VULNERABILITY ASSESSMENT AND BLUE CARBON POTENTIAL OF TWO MANGROVE SITES IN MALAYSIA

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ABSTRACT

Coastal blue carbon is an emerging subject in climate change science which looks into coastal habitats such as mangrove forests for its ability to sequester and store carbon from the atmosphere. Mirroring the concept of "Reducing Emissions from Deforestation and Forest Degradation" (REDD+), the concept of coastal blue carbon is also about the incentives given in return for preserving these coastal habitats for its role in climate change mitigation.

As mangrove forests in Malaysia are facing rapid rate of degradation, this study is about assessing the coastal blue carbon as a viability to facilitate better mangrove conservation measures in Malaysia through its incentives.

For this study, two mangrove forest sites were selected from southern Johor to determine the level of vulnerability that these habitats are facing, while taking into consideration of the current management and policy in place. For this assessment, the baseline information of the study sites were collected and used in developing criteria to which the vulnerability assessment was conducted. The aim of the vulnerability assessment is to identify the prevailing threats on mangrove forests and establish the notion that the current conservation approaches may not be sufficient to protect these habitats. As a following step, the Rapid Impact Assessment Matrix (RIAM) were used as a tool to evaluate the benefits of implementing coastal blue carbon in the current management approach. Subsequently, gaps and challenges faced by the current management and policies relating to mangrove conservation in Malaysia were identified, and case studies were conducted as a mean to ascertain how best the coastal blue carbon mechanism can be adapted into the current structure for it to be effective.

The research shows that while the mangrove in Malaysia has a large carbon storage potential, the prevailing threats currently faced by the vulnerable mangrove forests are quickly diminishing its capacity. It was also found that there is a need for Malaysia to

establish an extensive network of collaborations among the relevant agencies within the country, with concerting efforts from non-governmental organisations and academic institutions in working towards proper carbon measurement and accounting. The main aim is for a change in policy which can ensure that the protection of mangrove areas are accounted more distinctively in the current policies and legislations. Given that the importance of mangrove can be made quantifiable as an incentive in terms of carbon credits and climate change mitigation, the conservation priority for mangrove could be significantly increased.

ABSTRAK

Karbon biru persisiran pantai adalah tajuk yang baru muncul dalam bidang sains perubahan iklim yang menumpukan kepada habitat persisiran pantai seperti hutan paya bakau untuk keupayaannya dalam menyerap dan menyimpan karbon dari atmosfera. Mencerminkan konsep "Mengurangkan Pelepasan Karbon dari Perlupusan Hutan dan Degradasi Hutan" (REDD +), konsep karbon biru persisiran pantai juga adalah mengenai insentif yang diberikan untuk usaha memelihara habitat pantai demi peranan pentingnya dalam perubahan iklim. Oleh kerana hutan bakau di Malaysia kini menghadapi degradasi dengan kadar yang laju, kajian ini adalah untuk menilai karbon biru persisiran pantai sebagai dorongan untuk meningkatkan langkah-langkah pemuliharaan bakau di Malaysia melalui pemberian insentif.

Untuk kajian ini, dua kawasan hutan bakau telah dipilih dari selatan Johor untuk memastikan tahap pendedahan kepada cabaran yang dihadapi oleh hutan paya bakau, sambil mengambil kira pengurusan dan dasar- dasar negara yang sedia ada yang melindungi dan memelihara hutan paya bakau. Untuk penilaian ini, maklumat asas daripada tapak-tapak kajian telah dikumpul dan digunakan dalam menyediakan kriteria untuk penilaian pendedahan hutan paya bakau kepada cabaran. Tujuan penilaian ini adalah untuk mengenal pasti ancaman yang dihadapi oleh hutan bakau dan mewujudkan tanggapan bahawa pendekatan pemuliharaan semasa mungkin tidak mencukupi untuk melindungi habitat ini. Sebagai langkah berikut, Rapid Impact Assessment Matrix (RIAM) telah digunakan untuk menilai manfaat daripada melaksanakan karbon perisiran pantai biru dalam pengurusan semasa. Selepas itu, jurang dan cabaran yang dihadapi oleh pihak pengurusan dan dasar-dasar yang berkaitan dengan pemuliharaan paya bakau di Malaysia telah dikenal pasti, dan kajian kes telah dijalankan untuk menentukan cara terbaik mekanisme karbon biru persisiran pantai boleh diselaraskan ke dalam struktur

pengurusan yang sedia ada untuk meningkatkan keberkesanan perlindungan atas hutan paya bakau.

Kajian ini telah menunjukkan bahawa walaupaun bakau di Malaysia mempunyai potensi simpanan karbon yang besar, ancaman yang dihadapi oleh hutan bakau pada masa ini akan mengurangkan kapasitinya dalam masa yang singkat. Kajian ini juga mendapati bahawa Malaysia perlu mewujudkan rangkaian kerjasama yang luas di kalangan agensi-agensi negara yang berkaitan, termasuk usaha daripada pertubuhan-pertubuhan bukan kerajaan (NGO) dan institusi akademik untuk menuju ke arah pengukuran karbon yang betul. Hasil daripada usaha ini adalah untuk menjanakan perubahan dasar yang boleh memastikan bahawa perlindungan kawasan bakau akan diambil kira dengan lebih berat dalam dasar-dasar dan undang-undang. Kepentingan bakau sebagai insentif dari segi kredit karbon dan mitigasi kesan perubahan iklim, keutamaan untuk pemeliharaan dan pemuliharaan hutan paya bakau boleh dipertingkatkan dengan lebih ketara.

DEDICATION

The pursuance of this Master's degree has been nothing short of an enriching and memorable journey. I have been greatly blessed by the constant support and outpouring encouragement that has helped me from day one up to the submission of this dissertation. As a closure, I would like to dedicate this to the people who has invested their time, guidance and support in making the completion of this dissertation possible.

To Associate Professor Dr. Rozainah Binti Mohamad Zakaria and Dr. Ghufran Redzwan who are my supervisors; my highest appreciation for all the valuable feedback, guidance and support given throughout the research.

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To my precious family and in-laws who has been supporting me as I pursue this degree, thank you for your confidence in me, your patience and sacrifices.

Finally, to my beloved husband who stood by me every step of the way. Thank you for walking this journey together with me.

All praise be to God.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AFOLU	Agriculture, Forest, and Other Land Uses
AGB	Above-Ground Biomass
BGB	Below-Ground Biomass
CCT	Conditional Cash Transfer
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CI	Conservation International
CIFOR	Centre for International Forestry Research
CO_2	Carbon Dioxide
COP	UNFCCC Conference of the Parties
CTI	Coral Triangle Initiative
DBH	Diameter at Breast Height
DIC	Dissolved inorganic carbon
DOE	Department of Environment
DPM	Department of Prime Minister Malaysia
EPU	Economic Planning Unit
ETS	Emission Trading Scheme
FAO	Food and Agriculture Organization of the United Nations
FMFC	Forest Carbon, Markets and Communities
FRIM	Forestry Research Institute Malaysia
GEF	Global Environmental Facility
GHG	Greenhouse Gas
ICSEA-C-Change	Integrated Coastal Sensitivity, Exposure and Adaptive Capacity to Climate Change Vulnerability Assessment Tool
IOCCP	International Ocean Carbon Coordination Project
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
JPBD	Department of Town and Urban Planning Malaysia
kg C m^{-2}	Kilograms of Carbon per Metre Square
KP	Kyoto Protocol
LAC	Lack of Adaptive Capacity
LULUCF	Landuse, Landuse Change and Forestry
MNRE	Ministry of Natural Resources and Environment
MRV	Measurement, Reporting and Verification
Mt CO_2e	Metric Tonne Carbon Dioxide Equivalent
NAMA	Nationally Appropriate Mitigation Actions
NOAA	National Oceanographic and Oceanic Administration
NOD	National Ocean Directorate Malaysia
REALU	Reducing Emission from All Land Uses
REDD	Reducing Emissions from Deforestation and Forest Degradation
RIAM	Rapid Impact Assessment Matrix
SD	Sustainable Development
Tg C	Teragrams Carbon
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESCO-IOC	Intergovernmental Oceanic Commission (IOC) of UNESCO
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WMO	World Meteorological Organization

CHAPTER 1: INTRODUCTION

In light of climate change research and discoveries; forests and other terrestrial ecosystems have been acknowledged as a vital component in mitigating increased greenhouse gases (GHG) in the atmosphere caused by anthropogenic activities (Canadell & Raupach, 2008). Recognising the importance of preserving the forests and terrestrial ecosystems for this matter, a mechanism coined as REDD (Reducing Emissions from Deforestation and Forest Degradation) was developed, whereby it provides international payments and assistance to prevent anthropogenic GHG emissions due to deforestation. The mechanism creates financial value for the carbon stored in and sequestered by forests and offers incentives for developing countries to reduce emissions from forested lands. At the same time the mechanism promotes low-carbon paths in sustainable development by reducing deforestation and forest degradation (Bond, 2009). In an improved revision of the mechanism, REDD Plus (REDD+) was introduced at 14th Conference of the Parties[1] (COP14) in Poznan in 2008 which included the role of conservation, sustainable management of forests and enhancement of forest carbon stocks (Lawlor, 2010).

In more recent studies, the marine and coastal ecosystems such as mangroves, salt marches and seagrasses are found to store large amounts of carbon despite only covering 1-2% of the total area of forest ecosystems (Focus, 2011). The carbon stored by these ecosystems is generally coined as 'coastal blue carbon', or *blue carbon* in short. According to the same study by Climate Focus (Focus, 2011), such ecosystems are estimated to have an annual mitigation potential between 300 to 900 Mt CO_2e (Metric Tonne Carbon Dioxide Equivalent). This amount is equivalent to 7-20% of the annual emissions from global deforestation and forest degradation - of which, may facilitate to curtail part of what the REDD+ mechanisms strive to achieve. Blue carbon sinks,

[1] The Conference of Parties (COP), is the highest order of the Convention of United Nations Framework Convention on Climate Change (UNFCCC) when it comes to decision making. The body is responsible in reviewing the Convention and its pertaining legal instruments, as well as deciding on administration and institutional arrangements.

including estuaries are projected to have the capacity to capture and store between 235-450 Teragrams (Tg C) (870 - 1,650 million tons of CO_2) every year - or the equivalent of up to nearly a half of the annual emissions from the entire global transport sector (approximately 1,000 Tg C, or 3,700 million tons of CO_2) (Nellemann et al., 2009).

Incidentally, coastal and marine environment are also one of the ecosystems that are facing a rapid rate of degradation; where at some events it could be as much as four times that of rainforests (Nellemann et al., 2009). This is often and mainly caused by the undervaluation of the ecosystem services that these habitats offer. In comparison to industries such as aquaculture, wood harvest, land reclamation and agriculture - ecosystem services wanes in terms of offering tangible and immediate economic returns. However, should coastal blue carbon initiative is combined with the actions under REDD+, justifications of the value to conserve the coastal and marine environment can be garnered. Studies have suggested that halting degradation and restoring marine ecosystems may deliver up to 25% of emission reductions that is required to keep global warming below two degrees Celsius (Nellemann et al., 2009). On top of that, coastal and marine habitats are able to store carbon for as long as a millennia, in comparison with those stored on land which only last for several decades or centuries (Mitra, Wassmann, & Vlek, 2005).

Aside from protecting mangrove forests for its ability to sequester and store carbon from the atmosphere; preventing land conversion will ensure that the current storage of carbon are not released into the atmosphere. Therefore, coastal blue carbon project appears as an attractive incentive that increases the value to which justifies the conservation of mangrove - that which often comes as secondary priority when weighed against industry and urban development. Essentially, carbon storage should be given due consideration in the coastal and marine environment management decisions. It could be an important tool for preserving the critical marine ecosystem service, as there are

incentives in the form of payments made to landowners and managers for managing the mangrove forest for its blue carbon capacity.

As such, the focus of this study is to propose a policy and management strategy for implementing the blue carbon mechanism in the mangrove forest conservation in Malaysia. This is achieved by identifying and discussing the preliminary, but crucial components which are instrumental in materialising blue carbon projects. Implementing a mechanism of such scale will require scrutiny on various aspects related to mangrove – from its ecological health and vulnerability, to the current management and user groups. For this purpose, two mangrove forests in Johor (Pulau Kukup and Sungai Pulai) were chosen as a study site to assess its current vulnerability and demonstrate how the blue carbon mechanism could be applied.

