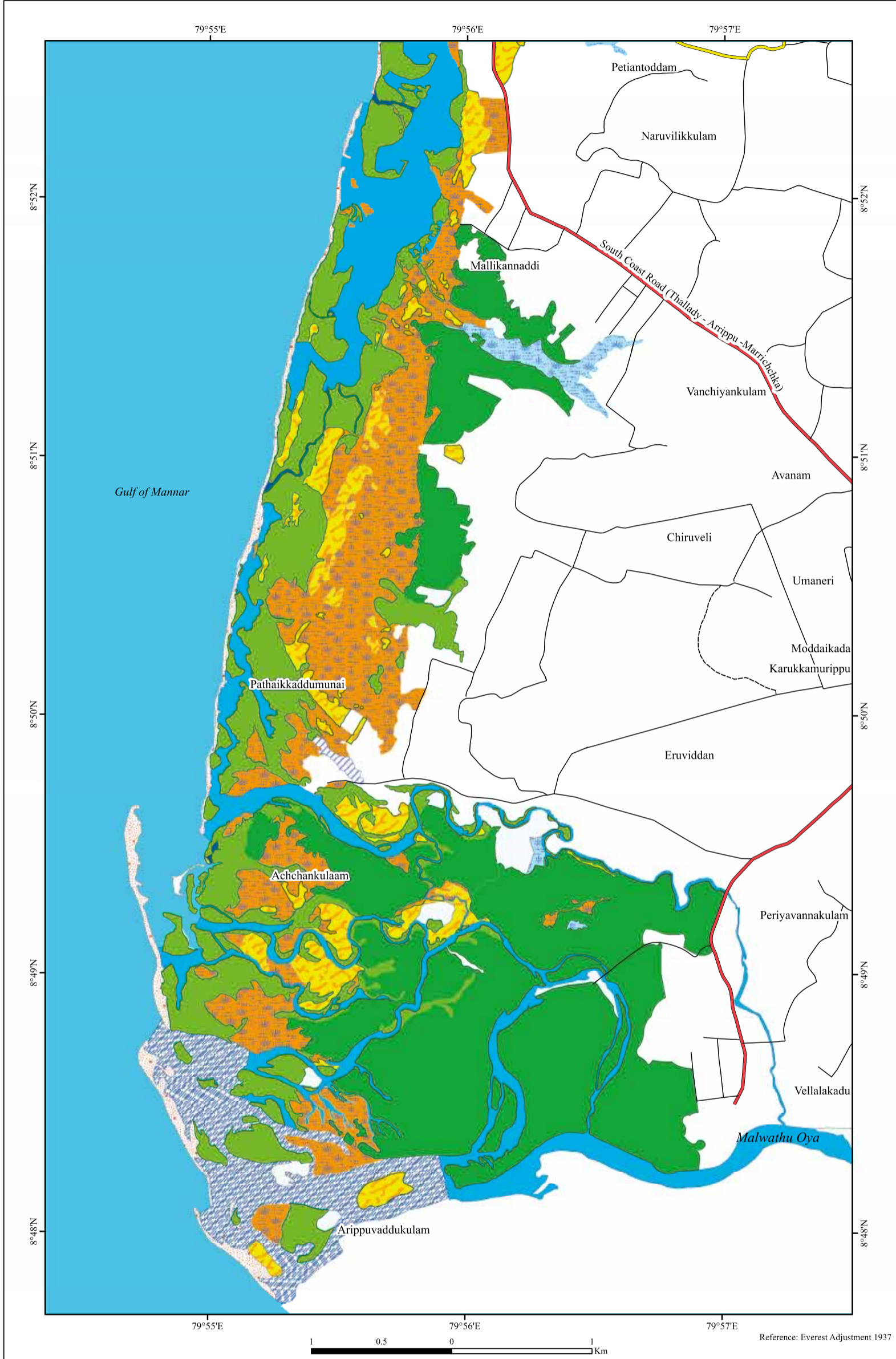
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02	Thirukethiswaram
03	Wedithalathive
04	Nedunkandal
05	Pallimunai
06	Talvupadu
07	Erukkalampiddy
08	Pesalai
09	Paaviluppaddaan Kudiyrippu
10	Talaimannar
11	Illuppaikkadavai
12	Mundampiddi
13	Mullikumam
14	Iranaitivu
15	Nochchimunai
16	Kiranchi
17	Ponnaveli
18	Manniyakulam
19	Pallanmadu
20	Nawaladi
21	Kovikoduttavil
22	Annatevanyal
23	Paranthan
24	Veddukadu
25	Ganimadam
26	Kurukkaithivu
27	Kavutharimunai

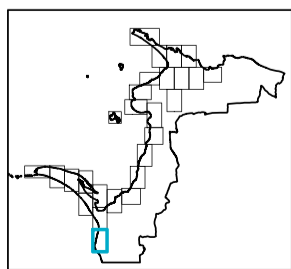
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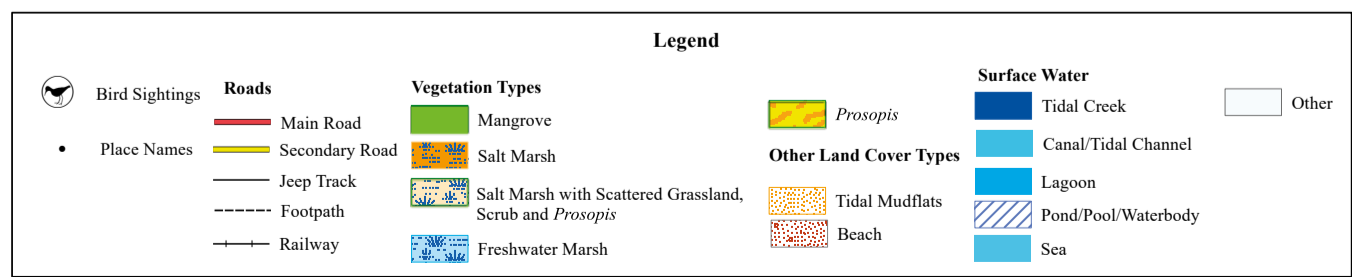
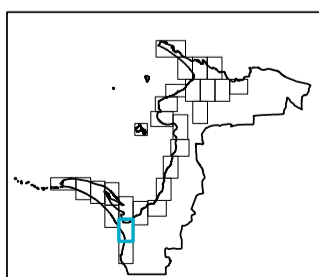
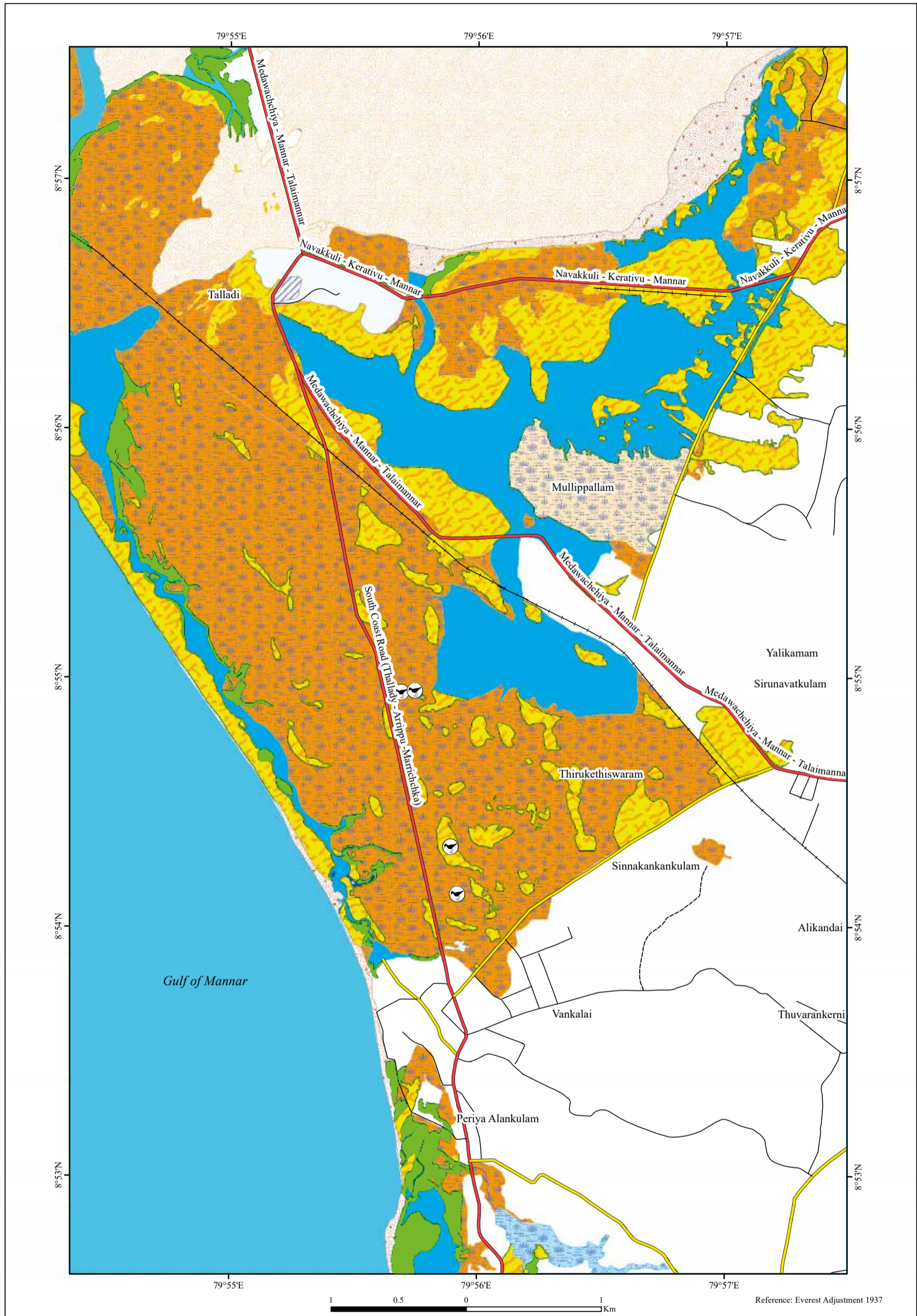
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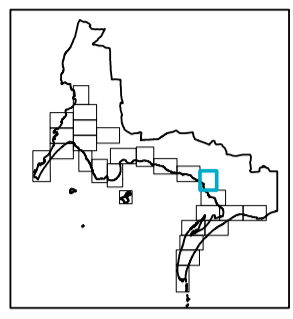
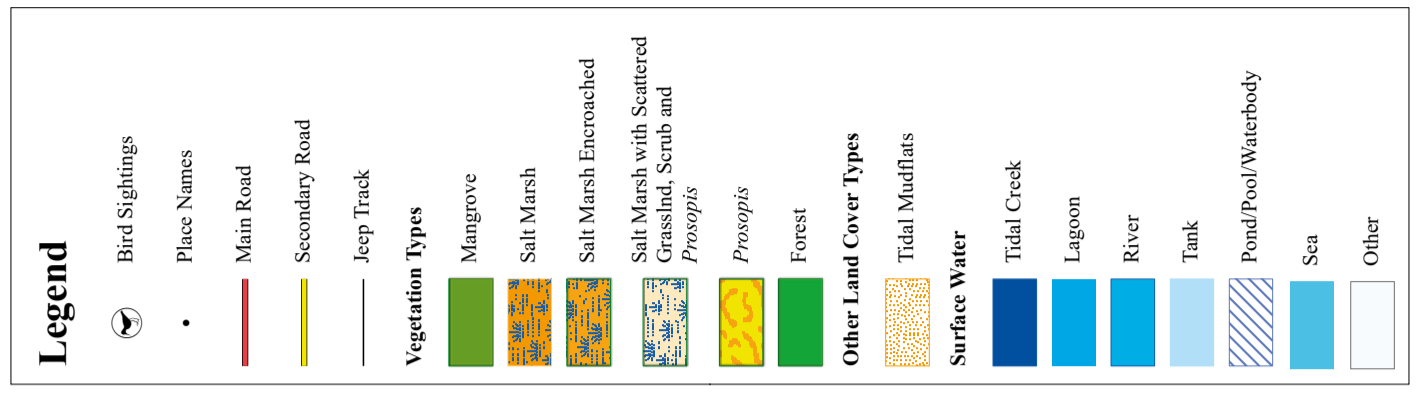
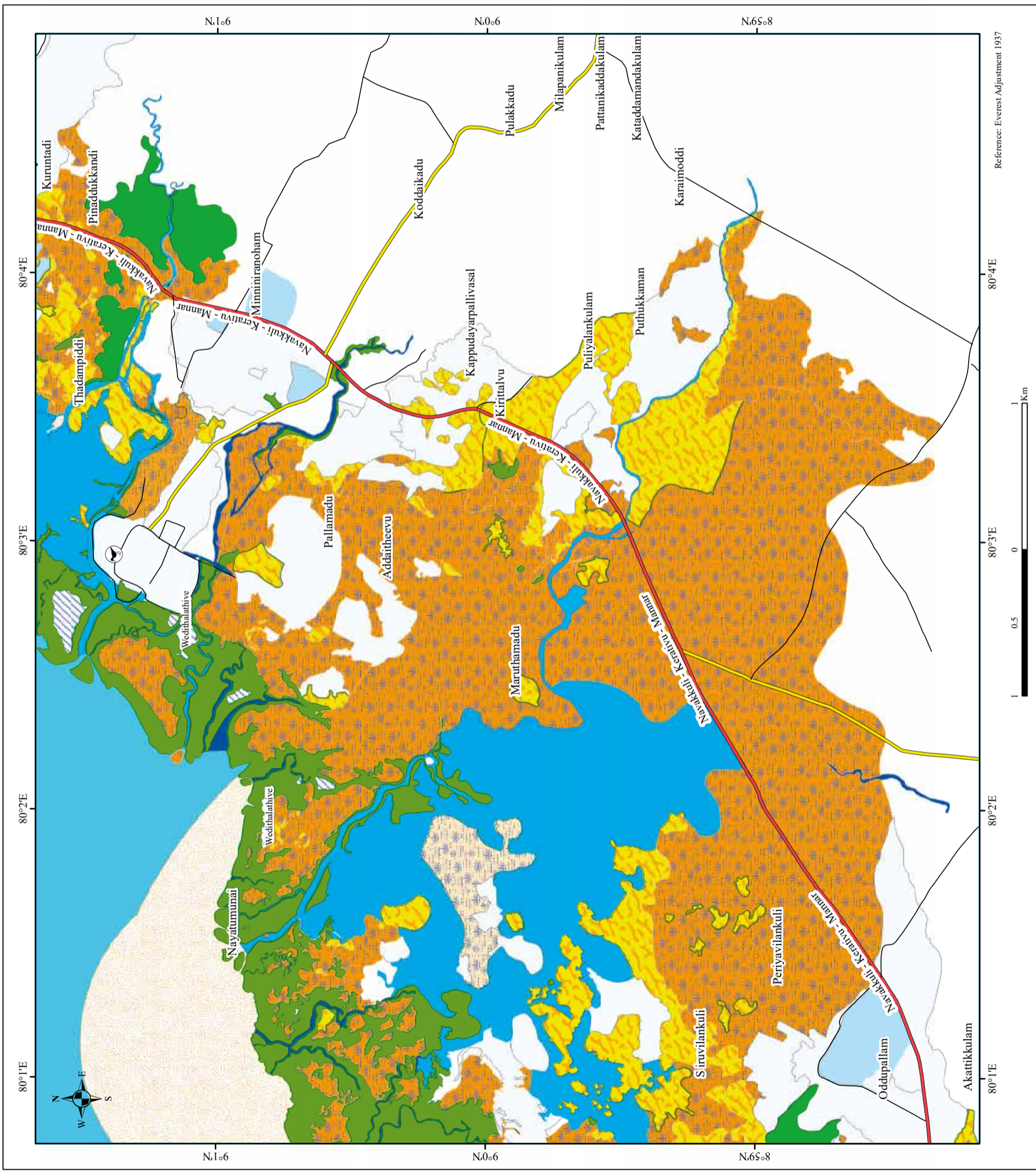


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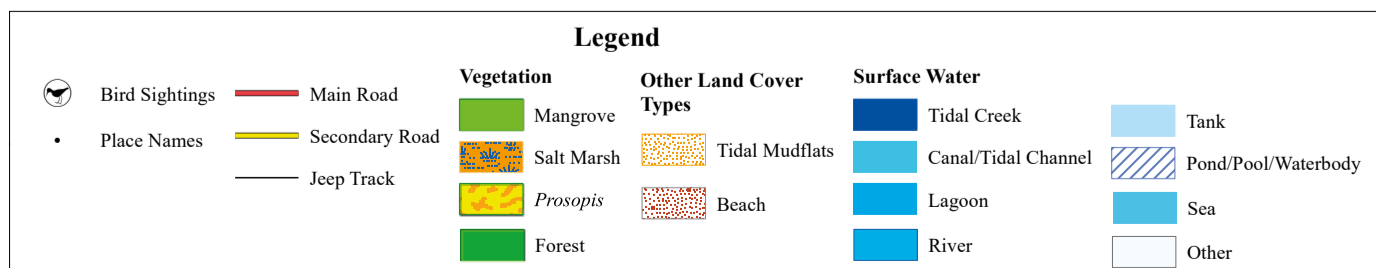
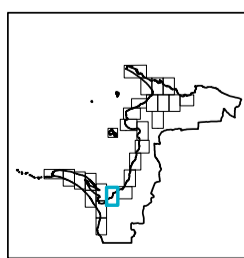
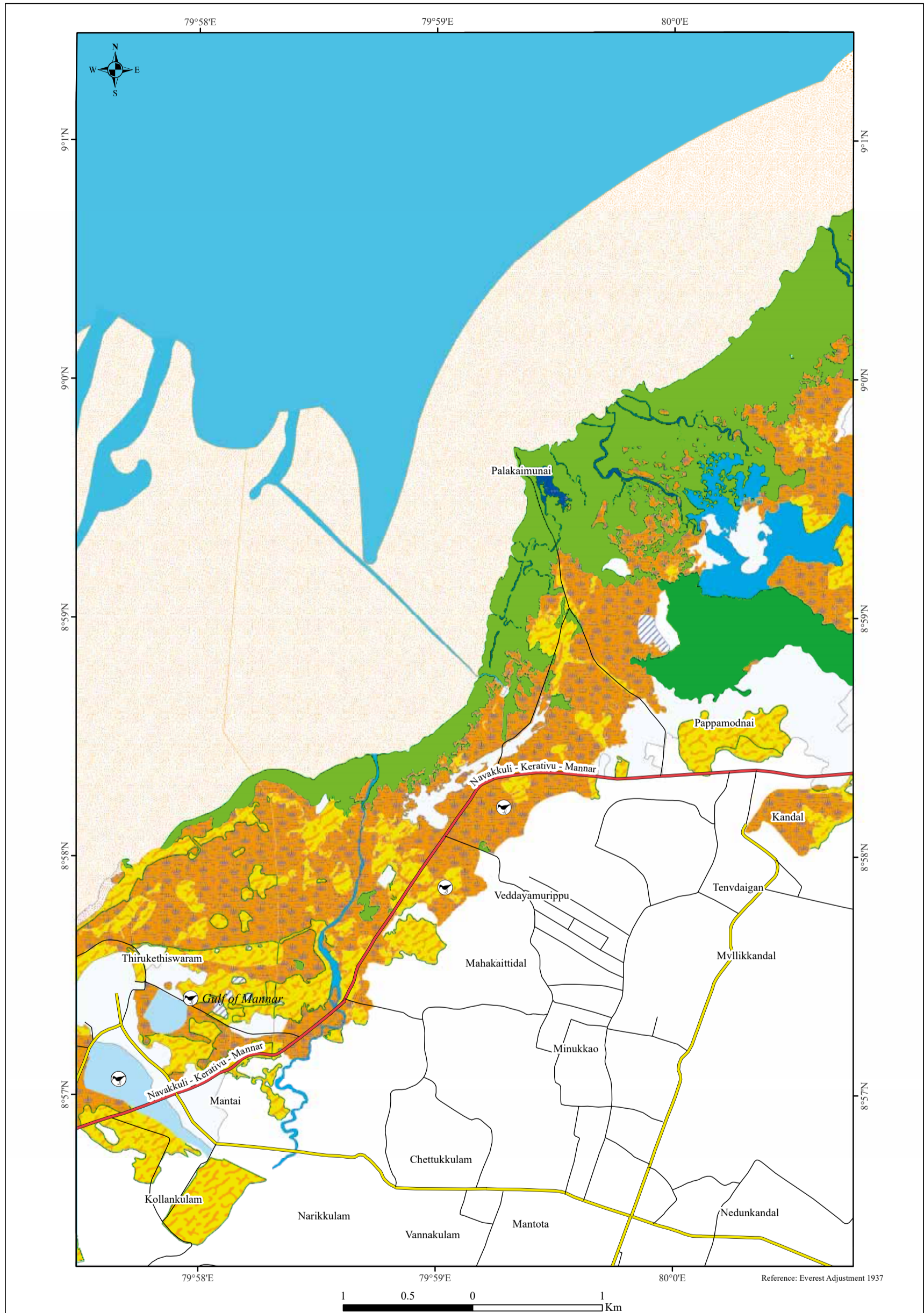
Legend			
• Place Names	Vegetation Types	Other Land Cover Types	
— Main Road	Mangrove	Beach	River
— Secondary Road	Salt Marsh	Surface Water	Pond/Pool/Waterbody
— Jeep Track	Freshwater Marsh	Tidal Creek	Sea
--- Footpath	Prosopis	Estuary	Other
	Forest	Lagoon	

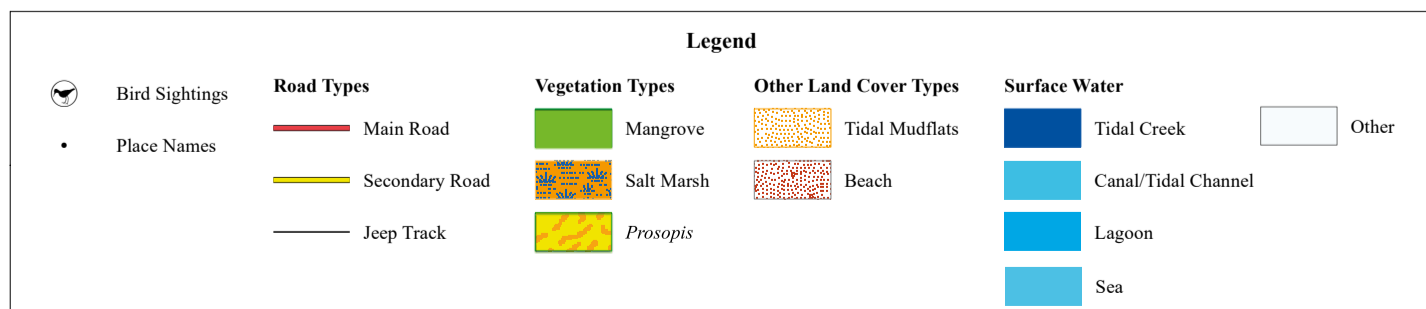
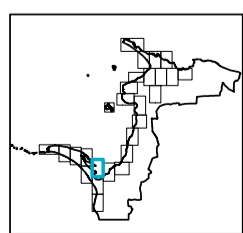
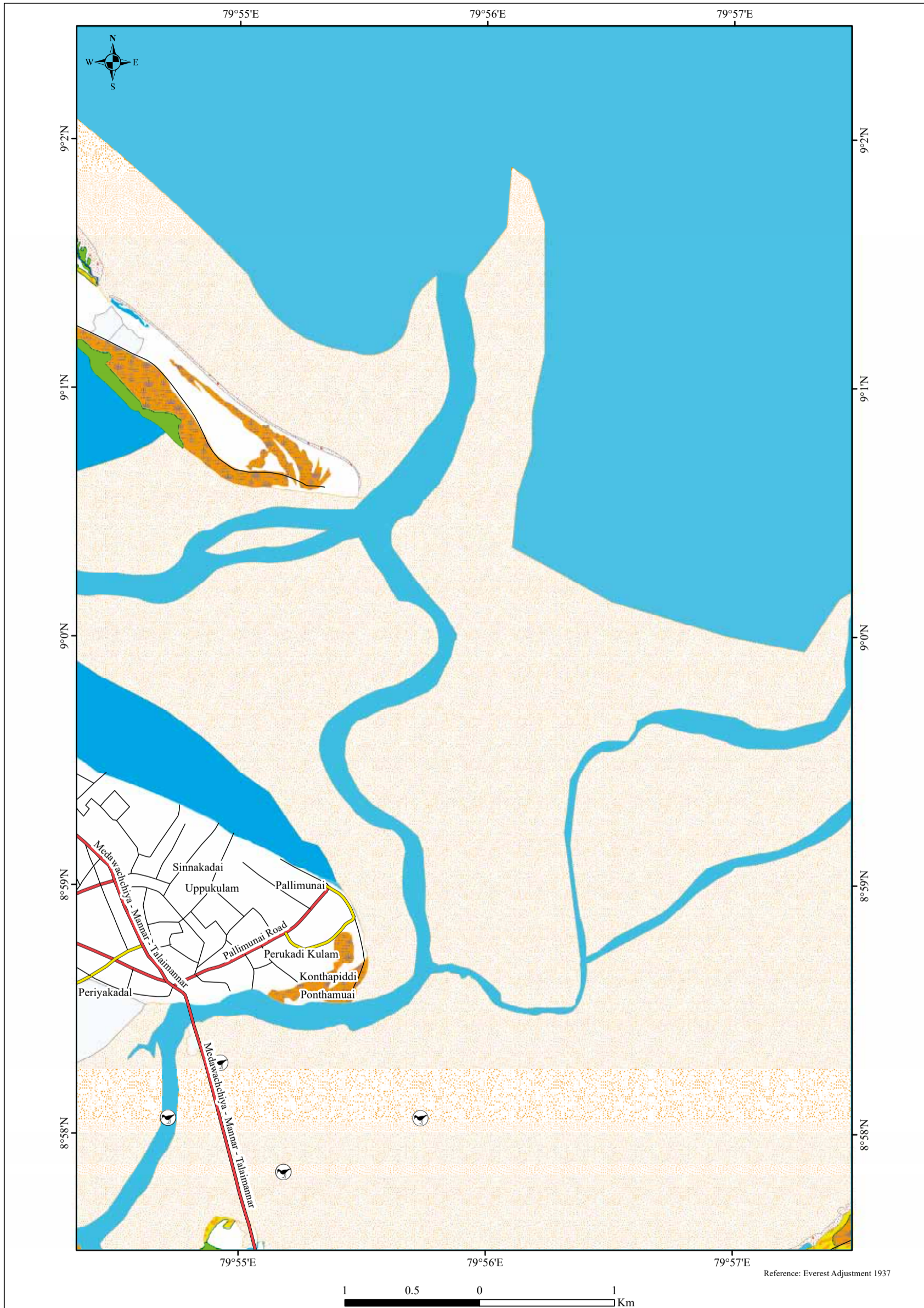


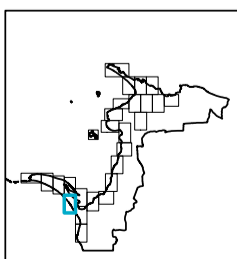
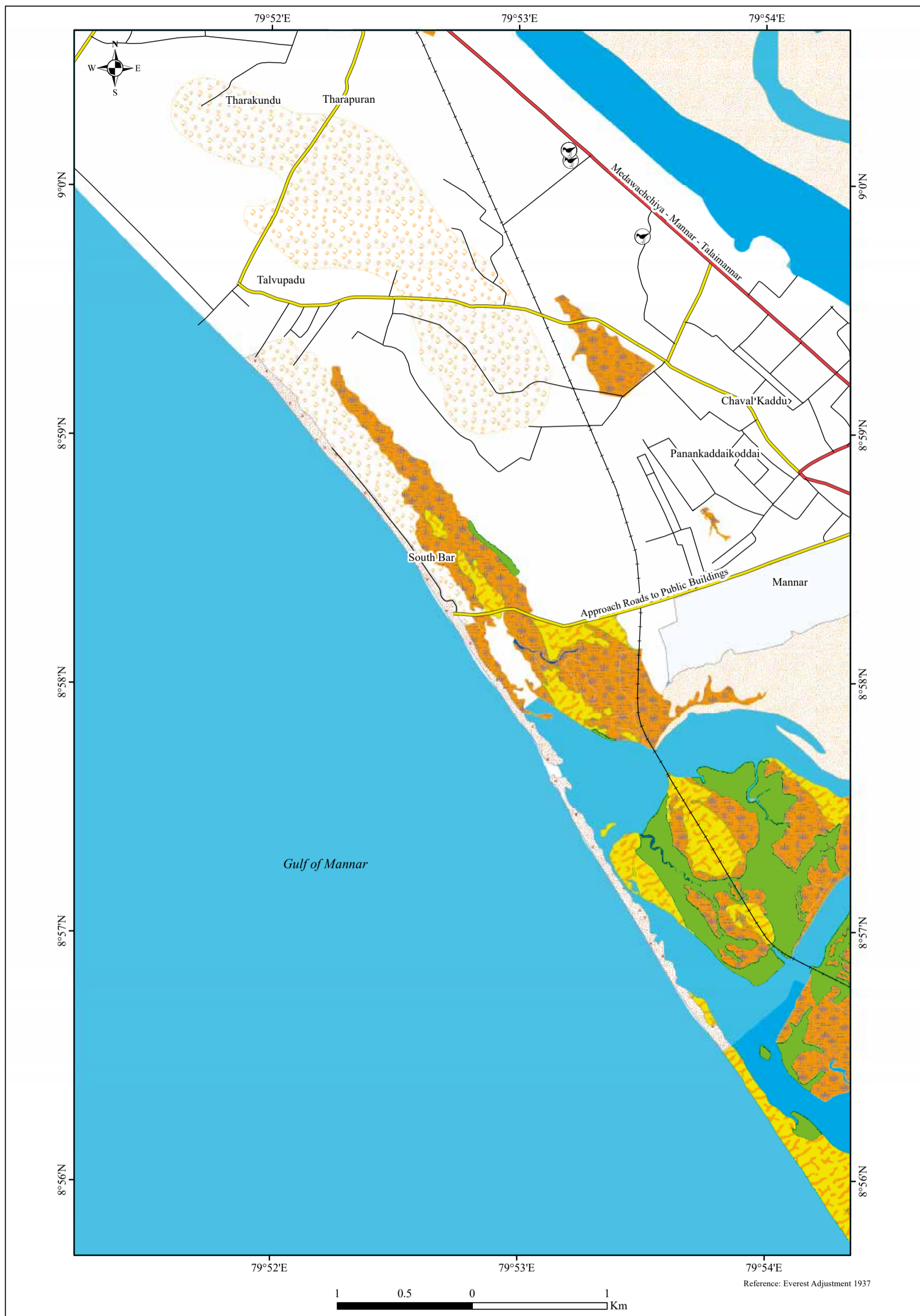


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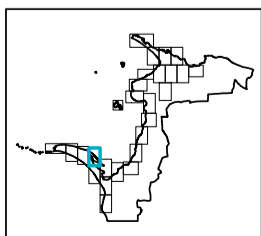




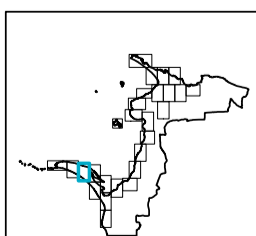
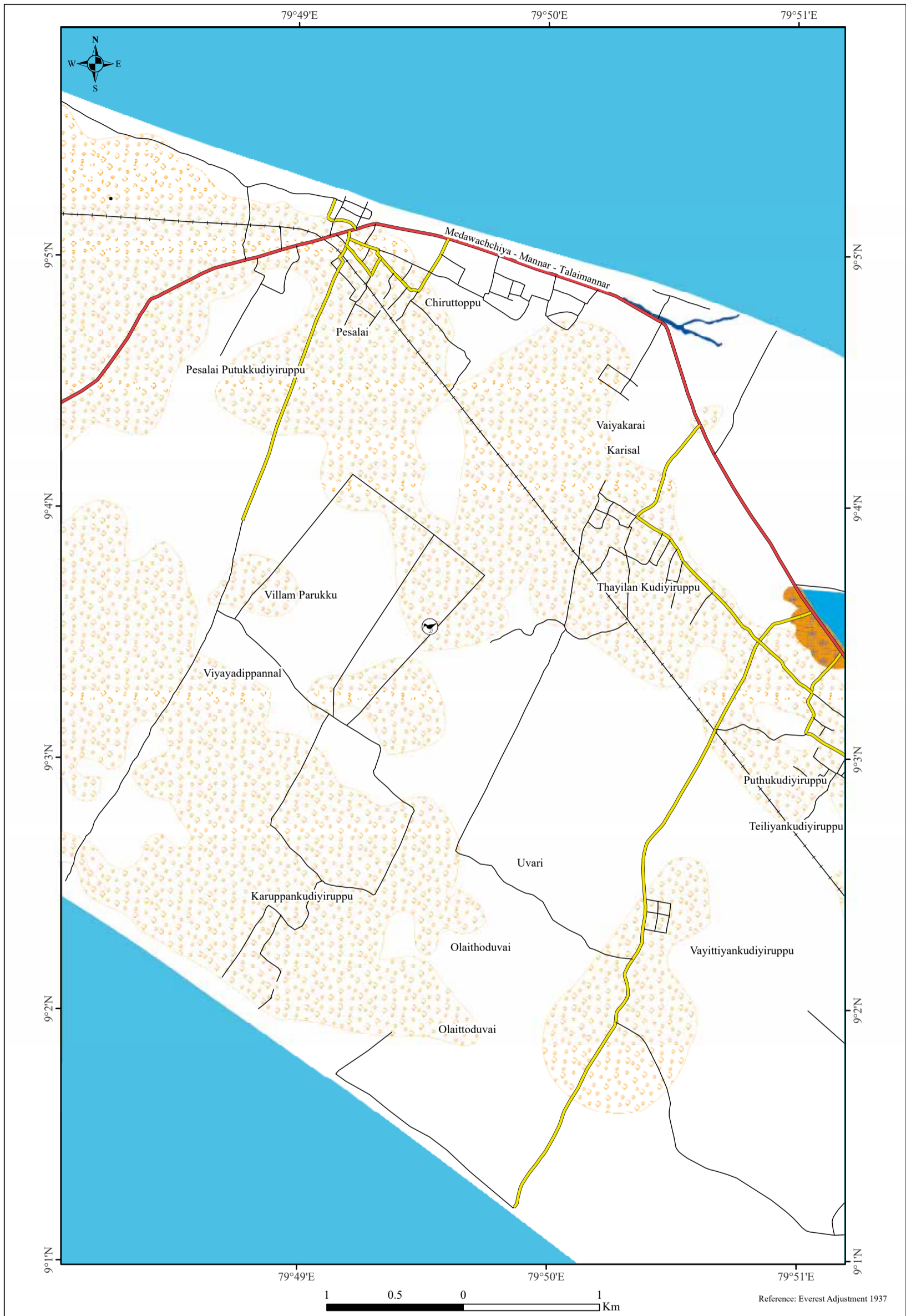




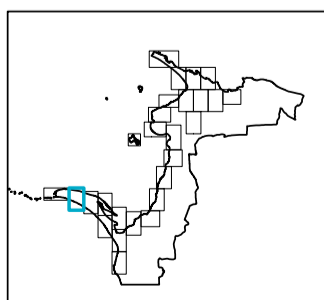
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Bird Sightings	Road Types	Vegetation Types	Other Land Cover Types	Surface Water
Place Names	Railway	Mangrove	Sand Dune	Tidal Creek
	Main Road	Salt Marsh	Tidal Mudflats	Canal/Tidal Channel
	Secondary Road	Prosopis	Beach	Lagoon
	Jeep Track			Sea
				Other



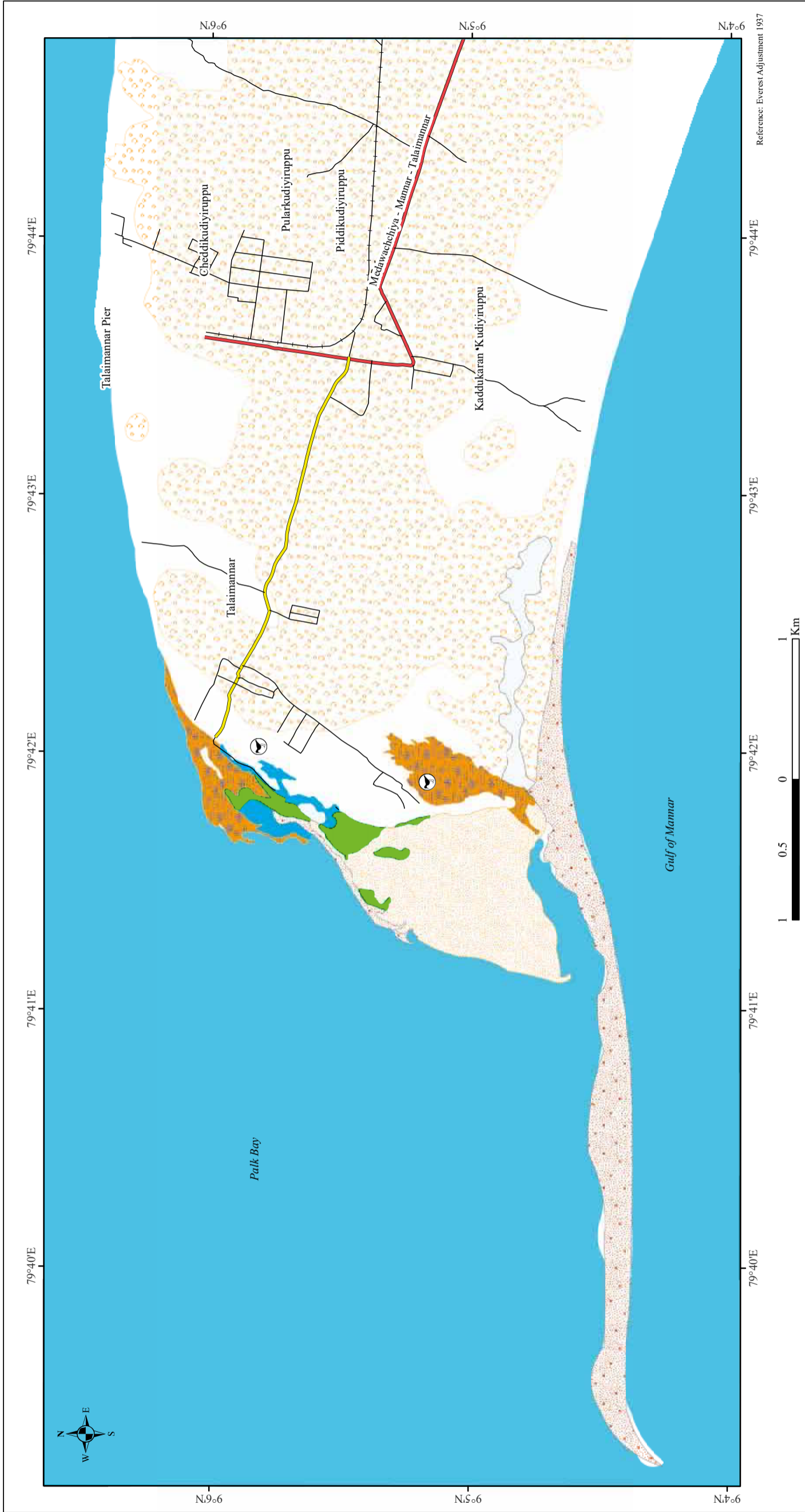
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Bird Sightings	Road Types	Vegetation Types	Other Land Cover Types	Surface Water
Place Names	Railway	Mangrove	Aquaculture Farm	Tidal Creek
	Main Road	Salt Marsh	Sand Dune	Canal/Tidal Channel
	Secondary Road	<i>Prosopis</i>	Tidal Mudflats	Lagoon
	Jeep Track		Beach	Sea
				Other



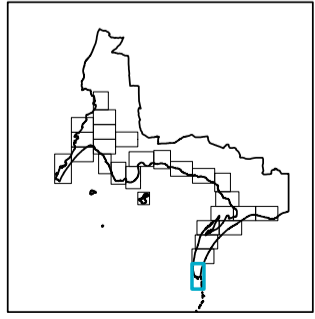
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	Road Types		Vegetation Types	Surface Water
			Other Land Cover Types	



Legend		
•	Place Names	Other Land Cover Types
	Main Road	
	Footpath	
	Railway	
	Jeep Track	