The question that marks this research is how the concept of coastal blue carbon can function as an incentive for mangrove conservation in Malaysia and to a larger extent, how prepared Malaysia is towards implementing blue carbon in its current mangrove conservation, protection and management. Based on these questions, the objectives of this study are as below:

- To establish baseline information of the selected mangrove forests study sites
- To identify the level of vulnerability of the mangrove forests at the study sites
- To determine the benefits of implementing coastal blue carbon concept for Malaysia.
- To identify how Malaysia can prepare for the implementation of coastal blue carbon concept in its current management approach on mangrove forests

CHAPTER 2: LITERATURE REVIEW

2.1 Overview of Mangrove

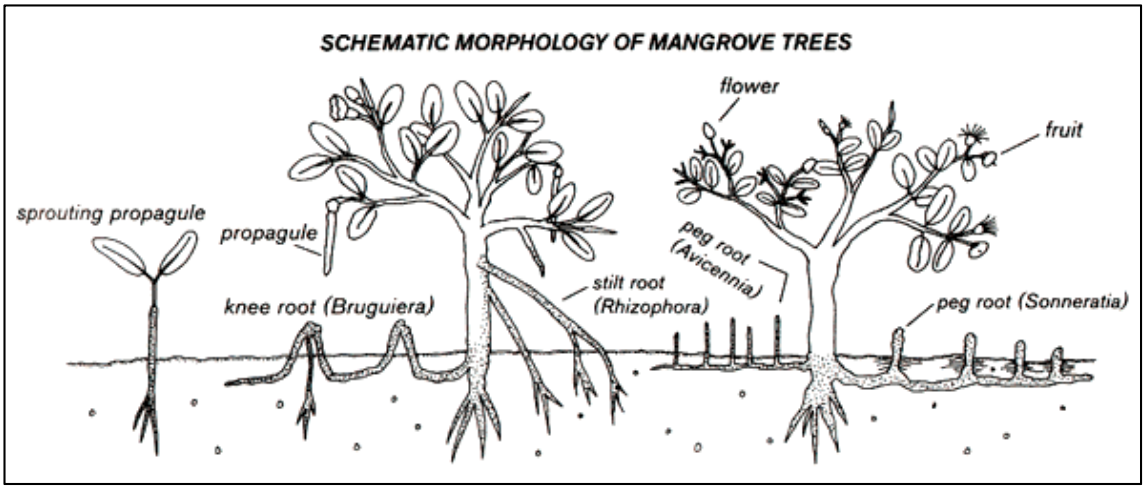


Figure 2.1 Basic morphologies of mangrove trees (Peck, 2014)

Mangrove is an assemblage of specially adapted trees to salinity that thrives in tidal environments along sheltered coastlines, riverbanks and lagoons (Figure 2.1). These mangrove trees are salt-tolerant, growing mainly on soft substrates with the support of an extensive aerial root system (Ye, Tam, Lu, & Wong, 2005). The unique salinity tolerance in mangrove trees is attributed to several osmoregulatory features such as ion compartmentation, selective transport and uptake of ions and also the capacity to cater to salt influx in the systems (Parida & Jha, 2010). In general, mangrove forests occupies about 181,000km^2 of coastlines of the world (Spalding, 2010); which is mainly concentrated around at the tropics and sub-tropical regions (Feller & Sitnik, 1996) as displayed in Figure 2.2.

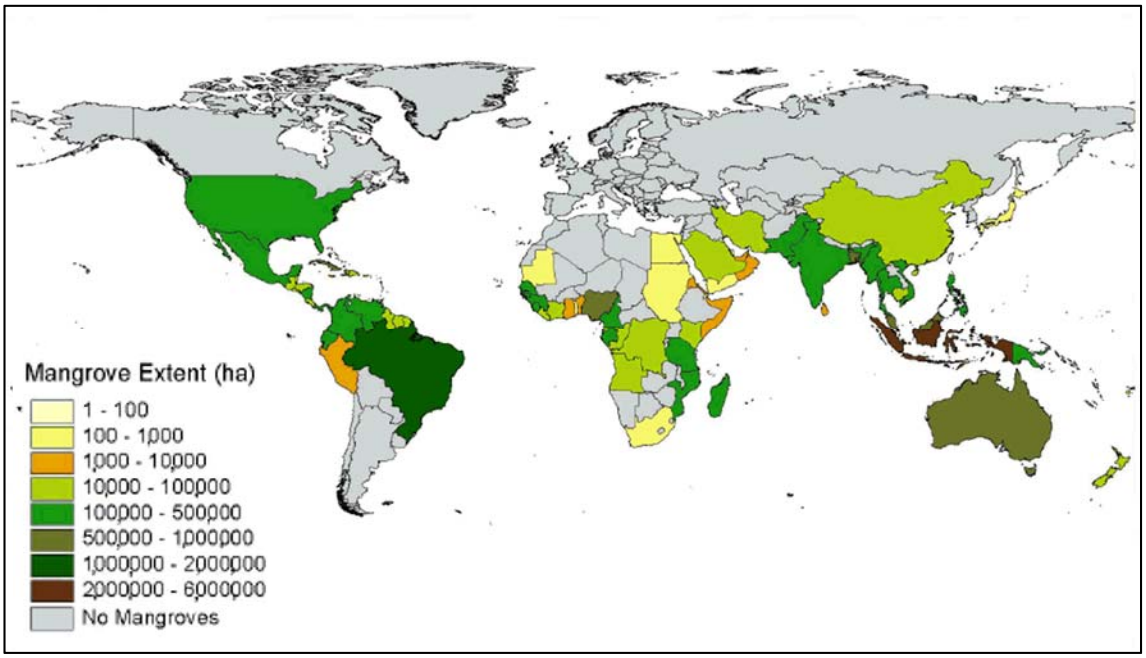


Figure 2.2 Mangrove extent per country (hectares) (Wilkie & Fortuna, 2003)

In an ideal coastal ecosystem, the mangrove forest is an integral part which forms the coastal plant communities, including mud flats, seagrass, tidal marshes and even coral reefs – all of which plays important interlinking roles that provides habitat and food for fish and wildlife (Lewis, 2001). Mangrove forests are also regarded as the economic foundation of many tropical coastal regions where it provides up to USD1.6 billion per year of ecosystem services worldwide, mainly due to its ability to recover mobile nutrients and removal or breakdown of excess or xenic nutrients and compounds (Costanza et al., 1998).

2.1.1 Global Distribution

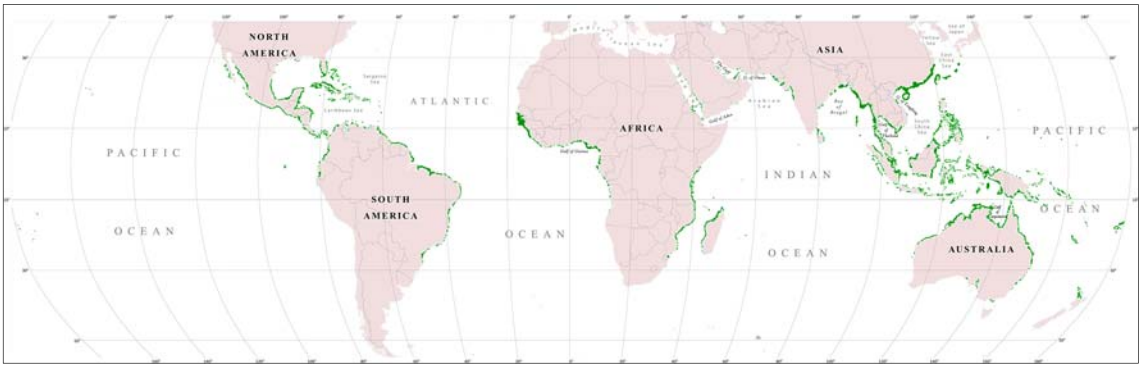


Figure 2.3 Green areas indicating the distribution of mangrove using earth observation satellite data (Giri et al., 2011)

Globally, mangrove forest is considered a rare ecosystem due to its limited distribution and extent that are almost exclusively found at tropical and sub-tropical regions of the world (Van Lavieren et al., 2012), as can be seen on Figure 2.3 and Figure 2.4 below.

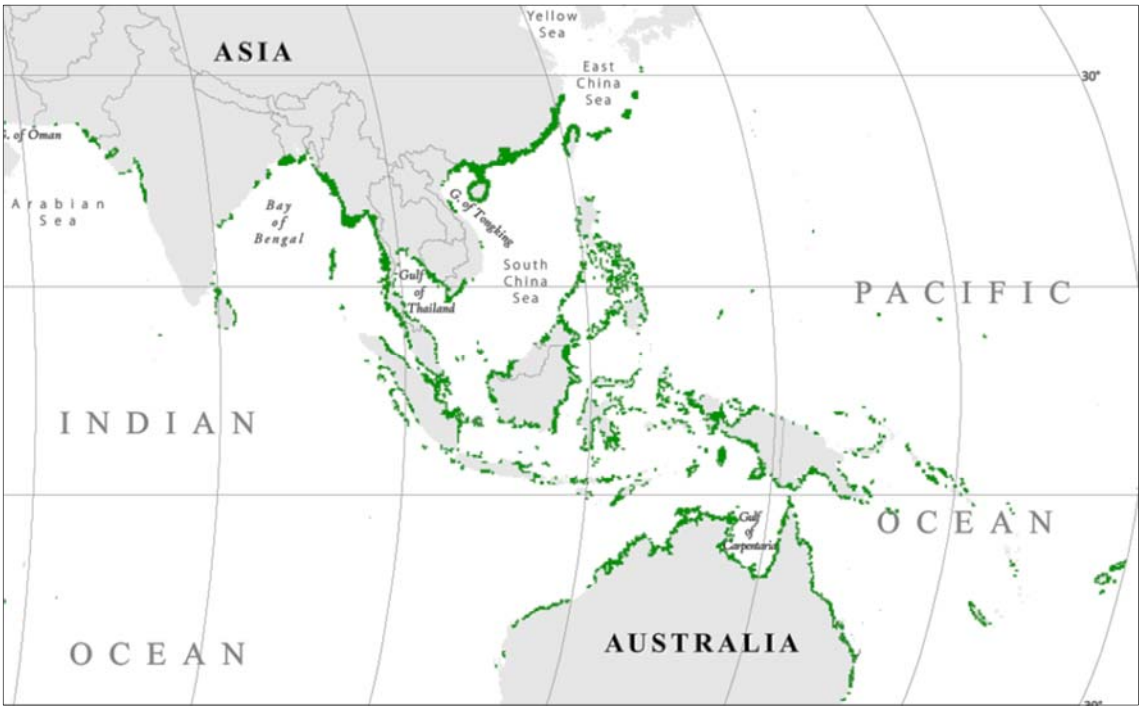


Figure 2.4 Mangrove distribution in Southeast Asia (Giri et al., 2011)

The distribution of mangrove underscores the importance of warm temperatures and also the high rainfall which is usually accompanied by silt-laden rivers forming suitable mudflats for the thriving mangroves. Within 9 orders, 20 families, 27 genera - there are about 70 known species of mangroves around the world (Alongi, 2002). Representing about 43% of total mangrove areas in the world, the top countries with the highest mangrove cover are Indonesia, Australia, Brazil and Nigeria. In regional terms, the highest percentage of mangrove distribution is concentrated in Asia with 38% or 58,000km^2 of the total mangrove cover in the world (Alongi, 2002) (Figure 2.5).

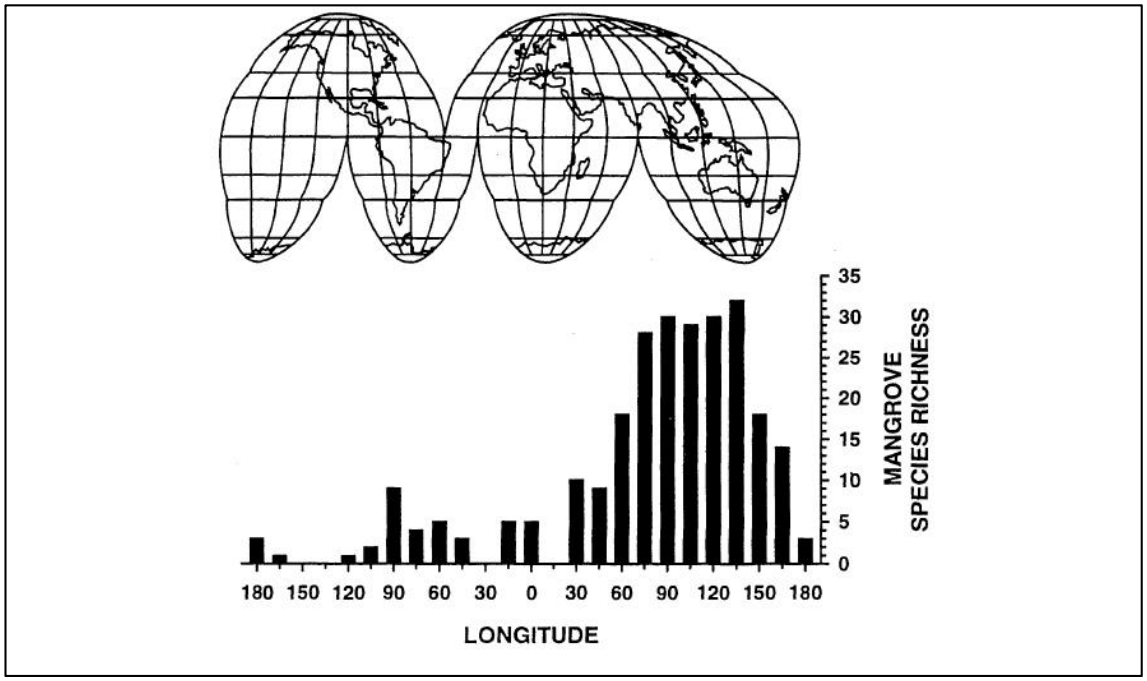


Figure 2.5 Species richness of mangrove as a function of longitude (in 15° increments) (A. M. Ellison, Farnsworth, & Merkt, 1999)

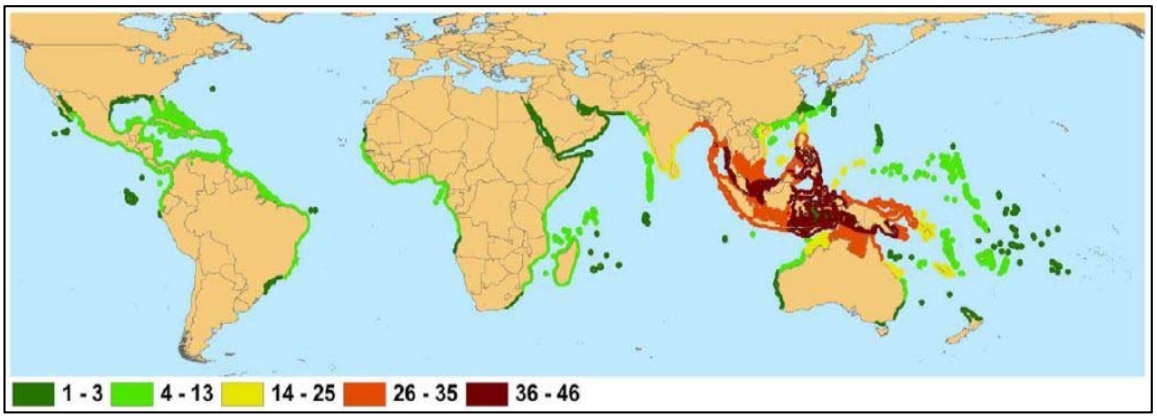


Figure 2.6 Mangrove Species Richness Index: Native distributions of mangrove species (Polidoro et al., 2010)

More specifically, Southeast Asia is regarded as the global centre of mangrove diversity (Figure 2.6). The country with the highest concentration of mangrove area is Indonesia, representing 49% (42,500 km^2) of all the mangrove species found in Asia (Figure 2.7) (Spalding, Blasco, & Field, 1997).

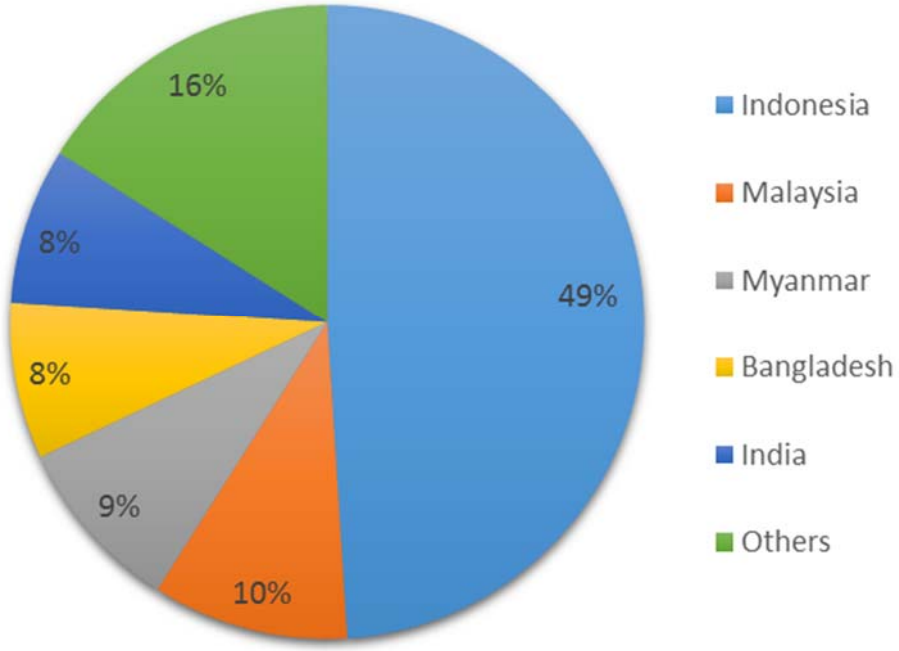


Figure 2.7 Top 5 countries in Asia with the largest mangrove area (as per 2005 data estimation) (Duarte, Culbertson, & Fundación, 2009)

2.1.2 Threats and Vulnerabilities

Over the past 50 years, approximately one-third of the world's mangrove forests had been lost due to uncontrolled and unmonitored anthropogenic activities (Alongi, 2002). Although mangroves has been traditionally providing goods and services for the local communities, the debate often focuses on the impact of uncontrolled exploitations and the myriad of modern industrialisation and economic activities that affects the mangrove as displayed on Table 2.1.

Table 2.1 Current human impacts on mangrove forests (Alongi, 2002)

Potentially sustainable	Unsustainable
Food	Eutrophication from the influx of nutrient from sewage discharge
Tannin and resins	Habitat modification/destruction/alteration for coastal development, including pond aquaculture
Medicines and other bioproducts	Disruption of hydrological cycles such as dams
Furniture, fencing, poles	Release of toxins and pathogens from industrial and domestic outfalls
Artisanal and commercial fishing	Introduction of exotic species that negatively affects the local species
Charcoal	Fouling by litter
Cage culture	Build-up of chlorinated and petroleum hydrocarbons
Ecotourism	Shoreline erosion/siltation accelerated by deforestation, desertification and other poor land use practices
Recreation	Uncontrolled resource exploitation
Education	Global climate change
	Noise pollution affecting the mangrove megafauna
	Mine tailings
	Herbicides and defoliants

The mangroves in the Americas experienced the highest percentage loss of 38% from its originally 43,161km^2 area (Valiela, Bowen, & York, 2001) (Table 2.2). In absolute number however, the mangrove area in Asia, which is double the size (77,169km^2) of that in Americas, hence the highest loss at 36% of the total cover. In another dataset published in 2009 (Duarte et al., 2009), available data reveals about 35% of mangrove forests have been lost in Asia between 1980 and 2005, which also averages to about 2.1% per year (Figure 2.8).

Table 2.2 Current mangrove areas, percent loss, annual loss rate and percent of original lost per year globally (Valiela et al., 2001)

Region	Current Mangrove Area (km^2)	% loss of mangrove forest area	Annual rate of loss (km^2y^{-1})	% of original area lost per year
Asia	77169	36	628	1.52
Africa	36529	32	274	1.25
Australasia	10287	14	231	1.99
Americas	43161	38	2251	3.62
World	**166876**	**35**	**2834**	**2.07**

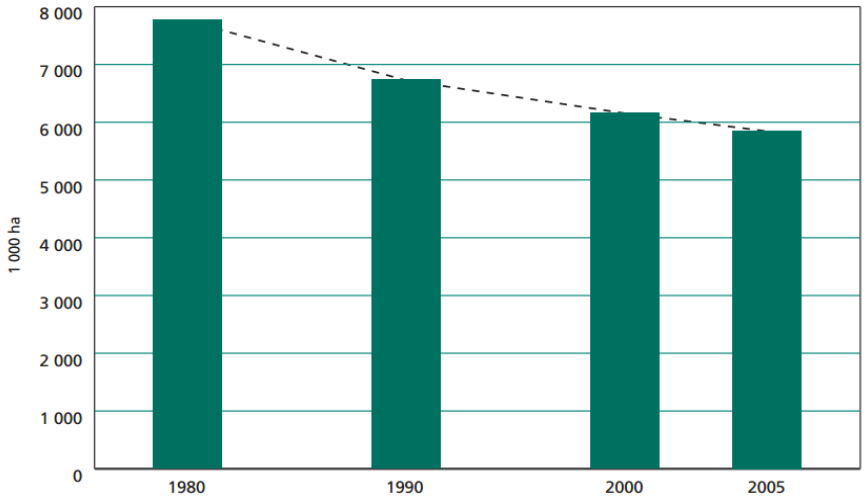


Figure 2.8 Mangrove area changes in Asia, from 1980 – 2005 (FAO, 2007)

2.1.3 Mangrove Vulnerability Assessment

There are various methods established for assessing the vulnerability of mangrove forests, usually qualitatively against anthropogenic threats (Odum, McIvor, & Smith III, 1982). Of late, there are more publications produced on assessing the vulnerability of mangrove against the impacts of climate change which takes into consideration the sea-level trends, sedimentation rates and the adjacent ecosystem resilience into the assessment (J. C. Ellison, 2012). Another assessment takes into account not only the vulnerability of mangrove, but also provide linkages to the vulnerability of the coastal population due to the former effect (Faraco, Andriguetto-Filho, & Lana, 2010). Some vulnerability assessment are also in qualitative form due to significant gaps in knowledge that prevented a good quantitative assessment from being conducted (Lovelock & Ellison, 2007).

2.2 Mangroves of Malaysia

2.2.1 Distribution and Species Diversity

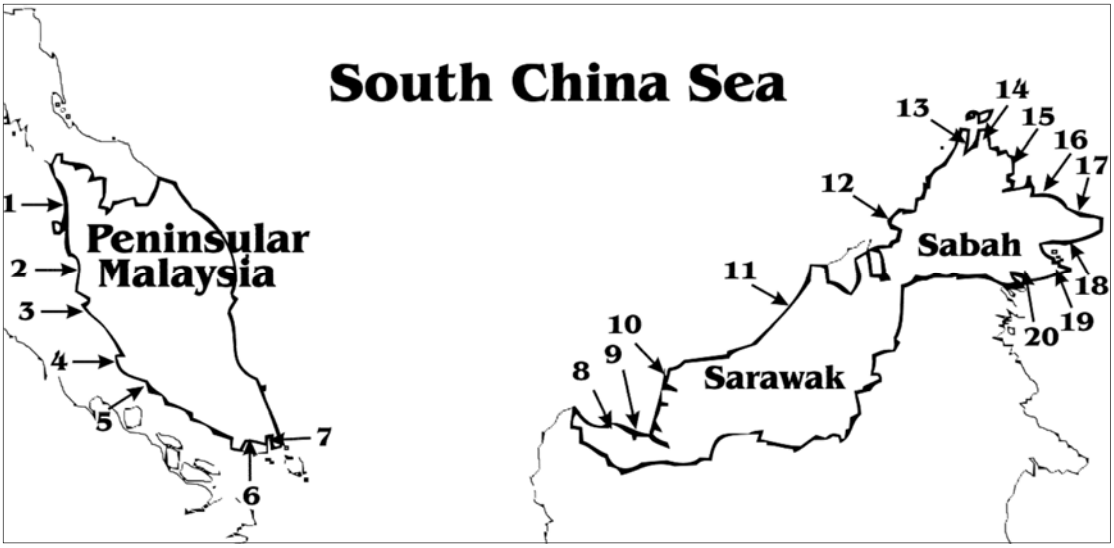


Figure 2.9 Location of mangrove forest reserves in Malaysia. This excludes the stateland mangrove forests which are scattered, patchy and not gazetted.

Legend: 1 = Merbok; 2 = Matang; 3 = Rungkup and Bernam; 4 = Klang; 5 = Sepang and Lukut; 6 = Pulai; 7 = Sungai Johor; 8 = Sungai Sarawak; 9 = Kampung Tian; 10 = Rajang; 11 = Kuala Sibuti; 12 = Menumbok; 13 = Kudat and Marudu Bay; 14 = Bengkoka; 15 = Sungai Sugut & Sungai Paitan; 16 = Trusan Kinabatangan; 17 = Kuala Segama and Kuala Maruap; 18 = Lahat Datu; 19 = Segarong and Semporna; 20 = Umas-Umas, Tawau and Batumapun. (V. Chong, 2006)

In Southeast Asia, Malaysia's mangrove is estimated to 572,100 hectares as stated by Food and Agriculture Organisation (FAO) in an unpublished assessment in 2003 (Wilkie & Fortuna, 2003), making it the second largest after Indonesia (3.2 million hectares) (Hartini, Saputro, & Yulianto, 2006). Mangroves are mostly found on marine alluvium along sheltered coasts and estuaries. The largest area is found on the coast of Sabah, particularly in the northeast portion (Figure 2.9). Mangrove forest in Sarawak are concentrated in the sheltered shores and estuaries within the major bays of Kuching, Sri Aman, Limbang, Rajang River and Trusan-Lawas River. Meanwhile in Peninsular Malaysia, mangroves are concentrated on sheltered west coast such as Perak (largest mangrove reserves), Johore and Selangor. Figure 2.10 shows the distribution of mangrove areas in Malaysia, whereby Sabah comprise 59% of all mangrove areas found in the country, followed by Sarawak with 23% and Peninsular Malaysia with 18%. Meanwhile,

there is a significant area undocumented small and fragmented mangrove areas called Stateland mangroves which are not gazetted as Permanent Reserved Forest (PRF) (Table 2.3) (V. C. Chong, 2006).

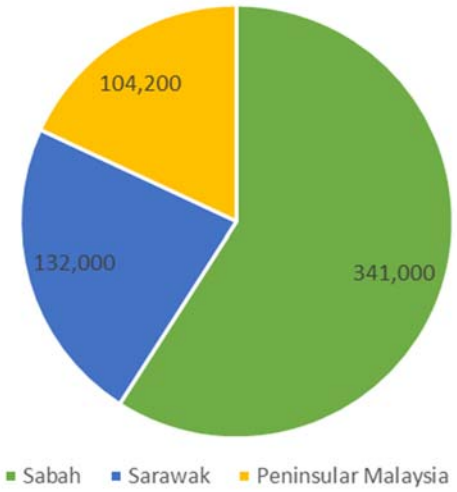


Figure 2.10 Distribution of mangrove areas in Malaysia (in hectares)

Table 2.3 Mangrove forest area and reserves in Malaysia (V. C. Chong, 2006)

Region	State	Total length of coastline (km)[c]	Gazetted Forest Reserve (ha)[a]	Stateland (ha)[a]	Total (ha)	Density (ha/km^2)	Gazetted Reserves [b]
Peninsular Malaysia	Perlis	20	0	20	20	1.0	0
	Kedah	148	7,248	400	7,648	51.7	11
	Penang	152	451	500	951	6.3	1
	Perak	230	43,500	150	43,650	189.8	21
	Selangor	213	15,090	4,500	19,590	92.0	15
	Negeri Sembilan	58	454	200	654	11.3	3
	Melaka	73	166	100	266	3.6	2
	Johor	492	17,832	6,500	24,332	49.5	10
	Pahang	271	2,675	2,000	4,675	17.3	11
	Terengganu	244	1,295	1,000	2,295	9.4	1
	Kelantan	71	0	100	100	1.4	0

Table 2.3, continued

Region	State	Total length of coastline (km)[c]	Gazetted Forest Reserve (ha)[a]	Stateland (ha)[a]	Total (ha)	Density (ha/km^2)	Gazetted Reserves [b]
East Malaysia	Sarawak	1,035	73,000	59,000	132,000	127.5	1
	Sabah	1,743	328,658	12,719	341,377	195.9	26
	Labuan	59	0	0	0	0.0	0
	Total	4809	490,369	87,189	577,558	120.1	112

(a = (Tan & Basiron, 2000), b= (Chan, Ong, Gong, & Sasekumar, 1993), c= (Ooi, 1996) Ooi (1996) (V. C. Chong, 2006)

Based on the FAO's Global Forest Resources Assessment 2005 (Thematic Study On Mangroves) report in 2005, species structure composition in Malaysia found in Malaysia is predominantly *Rhizophora, Avicennia, Bruguiera, Sonneratia* and *Xylocarpus* spp. – with regards also to the influences of soil and inundation patterns (FAO, 2005). Overall, a total of 41 species of mangrove found were listed.