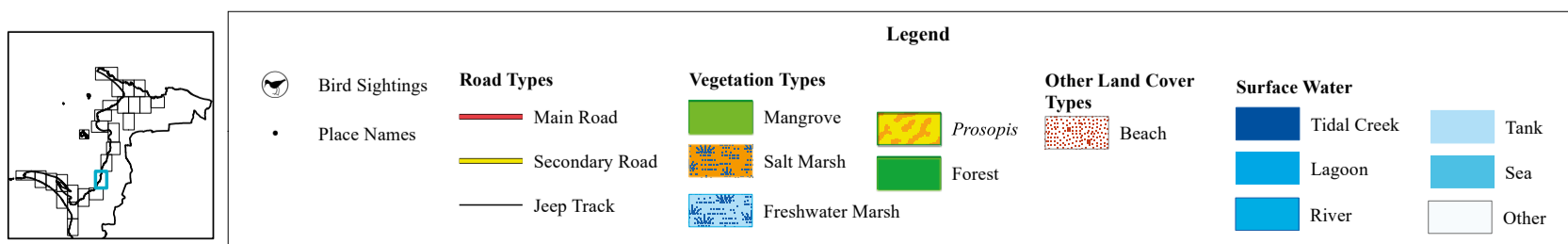
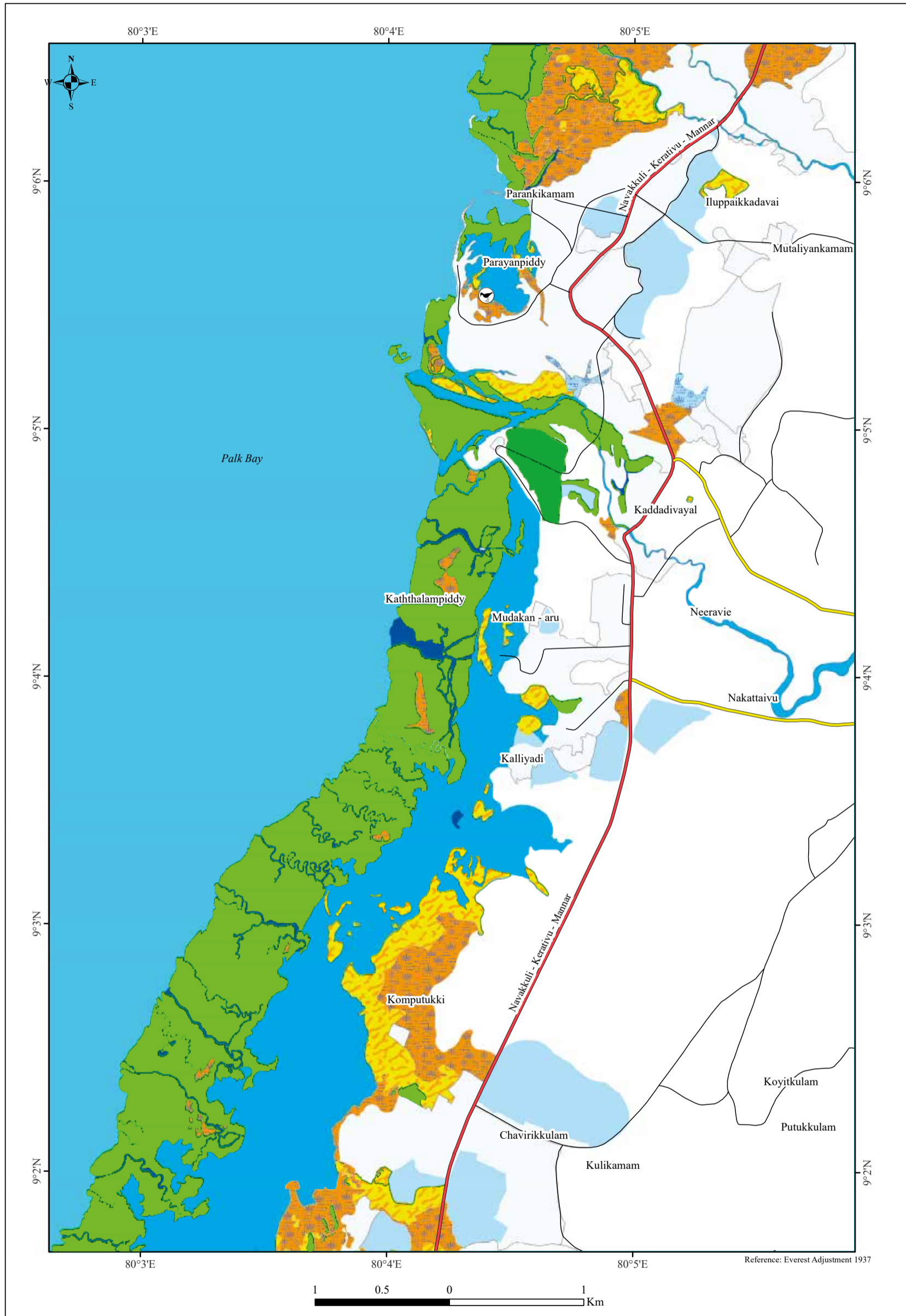


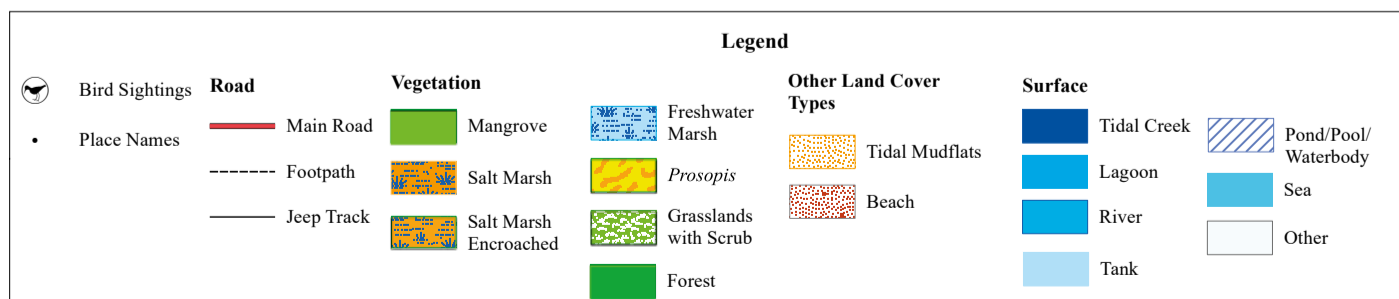
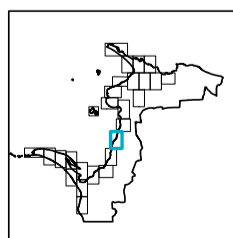
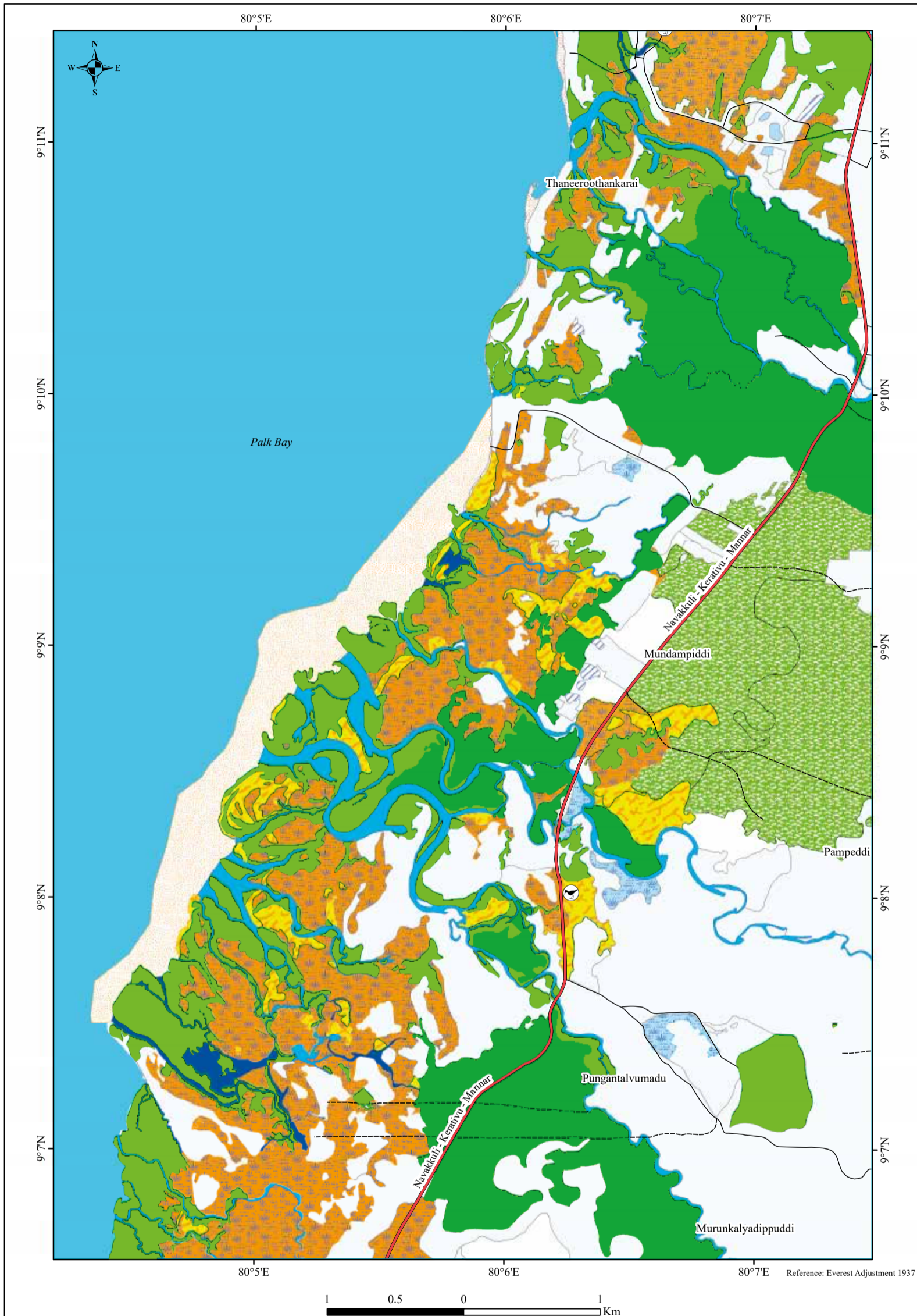
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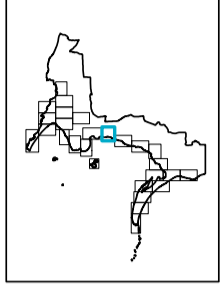
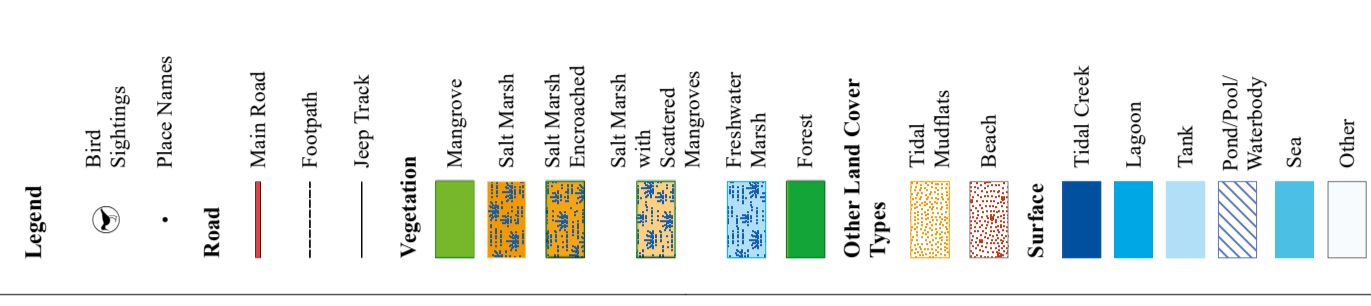
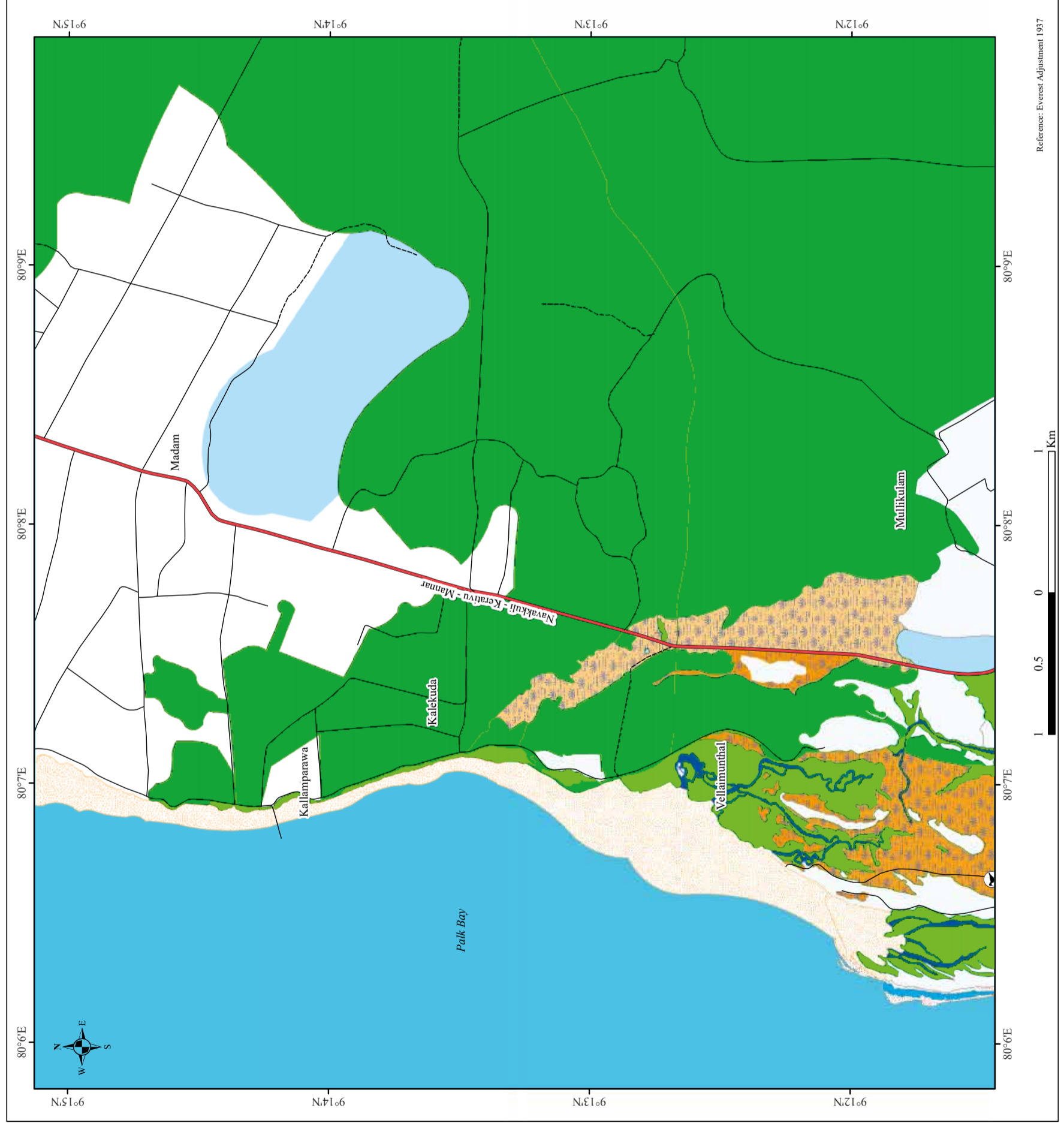


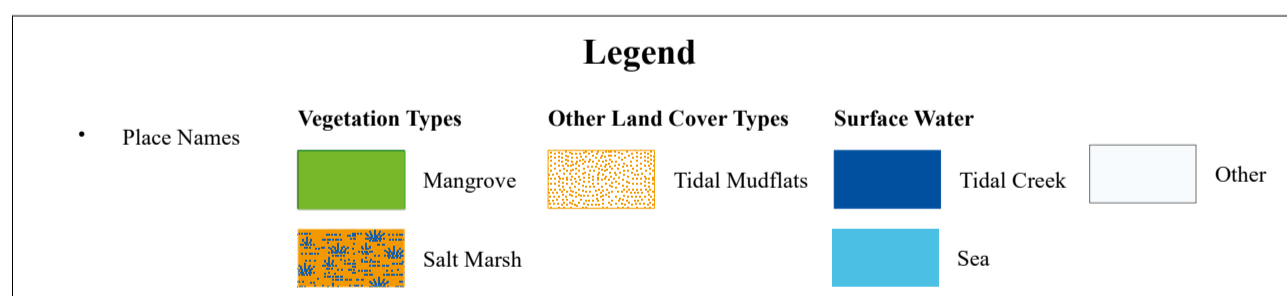
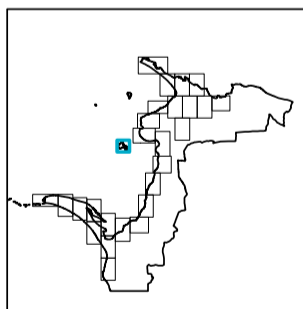
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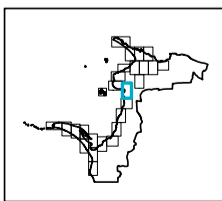
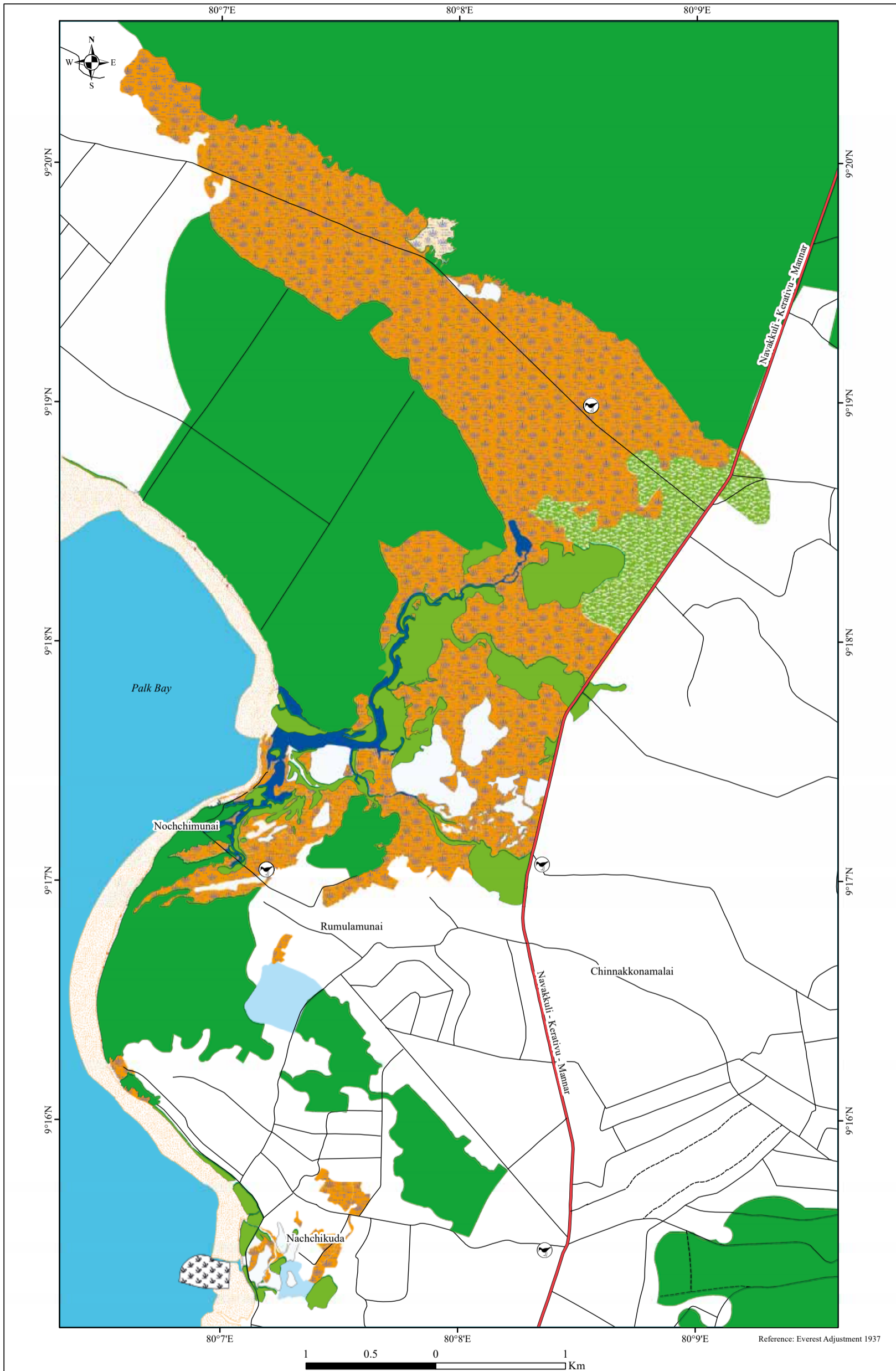
	Bird Sightings		Railway		Mangrove		Sand Dune		Lagoon
	Place Names		Main Road		Salt Marsh		Tidal Mudflats		Sea
			Jeep Track				Beach		
							Other		



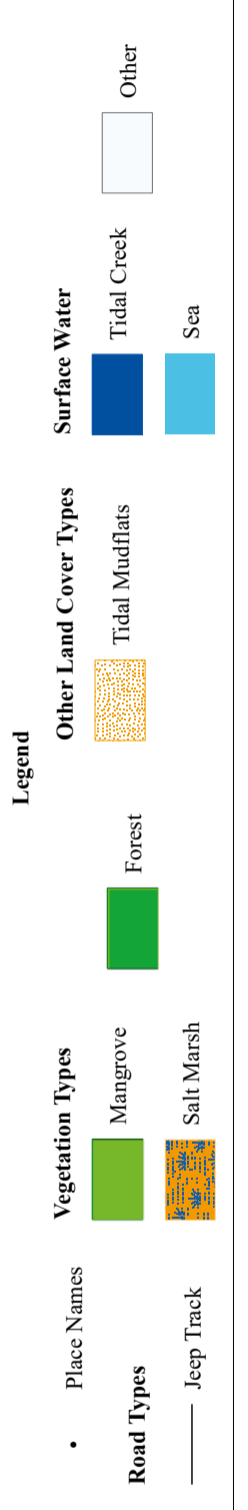
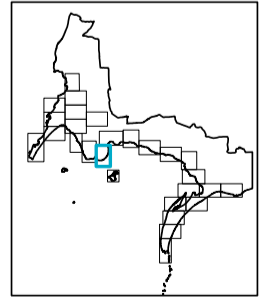