2.2.2 Status and Cover Area

It is important to note that information on mangrove area in Malaysia, especially ground-truth data, are generally poorly recorded and scarcely available – making any analysis of trend and status a difficult endeavour to be done accurately. According to FAO (2005), the annual change of mangrove cover from 1980 to 2000 is up to 0.8% is shown in Table 2.4. The annual change of mangrove cover has been on a declining state, with up to 0.8% of annual depletion of mangrove areas.

Table 2.4 Estimates of mangrove area in Malaysia based on the best estimates from available data (FAO, 2005)

Year	Area (in hectare)	% Annual Change
1980	669,000	NA
1990	620,500	-0.7 (between 1980 and 1990)
2000	572,100	-0.8 (between 1990 and 2000)

Malaysia has lost about 100,000 ha of mangroves from 1980 to 2005. This accounts to 29% loss within 25 years. Between 1980 and 1990, the mangrove loss is primarily caused by the conversion of land to agriculture, shrimp ponds and urban development (FAO, 2007). In Sabah, the mangroves found at the coastal areas of Kota Kinabalu faced significant loss and degradation in the 1980s due to land clearance for urban development as well as the construction of illegal settlements within the mangrove swamp (Han, 2011). In Sarawak, the mangrove areas are threatened by the conversion of land use to make way for aquaculture ponds, oil palm plantations, and to a certain extent also for housing and industrial development (Bennett & Reynolds, 1993).

Significant areas of mangrove are still being converted in Peninsular Malaysia into urban development and tourism resorts. As the majority of mangrove areas are found along the Straits of Malacca, the increased marine traffic and related oil spills, as well as port constructions became among the major threats. This is an inevitable impact due to the importance of the Straits of Malacca as an international maritime route between South China Sea and the Indian Ocean, with an estimation of up to 600 vessels using the strait daily (Kamaruzaman, 1998).

In a scenario where no actions are taken to halt the current pace of mangrove loss (-0.8% annually as per year 2000-2005 data) and disregard of preventing development on a gazetted mangrove forest, the estimated mangrove cover in Malaysia by the end of 2014 would be less than 270,000 hectares. This comprises 0.8% of the remaining area. Based

on the result of this extrapolation and the assumption that no action is taken to halt or remediate deforestation, a rough calculation would estimate that in less than 20 years' time (year 2034), only about 50,335 hectares of mangrove will be left in Malaysia. This is almost equivalent to the current size of Matang Mangrove Forest Reserve Area (50,511 hectares). The following Table 2.5 shows the mangrove forest loss and gain between the year 1980 and 2003.

Table 2.5 Loss and Gain of Mangrove Forest Reserves (Tan & Basiron, 2000)

State	Mangrove areas (ha)		Mangrove loss/gain	
	1980	2003	ha	%
Johor	25,619	17,029	-8,590	-33
Kedah	9,037	7,949	-1,088	-12
Kelantan	Nil	Nil	0	0
Malacca	77	77	0	0
Negeri Sembilan	1,352	204	-1,148	-85
Pahang	2,469	2,675	+206	+8
Perak	40,869	41,302	+433	+1
Perlis	Nil	Nil	0	0
Penang	406	451	+45	+11
Selangor	28,243	15,090	-13,153	-46
Terengganu	2,982	1,130	-1,852	-62
Sarawak	44,491	73,000	+28,509	+64
Sabah	349,773	325000	-24,773	-7
Total	**505,318**	**483,907**	**-21,411**	**-4**

A particular note to be taken from this data is that even with protection by enforcement agencies - some mangrove reserves still experience loss, although some mangroves do experience an increase in area cover. It is imperative to highlight that the trend for mangrove loss is more pronounced and significant as experienced in Johor (-33%), Selangor (-46%), Terengganu (-62%) and Negeri Sembilan (-85%). The percentage gains are mainly confined between 1-11%, with an exception of Sarawak with a significant increase of 64% of mangrove gained between 1980 and 2003.

Despite available literatures and studies that indicate the importance of mangrove habitats attributed to its ecosystem services and resource value, the conservation of mangrove as a coastal habitat that sits between land and sea, continues to receive

inadequate public attention compared to terrestrial forests and coral reefs (Duarte, Dennison, Orth, & Carruthers, 2008).

2.2.3 Management and Protection

Mangrove management practices in Malaysia vary from state to state. In general, the management and protection of mangroves comes under the jurisdiction of the respective State Forest Departments; in the exception to Johor, Sabah and Sarawak, as these states possess their own National Park Authority who manages their forestry areas according to their respective enactments. The percentage of mangrove areas that has been gazetted in Malaysia and the respective governing authorities are as shown on Table 2.6.

Table 2.6 Area of mangroves within legally gazetted areas and their respective governing authorities (FAO, 2005)

	Peninsular Malaysia	**Johor**	**Sabah**	**Sarawak**
Percentage and absolute area of mangroves within legally gazetted areas	88.7% (70, 879ha)	73.3% (17, 832ha)	96.3% (328,658ha)	55.3% (73, 000ha)
Management	Forestry Department (general across country)	– Johor National Park Authority – Forestry Department	Sabah Forestry Department	– Sarawak Forestry Cooperation – Forestry Department of Sarawak
Policy and Laws	National Forestry Act 1984	– Johor National Park Corporation Enactment 1989 – National Forestry Act 1984	Forest Enactment 1968	– Forest Ordinance (Cap.126), 1958 – Wild Life Protection Ordinance, 1998 and subsidiary regulations – National Parks and Nature Reserves Ordinance, 1998

In the international arena of mangrove conservation, Malaysia is a contracting party in the Ramsar Convention since 10 March 1995. To date, Malaysia has six designated Ramsar sites (134,158 ha) which partly protects the mangrove forests based on the international convention guidelines. The sites Ramsar in Malaysia are as listed in Table 2.7.

The Ramsar Convention, or also known as the Convention on Wetlands (held at Caspian seaside resort, Ramsar, Iran, on 2 February 1971) – is an international treaty that aims to promote the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world (Frazier, 1999).

Table 2.7 Ramsar Sites in Malaysia

State	Ramsar Site	Cover area (hectare)
Pahang	Tasik Bera	38,446
Johor	Sungai Pulai	9126
	Tanjung Piai	526
	Pulau Kukup	647
Sarawak	Kuching Wetlands National Park	6610
Sabah	Lower Kinabatangan-Segama Wetlands	78,803

2.3 Overview on Climate Change

Climate change is defined as the long term variability (which are often extreme) of weather patterns and cycles, which is intricately linked to the changes in mean atmospheric temperatures (Rosenzweig, Iglesias, Yang, Epstein, & Chivian, 2001). It is caused by the changes in the atmospheric abundance of greenhouse gases and aerosols, as well as in the solar radiation and land surface properties. The changes in these energy balances in the form of radiative forcing affects the climate system (Solomon et al., 2007). The quantitative estimates of radiative forcing is used to compare how a range of human and natural forces drive warming or cooling of the global climate. Such changes will

inevitably cause negative impacts on a myriad of aspects ranging from ecosystem balance, agriculture, water supply, to the climatic systems.

Since the onset of mass agriculture and the industrial age from the 1750's, there is a significant increase of global atmospheric concentration of carbon dioxide, methane and nitrous oxide which has now far exceeded the pre-industrial values as determined by ice cores from thousands of years ago (Dansgaard et al., 1993). The largest known human contribution to climate change comes from the burning of fossil fuels and land use change - both which releases carbon dioxide gas; and also from agriculture which releases methane, into the atmosphere (Solomon et al., 2007). This increase of GHG due to anthropogenic activities is linked to climate change and its impacts that are currently seen around the world such as severe drought, rainfall, storm events, among some (Ledley et al., 1999).

2.4 Climate Change International Treaties, Agreements and Mechanisms

The United Nations Framework Convention on Climate Change (UNFCCC) is an overarching international climate change treaty ratified in 1992 sets out a broad framework to address the issues of climate change (Mace, 2005). It plays a pivotal role in establishing the basis of international policy relating to climate change agenda, where the acknowledgement, legitimisation and implementation of climate change actions are approved. Another important international agreement is the Kyoto Protocol (KP) which is linked to the UNFCCC. It entered into force on 16 February 2005 where it commits its Parties by setting internationally binding emission reduction targets.

In the context of sustainable development, the 'Nationally Appropriate Mitigation Actions' (NAMA) is an outcome from the Bali Action Plan that was concluded at the UNFCCC Conference of the Parties (COP) 18 in Doha in 2012. This is agreed in the pretext that any action that reduces emissions in developing countries which is prepared under the respective national governmental initiative will be included.

Closely linked to the UNFCCC, the Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of climate change as established by United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) that was established in 1988. The function of the IPCC is to provide the world with a clear scientific view and advice on the current state of knowledge in climate change and its potential impacts.

UNFCCC's COP is the platform where international discussions and commitments of climate change are carried out. However, according to the report prepared by Climate Focus for the Linden Trust for Conservation (Focus, 2011), the current negotiations are beyond its capacity to add another agenda, until and unless the existing IPCC reporting guidelines are improved and to increase its extent of coverage to include blue carbon into the existing NAMAs[2] and REDD+[3] agendas.

2.5 Carbon Sequestration and Storage by Mangrove

Mangroves forests are known to be carbon sinks due to the ability of its biomass to contain carbon in its biomass and sediments for a long period of time. For a meaningful CO_2 sequestration estimate, the rate of carbon burial is very crucial and often varies from one mangrove area to another. It is generally determined from sedimentation estimates and the typical organic carbon concentration in mangroves (Chmura, Anisfeld, Cahoon, & Lynch, 2003), or from mass-balance considerations (Caraco, Duarte, & Middelburg, 2005). The following sections deliberate further the major components in relation to carbon sequestration and storage by mangrove.

[2] NAMAs - Nationally Appropriate Mitigation Actions are voluntary mitigation actions by developing (Non-Annex I) countries in the context of sustainable development, supported and enabled by technology, financing and capacity-building, aimed at achieving a deviation in emissions relative to 'business as usual' emissions in 2020. Defined by the Cancun Agreement, December 2010 - UN Framework Convention on Climate Change

[3] REDD+ or REDD Plus - Reducing Emissions from Deforestation and Forest Degradation in Developing Countries

2.5.1 Carbon Cycle in Mangrove Ecosystem

The carbon cycle within the mangrove ecosystem is centred on the biomass and the sediment. There are different pathways to which carbon are cycled, firstly as biomass that are consumed by mangrove-associated fauna; secondly it could be incorporated into the sediment; thirdly carbon could be remineralised and released back into the atmosphere or exported as dissolved inorganic carbon (DIC); and finally, carbon could also be exported to adjacent ecosystems and follow the designated ecology carbon cycle (Bouillon, 2009).

2.5.2 Carbon Sequestration

Carbon sequestration takes place when the CO_2 in the atmosphere is absorbed by mangrove leaves during the process of photosynthesis; although some CO_2 escapes during the respiration process. Otherwise, the carbon absorbed from the atmosphere are stored inside the mangrove plant's roots, leaves and branches – making it part of the standing biomass. The capacity for assimilating carbon into the biomass depends on several factors such as the age of the tree (which determines the diameter at breast height – DBH, and height of the tree), the type of species, and other factors related to the primary productivity and photosynthetic efficiency of the mangrove (Ray et al., 2011).

Different part of the mangrove tree (i.e. leaf, stem and branch) have different capacity for carbon assimilation due to the differing biomass, and these capacities changes according to the age of the tree (Kridiborworn, Chidthaisong, Yuttitham, & Tripetchkul, 2012). The amount of carbon sequestered is typically estimated as the net change in carbon stocks over time – and is usually based on the measurement of living above-ground biomass (AGB) such as the leaves, stems and branches as described earlier (Pearson, Brown, & Birdsey, 2007).

2.5.3 Carbon Burial Rate

Mangrove tree litter are the dead leaves, shoots and branches that is fallen and subsequently buried in the anoxic sediment. This is part of the process of carbon dynamics in the benthic community where the carbon in the tree litter are gradually broken down in a slow process of decaying and degradation (Kristensen, 2007). Benthic communities which consists of macrobenthos (i.e. crabs, gastropods, bivalves, etc) and microbes (i.e. bacteria) will break down the litter (organic matter) via respiration and fermentation processes – therefore the presence and abundance of these benthic and microbial communities play an important role in the mangrove carbon cycle. However, the rate of burial is deemed to be highly variable among mangrove forests; being less dependent on the deposition of detritus than it is on the overall sediment accretion. As such the trapping efficiency of the extensive root system which prevents sediment erosion becomes the key factor in the burial process (Kristensen, 2007). Again, this goes back to the different abilities of mangrove to sequester and store carbon based on the species type.

Playing a big influence on the rate of carbon burial also is the local hydrology patterns at the mangrove area, which influences the rate of carbon degradation and the fate of carbon transportation (Twilley, Chen, & Hargis, 1992). The rate of carbon burial also largely depends on the geomorphology at the mangrove forest, whereby the chemical characteristics of the sediment, such as the concentration of certain ions influencing the aerobic respiration and anaerobic sulphate reduction which usually occurs in mangrove sediment (Kristensen, 2007).

2.5.4 Carbon Storage

Carbon in the mangrove ecosystems is stored in the above-ground biomass, as well as in the below-ground/sediment. Carbon stored in the living above-ground biomass (AGB) are found in the leaves, stems, branches and even the roots of mangrove (Ray et al., 2011). For example, a study conducted at the Indian Sundarbans mangrove forest

found that the carbon concentrations to be 43.0- 45.1% at the roots, 42.4- 43.05% at the stems and 42.09 - 42.5% at the leaves (Ray et al., 2011). The study also discovered that the AGB is 24% higher in stems compared to leaf and branches.

Carbon storage in the sediment (below ground biomass – BGB) occurs when the carbon present in the AGB becomes tree litter, such as when dead leaves or branches fall from the tree and buried indefinitely in the sediment. It is in the sediment where the biomass undergo a very slow process of breakdown in the oxygen-poor soil which forms a significant non-volatile carbon storage. The extent to which the sediment could store carbon is also influenced by the existing soil carbon content, soil depth and to a certain extent also the tidal frequency – and this also highlights the possibility of huge amount of carbon stocks stored in the sediment (Donato et al., 2011). In a recent study conducted in Malaysia at the mangrove forest of Sungai Haji Dorani (35 hectare) and Kuala Selangor (95 hectare) (Hemati, Hossain, Emenike, & Rozainah, 2014), it was found that the former mangrove forest store about 25.26 kg C m^{-2} of total carbon compared to the latter with only 22.61 kg C m^{-2} despite the latter having a larger mangrove coverage and in a better condition. The bulk densities of these two mangrove forests at Sungai Haji Dorani and Kuala Selangor were 0.57g/cm^3 and 0.65g/cm^3 respectively.

In a recent study conducted by the Forest Research Institute Malaysia (FRIM), it was found that the *Rhizophora apiculata* showed the highest carbon stock (up to 210 tonne Carbon per hectare for matured trees – aboveground biomass) compared to other species such as *Buguiera parvifora*, *Avicennia alba*, *Sonneratia caseolaris* and *Bruguiera cylindrical* (Noraishah, Philip, & Samsudin, 2011). Results from the study also found that diameter at breast height (DBH), age of tree, as well as the photosynthetic rate and the leaf area index contributes to the capacity of carbon storage capacities. Therefore, it is imperative to note that land conversion, an anthropogenic threat usually faced by mangroves in developing countries such as Malaysia, does not only losses the carbon

sequestration service but also risks releasing the stored carbon and other greenhouse gases (GHG) such as methane (CH_4) and nitrous oxide (N_2O) trapped in the mangrove ecosystems into the atmosphere [(Corredor, Morell, & Bauza, 1999) and (Lekphet, Nitisoravut, & Adsavakulchai, 2005)].

Another study showed that precipitation seasons play a significant role in determining the level of carbon content stored in the sediment (Rozainah & Naem, 2014). During the dry season, the carbon content in the sediment of the mangrove forest at Delta Kelantan was lower compared to that at Pulau Kukup. However, during the wet season the results were opposite where the carbon content in the sediment of Delta Kelantan was higher, albeit by a marginal difference. While further correlation of this trend with the type of sediment and its relationship with moisture content (in the context of influencing the carbon content found in the sediment) is to be further established, this indicates that there are many variables– including climatic factors having an influence on the efficiency of carbon sequestration and storage. Carbon measurement is a complex and multi-faceted estimation that goes beyond mangrove-species-dependent calculations, and also the above-ground and below-ground carbon storage assessment - as it requires an intricate look into its environment at large.

2.6 Carbon Credit and Trading Mechanisms

An adequate discussion pertaining to the possibility of the blue carbon concept as a functioning incentive for conservation must take into account the available carbon credit and pricing mechanisms in place today. Essentially, these are the markets that will ultimately determine and define the value of the carbon sequestered and stored by mangroves. The sections below discuss the prevailing carbon markets, the prices and mechanisms that are relevant to blue carbon.

2.6.1 Global Carbon Market

According to World Bank in its 2014 report on the state and trends of carbon pricing (WorldBank, 2014), there are approximately 40 national and more than 20 sub-national jurisdictions that are putting a price on carbon. There are three main types of carbon pricing mechanisms, which is the Emission Trading Scheme (ETS), the carbon taxes, and to a lesser extent – the offsets and results-based financing. Taking a look into the current prices in the existing carbon pricing schemes, the Swedish Carbon Tax is the highest with a price of USD168/tCO_2, followed by the Tokyo Cap-and-Trade at USD95/ tCO_2 – although the lowest trading price for carbon credits could go as low as USD1/ tCO_2 with the New Zealand ETS (WorldBank, 2014).

For a long time, the European Union (EU) ETS maintained its position as the largest market for carbon trading as it is the only regional- based ETS with USD9/ tCO_2, where as many as 69 companies from the United States are participating in this scheme (CDP, 2014). Other ETS that are available are national-based, such as those in Australia, Kazakhstan, New Zealand, Switzerland, Republic of Korea, Brazil, Chile, China, Japan, Mexico, Thailand, Turkey and Ukraine. Meanwhile, carbon taxes are being implemented in Denmark, Finland, France, Iceland, Ireland, Japan, Mexico, Norway, Sweden, Switzerland and the United Kingdom (WorldBank, 2014). The extent of ETS and carbon taxes implementation is as illustrated on Figure 2.11.

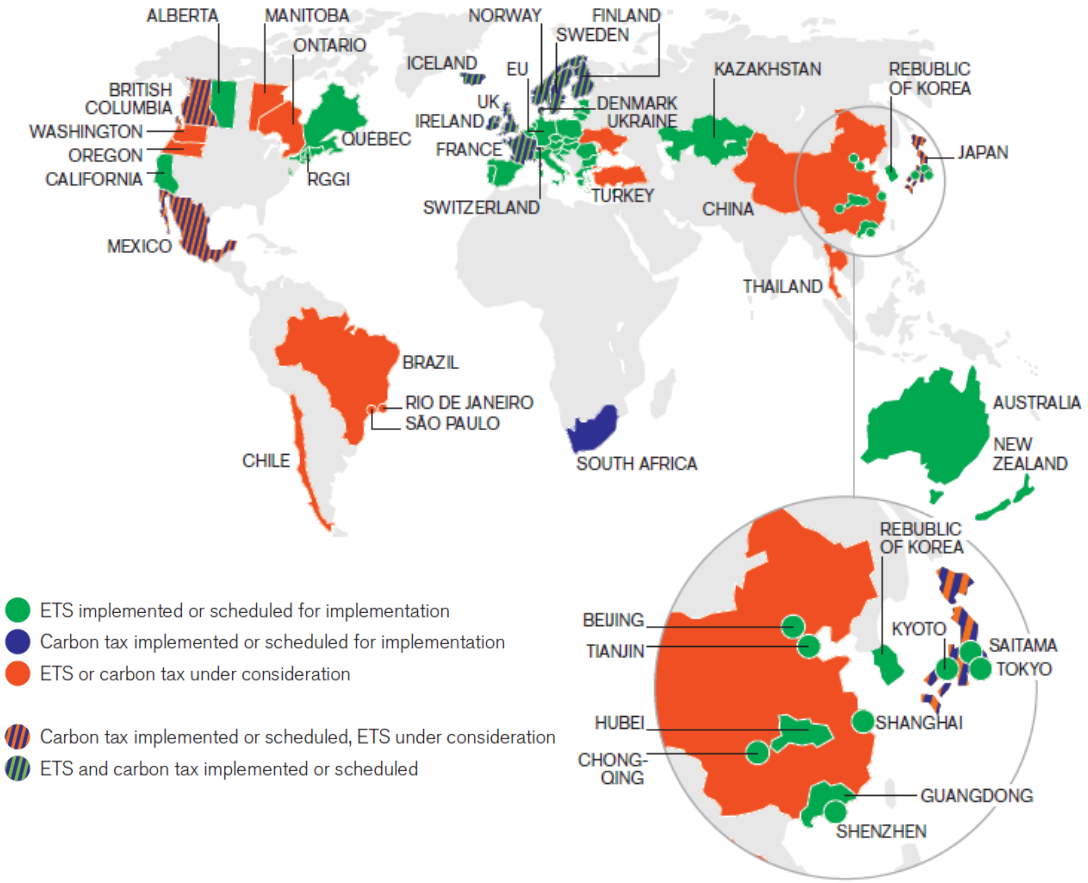


Figure 2.11 Summary map of existing, emerging, and potential regional, national and sub-national carbon pricing instruments (ETS and tax) (WorldBank, 2014)

Aside from ETS and carbon tax, another approach which puts a price on carbon is the cap-and-trade scheme. A maximum carbon emission limit, or *cap*; will be set by the government where enterprises will have to adopt ways to reduce their emissions through their own compliance strategy in order to keep the carbon emissions below the cap (UN ESCAP, 2012). Among the strategies that can be undertaken includes the sale or purchase of carbon credit allowances, installation of pollution controls or the optimisation of operation procedures to reduce as much carbon footprint and emissions as possible (USEPA, 2003). This approach however is deemed to be complicated and complex, and even costly to monitor and measure. Paired with the variability of cap-and-trade prices, this scheme is susceptible to the falling or fluctuating carbon prices when low emitters sell their approved but unused allotment of emissions to high emitters.

Uncertainties in carbon prices through the cap-and-trade scheme greatly reduces its potential as a long term investment (UN ESCAP, 2012).

2.6.2 REDD+

REDD+ (Reducing Emissions from Deforestation and Forest Degradation in Developing Countries) is the mechanism that aims to mitigate the impacts of climate change by reducing the emissions of greenhouse gases (GHG) and removing the GHG through enhanced forest management in developing countries. The participating developing countries will receive financial reward for the emission reductions achieved which is associated to the decrease in the conversion of terrestrial forests to alternate land uses. It replaces its predecessors, RED and REDD (reducing emissions from deforestation and forest degradation) whereby the former is a mechanism that was first discussed within the UNFCCC in 2005 and later on in 2007, the latter was committed as an agreement at the Conference of the Parties (COP) to the UNFCCC (Angelsen, Brown, & Loisel, 2009). The evolution of the design and implementation of this mechanism follows the chronological order as displayed on Figure 2.12.

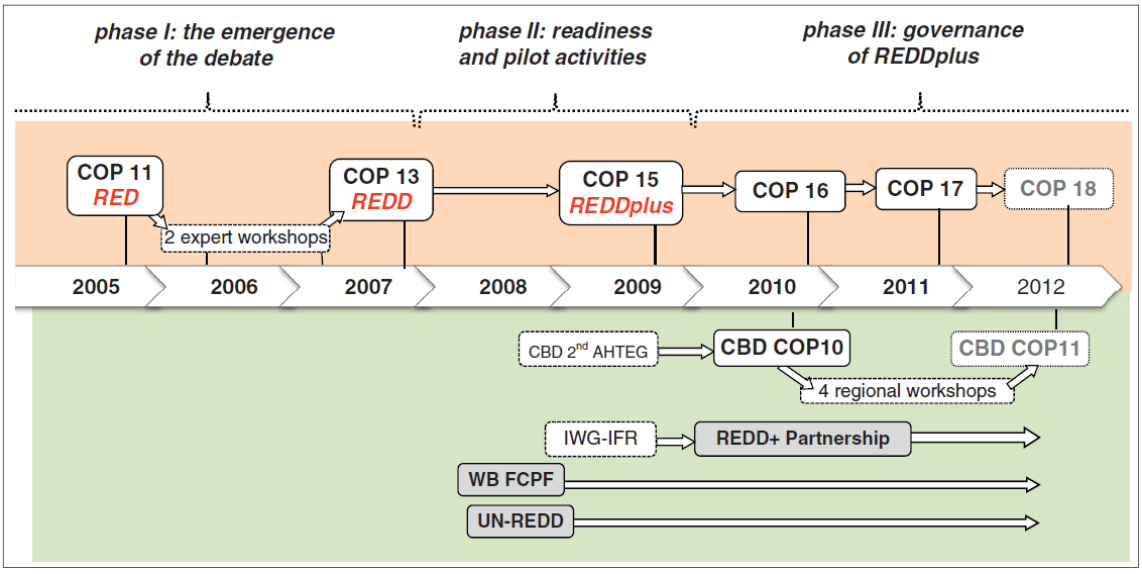


Figure 2.12 Phases of the debate and milestones for the design and implementation of REDD+ (Pistorius, 2012)

Based on Centre for International Forestry Research (CIFOR) (Sunderland, 2010), the simplified description of the evolution from RED mechanism to REDD++ in the aspect of terminology and principles is as below:

1 Reducing Emissions from Deforestation (RED): a concept first mooted in COP 11 in Montreal in 2005
2 REDD: second "D" added to include "degradation" THINKING beyond the canopy
3 REDD+: "plus" includes afforestation, poverty alleviation, biodiversity conservation and improved forest governance
4 REDD++: includes emissions from other land conversion (e.g. agriculture)

Note should be taken that although REDD++ was not discussed at the UNFCCC level, it nevertheless encompasses the principle of carbon accounting throughout the entire spectrum of Agriculture, Forest, and Other Land Uses (AFOLU), otherwise known as Reducing Emission from All Land Uses (REALU) (White et al., 2011).

Since the inception of the idea of RED in 2005 to the current revised mechanism, REDD+ today; there has always been the same scepticism entailing this presumably simple concept even after a decade. Questions are often raised regarding its effectiveness, as the mechanism constantly face a series of complex execution pathways due to the dearth of forest data (Angelsen et al., 2009), coupled with the absence of distinctive modalities and funding to ensure that this mechanism is sustainable (Pistorius, 2012).

Despite the ongoing discussions, questions and changes; there has been significant development to this mechanism since 2005 which managed to garner a more seasoned and solid commitment by the international committee. Among some of the positive development from this mechanism includes a renewed focus on restoring and conserving forests, creation of multi-lateral organisation to facilitate developing countries in implementing REDD+, in addition to multiple public and private bodies initiating projects and studies to further strengthen this mechanism in all of its facets (Pistorius, 2012).

Malaysia has developed National REDD+ Strategy which is coordinated by the Ministry of Natural Resources and Environment (MNRE). Under this umbrella, there are

several technical working groups that are assigned to different tasks pertaining to materialising the REDD+ concept which includes Baselines, Monitoring, Reporting and Verification (MRV), Institutional arrangement, Governance, Payment of benefits and Capacity building. However, a search of published literature on journals as well as proceedings suggested that studies concerning the rights and tenure for REDD+ have yet to be fully considered in Malaysia to date.