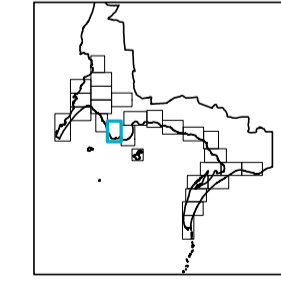
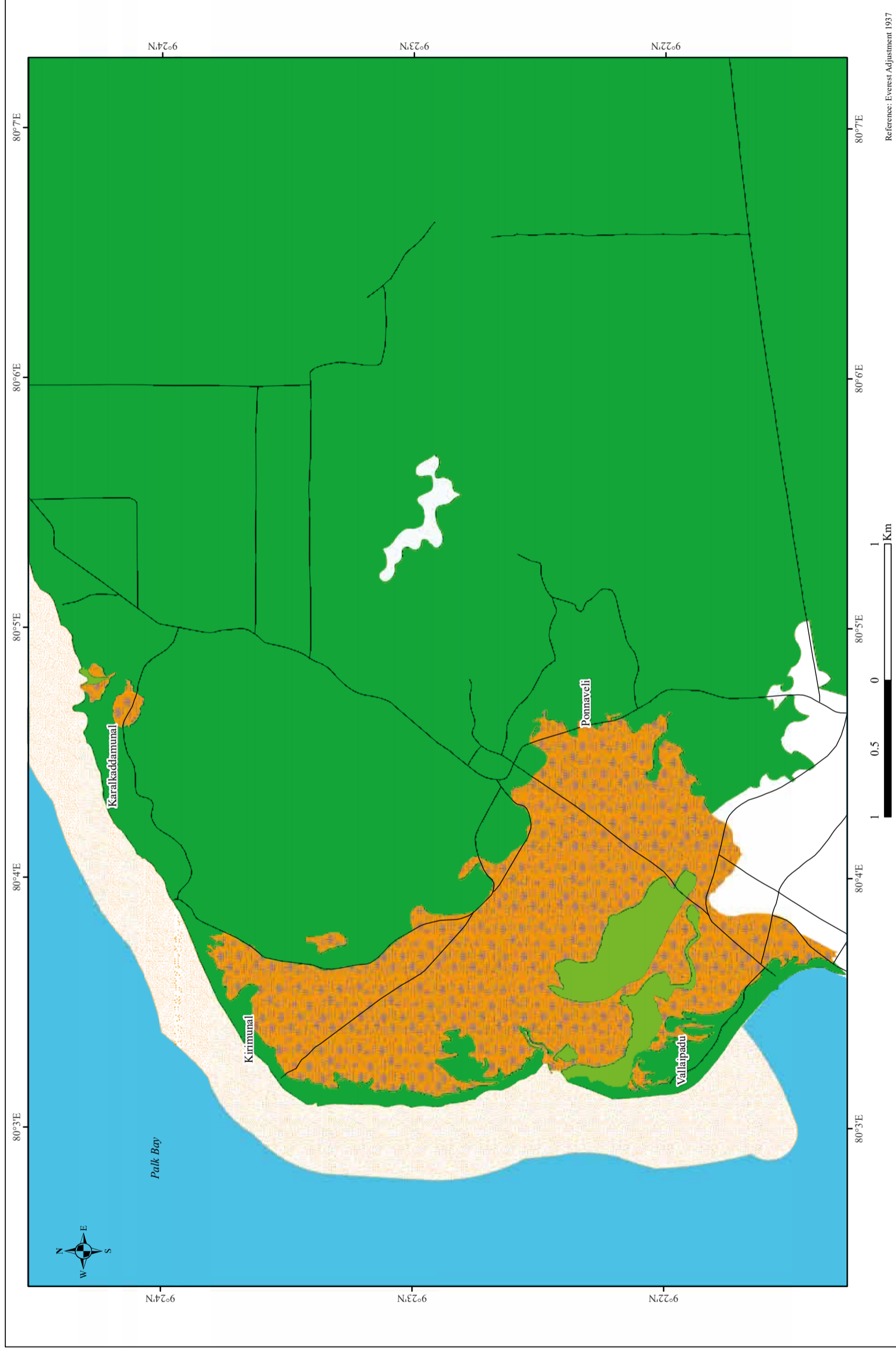




Legend			
Bird Sightings	Road Types	Vegetation Types	Grasslands with Scrub
Place Names	Main Road	Mangrove	Beach
	Footpath	Salt Marsh	Surface Water
	Jeep Track	Salt Marsh with Scattered Grassland, Scrub and <i>Prosopis</i>	Tidal Creek
		Other Land Cover Types	Tank
		Aquaculture Farm	Pond/Pool/Waterbody
			Sea
			Other
			Canal/Tidal Channel

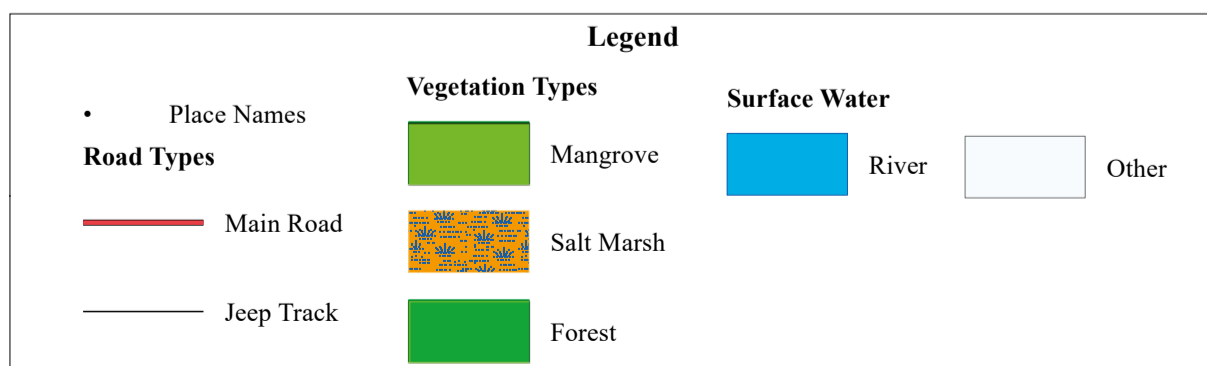
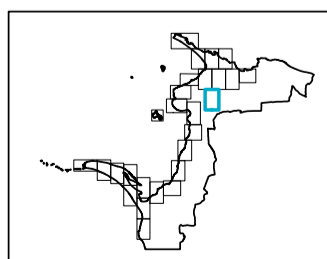
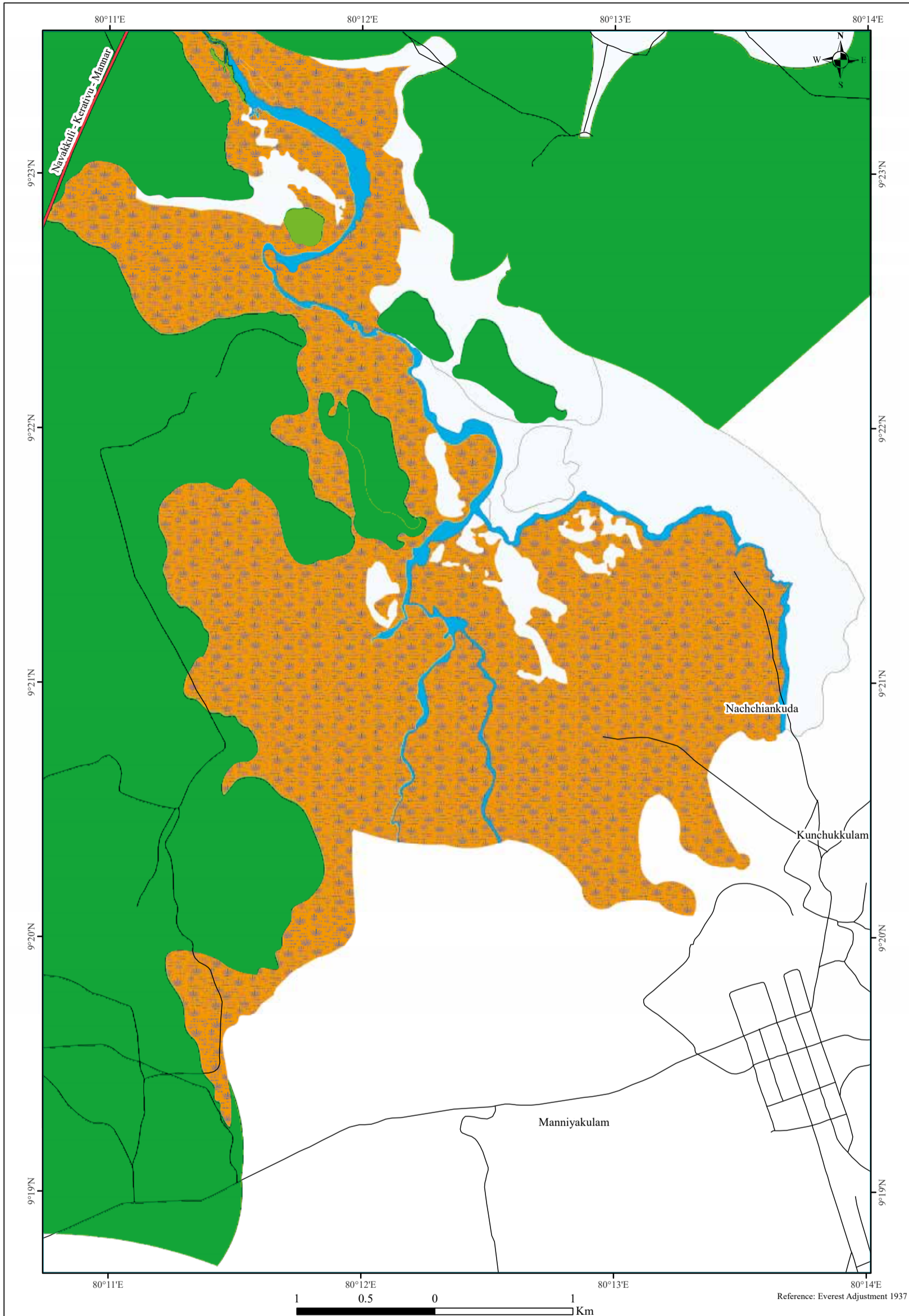


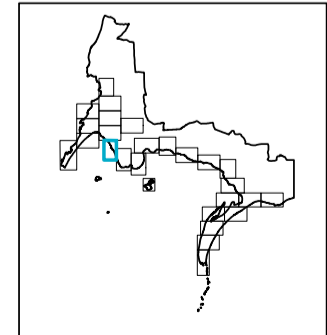
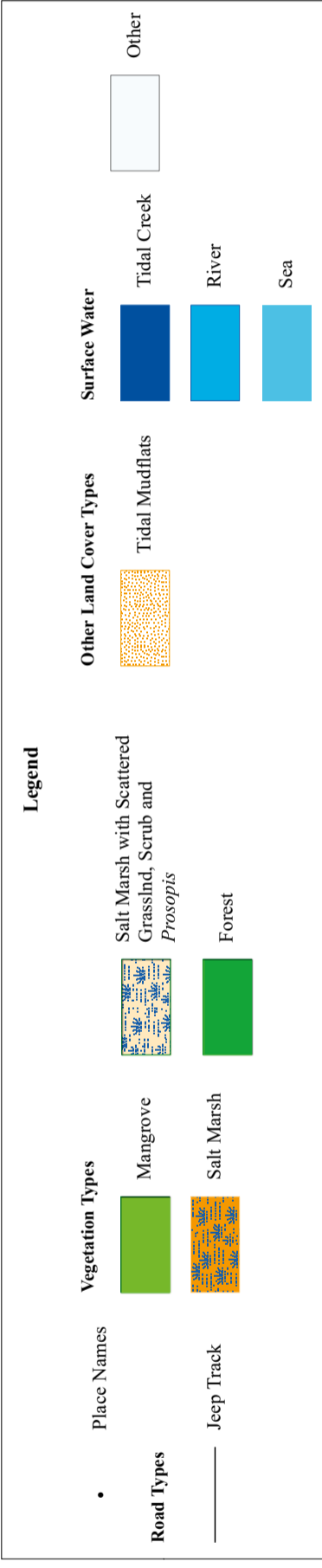
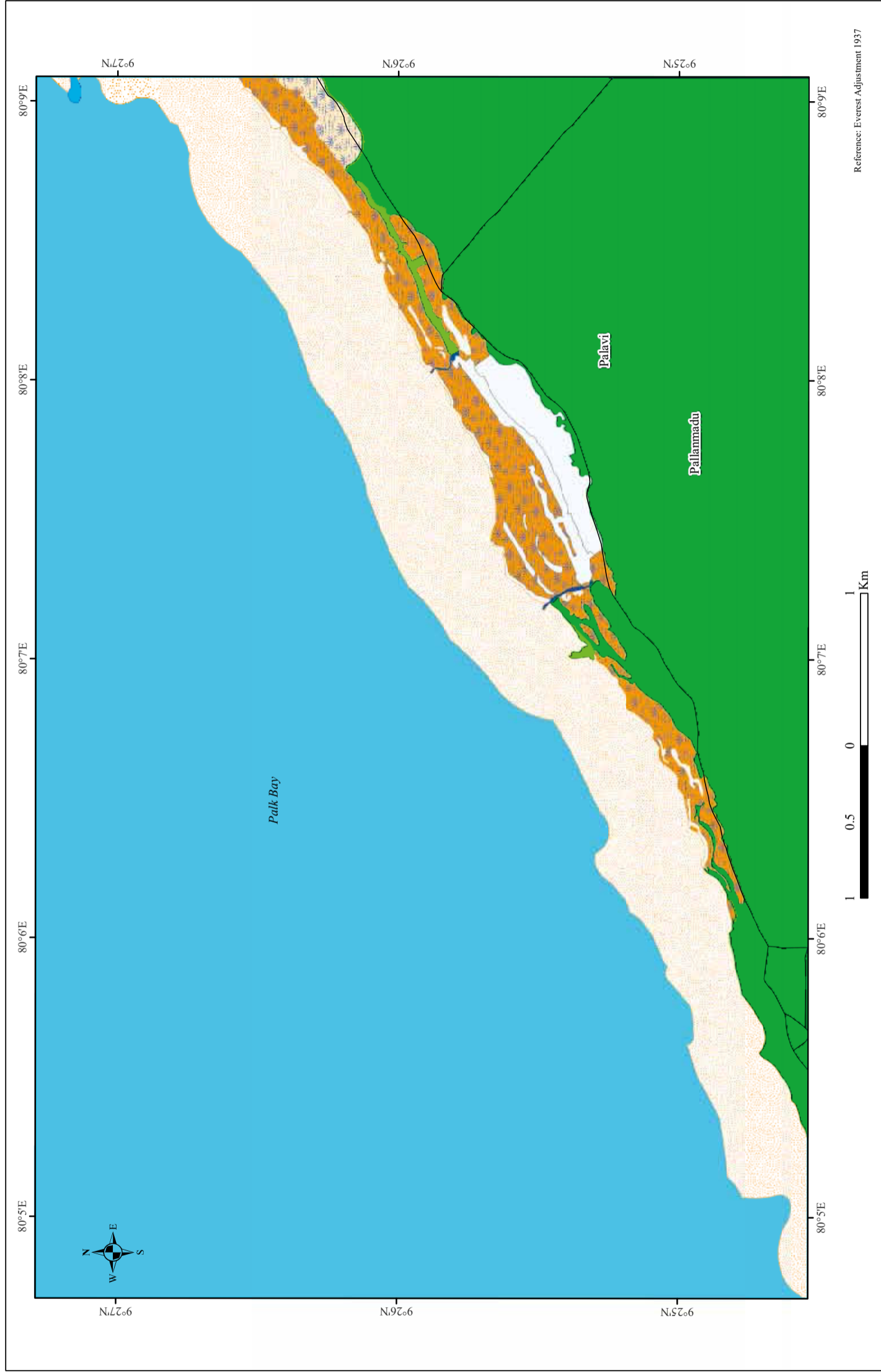
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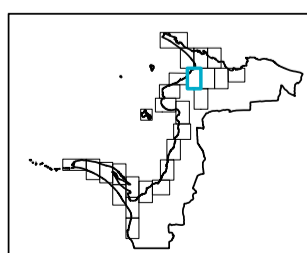


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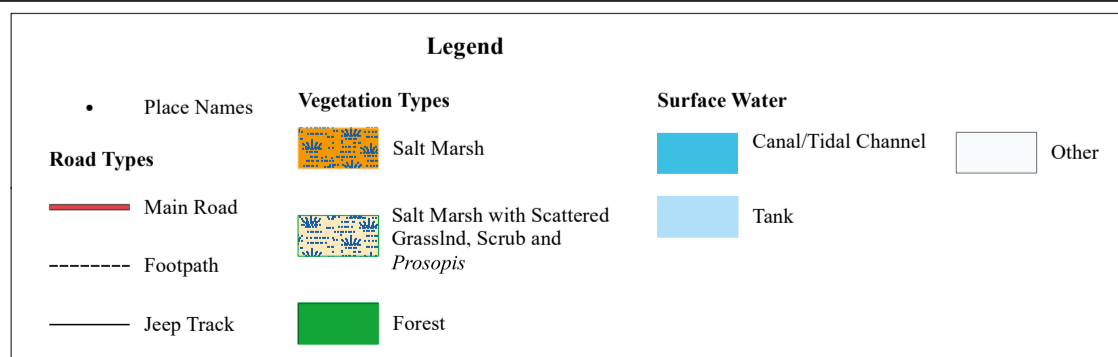
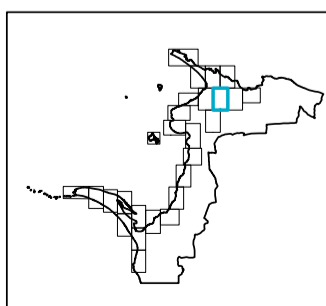
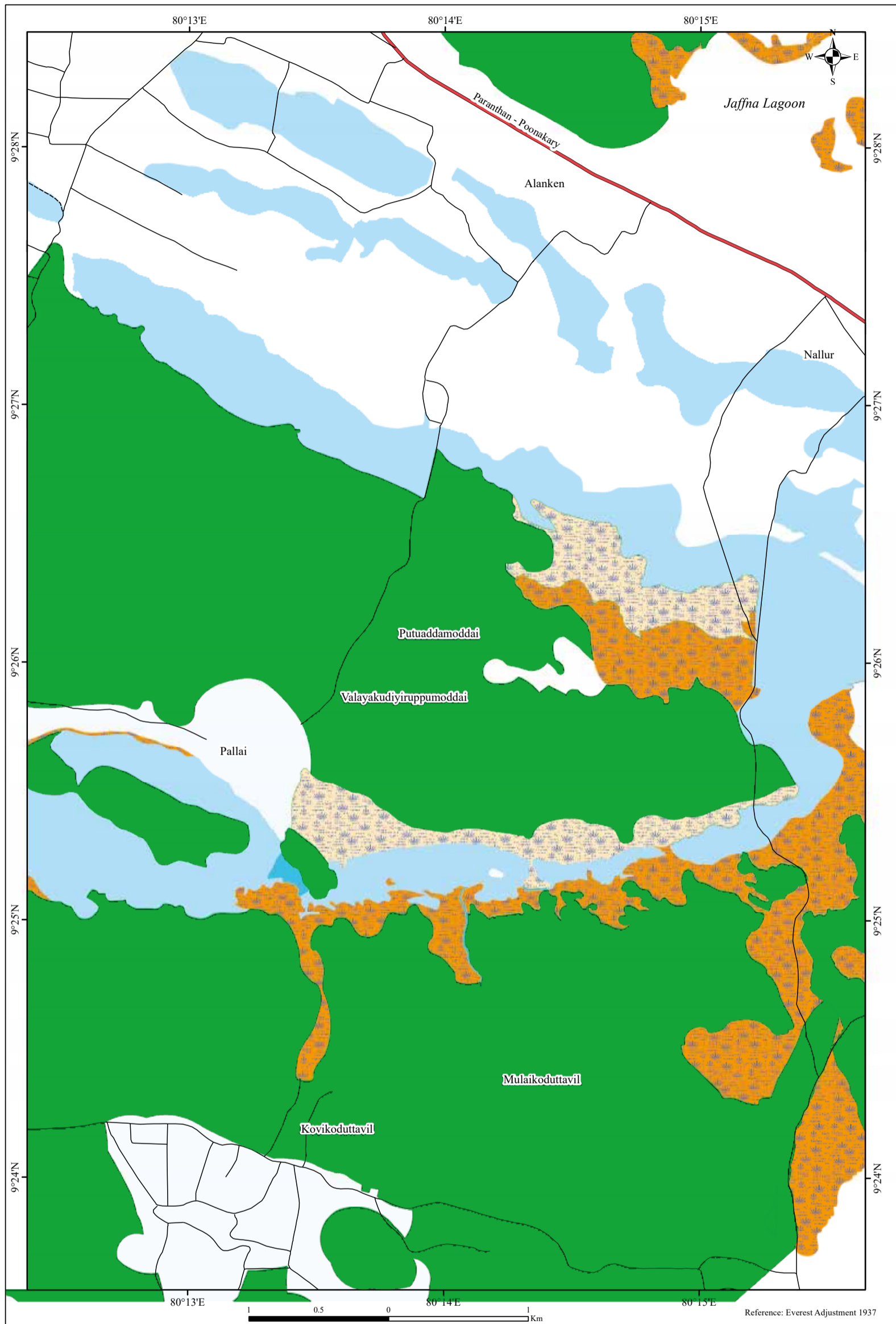
- | | | | | | |
|-------------|------------|--------|----------------|-----|-------|
| Place Names | Mangrove | Forest | Tidal Mudflats | Sea | Other |
| Road Types | Salt Marsh | | | | |
| Jeep Track | | | | | |

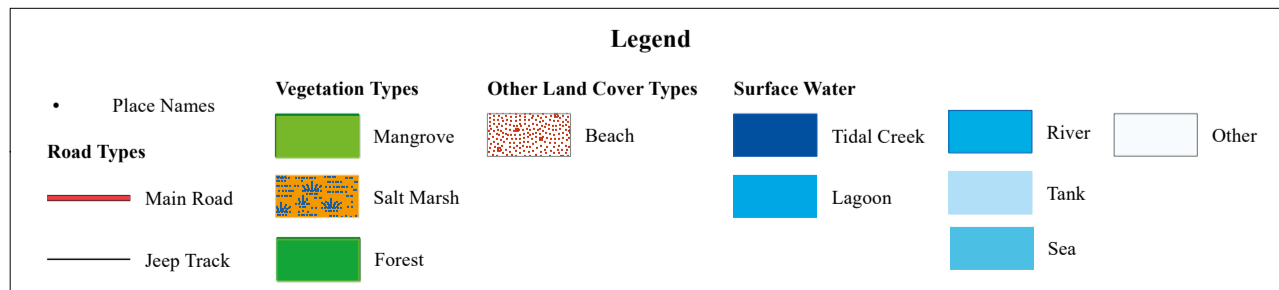
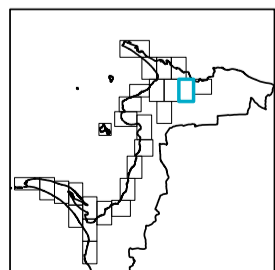
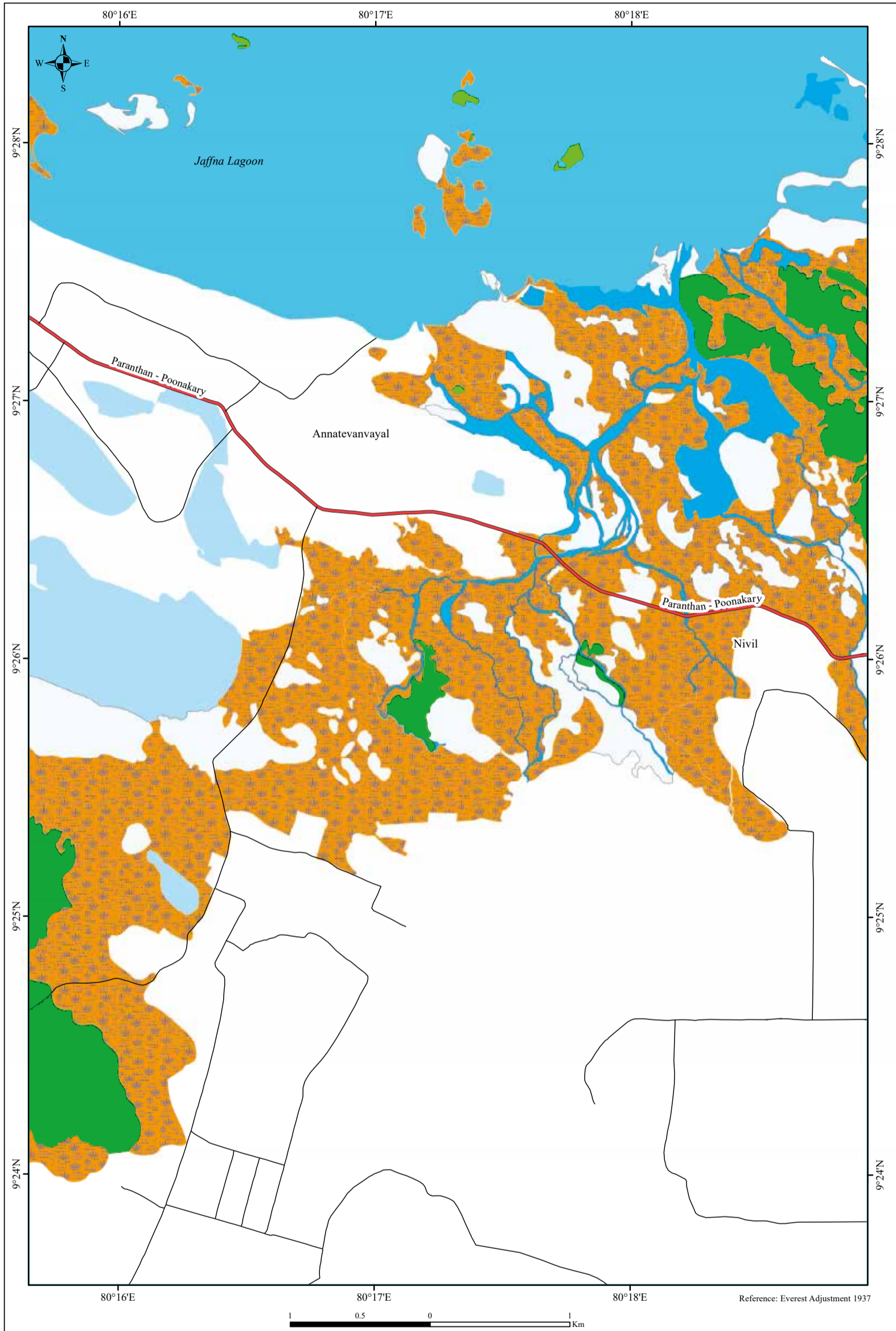


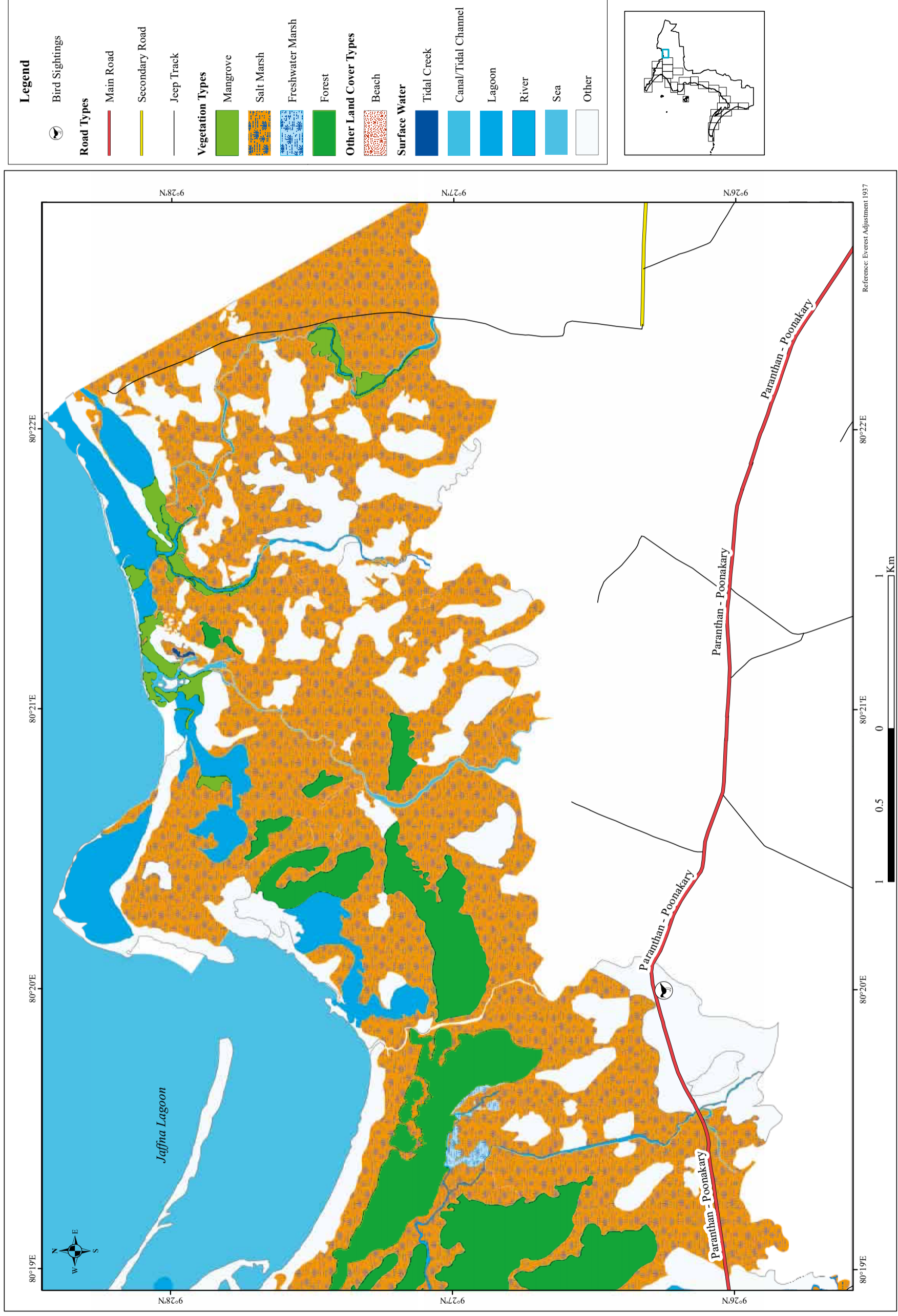


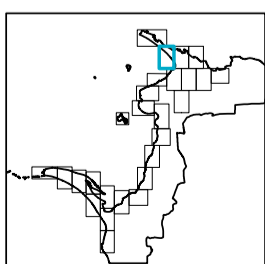
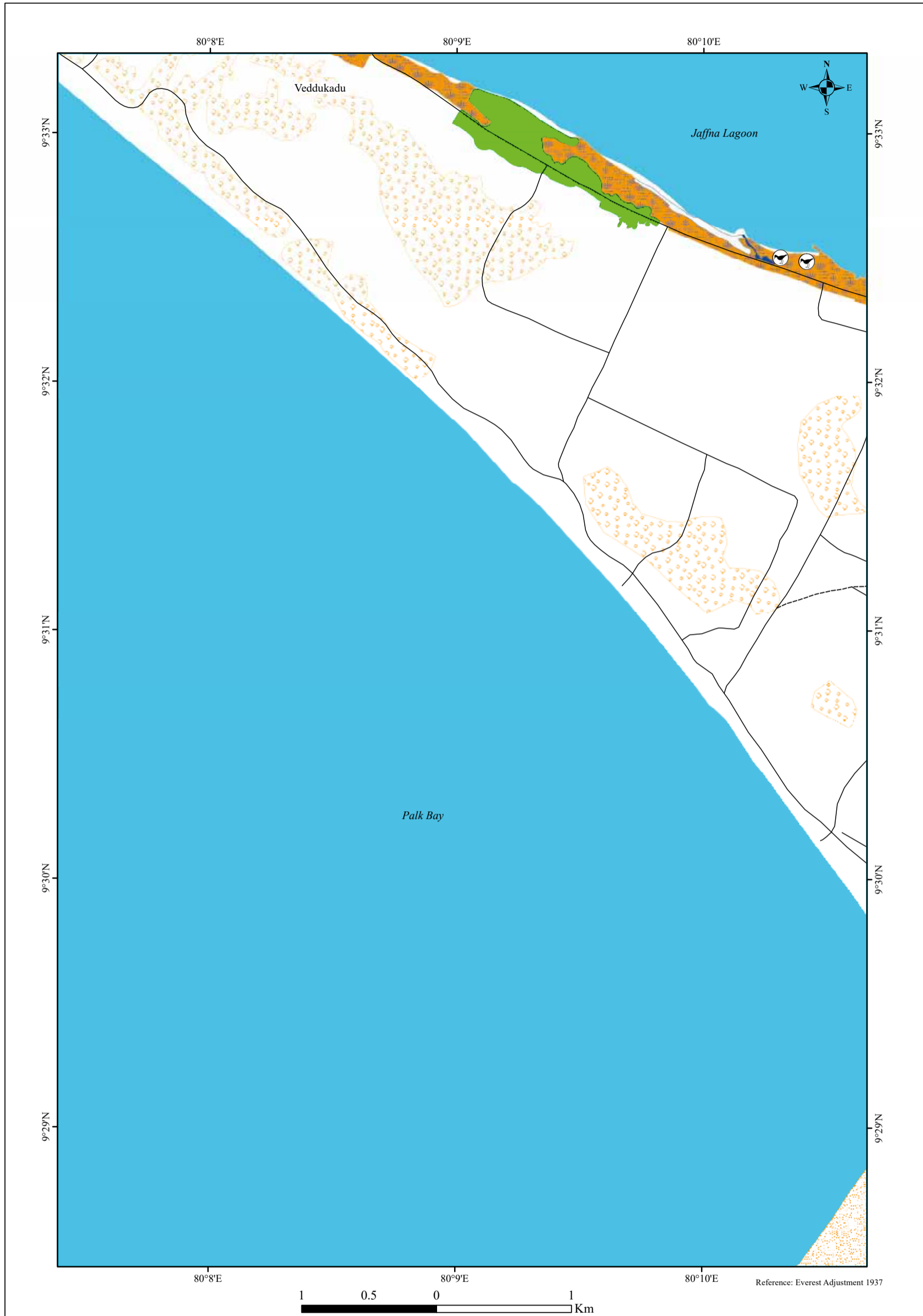


Legend			
• Place Names	Vegetation Types	Other Land Cover Types	Pond/Pool/Waterbody
Road Types	Mangrove	Tidal Mudflats	Sea
Main Road	Salt Marsh	Surface Water	Other
Footpath	Salt Marsh with Scattered Grassland, Scrub and <i>Prosopis</i>	Tidal Creek	
Jeep Track	Forest	River	
		Tank	

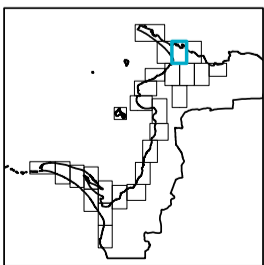




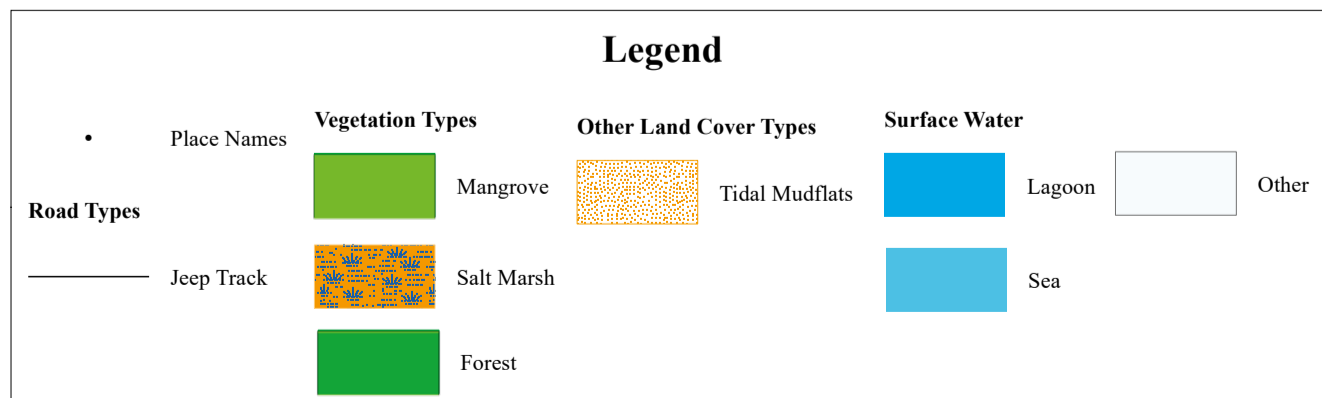
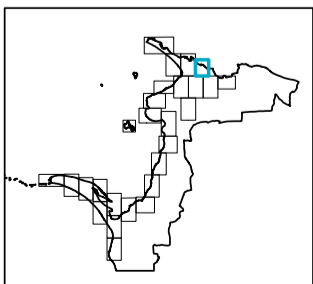
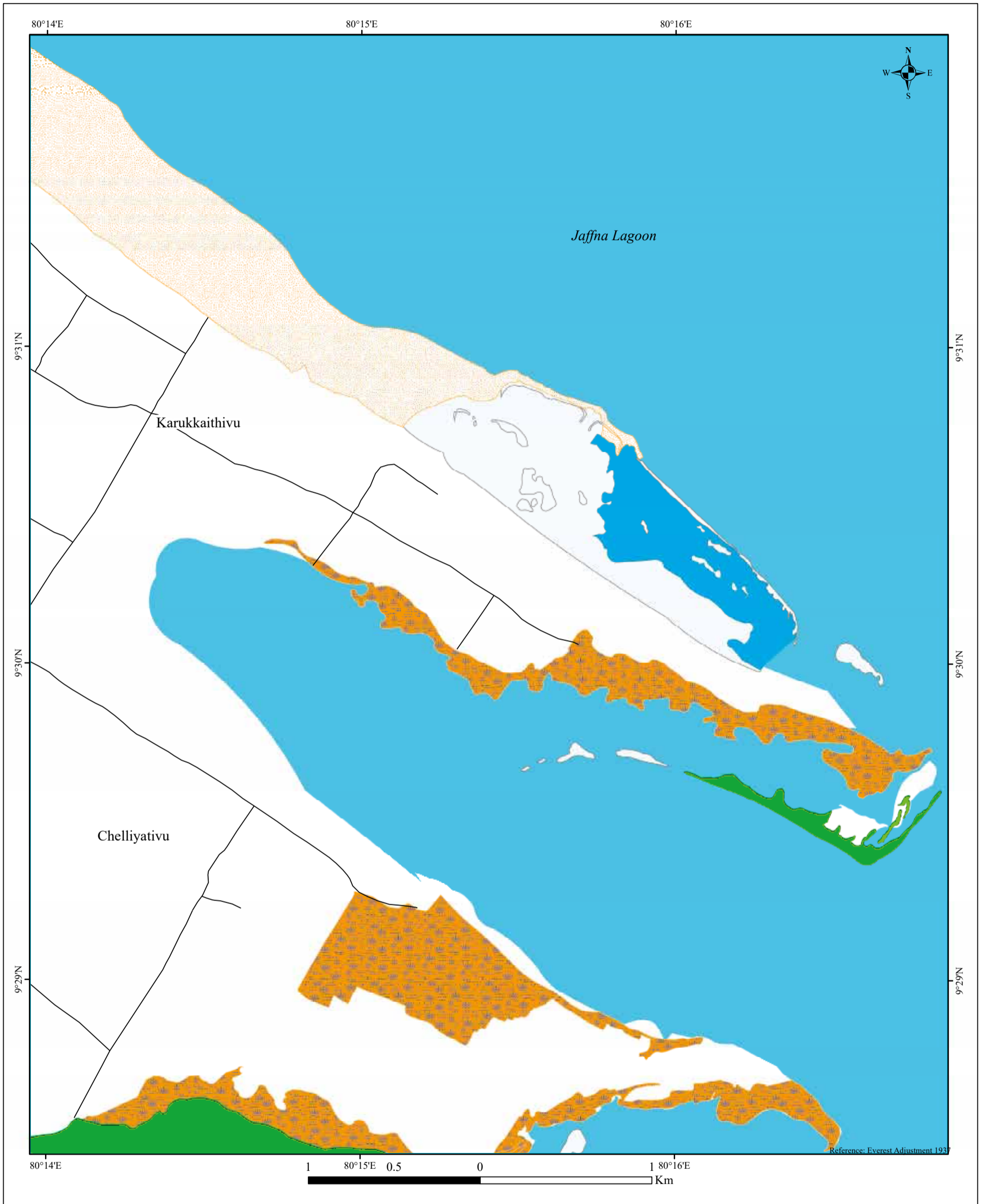