Based on the assessment of several projects around the world in relation to the lessons learned from implementing the REDD+ mechanism (UN-REDD, 2011), below are the summary of the key lessons which Malaysia should consider as a guide when designing a framework for blue carbon implementation. It is to be noted as well that Malaysia joined the UN-REDD Programme in May 2012, when much of the lessons learned have been identified prior to that period of time. This presumably puts Malaysia in the lead as the path towards a more efficient and refined REDD+ implementation has been paved by other projects around the world.

Long term and comprehensive data

Data is an important factor in generating international funding stakeholder engagement. Without which, it is challenging to justify the investment against the actual carbon sequestration amount that it is capable of delivering. Among some of the components that need to be identified and quantified are the number of parameters to be measured, time available for measurements and a cost-effective implementation of the new design. Among the parameters that should be collected are data of mangrove cover (both through remote sensing for a large extent and ground-truthing to detect small changes in area cover over a period of time), carbon stocks measurements in its various pools (i.e. above ground biomass, below ground biomass, litter rate, etc).

Lack of good quality data must not prevent decision making

Despite the importance of long term and comprehensive data in generating funds, the lack of good quality data should not necessarily prevent early policy intervention when it comes to mitigating climate change. There are no lack of scientific studies and socio-economic researchers that has been conducted and published worldwide, indicating the role of mangrove as a crucial carbon sequestration and storage place. In the spirit of precautionary principle, where when a possibly dangerous, irreversible, or catastrophic effects are identified – the uncertainty about the damage is not an argument for delayed action. Ultimately, precautionary principle is deemed as the solution towards adverting an impact that may prove to be too costly or impossible to avert if no action was taken.

Awareness programmes

One of the major but often undermined component which contributes to the success of a project is how well an awareness programme is executed to achieve its objectives. More often than not, ownership and collaboration across the stakeholders and managers determines the sustainability of a particular goal- especially when there are different layers of community and user-groups involved in the areas managed. Adequate time and resource must be invested to communicate complex concept to locals and indigenous to encourage the buy-in of the new concept.

One of the ways to facilitate effective communication is also by recruiting and training local facilitators which would more likely overcome barriers in terms of culture, language and understanding. It is crucial that every awareness programme is conducted at an early stage which would more likely overcome barriers in terms of culture, language and understanding. It is crucial that every awareness programme is conducted and raised at an early stage of the project to ensure that a balance of influence and position between

the different stakeholders – hence avoiding a certain party from dominating the consultation sessions.

Government, NGO and local community's engagement in pilot projects

Pilot projects are essential indicators of what works and what doesn't in the initial implementation, therefore paving a better way forward for the subsequent projects that will be designed after it. Hence, the engagement between the government, NGO and local community should be forged from the early stage as it will prove to be cost effective in the long run as failures can be premediated, aside from increasing the engagement and ownership of the project across the board. Among some of the recommendations taken out from implementing REDD+ projects were to encourage the local people to submit a written statement as and when they make a verbal decision – especially in decision regarding indigenous rights and tenure. With a recorded statement, this would prevent future conflicts which may occur. In addition, the facilitator of the consultation session must come from a neutral party in order to reduce biasness and promote an equal ground for all side of parties to communicate and get their points and concerns across.

Monetizing carbon

Due to circumstances at different areas, it was found that carbon alone may not be a sufficient driver to implement REDD+ activities – therefore other potential income (whether it is monetary and non-monetary values) from other benefits from conserving the ecosystem must be integrated into the decision making for REDD+. Before a project such as REDD+ can be implemented, project and resource managers must be aware of the cost incurred to set up the project and the sources of funding it needed for kick-starting the implementation. The cost- benefit ratios of REDD+ projects must be thoroughly calculated, with proper consideration of the value of the land when determining the opportunity cost as to avoid over or under-estimation of the anticipated values which the carbon stored may fetch in the existing market.

Management of revenues from project

It must be emphasized that the revenues generated from projects like REDD+ where multi-stakeholders exists - must always conform to good governance and equity. Ideally, it should be managed by major stakeholder groups and beneficiaries and is subject to mandatory external audits. In addition, the Conditional Cash Transfer (CCT) must be practised to ensure that payments are only given when the legally agreed criteria are met and reduce the risk of corruption by certain parties.

2.6.3 Clean Development Mechanism (CDM)

In the discussion regarding climate change mitigation, it is almost inevitable to include Clean Development Mechanism (CDM) into the picture. CDM is a component in the rapidly developing global carbon market, acknowledged by the Kyoto Protocol in December 1997 as a response towards the mitigation of climate change (Olsen, 2007). It was first proposed by the government of Brazil as a means for countries that does not accept binding emission limits to cooperate with Annex 1[4] countries on a project-specific to reduce their carbon emissions (Fearnside, 1999). Therefore, CDM is supposed to facilitate developing countries achieve sustainable development (SD) that which at the same time, does not lend to an increased magnitude of climate change impacts by way of reducing greenhouse gas emissions. Ultimately, the CDM aims to reduce poverty, enhance environmental benefits and assist Annex 1 countries to achieve their emission reduction targets in the most cost-efficient manner (Sutter & Parreño, 2007).

Defined in the Article 12 of the Kyoto Protocol, CDM projects implemented by Annex B parties[5] (i.e. countries with emission-reduction/ emission-limitation commitment under the Kyoto Protocol) are eligible to earn certified emission reduction

[4] Annex 1 Countries (also known as Parties to the Convention) are countries classified as industrialized countries and economies in transition according to the United Nations Framework Convention on Climate Change. Currently there are 43 Annex 1 Countries including the European Union.

[5] Group of countries included in Annex B in the Kyoto Protocol that have agreed to a target for their greenhouse gas emissions, including all the Annex I countries (as amended in 1998) but Turkey and Belarus. See also Annex II, non-Annex I, and non-Annex B countries/Parties.

(CER) credits, which can be sold to offset carbon emission. Each of these projects undergo strict and arduous process before it is approved by the designated national authorities as CER credits which can be traded in the carbon market.

In an ideal setting, the blue carbon mechanism could be one of the projects under CDM however the implementation of this mechanism has met with much scepticism and criticism over the past decade since its launch – even despite passing its 7000 project mark in the UN carbon market scheme. One of the major concerns surrounding the CDM and the CER it provides, is that the prices of carbon credits have been on a decreasing trend since 2008 with minor fluctuations (WorldBank, 2014). This trend is partially caused by fall of the European Union (EU) Emission Trading Scheme (ETS) as the world's largest carbon market to which the prices of CER heavily depended upon. The estimated carbon price dropped from €11.45 per metric ton in 2011 to €5.82 per metric ton in 2012 (approximately 49% decrease within a span of a year) (Lang, 2013).

The struggles of this scheme is mainly attributed to the often unpredictable market forces, much like any trade commodities which are influenced by the supply-and-demand mechanism. Despite generating more than USD 215 billion worth of low-carbon investment in developing countries, coupled with the commitment of producing credits which are equivalent to 1.3 billion tonnes of CO_2 - the prices of CDM's CER has fallen as its supply has surpassed demand, as governments continue to set low emission reduction targets (King, 2013). With no increase in countries' ambitions under the UNFCCC, the demand for Kyoto credits (CERs and Emission Reduction Units – ERUs) remains low (WorldBank, 2014).

Although there is a high likelihood that CDM projects could deliver significant emission reductions, it was rarely seen to be successful in terms of contributing to the host countries' sustainable development goals (Sutter & Parreño, 2007). Most likely, there may have been a gap in the CDM approval and certification process whereby the

scale of contributions given into sustainable development via these CDM projects are not a pivotal requirement when setting the price for CER[6]. Should the prices of CER continues to decrease beyond its ability to breakeven the cost of project capital, it will inevitably cause project owners to cut their losses early by halting their participation in the CDM projects.

Taking the fate of CDM as an example, it is imperative to scrutinize the most suitable and sustainable carbon market and pricing when implementing the blue carbon mechanism in order to ensure that the incentives from providing carbon sequestration and storage services can be materialised.

2.7 Blue Carbon

In recent studies, marine and coastal ecosystems such as mangroves, salt marches and seagrasses are found to have the ability to store considerably large amounts of carbon, despite covering only 1-2% of the total area of forest ecosystems. The carbon stored by these coastal ecosystems is generally coined as 'blue carbon'. Such ecosystems are estimated to have an annual mitigation potential between 300 to 900 Mt CO_2e (Metric Tonne Carbon Dioxide Equivalent), which is an amount equivalent to 7-20% of the annual emissions from global deforestation and forest degradation (Focus, 2011). In addition to that, coastal blue carbon sinks could capture and store between 235-450 Teragrams (Tg C) or 870 to 1,650 million tons of CO_2 every year - or the equivalent of up to nearly a half of the emissions from the entire global transport sector which is estimated annually at around 1,000 Tg C, or around 3,700 million tons of CO_2, and rising (Parida & Jha, 2010).

Studies also have suggested that halting the degradation and restoring the lost coastal marine ecosystems may deliver up to 25% of emission reductions required to keep

[6] The current CER prices is known to only reflect the price per reduced ton of CO_2 equivalent, which are largely influenced by market forces.

global warming below two degrees Celsius. In addition to that, mangrove habitats are able to capture and store carbon that will remain for millennia, in comparison with carbon stored on land by forests, which can only last for several decades or centuries. The ability of mangrove habitat to absorb and store carbon augurs well with the on-going effort to realise commitment made by the Prime Minister of Malaysia to reduce 40% of carbon emission by year 2020 compared to 2005 figure at the closing of Copenhagen Climate Change Summit COP15 on 17-18 December 2009.

2.7.1 Definition

The term, 'blue carbon' has yet to be officially defined although various institutes and organizations have produced very similar definitions to encompass the importance and value of the coastal and marine components in capturing and storing carbon. Displayed on Table 2.8 are some of the main definitions given by various organizations which are currently looking at developing the blue carbon mechanism. Collaborating organizations are grouped in the same cell, hence sharing a common definition.

Table 2.8 Terms and definition of "blue carbon" according to organizations

Organization	Term	Definition	Reference
• United Nations Environmental Programme (UNEP) • International Union for Conservation of Nature (IUCN) • Conservation International (CI) • Linden Trust for Conservation	Blue Carbon	Over half (55%) of all biological carbon in the world is captured by marine living organisms – not on land – hence it is called blue carbon. "Blue carbon" is the carbon stored by coastal and marine ecosystems. Mangroves, seagrasses, and salt marshes store carbon both in the plants and in the sediment immediately beneath them. The ocean's vegetated habitats, in particular mangroves, salt marshes and seagrasses, are earth's blue carbon sinks and account for more than 50%, perhaps as much as 71%, of all carbon storage in ocean sediments.	Nellemann, C., & Corcoran, E. (Eds.). (2009). Blue carbon: the role of healthy oceans in binding carbon: a rapid response assessment. UNEP/Earthprint.

Table 2.8, continued

Organization	Term	Definition	References
• United Nations Educational, Scientific and Cultural Organization (UNESCO) • Intergovernmental Oceanographic Commission (IOC) Food and Agricultural Organization (FAO)	Blue Carbon	Over half (55%) of all biological carbon in the world is captured by marine living organisms – not on land – hence it is called blue carbon. "Blue carbon" is the carbon stored by coastal and marine ecosystems. Mangroves, seagrasses, and salt marshes store carbon both in the plants and in the sediment immediately beneath them. The ocean's vegetated habitats, in particular mangroves, salt marshes and seagrasses, are earth's blue carbon sinks and account for more than 50%, perhaps as much as 71%, of all carbon storage in ocean sediments.	Nellemann, C., & Corcoran, E. (Eds.). (2009). Blue carbon: the role of healthy oceans in binding carbon: a rapid response assessment. UNEP/Earthprint.
• Nicholas Institute for Environmental Policy Solutions	Coastal Blue Carbon	Carbon captured and stored by coastal marine and wetland ecosystems.	Murray, B. C., Pendleton, L., Jenkins, W. A., & Sifleet, S. (2011). Green payments for blue carbon: Economic incentives for protecting threatened coastal habitats. Nicholas Institute for Environmental Policy Solutions, Report NI, 11(04).
• National Oceanic and Atmospheric Administration (NOAA)	Coastal Blue Carbon	Blue carbon is the biological carbon captured by living coastal and marine organisms. A significant fraction of this blue carbon is stored in coastal habitat (salt marsh, mangrove forests, and seagrass beds).	NOAA Habitat Conservation | NOAA Expedition Discovers New Deep-Sea Coral Mounds. (n.d.). Retrieved September 3, 2015, from http://www.habitat.noaa.gov/coastalbluecarbon.html

According to the Nicholas Institute Report entitled, "State of the Science on Coastal Blue Carbon: A Summary for Policy Makers" published in May 2011 (Pendleton et al., 2012), scientists have agreed that blue carbon sequestration and storage involves

three components, which is the rate of carbon sequestration from the atmosphere, the amount of carbon stored in the mangrove biomass and the total carbon stock stored in soils prior sequestration. Although it may appear to be a misnomer to some readers, the blue carbon concept as discussed in international forum does not include carbon stored, sequestered or released by the open ocean or its closely related ecosystems and organisms, i.e. phytoplankton and diatoms. For this study, the definition adopted by the United Nations Environmental Program (UNEP) was adopted as it is the definition that is most widely adopted among international organisations that are involved in blue carbon mechanism in one way or the other. Further details on the developing mechanism for measuring blue carbon sequestration will be discussed in the following section.