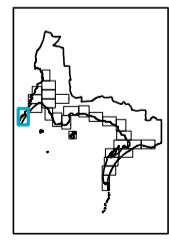
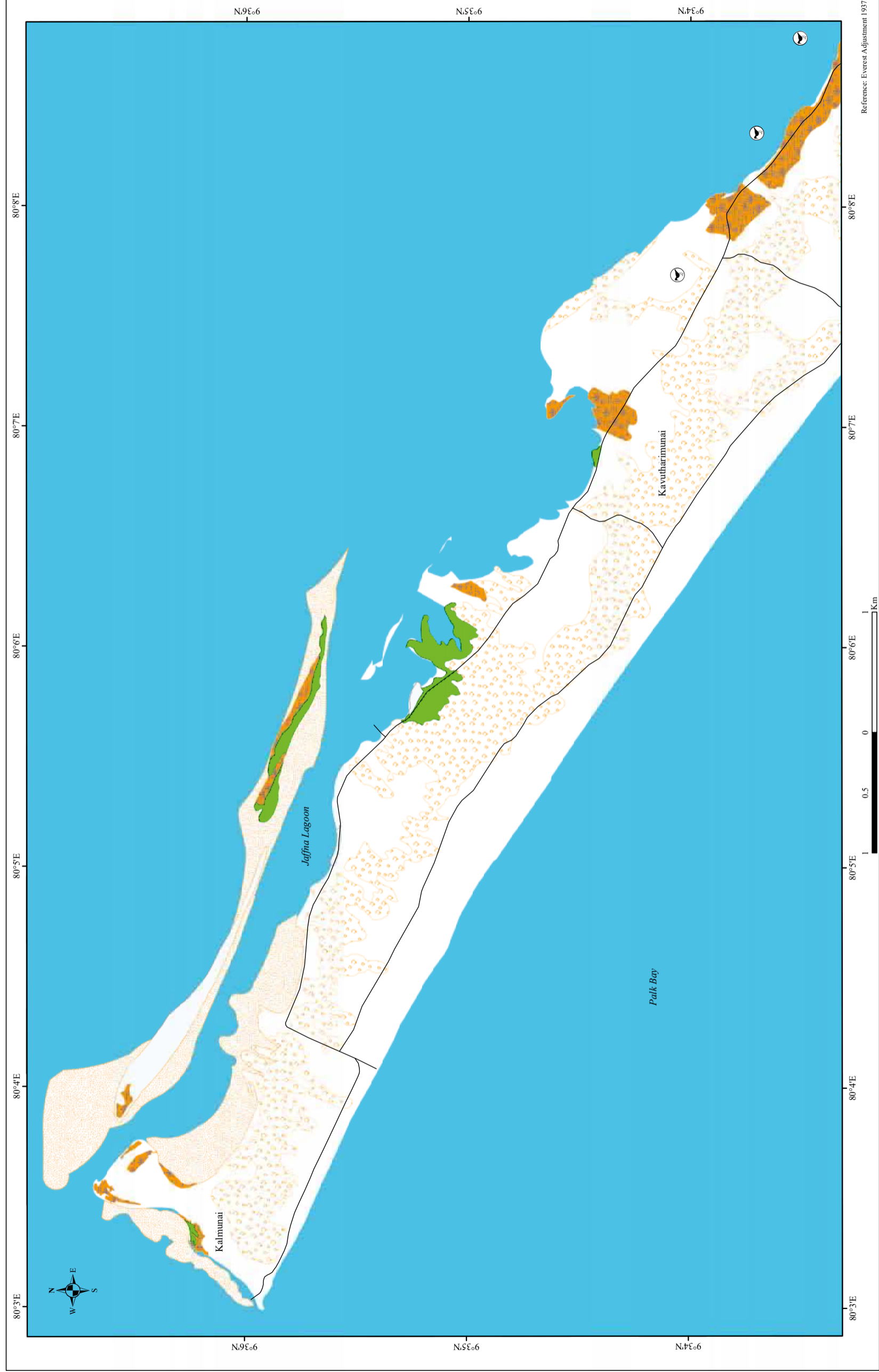


Legend					
Bird Sightings	Road Types	Vegetation Types	Other Land Cover Types	Surface Water	
Place Names	----- Footpath	Mangrove	Sand Dune	Tidal Creek	Other
	——— Jeep Track	Salt Marsh	Tidal Mudflats	Sea	



Legend				
Bird Sightings	Road Types	Vegetation Types	Other Land Cover Types	Surface Water
Place Names	Main Road	Mangrove	Aquaculture Farm	Tidal Creek
	Secondary Road	Salt Marsh	Sand Dune	Tank
	Footpath	Forest	Tidal Mudflats	Sea
	Jeep Track			Other





Legend

Bird Sightings	Jeep Track	Vegetation Types	Mangrove	Other Land Cover Types	Sea
Place Names		Salt Marsh	Sand Dune	Tidal Mudflats	Other

APPENDICES

Appendix I. List of plants recorded in mangroves

Family	Species	English name	Sinhala name	Tamil name	Life form	NCS
True mangroves						
Acanthaceae	<i>Avicennia marina</i>	Grey mangrove	Manda, Manda Gas		Tree	LC
Combretaceae	<i>Lumnitzera racemosa</i>	Black Mangrove	Beraliya, Beriya		Tree	NT
Euphorbiaceae	<i>Excoecaria agallocha</i>	Blind your eye tree, Blinding tree	Talakiriya, Tela kiriya	Tilai	Tree	LC
Lythraceae	<i>Pemphis acidula</i>		Muhudu wara		Shrub	NT
Lythraceae	<i>Sonneratia alba</i>		Kirilla / Kirala	Kinnai	Tree	EN
Primulaceae	<i>Aegiceras corniculata</i>	River mangrove	Hin-Kadol, Avari Kadol	Vitlikanna	Shrub	LC
Rhizophoraceae	<i>Bruguiera cylindrica</i>		Heen Mal Kadol		Tree	EN
Rhizophoraceae	<i>Rhizophora mucronata</i>	Asiatic mangrove	Kadol, Maha Kadol	Kandal	Tree	LC
Rubiaceae	<i>Scyphiphora hydrophyllacea</i>		Kalu-kadol		Tree	VU
Mangrove associates						
Lamiaceae	<i>Clerodendrum inerme</i>		Burende, Gulinda		Shrub	
Lamiaceae	<i>Premna obtusifolia</i>	Headache tree	Midhi, Wal-Midi	Pasumunnai	Shrub	LC
Malvaceae	<i>Thespesia populnea</i>	Tulip tree, Pacific rosewood	Suriya, Gansuriya	Kavarachu	Tree	LC
Salvadoraceae	<i>Salvadora persica</i>	Salt bush / Tooth brush tree	Malittan, Peelu	Perungoli	Tree	NT
Sapotaceae	<i>Manilkara hexandra</i>	Obtuse leaved mimusops	Palu	Palai / Sivandi	Tree	VU
Tamaricaceae	<i>Tamarix indica</i>		Kiri		Shrub	LC
Typhaceae	<i>Typha agustifolia</i>	Bullrush, Cat-tail, Lessar bulsrush,	Hambu-pan		Herb	LC
Other dry zone species record in mangroves						
Aizoaceae	<i>Sesuvium portulacastrum</i>	Seaside purslane, Shore purselane	Maha sarana		Herb	NT
Amaranthaceae	<i>Aerva lanata</i>	Aerva	Polkudu pala, Polpala	Cerupulai	Herb	LC
Amaranthaceae	<i>Halosarcia indica</i>				Herb	NT
Amaranthaceae	<i>Salicornia branchiata</i>				Herb	NT
Amaranthaceae	<i>Suaeda maritima</i>		Umiri		Herb	NT
Amaranthaceae	<i>Suaeda monoica</i>				Shrub	NT
Amaranthaceae	<i>Suaeda vermiculata</i>	Wormleaf saltwort			Herb	NT
Arecaceae	<i>Cocos nucifera</i>	Coconut, King coconut	Pol, Thembili	Tennai	Tree	
Arecaceae	<i>Phonix pusilla</i>	Small wild date palm	Indi, Wal indi	Inchu	Shrub	LC
Asteraceae	<i>Vernonia cinerea</i>	Little iron weed, Ash fleabane	Monorakudumbiya	Ehitiviyarchenkalainir	Herb	LC
Cactaceae	<i>Opuntia dillenii</i>	Prickly pear / Snake hood fig	Katu-pathok	Kalli	Herb	
Capparaceae	<i>Crateva adansonii</i>	Three-leaved caper	Lunuwarana	Navala	Tree	LC
Celastraceae	<i>Maytenus emarginata</i>				Shrub	
Celastraceae	<i>Salacia chinensis</i>		Heen-himbutu		Liana	NT
Connvolvulaceae	<i>Evolvulus alsinoides</i>	Little glory, Dwarf morning glory	Visnu-kranthi	Vishnu kiranthi	Herb	LC
Connvolvulaceae	<i>Ipomoea pes-caprae</i>	Goat's foot glory	Mudu-bin-thamburu	Adambu	Runner	LC
Cyperaceae	<i>Cyperus stoloniferus</i>				Herb	LC
Euphorbiaceae	<i>Euphorbia indica</i>	Hypericum-leaf spurge	Ela-dada-kiriya		Herb	LC
Fabaceae	<i>Acacia eburnea</i>	Cockspur thron	Gini andara, Udai-Vel	Kaludai / Udai-vel	Tree	LC
Fabaceae	<i>Acacia planifrons</i>	Jungle nail, Umbrella tree			Tree	LC
Fabaceae	<i>Indigofera oblongifolia</i>		Nari Mun		Shrub	VU
Fabaceae	<i>Prosopis juliflora</i>	Mesqite	Katu-siyambala		Tree	
Fabaceae	<i>Senna auriculata</i>	Matara tea, Tanner's cassia	Ranawara	Avarai	Tree	VU
Goodeniaceae	<i>Scaevola taccada</i>	Half flower, Beachberry	Takkada		Shrub	LC
Lamiaceae	<i>Leucas zeylanica</i>	Thumbe	Geta-Thumba	Mudi-tumpai	Herb	LC
Lythraceae	<i>Lawsonia inermis</i>	Camphire, Henna, Tree-mignonette	Marathodi	Maruthondi	Shrub	LC
Meliaceae	<i>Azadirachta indica</i>	Margosa, Neem	Kohomba	Vembu	Tree	
Myrtaceae	<i>Syzygium cumini</i>	Java plum, Jambol, Black plum	Ma-Dan, Dan	Naval / Perunaval	Tree	LC
Orobanchaceae	<i>Striga angustifolia</i>	White withchweed			Herb	NT
Pandanaceae	<i>Pandanus odorifer</i>	Screw-pine / Umbrella tree	Mudu keyiya, Weta-Keiya	Talai / Kaidai	Shrub	LC
Phyllanthaceae	<i>Flueggea leucopyrus</i>	Water caltrop / Spinous fluggea	Heen Katu pila	Mudpulanti / Pulanji	Shrub	LC
Poaceae	<i>Aeluropus lagopoides</i>				Herb	LC
Poaceae	<i>Cynodon dactylon</i>	Bermuda grass, Doob grass	E thana / Ruha	Arugampullu	Herb	LC
Poaceae	<i>Spinifex littoreus</i>		Maha-rawana-revula	Ravanan-meesai	Herb	LC
Vitaceae	<i>Cissus quadrangularis</i>	Weld grape, Edible-stemmed vine	Heeressa, Heeressa palu	Arugani / Kiritti	Vine	LC

NCS - National Conservation Status (based on the National Red List 2012 of Sri Lanka, MOE 2012)

CR - Critically Endangered, EN - Endangered, VU - Vulnerable, NT - Near Threatened, LC - Least Concerned, DD - Data Deficient

Appendix II. List of fauna recorded in different habitats within the project area

GROUP	English Name	NCS	GCS	Mangroves	Salt marshes	Sand dunes	Prosopsis stands
Family							
Species							
LAND SNAILS							
Ariophantidae							
<i>Cryptozona bistrialis</i>	Common Translucent Snail	LC	-	-	-	-	+
Bradybaenidae							
<i>Bradybaena similaris</i> ^{EX}		-	-	-	+	-	+
Camaenidae							
<i>Trachia vittata</i>		CR	-	+	-	-	-
DRAGONFLIES							
Coenagrionidae							
<i>Ischnura aurora</i>	Dawn Bluetail	NT	LC	-	+	-	-
<i>Ischnura senegalensis</i>	Common Bluetail	LC	LC	-	+	-	+
Libellulidae							
<i>Acisoma panorpoides</i>	Asian Pintail	LC	LC	-	+	-	-
<i>Brachydiplax sobrina</i>	Sombre Lieutenant	LC	LC	-	+	-	-
<i>Brachythemis contaminata</i>	Asian Groundling	LC	LC	+	+	-	-
<i>Diplacodes trivialis</i>	Blue Percher	LC	LC	-	+	-	+
<i>Macrodiplax cora</i>	Coastal Pennant	VU	LC	-	+	-	-
<i>Orthetrum prunosum</i>	Pink Skimmer	NT	LC	+	+	-	-
<i>Orthetrum sabina</i>	Green Skimmer	LC	LC	-	+	-	-
<i>Pantala flavescens</i>	Wandering Glider	LC	LC	-	+	-	-
<i>Trithemis aurora</i>	Crimson Dropwing	LC	LC	+	+	-	-
Platycnemididae							
<i>Copera marginipes</i>	Yellow featherleg	LC	LC	-	+	-	-
BUTTERFLIES							
Lycaenidae							
<i>Azanus jesus</i>	African Babul Blue	LC	-	-	+	+	+
<i>Castalius rosimon</i>	Common Pierrot	LC	-	-	+	-	-
<i>Catochrysops strabo</i>	Forget-me-not	LC	-	-	+	-	-
<i>Chilades pandava</i>	Plains Cupid	LC	-	-	+	-	+
<i>Chilades parrhasius</i>	Small Cupid	LC	-	-	+	-	-
<i>Freyeria putli</i>	Eastern Grass Jewel	LC	-	-	+	-	+
<i>Jamides celeno</i>	Common Cerulean	LC	-	-	+	+	-
<i>Junonia almana</i>	Peacock Pansy	LC	-	-	+	-	-
<i>Zizeeria karsandra</i>	Dark Grass Blue	LC	-	-	+	-	+
<i>Zizina otis</i>	Lesser Grass Blue	LC	-	-	+	-	+
Nymphalidae							
<i>Acraea violae</i>	Tawny Coster	LC	-	-	+	-	-
<i>Danaus chrysippus</i>	Plain Tiger	LC	-	+	+	+	+
<i>Danaus genutia</i>	Common Tiger	LC	-	-	+	-	+
<i>Elymnias hypermnestra</i>	Common Palmfly	LC	-	-	+	+	-
<i>Euploea core</i>	Common Indian Crow	LC	-	+	+	+	+
<i>Euploea klugii</i>	Brown King Crow	LC	-	-	+	-	-
<i>Junonia iphita</i>	Chocolate Soldier	LC	-	-	+	-	+
<i>Neptis hylas</i>	Common Sailor	LC	-	-	+	-	+
<i>Tirumala limniace</i>	Blue Tiger	LC	-	+	+	-	+
<i>Ypthima ceylonica</i>	White Four-ring	LC	-	-	+	-	+
Papilionidae							
<i>Pachliopta hector</i>	Crimson Rose	LC	-	+	+	+	+
<i>Papilio demoleus</i>	Lime Butterfly	LC	-	-	+	+	-
<i>Papilio polytes</i>	Common Mormon	LC	-	+	+	-	+
Pieridae							
<i>Appias albina</i>	Common Albatross	LC	-	-	+	-	-
<i>Appias galene</i> *	Sri Lanka Lesser Albatross	LC	-	-	+	+	-
<i>Catopsilia pomona</i>	Lemon Emigrant	LC	-	+	+	+	+
<i>Catopsilia pyranthe</i>	Mottled Emigrant	LC	-	-	+	-	-
<i>Colotis amata</i>	Small Salmon Arab	LC	-	-	+	+	+
<i>Colotis aurora</i>	Plain Orange Tip	VU	-	-	-	-	+
<i>Delias eucharis</i>	Jezebel	LC	-	+	+	+	+
<i>Eurema hecabe</i>	Common Grass Yellow	LC	-	-	+	-	+

Appendix II. cont.

GROUP	English Name	NCS	GCS	Mangroves	Salt marshes	Sand dunes	Prosopis stands
FISHES							
Adrianichthyidae							
<i>Oryzias dancena</i>	Common Blue Eye	DD	LC	+	+	-	-
Anabantidae							
<i>Anabas testudineus</i>	Climbing Perch	LC	DD	+	+	-	-
Channidae							
<i>Chanos chanos</i>	Milkfish	LC	-	+	+	-	-
AMPHIBIANS							
Dicroglossidae							
<i>Euphlyctis cyanophlyctis</i>	Indian skipper frog	LC	-	-	+	-	-
<i>Fejervarya syhadrensis</i>	Common paddy field frog	LC	-	-	+	-	-
<i>Hoplobatrachus crassus</i>	Jurdon's bullfrog	LC	-	-	+	+	-
<i>Sphaerotheca breviceps</i>	Short-headed burrowing frog	LC	-	-	+	+	-
REPTILES							
Agamidae							
<i>Calotes versicolor</i>	Common garden lizard	LC	-	-	+	+	+
<i>Sitana devakai*</i>	-	-	-	-	+	+	-
Colubridae							
<i>Cerberus rynchops</i>	Dog-faced water snake	LC	LC	+	-	-	-
<i>Ptyas mucosa</i>	Rat snake	LC	-	-	+	-	-
<i>Xenochrophis asperrimus*</i>	Sri Lanka keelback	LC	-	+	-	-	-
Viperidae							
<i>Echis carinatus</i>	Saw scale viper	VU	-	-	-	+	-
BIRDS							
Aegithinidae							
<i>Aegithina tiphia</i>	Common lora	LC	LC	-	+	-	-
Alaudidae							
<i>Alauda gulgula</i>	Oriental Skylark	LC	LC	-	+	-	-
<i>Mirafra affinis</i>	Jerdon's Bush Lark	LC	LC	-	+	-	-
Alcedinidae							
<i>Alcedo atthis</i>	Common Kingfisher	LC	LC	+	+	-	-
<i>Ceryle rudis</i>	Pied Kingfisher	LC	LC	+	+	-	-
<i>Halcyon smyrnensis</i>	White-Throated Kingfisher	LC	LC	+	+	-	-
Anatidae							
<i>Anas acuta</i>	Northern Pintail	-	-	-	+	-	-
<i>Anas clypeata</i>	Northern Shoveler	-	-	-	+	-	-
<i>Anas poecilorhyncha</i>	Spot-billed Duck	-	-	-	+	-	-
<i>Spatula querquedula</i>	Garganey	-	-	-	+	-	-
Ardeidae							
<i>Ardea cinerea</i>	Grey Heron	LC	LC	+	+	-	-
<i>Bubulcus ibis</i>	Western Cattle Egret	LC	LC	-	+	-	-
<i>Casmerodius albus</i>	Great Egret	LC	LC	+	+	-	-
<i>Egretta garzetta</i>	Little Egret	LC	LC	+	+	-	-
<i>Egretta gularis</i>	Western Reef Egret	-	-	-	+	-	-
<i>Mesophoyx intermedia</i>	Intermediate Egret	LC	LC	+	+	-	-
Artamidae							
<i>Artamus fuscus</i>	Ashy Woodswallow	LC	LC	-	+	-	+
Burhinidae							
<i>Burhinus oedicnemus</i>	Eurasian Stone-curlew	LC	LC	-	+	-	-
<i>Esacus recurvirostris</i>	Great Stone-curlew	LC	LC	-	+	-	-
Charadriidae							
<i>Charadrius alexandrinus</i>	Kentish Plover	VU	LC	+	+	-	-
<i>Charadrius dubius</i>	Little Ringed Plover	VU	LC	-	+	-	-
<i>Charadrius hiaticula</i>	Common Ringed Plover	-	-	+	+	-	-
<i>Charadrius leschenaultii</i>	Greater Sand Plover	-	-	-	+	-	-
<i>Charadrius mongolus</i>	Lesser Sand Plover	-	-	-	+	-	-

GROUP	English Name	NCS	GCS	Mangroves	Salt marshes	Sand dunes	Prosopis stands
Family							
<i>Species</i>							
<i>Pluvialis fulva</i>	Pacific Golden Plover	-	-	-	+	-	-
<i>Pluvialis squatarola</i>	Grey Plover	-	-	-	+	-	-
<i>Vanellus indicus</i>	Red-Wattled Lapwing	LC	LC	-	+	-	-
<i>Vanellus malarbaricus</i>	Yellow-Wattled Lapwing	LC	LC	-	+	-	-
Ciconiidae							
<i>Mycteria leucocephala</i>	Painted Stork	LC	NT	-	+	-	-
<i>Anastomus oscitans</i>	Asian Openbill	LC	LC	-	+	-	-
<i>Ciconia episcopus</i>	Woolly-necked Stork	NT	LC	-	+	-	-
Cisticolidae							
<i>Cisticola juncidis</i>	Zitting Cisticola	LC	LC	-	+	-	-
<i>Prinia inornata</i>	Plain Prinia	LC	-	+	+	+	+
<i>Prinia sylvatica</i>	Jungle Prinia	LC	LC	-	+	-	+
Corvidae							
<i>Corvus leuillantii</i>	Jungle Crow	LC	LC	+	+	+	+
<i>Corvus splendens</i>	House Crow	LC	LC	+	+	+	+
Dicaeidae							
<i>Dicaeum erythrorhynchos</i>	Pale Billed Flowerpecker	LC	LC	+	+	+	+
Dicruridae							
<i>Dicrurus leucophaeus</i>	Ashy Drongo	-	-	-	+	-	-
<i>Dicrurus macrocercus</i>	Black Drongo	LC	LC	+	+	-	-
Estrididae							
<i>Lonchura striata</i>	White Rumped Munia	LC	LC	-	+	-	+
<i>Lonchura punctulata</i>	Scaly Breasted Munia	LC	LC	-	+	-	-
Glareolidae							
<i>Glareola lactea</i>	Small Pratincole	-	-	+	+	-	-
Hirundinidae							
<i>Cecropis hyperythra*</i>	Sri Lanka Swallow	LC	LC	-	+	-	+
<i>Hirundo rustica</i>	Barn Swallow	-	-	+	+	+	+
Jacaniidae							
<i>Hydrophasianus chirurgus</i>	Pheasant-tailed Jacana	LC	LC	-	+	-	-
Laniidae							
<i>Lanius cristatus</i>	Brown Shrike	-	-	-	+	+	-
Laridae							
<i>Chlidonias hybrida</i>	Whiskered Tern	-	-	+	+	-	-
<i>Chroicocephalus brunnicephalus</i>	Brown-headed Gull	-	-	+	+	-	-
<i>Gelochelidon nilotica</i>	Gull-billed Tern	-	-	-	+	-	-
<i>Hydroprogne caspia</i>	Caspian Tern	-	-	-	+	-	-
<i>Larus fuscus</i>	Heuglin's Gull	-	-	-	+	-	-
<i>Sterna hirundo</i>	Common Tern	-	-	-	+	-	-
<i>Sterna sumatrana</i>	Black-naped Tern	-	-	-	+	-	-
<i>Sternula albifrons</i>	Little Tern	-	-	-	+	-	-
<i>Thalasseus bengalensis</i>	Lesser Crested Tern	-	-	-	+	-	-
<i>Thalasseus bergii</i>	Greater Crested Tern	-	-	-	+	-	-
Megalaimidae							
<i>Psilopogon zeylanicus</i>	Brown-headed Barbet	LC	LC	+	+	+	+
<i>Psilopogon haemacephalus</i>	Coppersmith Barbet	LC	LC	-	+	-	-
<i>Psilopogon rubricapillus*</i>	Crimson-fronted Barbet	LC	LC	-	+	-	-
Meropidae							
<i>Merops leschenaulti</i>	Chestnut-headed Bee-eater	LC	LC	+	+	-	+
<i>Merops orientalis</i>	Little Green Bee-eater	LC	LC	+	+	+	+
<i>Merops philippinus</i>	Blue tailed Bee-eater	-	-	-	+	-	-
Motacillidae							
<i>Anthus rufulus</i>	Paddyfield Pipit	LC	LC	-	+	-	-
Muscicapidae							
<i>Saxicoloides fulicatus</i>	Indian Robin	LC	LC	-	+	-	+
Nectariniidae							
<i>Cinnyris lotenius</i>	Loten's Sunbird	LC	LC	-	+	-	+
<i>Leptocoma zeylonica</i>	Purple-rumped Sunbird	LC	LC	-	+	-	+
Pelecanidae							
<i>Pelecanus philippensis</i>	Spot-billed Pelican	LC	NT	-	+	-	-

Appendix II. cont.