2.7.2 Concept

Although healthy coastal habitats (such as mangrove forests, seagrass beds and salt marshes) have been known to store and sequestrate large amounts of CO_2, there is an absence of a formal policy anywhere in the world that protects and restores these habitats for the benefit of reducing GHG concentration in the atmosphere. According to the National Oceanographic and Oceanic Administration (NOAA), there is no mechanism to leverage existing markets to pay for the protection and restoration to keep the carbon in coastal habitats and out of the atmosphere. However, there is a steady increase of international awareness and interests on the role of the coastal habitats as carbon storage and sequesters and before the blue carbon mechanism can come into order, there are several instruments that needs to be in place. Among them includes developing the procedures for incorporating carbon services into federal agency decision-making and the adoption of protocols to enable private sector investment in coastal habitat carbon services via voluntary carbon markets. However, it is important to note that the Blue Carbon is not a new or separate policy or financing scheme. The objectives of the Blue Carbon policy are:

1 Integration into the international policy and financing processes of the UNFCCC
2 Integration of Blue Carbon fully into other carbon finance mechanisms such as the voluntary carbon market
3 Develop a network of Blue Carbon demonstration projects
4 Integration of Blue Carbon into other international, regional and national frameworks and policies, including coastal and marine frameworks and policies
5 Facilitate the inclusion into the accounting of ecosystem services

Coastal blue carbon sequestration and storage involves three components. The first is the annual sequestration rate, which is the yearly flux of organic material transferred into anaerobic soils, where it cannot undergo oxidation to carbon dioxide (CO_2) that could be released to the atmosphere. The second component is the amount of carbon stored in biomass, both above and below the ground. The third and largest component is the total carbon stock stored in soils as a result of prior sequestration. Over half (55%) of all biological carbon in the world is captured by marine living organisms hence it is called blue carbon. The ocean's coastal and vegetated habitats, in particular mangroves, salt marshes and seagrasses, are earth's blue carbon sinks and they account for more than 50% of all carbon storage in ocean sediments. It is also estimated that half the annual emissions of the global transport sector are captured and stored by these coastal ecosystems (B.C. Murray, Pendleton, Jenkins, & Sifleet, 2011).

Based on the Nicholas Institute Report (Blue Carbon for Policymakers) (Solomon et al., 2007), the total carbon stock integrates the complete column of organic soil lying beneath coastal habitats and it is a function of soil carbon density and the depth of the rich organic soils beneath the ecosystems. Total carbon storage estimates are generally available for at least the first meter of soil—which is the depth at which carbon is most susceptible to release. In a separate report from the same institute, the three largest coastal repositories of carbon are thought to be in seagrass meadows, salt marshes and mangroves (Figure 2.13).

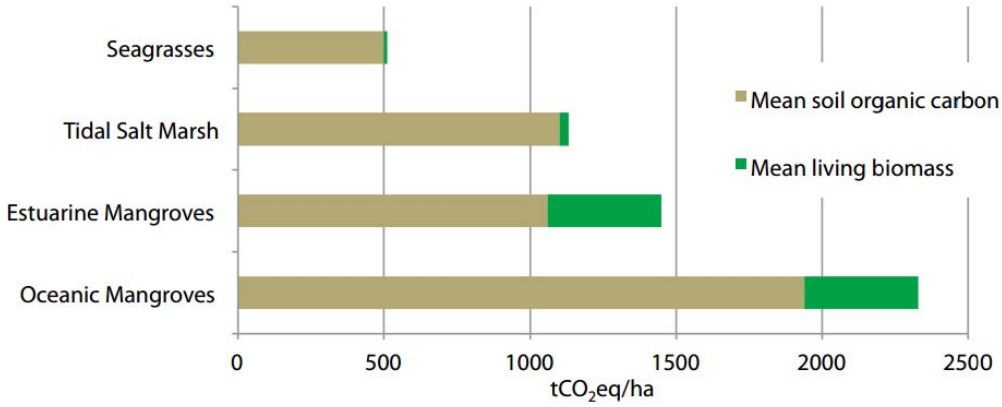


Figure 2.13 Global averages for carbon pools (soil organic carbon and living biomass) of coastal habitats (Brian C Murray, Jenkins, Sifleet, Pendleton, & Baldera, 2010). In coastal habitats, most carbon is stored in sediments and less in biomass (Lehmann, 2007).

2.7.3 International Acceptance

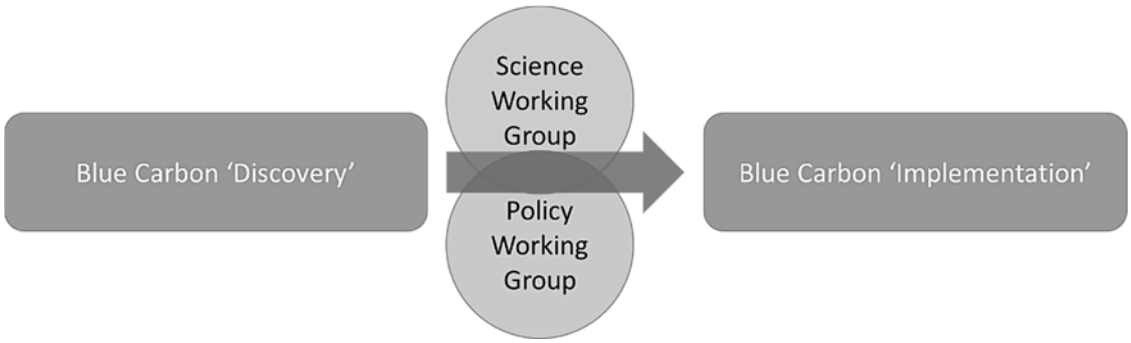


Figure 2.14 Framework towards implementing Blue Carbon at the IPCC (Pendleton et al., 2012)

The simple framework above (Figure 2.14) depicts the process of gaining recognition for blue carbon concept in the UNFCCC – whereby the roles of seagrass, mangroves and salt marshes ecosystems are highlighted as a viable carbon sequestrating and storing ecosystems. In mobilizing this process, two key working groups (WG); consisting of the Scientific Working Group and the Policy Working Group, are instrumental in bringing the concept into integration and implementation in the current management of carbon mitigation initiatives. However, this does not imply that the blue carbon concept is seeking for a new or separate policy/financing scheme but instead, it seeks for fundamental integration into existing international policy and financing

processes whenever possible. To put into perspective, the blue carbon concept may adopt the same building blocks as how the REDD+ mechanism was developed, as illustrated in the following diagram (Figure 2.15).

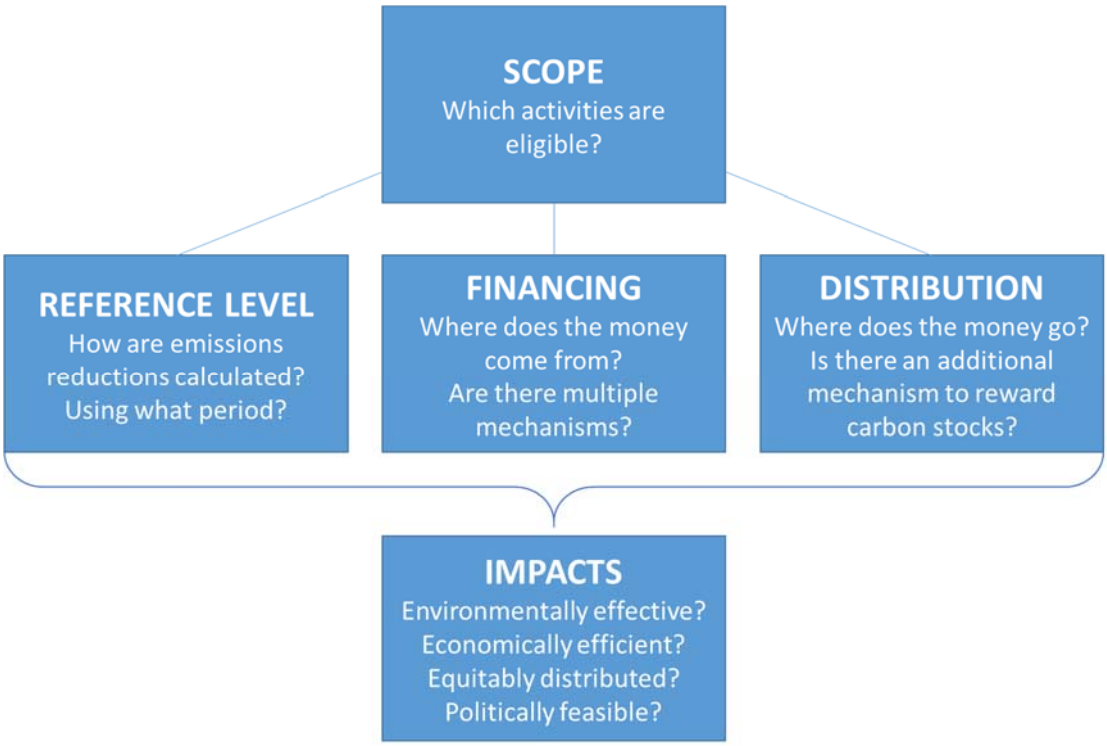


Figure 2.15 Building blocks of the REDD proposal

2.7.4 Economics of the Coastal Carbon Sequestration and Loss

Studies found that Asia and Oceania region has the largest potential emissions offset supply, comprising roughly two-third (2/3) of the total emission. Given the recent range of market price for carbon offsets and the cost of reducing emissions from other sources, it suggests that protecting mangroves for their carbon is an economically viable proposition of potential global offset availability (Table 2.9). Conservative values for the carbon released due to land conversion/loss of mangroves and seagrasses is 1028 Mg and 512 Mg of potential CO_2 emissions per hectare, respectively. To quote from Siikamäkia et al (2012), "Combining the uncertainty range in emissions with a central estimate for the social cost of carbon gas emissions of $41 per Mg of CO_2, we estimate the current global cost of coastal ecosystem conversion to be between $6.1 and $42 billion incurred annually."

Table 2.9 Estimates of carbon released by land-use change in coastal ecosystems globally and associated economic impact (Pendleton et al., 2012).

	Inputs			Results	
Ecosystem	Global extent (Mha)	Current conversion rate (% yr^{-1})	Near-surface carbon susceptible (top meter sediment+biomass, Mg CO_2 ha^{-1})	Carbon emissions (Pg CO_2 yr^{-1})	Economic cost (Billion US$ yr^{-1})
Tidal Marsh	2.2–40 (5.1)	1.0–2.0 (1.5)	237–949 (593)	**0.02–0.24 (0.06)**	**0.64–9.7 (2.6)**
Mangroves	13.8–15.2 (14.5)	0.7–3.0 (1.9)	373–1492 (933)	**0.09–0.45 (0.24)**	**3.6–18.5 (9.8)**
Seagrass	17.7–60 (30)	0.4–2.6 (1.5)	131–522 (326)	**0.05–0.33 (0.15)**	**1.9–13.7 (6.1)**
Total	33.7–115.2 (48.9)			**0.15–1.02 (0.45)**	**6.1–41.9 (18.5)**

1Mg = 1 tonne

2.7.5 International Blue Carbon Working Groups

The Blue Carbon Initiative was spearheaded by Conservation International (CI), the International Union for Conservation of Nature (IUCN), and the Intergovernmental Oceanic Commission (IOC) of UNESCO, working with partners from national governments, research institutions, NGOs, coastal communities, intergovernmental and international bodies and stakeholders. In materializing and mobilizing the Blue Carbon mechanism, two international working groups were formed to define and develop the

Blue Carbon mechanism from the scientific and policy angle. Below explains the tasks and mandate.

2.7.5.1 Scientific Working Group

The IUCN, IOC of UNESCO and CI established the International Blue Carbon Scientific Working Group to conduct scientific research on the role of coastal vegetated ecosystems in carbon storage and sequestration. Up to 2012, there have been three major workshops conducted:

- First Workshop, 15-17 February 2011 (Paris)
- Second Workshop, 26-29th July 2011 (Bali)
- Third Workshop, 19-24 March 2012 (San Jose, Costa Rica)

The roles of the International Blue Carbon Scientific Working Group are to develop coastal marine conservation and management approaches that maximize sequestration of carbon and avoided emissions in coastal systems, design and implement the program of work for carbon accounting in coastal systems and in turn develop economic incentives, coordinate with and synthesize other related existing science and policy activities, identify relevant pilot field projects, and providing guidance, technical advice, and support to the pilot projects and as well as to identify essential science gaps for research programs.

2.7.5.2 Policy Working Group

Formed in July 2011, this working group is mandated to develop policy options for implementation (at international and national levels) for coastal Blue Carbon-based incentives and management. The working group consists of experts in coastal science, environmental policy and economics, and project implementation from within the climate change and marine communities. To date, there have been two workshops conducted:

- 1st workshop in Arlington, VA 12-14 July, 2011
- 2nd workshop in Brussels, Belgium 10-12 January 2012

The roles of the International Blue Carbon Scientific Working Group includes providing strategic framework and support required policy development to advance coastal "blue carbon" in relevant international and regional climate, ocean and coastal fora. The group will focus on a comprehensive approach and financing of natural carbon management for climate change mitigation under the UNFCCC and other relevant agreements and mechanisms. Among some of the approaches in achieving the focus are through developing a strategic framework outlining key policy, program activities and financing opportunities needed to support climate change mitigation through coastal carbon management including ecosystem conservation, restoration and sustainable use; and also to build an integrated Blue Carbon community supporting the implementation of the Blue Carbon Policy Framework that will include climate, coastal and marine stakeholders. Five policy objectives have been identified as priorities to supporting climate change mitigation through the conservation, restoration and sustainable use of coastal ecosystems:

1 Integrate Blue Carbon activities fully into the international policy and financing processes of the UNFCCC as part of mechanisms for climate change mitigation
2 Integrate Blue Carbon activities into other carbon finance mechanisms such as the voluntary carbon market as mechanism for climate change mitigation
3 Develop a network of demonstration projects
4 Integrate Blue Carbon activities into other international, regional and national frameworks and policies, including coastal and marine frameworks and policies
5 Facilitate the inclusion of the carbon value of coastal ecosystems in the accounting of ecosystem services

2.7.5.3 Current Progress

The UNESCO-IOC Working Group, which key international organizations and NGOs (CI, IUCN, and UNEP) has emerged as a focal point for moving forward the coastal blue carbon concept. The UNESCO-IOC has formed the International Ocean

Carbon Coordination Project (IOCCP) as a communication and coordination service for the ocean carbon community (http://www.ioccp.org/). However there are still important science questions to be addressed before building substantial policy action. Many groups have been working, together and separately, in the organization and dissemination of reports, programs and other emerging international efforts. All efforts face funding constraints, particularly the policy-related efforts.