GROUP	English Name	NCS	GCS	Mangroves	Salt marshes	Sand dunes	Prosopis stands
Family							
Species							
Phasianidae							
<i>Francolinus pondicerianus</i>	Grey Francolin	NT	LC	-	+	+	+
<i>Gallus lafayetii</i> *	Sri Lanka Junglefowl	LC	LC	-	+	-	+
<i>Gallus sp.</i>	Domestic fowl	-	-	-	+	-	-
<i>Pavo cristatus</i>	Indian Peafowl	LC	LC	-	+	-	-
Pycnonotidae							
<i>Pycnonotus cafer</i>	Red Vented Bulbul	LC	LC	-	+	+	+
<i>Pycnonotus luteolus</i>	White Browed Bulbul	LC	LC	-	+	-	-
Recurvirostridae							
<i>Himantopus himantopus</i>	Black-Winged Stilt	LC	LC	-	+	-	-
Scolopacidae							
<i>Actitis hypoleucos</i>	Common Sandpiper	-	-	+	+	-	-
<i>Arenaria interpres</i>	Ruddy Turnstone	-	-	-	+	-	-
<i>Calidris alba</i>	Sanderling	-	-	-	+	-	-
<i>Calidris alpina</i>	Dunlin	-	-	-	+	-	-
<i>Calidris falcinellus</i>	Broad-billed Sandpiper	-	-	-	+	-	-
<i>Calidris ferruginea</i>	Curlew Sandpiper	-	-	-	+	-	-
<i>Calidris minuta</i>	Little Stint	-	-	-	+	-	-
<i>Calidris temminckii</i>	Temminck's Stint	-	-	-	+	-	-
<i>Calidris pugnax</i>	Ruff	-	-	-	+	-	-
<i>Limosa lapponica</i>	Bar-tailed Godwit	-	-	-	+	-	-
<i>Limosa limosa</i>	Black-tailed Godwit	-	-	-	+	-	-
<i>Numenius phaeopus</i>	Whimbrel	-	-	-	+	-	-
<i>Numenius arquata</i>	Eurasian Curlew	-	-	+	+	-	-
<i>Tringa glareola</i>	Wood Sandpiper	-	-	-	+	-	-
<i>Tringa nebularia</i>	Common Greenshank	-	-	+	+	-	-
<i>Tringa ochropus</i>	Green Sandpiper	-	-	-	+	-	-
<i>Tringa stagnatilis</i>	Marsh Sandpiper	-	-	-	+	-	-
<i>Tringa totanus</i>	Common Redshank	-	-	+	+	-	-
Sturnidae							
<i>Acridotheres tristis</i>	Common Myna	LC	LC	+	+	+	+
Sylviidae							
<i>Acrocephalus stentoreus</i>	Clamorous Reed Warbler	NT	LC	-	+	-	-
<i>Orthotomus sutorius</i>	Common Tailorbird	LC	LC	+	+	+	+
Threskiornithidae							
<i>Platalea leucorodia</i>	Eurasian Spoonbill	LC	LC	-	+	-	-
<i>Plegadis falcinellus</i>	Glossy Ibis	-	-	-	+	-	-
<i>Threskiornis melanocephalus</i>	Black-headed Ibis	LC	NT	-	+	-	-
MAMMALS							
Bovidae							
<i>Bos taurus</i>	Domestic cattle	-	-	+	+	-	+
Canidae							
<i>Canis familiaris</i>	Domestic dog	-	-	+	+	-	+
Cercopithecidae							
<i>Semnopithecus priam</i>	Grey langur	LC	NT	-	+	-	+
Cervidae							
<i>Axis axis</i>	Spotted deer	LC	LC	-	+	-	-
Equidae							
<i>Equus asinus</i>	Donkey	-	-	-	+	-	+
Felidae							
<i>Felis catus</i>	Domestic cat	-	-	-	+	-	+
Herpestidae							
<i>Herpestes fuscus</i>	Brown Mongoose	LC	-	-	+	-	-
Leporidae							
<i>Lepus nigricollis</i>	Black-naped hare	LC	LC	-	+	-	+
Suidae							
<i>Sus scrofa</i>	Wild boar	LC	LC	-	+	-	-

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GCS - Global Conservation Status (based on the National Red List 2012 of Sri Lanka, MOE 2012)

CR - Critically Endangered, EN - Endangered, VU - Vulnerable, NT - Near Threatened, LC - Least Concerned, DD - Data Deficient

Appendix III. List of plants recorded in salt marshes

Family	Species	Life form	NCS
<u>True salt marsh species</u>			
Aizoaceae	<i>Sesuvium portulacastrum</i>	Herb	NT
Amaranthaceae	<i>Halosarcia indica</i>	Herb	NT
Amaranthaceae	<i>Salicornia branchiata</i>	Herb	NT
Amaranthaceae	<i>Suaeda maritima</i>	Herb	NT
Amaranthaceae	<i>Suaeda monoica</i>	Shrub	NT
Amaranthaceae	<i>Suaeda vermiculata</i>	Herb	NT
Boraginaceae	<i>Heliotropium curassavicum</i>	Herb	LC
Connvolvulaceae	<i>Cressa cretica</i>	Herb	LC
<u>Salt marsh associates</u>			
Amaranthaceae	<i>Atriplex repens</i>	Herb	NT
Asteraceae	<i>Epaltes divaricata</i>	Herb	LC
Cyperaceae	<i>Cyperus arenarius</i>	Herb	LC
Cyperaceae	<i>Cyperus rotundus</i>	Herb	LC
Cyperaceae	<i>Cyperus stoloniferus</i>	Herb	LC
Cyperaceae	<i>Eleocharis geniculata</i>	Herb	LC
Cyperaceae	<i>Fimbristylis nigro-brunnea</i>	Herb	
Cyperaceae	<i>Fimbristylis polytrichoides</i>	Herb	LC
Cyperaceae	<i>Fimbristylis pubisquama</i>	Herb	LC
Cyperaceae	<i>Fimbristylis triflora</i>	Herb	LC
Cyperaceae	<i>Scripus supinus</i>	Herb	
Euphorbiaceae	<i>Euphorbia indica</i>	Herb	LC
Fabaceae	<i>Indigofera oblongifolia</i>	Shrub	VU
Gentianaceae	<i>Enicostema axillare</i>	Herb	LC
Lythraceae	<i>Ammannia baccifera</i>	Herb	LC
Orobanchaceae	<i>Striga angustifolia</i>	Herb	NT
Poaceae	<i>Aeluropus lagopoides</i>	Herb	LC
Poaceae	<i>Cynodon dactylon</i>	Herb	LC
Poaceae	<i>Panicum repens</i>	Herb	LC
Poaceae	<i>Zoysia matrella</i>	Herb	LC
Tamaricaceae	<i>Tamarix indica</i>	Shrub	LC
<u>Subordinate species</u>			
Acanthaceae	<i>Avicennia marina</i>	Tree	LC
Acanthaceae	<i>Dyschoriste erecta</i>	Herb	LC
Acanthaceae	<i>Justicia diffusa</i>	Herb	LC
Acanthaceae	<i>Justicia procumbens</i>	Herb	LC
Arecaceae	<i>Borassus flabellifer</i>	Tree	
Arecaceae	<i>Phonix pusilla</i>	Shrub	LC
Asteraceae	<i>Vicoa indica</i>	Herb	LC
Cactaceae	<i>Opuntia dillenii</i>	Herb	
Combretaceae	<i>Lumnitzera racemosa</i>	Tree	NT
Commelinaceae	<i>Commelina benghalensis</i>	Herb	LC
Commelinaceae	<i>Commelina diffusa</i>	Herb	LC
Commelinaceae	<i>Commelina ensifolia</i>	Herb	LC
Commelinaceae	<i>Cyanotis burmanniana</i>	Herb	VU
Commelinaceae	<i>Cyanotis cristata</i>	Herb	LC
Connvolvulaceae	<i>Evolvulus alsinoides</i>	Herb	LC
Cyperaceae	<i>Bulbostylis barbata</i>	Herb	LC
Cyperaceae	<i>Cyperus compressus</i>	Herb	
Cyperaceae	<i>Cyperus squarrosus</i>	Herb	LC
Cyperaceae	<i>Cyperus tenuispica</i>	Herb	LC
Cyperaceae	<i>Fimbristylis miliacea</i>	Herb	LC
Cyperaceae	<i>Fimbristylis ovata</i>	Herb	LC
Cyperaceae	<i>Kyllinga nemoralis</i>	Herb	
Euphorbiaceae	<i>Excoecaria agallocha</i>	Tree	LC
Fabaceae	<i>Acacia eburnea</i>	Tree	LC
Fabaceae	<i>Alysicarpus ovalifolius</i>	Herb	
Fabaceae	<i>Desmodium triflorum</i>	Herb	LC
Fabaceae	<i>Prosopis juliflora</i>	Tree	
Fabaceae	<i>Rhynchosia minima</i>	Vine	LC
Fabaceae	<i>Sesbania bispinosa</i>	Shrub	LC
Lamiaceae	<i>Clerodendrum inerme</i>	Shrub	
Lamiaceae	<i>Platostoma menthoides</i>	Herb	LC

Appendix III. cont.

Family	Species	Life form	NCS
<u>Subordinate species cont.</u>			
Lamiaceae	<i>Premna obtusifolia</i>	Shrub	LC
Lythraceae	<i>Pemphis acidula</i>	Shrub	NT
Lythraceae	<i>Sonneratia alba</i>	Tree	EN
Malvaceae	<i>Thespesia populnea</i>	Tree	LC
Poaceae	<i>Aegilops geniculata</i>	Herb	
Poaceae	<i>Aristida adscensionis</i>	Herb	VU
Poaceae	<i>Chloris barbata</i>	Herb	
Poaceae	<i>Chloris montana</i>	Herb	LC
Poaceae	<i>Digitaria longiflora</i>	Herb	LC
Poaceae	<i>Diplachne fusca</i>	Herb	
Poaceae	<i>Eragrostis ciliaris</i>	Herb	LC
Poaceae	<i>Eragrostis riparia</i>	Herb	LC
Poaceae	<i>Eragrostis tenella</i>	Herb	
Poaceae	<i>Eragrostis uniolooides</i>	Herb	LC
Poaceae	<i>Eragrostis viscosa</i>	Herb	LC
Poaceae	<i>Eriochloa procera</i>	Herb	LC
Poaceae	<i>Leersia hexandra</i>	Herb	LC
Poaceae	<i>Panicum sumatrense</i>	Herb	
Poaceae	<i>Paspalum scrobiculatum</i>	Herb	LC
Poaceae	<i>Perotis indica</i>	Herb	LC
Poaceae	<i>Spinifex littoreus</i>	Herb	LC
Poaceae	<i>Sporobolus coromandelianus</i>	Herb	LC
Poaceae	<i>Sporobolus diander</i>	Herb	LC
Poaceae	<i>Sporobolus virginicus</i>	Herb	LC
Poaceae	<i>Trachys muricata</i>	Herb	
Poaceae	<i>Urochloa setigera</i>	Herb	LC
Rhizophoraceae	<i>Rhizophora mucronata</i>	Tree	LC
Salvadoraceae	<i>Salvadora persica</i>	Tree	NT
Typhaceae	<i>Typha agustifolia</i>	Herb	LC
Verbenaceae	<i>Stachytarpheta indica</i>	Herb	
Violaceae	<i>Hybanthus enneaspermus</i>	Herb	LC

NCS - National Conservation Status (based on the National Red List 2012 of Sri Lanka, MOE 2012)

CR - Critically Endangered, EN - Endangered, VU - Vulnerable, NT - Near Threatened, LC - Least Concerned, DD - Data Deficient

Appendix IV. List of migratory birds and water birds recorded in the project area

GROUP	English Name	NCS	GCS	Status
Family				
Species				
Anatidae				
<i>Anas acuta</i>	Northern Pintail	-	-	M
<i>Anas clypeata</i>	Northern Shoveler	-	-	M
<i>Anas poecilorhyncha</i>	Spot-billed Duck	-	-	M
<i>Dendrocygna javanica</i>	Lesser Whistling-duck	LC	LC	R
<i>Spatula querquedula</i>	Garganey	-	-	M
Ardeidae				
<i>Ardea cinerea</i>	Grey Heron	LC	LC	R
<i>Bubulcus ibis</i>	Western Cattle Egret	LC	LC	R
<i>Casmerodius albus</i>	Great Egret	LC	LC	R
<i>Egretta garzetta</i>	Little Egret	LC	LC	R
<i>Egretta gularis</i>	Western Reef Egret	-	-	M
<i>Mesophoyx intermedia</i>	Intermediate Egret	LC	LC	R
Burhinidae				
<i>Burhinus oedicnemus</i>	Eurasian Stone-curlew	LC	LC	R/M
<i>Esacus recurvirostris</i>	Great Stone-curlew	LC	LC	R/M
Charadriidae				
<i>Charadrius alexandrinus</i>	Kentish Plover	VU	LC	R/M
<i>Charadrius dubius</i>	Little Ringed Plover	VU	LC	R/M
<i>Charadrius hiaticula</i>	Common Ringed Plover	-	-	M
<i>Charadrius leschenaultii</i>	Greater Sand Plover	-	-	M
<i>Charadrius mongolus</i>	Lesser Sand Plover	-	-	M
<i>Pluvialis fulva</i>	Pacific Golden Plover	-	-	M
<i>Pluvialis squatarola</i>	Grey Plover	-	-	M
Ciconiidae				
<i>Mycteria leucocephala</i>	Painted Stork	LC	NT	R
<i>Anastomus oscitans</i>	Asian Openbill	LC	LC	R
Glareolidae				
<i>Glareola lactea</i>	Small Pratincole	-	-	M
Jacanidae				
<i>Hydrophasianus chirurgus</i>	Pheasant-tailed Jacana	LC	LC	R
Laridae				
<i>Chlidonias hybrida</i>	Whiskered Tern	-	-	M
<i>Chroicocephalus brunnicephalus</i>	Brown-headed Gull	-	-	M
<i>Gelochelidon nilotica</i>	Gull-billed Tern	-	-	M
<i>Hydroprogne caspia</i>	Caspian Tern	-	-	M
<i>Larus fuscus</i>	Heuglin's Gull	-	-	M
<i>Sterna hirundo</i>	Common Tern	-	-	M
<i>Sterna sumatrana</i>	Black-naped Tern	-	-	M
<i>Sternula albifrons</i>	Little Tern	-	-	M
<i>Thalasseus bengalensis</i>	Lesser Crested Tern	-	-	M
<i>Thalasseus bergii</i>	Greater Crested Tern	-	-	M
Pelecanidae				
<i>Pelecanus philippensis</i>	Spot-billed Pelican	LC	NT	R
Phoenicopteridae				
<i>Phoenicopus roseus</i>	Greater Flamingo	-	-	M
Recurvirostridae				
<i>Himantopus himantopus</i>	Black-Winged Stilt	LC	LC	R
Scolopacidae				
<i>Actitis hypoleucos</i>	Common Sandpiper	-	-	M
<i>Arenaria interpres</i>	Ruddy Turnstone	-	-	M
<i>Calidris alba</i>	Sanderling	-	-	M
<i>Calidris alpina</i>	Dunlin	-	-	M
<i>Calidris falcinellus</i>	Broad-billed Sandpiper	-	-	M
<i>Calidris ferruginea</i>	Curlew Sandpiper	-	-	M
<i>Calidris minuta</i>	Little Stint	-	-	M
<i>Calidris temminckii</i>	Temminck's Stint	-	-	M
<i>Calidris pugnax</i>	Ruff	-	-	M
<i>Limosa lapponica</i>	Bar-tailed Godwit	-	-	M
<i>Limosa limosa</i>	Black-tailed Godwit	-	-	M
<i>Numenius phaeopus</i>	Whimbrel	-	-	M

Appendix IV. cont.

GROUP				
Family	English Name	NCS	GCS	Status
Species				
<i>Numenius arquata</i>	Eurasian Curlew	-	-	M
<i>Tringa glareola</i>	Wood Sandpiper	-	-	M
<i>Tringa nebularia</i>	Common Greenshank	-	-	M
<i>Tringa ochropus</i>	Green Sandpiper	-	-	M
<i>Tringa stagnatilis</i>	Marsh Sandpiper	-	-	M
<i>Tringa totanus</i>	Common Redshank	-	-	M
Threskiornithidae				
<i>Platalea leucorodia</i>	Eurasian Spoonbill	LC	LC	R
<i>Plegadis falcinellus</i>	Glossy Ibis	-	-	R/M
<i>Threskiornis melanocephalus</i>	Black-headed Ibis	LC	NT	R

NCS - National Conservation Status (based on the National Red List 2012 of Sri Lanka, MOE, 2012)

GCS - Global Conservation Status (based on the National Red List 2012 of Sri Lanka, MOE, 2012)

CR - Critically Endangered, EN - Endangered, VU - Vulnerable, NT - Near Threatened, LC - Least Concerned,
R - Resident, M - Migratory

Appendix V. List of plants recorded in *Prosopis* stands

Family	Species	English name	Sinhala name	Tamil name	Life form	NCS
Acanthaceae	<i>Justicia procumbens</i>	Common small justica			Herb	LC
Aizoaceae	<i>Sesuvium portulacastrum</i>	Seaside purslane	Maha sarana		Herb	NT
Amaranthaceae	<i>Aerva lanata</i>	Aerva	Polkudu pala, Polpala	Cerupulai	Herb	LC
Amaranthaceae	<i>Halosarcia indica</i>				Herb	NT
Amaranthaceae	<i>Suaeda maritima</i>		Umiri		Herb	NT
Amaranthaceae	<i>Suaeda monoica</i>				Shrub	NT
Amaryllidaceae	<i>Crinum zeylanicum</i>				Herb	VU
Apocynaceae	<i>Calotropis gigantea</i>	Giant milkweed	Ela WaraWara	Errukalai	Shrub	LC
Apocynaceae	<i>Carissa spinarum</i>		Heen-Karamba, Karamba	Chiru-kila	Shrub	LC
Apocynaceae	<i>Hemidesmus indicus</i>	Indian sarssaparilla	Heen-iramusu, Iramusu	Nannari	Vine	LC
Apocynaceae	<i>Pentatropis capensis</i>				Vine	LC
Arecaceae	<i>Borassus flabellifer</i>	Palmyrah / Plam	Thal	Panai	Tree	
Arecaceae	<i>Phonix pusilla</i>	Small wild date palm	Indi, Wal indi	Inchu	Shrub	LC
Asparagaceae	<i>Asparagus racemosus</i>	Wild asparagus	Hatawariya	Chattavari	Vine	LC
Asteraceae	<i>Vernonia cinerea</i>	Little iron weed, Ash fleabane	Monorakudumbiya	Ehitiviyarchenkalainir	Herb	LC
Asteraceae	<i>Vernonia zeylanica</i>		Hin-botiya, Papula	Kappilay	Herb	LC
Cactaceae	<i>Opuntia dillenii</i>	Prickly pear / Snake hood fig	Katu-pathok	Kalli	Herb	
Capparaceae	<i>Crateva adansonii</i>	Three-leaved caper	Lunuwarana	Navala	Tree	LC
Cleomaceae	<i>Cleome chelidonii</i>		Wal-aba		Herb	LC
Colchicaceae	<i>Gloriosa superba</i>	Glory lily, Flame lily, Vine lily	Niyagala	Karti kai kilanku	Vine	LC
Commelinaceae	<i>Commelina diffusa</i>		Gira-pala, Tanapala		Herb	LC
Commelinaceae	<i>Commelina ensifolia</i>				Herb	LC
Convolvulaceae	<i>Evolvulus alsinoides</i>	Little glory,	Visnu-kranthi	Vichna-	Herb	LC
Cucurbitaceae	<i>Coccinia grandis</i>	Ivy gourd	Kowakka	Kovvai	Vine	LC
Cyperaceae	<i>Bulbostylis barbata</i>		Uru hiri		Herb	LC
Cyperaceae	<i>Cyperus arenarius</i>		Mudu-kalanduru		Herb	LC
Cyperaceae	<i>Cyperus compressus</i>				Herb	
Cyperaceae	<i>Cyperus rotundus</i>	Nut grass	Kaladuru	Korai	Herb	LC
Cyperaceae	<i>Cyperus tenuispica</i>				Herb	LC
Cyperaceae	<i>Fimbristylis miliacea</i>		Mudu-hal-pan		Herb	LC
Cyperaceae	<i>Fimbristylis ovata</i>		E thana	Arukkam-pullu	Herb	LC
Cyperaceae	<i>Fimbristylis pubisquama</i>				Herb	LC
Cyperaceae	<i>Kyllinga nemoralis</i>				Herb	
Erythroxylaceae	<i>Erythroxylum monogynum</i>	Bastard sandal	Devadaram, Agil	Chemanatti	Tree	NT
Fabaceae	<i>Acacia eburnea</i>	Cockspur thron	Gini andara, Kludai	Kaludai / Udai-vel	Tree	LC
Fabaceae	<i>Acacia planifrons</i>	Jungle nail, Umbrella tree			Tree	LC
Fabaceae	<i>Alysicarpus ovalifolius</i>				Herb	
Fabaceae	<i>Desmodium triflorum</i>	Creeping tick threefoil	Heen-undupiyaliya	Sirupulladi	Herb	LC
Fabaceae	<i>Dichostachys cinerea</i>	Sickle bush	Andara, Katu andara	Vindattai / Anatter	Shrub	LC
Fabaceae	<i>Indigofera oblongifolia</i>		Nari Mun		Shrub	VU
Fabaceae	<i>Prosopis juliflora</i>		Katu-siyambala		Tree	
Lamiaceae	<i>Clerodendrum inerme</i>		Burende, Gulinda		Shrub	
Lamiaceae	<i>Leucas zeylanica</i>	Thumbe	Geta-Thumba	Mudi-tumpai	Herb	LC
Lamiaceae	<i>Leucas zeylanica</i>				Herb	
Lamiaceae	<i>Premna obtusifolia</i>	Headache tree	Midhi, Wal-Midi, Maha-midi	Pasumunnai	Shrub	LC
Loranthaceae	<i>Dendrophthoe falcata</i>		Delum pilia		Parasitic	LC
Lythraceae	<i>Ammannia baccifera</i>				Herb	LC
Malvaceae	<i>Thespesia populnea</i>	Tulip tree, Pacific rosewood	Suriya, Gansuriya	Kavarachu / Puvarachu	Tree	LC
Meliaceae	<i>Azadirachta indica</i>	Margosa, Neem	Kohomba	Vembu	Tree	
Molluginaceae	<i>Glinus oppositifolius</i>		Heen-ala	Kachchantirai	Herb	LC
Molluginaceae	<i>Mollugo cerviana</i>		Udetta, Pathpadagam		Herb	LC
Pedaliaceae	<i>Pedaliium murex</i>	Common pedaliium	Et-Nerenchi, Gokatu	Anai-nerechchi	Herb	LC
Phyllanthaceae	<i>Flueggea leucopyrus</i>	Water caltrop	Heen Katu pila	Mudpulanti / Pulanji	Shrub	LC
Poaceae	<i>Aristida setacea</i>		Et-tuttiri		Herb	LC
Poaceae	<i>Chloris barbata</i>		Mayuru-tana	Kondai-pal	Herb	
Poaceae	<i>Chloris montana</i>				Herb	LC
Poaceae	<i>Cynodon dactylon</i>	Bermuda grass	E thana / Ruha	Arugampullu	Herb	LC
Poaceae	<i>Digitaria longiflora</i>				Herb	LC
Poaceae	<i>Eragrostis ciliaris</i>				Herb	LC
Poaceae	<i>Eragrostis tenella</i>				Herb	
Poaceae	<i>Eragrostis unioloides</i>				Herb	LC
Poaceae	<i>Eragrostis viscosa</i>				Herb	LC
Poaceae	<i>Eriochloa procera</i>				Herb	LC
Poaceae	<i>Panicum repens</i>		Etora	Inji-pul	Herb	LC

Appendix V. cont.

Family	Species	English name	Sinhala name	Tamil name	Life form	NCS
Poaceae	<i>Paspalum scrobiculatum</i>	Kodo millet	Amu	Varagu	Herb	LC
Poaceae	<i>Perotis indica</i>				Herb	LC
Poaceae	<i>Sporobolus diander</i>				Herb	LC
Poaceae	<i>Sporobolus virginicus</i>		Mudu-etora		Herb	LC
Poaceae	<i>Zoysia matrella</i>				Herb	LC
Rhamnaceae	<i>Scutia myrtina</i>				Straggler	LC
Rhamnaceae	<i>Zizyphus oenopila</i>	Jacka / Jujube	Hin-Eraminia	Churai/Perilantai	Straggler	LC
Rubiaceae	<i>Catunaregam spinosa</i>	Spiny randia, Enetic-nut	Kukuruman	Karai	Shrub	LC
Rubiaceae	<i>Oldenlandia corymbosa</i>	Old world diamond flower	Wal-pathpadagam	Parpatagam	Herb	LC
Rubiaceae	<i>Oldenlandia umbellata</i>	Chay-root	Saummal / Saya, Chaya	Chaya	Herb	LC
Rubiaceae	<i>Spermacoce assurgens</i>				Herb	
Tamaricaceae	<i>Tamarix indica</i>		Kiri		Shrub	LC
Verbenaceae	<i>Stachytarpheta indica</i>	Dog's tail	Balunakuta	Nai-oringi	Herb	
Vitaceae	<i>Cissus quadrangularis</i>	Weld grape	Heeressa, Sirassa	Arugani / Indiravalli	Vine	LC
Zygophyllaceae	<i>Tribulus terrestris</i>	Puncture plant	Gokatu	Shivanarbembu	Herb	LC

NCS - National Conservation Status (based on the National Red List 2012 of Sri Lanka, MOE, 2012)

CR - Critically Endangered, EN - Endangered, VU - Vulnerable, NT - Near Threatened, LC - Least Concerned,

Appendix VI. List of plants recorded in sand dunes

Family	Species	English name	Sinhala name	Tamil name	Life form	NCS
Acanthaceae	<i>Dyschoriste erecta</i>				Herb	LC
Aizoaceae	<i>Sesuvium portulacastrum</i>	Seaside purslane	Maha sarana		Herb	NT
Amaranthaceae	<i>Aerva lanata</i>	Aerva	Polkudu pala, Polpala	Cerupulai	Herb	LC
Amaranthaceae	<i>Nothosaerva brachiata</i>		Thampala		Herb	NT
Amaranthaceae	<i>Salicornia brachiata</i>				Herb	NT
Amaryllidaceae	<i>Crinum zeylanicum</i>					VU
Apocynaceae	<i>Calotropis gigantea</i>	Giant milkweed,	Ela Wara, Wara	Errukalai	Shrub	LC
Apocynaceae	<i>Carissa spinarum</i>		Heen-Karamba, Karamba	Chiru-kila	Shrub	LC
Apocynaceae	<i>Hemidesmus indicus</i>	Indian sarssaparilla	Heen-iramusu, Iramusu	Nannari	Vine	LC
Apocynaceae	<i>Pentatropis capensis</i>				Vine	LC
Apocynaceae	<i>Tylophora indica</i>	Wild ipeca cuanha	Bin nuga, Mi nuga	Nancharapanchan	Vine	
Araceae	<i>Amorphophallus sylvaticus</i>					NT
Arecaceae	<i>Borassus flabellifer</i>	Palmyrah / Plam	Thal	Panai	Tree	
Arecaceae	<i>Cocos nucifera</i>	Coconut, King coconut	Pol, Thembili	Tennai	Tree	
Arecaceae	<i>Phonix pusilla</i>	Small wild date palm	Indi, Wal indi	Inchu	Shrub	LC
Asparagaceae	<i>Asparagus racemosus</i>	Wild asparagus	Hatawariya	Chattavari	Vine	LC
Asteraceae	<i>Vernonia cinerea</i>	Little iron weed	Monorakudumbiya	Ehitiviyarchenkalainir	Herb	LC
Asteraceae	<i>Vernonia zeylanica</i>		Hin-botiya, Papula	Kappilay	Herb	LC
Asteraceae	<i>Vicoa indica</i>		Ran-hiriya		Herb	LC
Cactaceae	<i>Opuntia dillenii</i>	Prickly pear	Katu-pathok	Kalli	Herb	
Cactaceae	<i>Portulaca quadrifida</i>		Heen-genda-kola			LC
Capparaceae	<i>Crateva adansonii</i>	Three-leaved caper	Lunuwarana	Navala	Tree	LC
Caryophyllaceae	<i>Polycarpaea corymbosa</i>	Oldman's cap			Herb	LC
Celastraceae	<i>Pleurostyliya opposita</i>		Panakka, Piyari	Chiru piyari	Tree	LC
Celastraceae	<i>Salacia oblonga</i>		Himbutu, Gal Himbutu		Liana	EN
Cleomaceae	<i>Cleome chelidonii</i>		Wal-aba			LC
Colchicaceae	<i>Gloriosa superba</i>	Glory lily, Flame lily	Niyagala	Karti kai kilanku	Vine	LC
Commelinaceae	<i>Commelina benghalensis</i>	Benghal dayflower	Diya-meneriya	Kananga	Herb	LC
Commelinaceae	<i>Cyanotis cristata</i>		Bol-hinda			LC
Convolvulaceae	<i>Evolvulus alsinoides</i>	Little glory	Visnu-kranthi	Vichna-kiranthi	Herb	LC
Convolvulaceae	<i>Ipomoea pes-caprae</i>	Goat's foot glory	Mudu-bin-thamburu	Adambu	Runner	LC
Cucurbitaceae	<i>Coccinia grandis</i>	Ivy gourd	Kowakka	Kovvai	Vine	LC
Cucurbitaceae	<i>Trichosanthes cucumerina</i>		Dum-mella, Kunu-mella,			LC
Ebenaceae	<i>Diospyros ferrea</i>				Tree	
Ebenaceae	<i>Diospyros malabarica</i>	Gaub persimmon / Riber ebony	Thimbiri	Panichchai	Tree	LC
Erythroxylaceae	<i>Erythroxylum monogynum</i>	Bastard sandal	Devadaram, Agil	Chemantti	Tree	NT
Euphorbiaceae	<i>Euphorbia indica</i>	Hypericum-leaf spurge	Ela-dada-kiriya		Herb	LC
Fabaceae	<i>Acacia eburnea</i>	Cockspur thron	Gini andara, Kludai,	Kaludai / Udai-vel	Tree	LC
Fabaceae	<i>Acacia planifrons</i>	Jungle nail, Umbrella tree			Tree	LC
Fabaceae	<i>Alysicarpus ovalifolius</i>				Herb	
Fabaceae	<i>Bauhinia racemosa</i>		Maila	Atti / Arai	Tree	LC
Fabaceae	<i>Caesalpinia bonduc</i>	Gray nicker	Kalu-Wavul-Atiya	Punai kkalaichchi	Straggler	LC
Fabaceae	<i>Canavalia linneata</i>				Liana	
Fabaceae	<i>Desmodium triflorum</i>	Creeping tick threefoil	Heen-undupiyaliya	Sirupulladi	Herb	LC
Fabaceae	<i>Dichostachys cinerea</i>	Sickle bush	Andara, Katu andara	Vindattai / Anatter	Shrub	LC
Fabaceae	<i>Indigofera aspalathoides</i>		Rat-Kohomba	Chivanarvempu	Herb	NT
Fabaceae	<i>Indigofera oblongifolia</i>		Nari Mun		Shrub	VU
Fabaceae	<i>Rhynchosia minima</i>		Maha-wal-kollu		Vine	LC
Fabaceae	<i>Tephrosia purpurea</i>	Common tephrosia, Fishpoison	Pila, Katuru pila,	Kavilai / Kawati	Herb	LC
Fabaceae	<i>Vigna trilobata</i>		Bin-me, Munwenna		Vine	NT
Goodeniaceae	<i>Scaevola taccada</i>	Half flower, Beachberry	Takkada		Shrub	LC
Lamiaceae	<i>Clerodendrum inerme</i>		Burende, Gulinda		Shrub	
Lamiaceae	<i>Leucas zeylanica</i>					
Lamiaceae	<i>Leucas zeylanica</i>	Thumbe	Geta-Thumba	Mudi-tumpai	Herb	LC
Lamiaceae	<i>Premna obtusifolia</i>	Headache tree	Midhi, Wal-Midi	Pasumunnai	Shrub	LC
Lauraceae	<i>Cassytha filiformis</i>	Love vine			Vine	LC
Loranthaceae	<i>Dendrophthoe falcata</i>		Delum pilia		Parasitic	LC
Lythraceae	<i>Lawsonia inermis</i>	Camphire, Henna	Marathodi	Maruthondi	Shrub	LC
Malvaceae	<i>Thespesia populnea</i>	Tulip tree, Pacific rosewood,	Suriya, Gansuriya	Kavarachu	Tree	LC
Meliaceae	<i>Azadirachta indica</i>	Margosa, Neem	Kohomba	Vembu	Tree	
Menispermaceae	<i>Hyserpa nitida</i>		Niri wel, Kiri wel		Vine	EN
Molluginaceae	<i>Glinus oppositifolius</i>		Heen-ala	Kachchantirai	Herb	LC
Molluginaceae	<i>Mollugo cerviana</i>		Udetta, Pathpadagam			LC

Appendix VI. cont.

Family	Species	English	Sinhala	Tamil	Life form	NCS
Moraceae	<i>Ficus benghalensis</i>	Krishna bo, Krishna's cup	Gotu nuga		Tree	
Moraceae	<i>Ficus microcarpa</i>		Panu-nuga, lti	Kallichchi	Tree	LC
Myrtaceae	<i>Syzygium cumini</i>	Java plum, Jambol, Black plum	Ma-Dan, Dan	Naval / Perunaval	Tree	LC
Myrtaceae	<i>Syzygium gardneri</i>		Damba, Dambu		Tree	LC
Ochnaceae	<i>Ochna obtusata</i>		Mal-Kera		Shrub	LC
Olacaceae	<i>Olax imbricata</i>		Telatiya		Shrub	NT
Orobanchaceae	<i>Striga angustifolia</i>	White withchweed			Herb	NT
Pandanaceae	<i>Pandanus odorifer</i>	Screw-pine / Umbrella tree	Mudu keyiya, Weta-Keiya	Talai / Kaidai	Shrub	LC
Pedaliaceae	<i>Pedaliium murex</i>	Common pedaliium	Et-Nerenchi, Gokatu	Anai-nerechchi	Herb	LC
Phyllanthaceae	<i>Flueggea leucopyrus</i>	Water caltrop	Heen Katu pila, Katupila	Mudpulanti / Pulanji	Shrub	LC
Plantaginaceae	<i>Dopatrium lobelioides</i>				Herb	LC
Poaceae	<i>Aristida adscensionis</i>		Boleela / Teli tana		Herb	VU
Poaceae	<i>Aristida setacea</i>		Et-tuttiri		Herb	LC
Poaceae	<i>Chloris barbata</i>		Mayuru-tana	Kondai-pal	Herb	
Poaceae	<i>Chloris montana</i>				Herb	LC
Poaceae	<i>Eragrostis ciliaris</i>				Herb	LC
Poaceae	<i>Eragrostis uniolooides</i>				Herb	LC
Poaceae	<i>Perotis indica</i>				Herb	LC
Poaceae	<i>Spinifex littoreus</i>		Maha-rawana-revula	Ravanan-meesai	Herb	LC
Poaceae	<i>Trachys muricata</i>				Herb	
Rhamnaceae	<i>Scutia myrtina</i>				Straggler	LC
Rhamnaceae	<i>Zizyphus oenopila</i>	Jacka / Jujube	Hin-Eraminia	Churai/Perilantai	Straggler	LC
Rubiaceae	<i>Canthium coromandelicum</i>		Kara	Karai	Tree	LC
Rubiaceae	<i>Catunaregam spinosa</i>	Spiny randia, Enetic-nut	Kukuruman, Kukurummuwan	Karai	Shrub	LC
Rubiaceae	<i>Ixora pavetta</i>	Toarch tree	Maha-Rathambala	Kanmuttankirai	Tree	LC
Rubiaceae	<i>Oldenlandia corymbosa</i>	Old world diamond flower	Wal-pathpadagam	Parpatagam	Herb	LC
Rubiaceae	<i>Oldenlandia umbellata</i>	Chay-root	Saummal /Saya, Chaya	Chaya	Herb	LC
Rubiaceae	<i>Spermacoce assurgens</i>					
Rubiaceae	<i>Spermacoce hispida</i>		Hin-geta-kola	Yar / Nattaichchuri	Herb	LC
Rubiaceae	<i>Tarenna asiatica</i>		Tarana, Maha Tarana	Karanai	Tree	LC
Rutaceae	<i>Toddalia asiatica</i>	Forest pepper	Kudu-Miris	Kandai	Straggler	LC
Salicaceae	<i>Flacourtia indica</i>	Governor's plum	Katukutundu	Katukali	Tree	LC
Sapindaceae	<i>Allophylus cobbe</i>		Bu-Kobbe, Kobbe	Amarai	Tree	LC
Sapindaceae	<i>Dodanaea viscosa</i>		Et-Werella	Virali	Shrub	LC
Sapotaceae	<i>Manilkara hexandra</i>	Obtuse leaved mimusops	Palu	Palai / Sivandi	Tree	VU
Solanaceae	<i>Physalis minima</i>		Heen-mottu, Lin-mottu			DD
Tamaricaceae	<i>Tamarix indica</i>		Kiri		Shrub	LC
Violaceae	<i>Hybanthus enneaspermus</i>	Spade flower	Maha yotu wenna	Oritad-tamarai	Herb	LC
Vitaceae	<i>Cissus quadrangularis</i>	Weld grape	Heeressa, Sirassa	Arugani / Kiritti	Vine	LC
Zygophyllaceae	<i>Tribulus terrestris</i>	Puncture plant, Land caltrops	Gokatu, Sembu nerenchi	Shivanarbembu	Herb	LC

NCS - National Conservation Status (based on the National Red List 2012 of Sri Lanka, MOE, 2012)

CR - Critically Endangered, EN - Endangered, VU - Vulnerable, NT - Near Threatened, LC - Least Concerned, DD - Data Deficient



Caspian terns (*Hydroprogne caspia*) and Heuglin's gulls (*Larus fuscus*)
in Vankalai Sanctuary



Lesser whistling ducks
(*Dendrocygna javanica*)



Vankalai Sanctuary (during the dry season)



Global Environment Facility Small Grants Programme of United Nations Development Programme (UNDP/GEF/SGP) was established in 1992, the year of the Rio Earth Summit. Global Environment Facility / Small Grants Programme (GEF/SGP) embodies the very essence of sustainable development. SGP channels financial and technical support directly to Non-Governmental Organizations (NGOs) and Community Based Organizations (CBOs) for activities that conserve and restore the environment while enhancing people's well-being and livelihoods.

GEF/SGP supports activities in line with GEF priorities being, biodiversity conservation; abatement of climate change; protection of international waters; prevention of land degradation; and elimination of persistent organic pollutants.

This project is carried out as part of Operational Phase 6 of GEF/SGP following the landscape approach focusing on three environmentally sensitive areas namely; Coastal Region from Mannar Island up to Jaffna; Knuckles Conservation Forest and its buffer zone; and Colombo Wetlands.

Semi-detailed topographic mapping of Sri Lanka began at the turn of the 20th century, and these maps contain very limited amount of ecological information. The forest Department is another agency which has mapped the forest cover of Sri Lanka including mangroves but not salt marshes, sand dunes and *Prosopis*.

This is a thematic atlas with emphasis on ecology of a region which still has a significant extent of unique ecosystems. The atlas contains 27 original maps along the coastline of Mannar-Kilinochchi districts and covers three natural ecosystems and one alien plant species introduced to the area in the past. Mangroves, salt marshes, and sand dunes are the natural ecosystems and *Prosopis juliflora* is a introduced alien species. In addition to the maps, each ecosystem is described in terms of their floral and faunal content observed during the field study and the threats faced by them. Other ancillary data and map layers are from other sources, such as the Survey Department, Forest Department, Agriculture Department, and other published maps in hardcopy or digital formats. All the maps in the atlas are available in digital format as GIS data layers. This exercise was funded by a grant from UNDP/GEF/SGP under the Operational Phase 6 Programme.

As far as we are aware, this is the first ecological atlas covering a large area of the coastal landscape of an important part of Sri Lanka. Such thematic atlases are needed for other ecologically and economically important parts of Sri Lanka in order to facilitate informed decision making.