2.7.6 Protocols for Measurement, Monitoring and Reporting

The measurement of carbon in relation to the mitigation of climate change (i.e. REDD+) includes the amount that is sequestered from the atmosphere, the amount and rate of which it is released during degradation and conversion of the carbon sink, as well as the storage capacity and duration of which the carbon sink can retain the carbon that it stores. Even for the purpose of REDD+, the accounting for carbon measurement in terrestrial forest has been a complicated endeavour – however years of research through various pilot studies and demonstration projects around the world have gathered a good baseline for developing measurement guidelines. These measurement protocols are often packaged together with the well-developed method for monitoring and reporting in order to be viable in the carbon valuation market.

The United States Agency for International Development (USAID) in collaboration with Forest Carbon, Markets and Communities (FMFC) has produced a guideline called the "REDD+ Measurement, Reporting and Verification (MRV) Manual" (Hewson, 2014) which provides a review of data, models, techniques and accounting methods for the reduction of emissions via REDD+, targeting to inform policy makers at the UNFCCC. The comprehensive manual include the three main elements as quoted below in Table 2.10.

Table 2.10 Definitions of the elements of Monitoring, Reporting and Verification (Hewson, 2014)

No	Element	Definition
1	Measurement	Includes both the actual/physical measurement of emissions or removals from forest areas, as well as their calculation, using either simple formulas that rely on the use of land areas and specific emission factors, or complex models that take into account a number of different parameters that affect the release or sequestration of carbon and other GHGs.
2	Reporting	The process of documenting estimates of GHGs and the methodologies used to derive them, as well as other related issues, such quality assurance and quality control (QA/QC) activities, uncertainty estimation, etc.
3	Verification	Provides inputs to improve GHG inventories, build confidence in estimates and trends, and help to improve scientific understanding of GHGs. Specific activities include both internal and external checks of the inventory parameters.

The implementation of MRV calls for the setting up of working groups and task forces to undertake specific tasks which may include a combination of approaches and options depending on the needs and capacities of the respective countries. Among some of the recommendation for approaches are out-sourcing to an external organisation to prepare an inventory, set-up a team with core members from governmental agencies to oversee the inventory preparation by the outsourced parties, to form an advisory team which may be composed by representatives from single or multiple governmental agencies and ministries, or a combination of all the approaches.

The IUCN and CIFOR produced a report entitled 'Protocols for the Measurement, Monitoring and Reporting of Structure, Biomass and Carbon Stocks in Mangrove Forests' (Kauffman & Donato, 2012), where it describes the approaches necessary for the measurement, monitoring and reporting of structure, biomass and carbon stocks in mangrove forests. It outlines biologically relevant and statistically valid approaches to the efficient and accurate assessment of ecosystem structure, biomass and carbon stocks of mangrove forests.

A specific protocols of measuring blue carbon is still in the stage of development by the Blue Carbon Scientific Working Group (Section 2.7.5.1). The protocol, named as "Field Manual for Carbon Accounting in Mangroves, Seagrasses and Tidal Salt Marshes" will be a reference for other scientists, managers and also other related practitioners with a set of recommended standardised measurement and analysis of blue carbon.

Another supplement to the IPCC guidelines has been published on national greenhouse gas activities relating specifically to wetlands entitled, "The 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Supplement)" (Hiraishi et al., 2014). The progression of these published international guidelines will serve as a launch-pad for Malaysia to forge the first step towards integrating coastal blue carbon in the current state of resource management.

2.7.7 Policy Development

There has been an ongoing effort and opportunities that are existing to promote blue carbon as a recognised and legitimate climate change activity in the international arena. However, according to the report prepared by Climate Focus for the Linden Trust for Conservation (Focus, 2011), the current UNFCCC and Kyoto Protocol negotiations are beyond its capacity to add another agenda, until and unless the existing IPCC reporting guidelines are improved and to increase its extent of coverage to include blue carbon into the existing NAMAs[7] and REDD+[8] agendas.

Therefore, in order for blue carbon to be introduced and acceptance into the existing framework and mechanisms that are in place, the Climate Focus report presented some of the top priorities as follows:

1 Develop and improve IPCC reporting guidelines where they do not adequately cover blue carbon sinks and reservoirs.
2 Ensure NAMAs include actions that address blue carbon.

[7] NAMAs - Nationally Appropriate Mitigation Actions are voluntary mitigation actions by developing (Non-Annex 1) countries in the context of sustainable development, supported and enabled by technology, financing and capacity-building, aimed at achieving a deviation in emissions relative to 'business as usual' emissions in 2020. Defined by the Cancun Agreement, December 2010 - UN Framework Convention on Climate Change

[8] REDD+ or REDD Plus - Reducing Emissions from Deforestation and Forest Degradation in Developing Countries

3 Utilize REDD+, which has more developed policy structures and could include mangroves that meet the definition of a forest.
4 Leverage the multiple benefits of blue carbon to access financing.

2.7.8 Incentivisation

At the initiation stage before actual implementation, newly introduced concepts as such blue carbon would require a buy in, a form of incentives that would make adoption of this measure more marketable, desirable and sustainable in the long term basis. It is challenging for an environmental conservation or protection to gain traction without an economic visibility and feasibility, which is important to guide the decisions in policy-making. Essentially, the incentives produced from conserving coastal blue carbon sinks are a form of payment for environmental services (PES) (further discussed in Section 2.8.1).

Blue carbon was introduced only a few years ago at the UNFCCC in 2011, therefore blue carbon is currently not fully covered in the Kyoto Protocol accounting rules for Annex 1 Countries[9]. The blue carbon accounting (especially for wetlands like mangrove) has yet to gain recognition within the Annex 1 emission limitation or reduction commitments. For this to take place, the Landuse, Landuse Change and Forestry (LULUCF[10]) accounting rules in the Kyoto Protocol has to be changed first to accommodate blue carbon.

In its role as an overarching international climate change treaty, the UNFCCC adopts the perspective which sees the developing of blue carbon projects at country level such as NAMAs as a crucial step towards initialising and raising the profile for blue carbon. This is to enable higher international funding towards mitigation activities at the blue carbon ecosystem areas. Essentially this is the most attractive and plausible short

[9] Annex 1 Countries (also known as Parties to the Convention) are countries classified as industrialized countries and economies in transition according to the United Nations Framework Convention on Climate Change. Currently there are 43 Annex 1 Countries including the European Union.
[10] The sound management of LULUCF activities plays a pivotal role in the mitigation of climate change, whereby it increases the removal of greenhouse gases (GHGs) from the atmosphere and/or decrease emissions by sources leading to an accumulation of carbon stocks.

term action that can be developed and implemented, which is a comparatively quicker action pathway than to wait out the entire duration of time required for the necessary revision of Kyoto Protocol's accounting rules. Among the first steps to be taken (with due considerations of the policy and technical uncertainties) is to enable NAMAs as a platform to promote blue carbon readiness and funding opportunities. Malaysia is named as one of the countries (which also include Indonesia, Brazil and Mexico) that are ready for NAMA implementation through demonstration projects and pilot policies due to its existing national inventories that will enable a preliminary address of blue carbon ecosystems in its national policies and development plans (Hewson, 2014). NAMAs that are initiated by the respective countries can be proposed and submitted to the UNFCCC Secretariat – with an option of forging multilateral partnerships among countries to develop and submit a regional blue carbon NAMAs for funding.

The guarantee of a rewarding incentives are often less simplistic as the incentive mechanism may imply. This is because the effectiveness of the mechanism and its long-term success depends largely on many intertwined factors that are often complex and widespread. Playing a large role is the capacity and ability of the implementing country to develop a robust and credible monitoring and GHG inventory systems. This system may not necessary be strictly bound amount of carbon dioxide in tonnes but may also choose to adopt the approach to use estimated proxies and qualitative requirements while it gradually evolve to quantitative measures in due time (Focus, 2011).

2.7.9 Blue Carbon Implementations

Although the blue carbon concept may still be a new study and management approach, it has been adopted and initiated by various countries around the world through several implementations. Various projects have been started globally, some of which are integrated into a larger national-based projects such as disaster prevention measures, poverty eradication and biodiversity conservation initiatives.

Blue Carbon Portal is a site which has become an international platform of which various blue carbon project are reported and shared around. In general, the approaches has been categorised by the *Blue Carbon Portal* into four major groups with the number of the respective approaches recorded to date stated in Table 2.11.

Table 2.11 Categories of Blue Carbon approaches and implementations

Category	Description	Number
Demonstration Projects	Projects that demonstrate the application of blue carbon	10
Feasibility Assessment	Projects that explore the potential for blue carbon activities	3
Organisations	Groups that have a blue carbon project, focus or interest	23
Baseline Efforts	Projects that establish or explore a baseline for potential blue carbon activities	4
Initiatives	Multi-partner efforts or initiatives focused on blue carbon	7

Source: http://bluecarbonportal.org/

The summary of the categories listed in Table 2.11 are described in the following sections - capturing some of the common first approaches towards implementing coastal blue carbon projects that may build a framework for Malaysia.

2.7.9.1 Demonstration Projects

To date, there are ten (10) demonstration projects that has been conducted as displayed on Table 2.12. The summary presents the location of the project and its partners as well as the objectives that guides the demonstration projects.

Table 2.12 Blue Carbon Demonstration Projects to Date

No.	Demonstration Projects	Countries/Locations	Partners	Objectives
1.	Abu Dhabi Blue Carbon Demonstration Project	Abu Dhabi	Abu Dhabi Global Environmental Data Initiative (AGEDI), GRID-Arendal, UNEP, UNEP/WCMC, Forest trends	• Investigate the opportunities in building a local greener Emirate through the better understanding of carbon and coastal ecosystem services and its potential contribution to climate change mitigation efforts.
2.	Canary Current Large Marine Ecosystem (CCLME) Mangrove Project	Southern Senegal, Guinea, Guinea-Bissau, Sierra Leone	Agence Française de Développement, EAF-Nansen project, La Commission Sous-Régionale des Pêches, Wageningen UR, FAO, GEF, SIDA, NOAA, UNEP	• Improve knowledge of the mangroves of the Canary Current Large Marine Ecosystem (CCLME) and understanding of their role in the larger ecosystem • Formulation and adoption of innovative regional policies for sustainable conservation and management of mangroves • Elaboration, adoption and integration into the SAP of a regional instrument and management plan for the conservation of mangroves and • Evaluation and/or projection of the costs and benefits of cooperative transboundary conservation and management of mangroves.
3.	Coastal Plant Processes Working Group, University of Queensland	Australia and Indonesia	-	Information unavailable

Table 2.12, continued

No.	Demonstration Projects	Countries/Locations	Partners	Objectives
4.	Income for Coastal Communities For Mangrove Protection	Sri Lanka, Pakistan, Vietnam	Mangroves for the Future, UNEP, Food and Agriculture Organization of the United Nations (FAO), Regional Fisheries Livelihood Programme for South and Southeast Asia (RFLP)	• Develop a mechanism enabling investors to responsibly promote mangrove conservation/restoration, carbon emissions reduction and sustainable development through the provision of funding to local communities • Facilitate flows of funding to smaller mangrove areas in support of environmental externalities where entry into voluntary and compliance markets for carbon is not economically feasible. • Facilitate mangrove conservation/restoration, replenishment of fish stocks and livelihood development
5.	Livelihood Fund Restoration Projects	Sundarbans, India; Casamance, Senegal	IUCN, Danone	• Ecosystem restoration and preservation • Agro-forestry with soil restoration • Rural energy development that will reduce deforestation

Table 2.12, continued

No.	Demonstration Projects	Countries/Locations	Partners	Objectives
6.	Mikoko Pamoja Mangrove Restoration	Kenya	Earthwatch International, and Kenya Marine and Fisheries Research Institute	• Protect, enhance and expand an area of mangroves in Gazi Bay • Preserve the current quality and extent of the mangrove forests and the services they provide to local communities as well as restoring degraded areas of mangrove forest in Gazi Bay • Raise income from forest resources, including carbon credits for community benefit and establish alternative sources of timber and firewood in the Gazi area • Aim to establish a pilot project demonstrating sustainable mangrove management that will influence mangrove management nationally in Kenya • Work with the Kenya Forest Service and other government agencies to determine policy about engaging communities in land management, particularly through the provision on ecosystem services through international carbon offset markets

Table 2.12, continued

No.	Demonstration Projects	Countries/Locations	Partners	Objectives
7.	Multiple Benefits of Mangroves for REDD+ and Blue Carbon in Central Africa	Gabon, Republic of Congo, Democratic Republic of Congo, Cameroon	Cameroon Wildlife Conservation Society, National Governments (Gabon, the Republic of Congo, the Democratic Republic of Congo), Selected national/regional research institutions, UNEP-DEPI, UN-REDD, UNEP-WCMC	• Conduct a study of the values of ecosystem services (including carbon) of the mangroves of the western central Africa region (encompassing Gabon, the Republic of Congo, and Democratic Republic of Congo) in order to inform the REDD+ processes in these countries and to make the case for the inclusion of mangrove forests in REDD+ or voluntary carbon market schemes.
8.	Rehabilitating Blue Carbon Habitats Programme	Indonesia, Australia	UNEP, Mangrove Action Project (MAP), Operation Wallacea, RIEL Institute, Charles Darwin University, Alfred Wegner Institute (AWI)	• To research, develop and apply innovative tools and protocols for measuring, reporting and verifying project derived carbon storage and sequestration in mangrove and seagrass habitats. • To conserve, sustainably manage and ecologically rehabilitate mangrove forest. • To generate Blue Carbon Credits at project Demonstration Sites through mangrove ecological rehabilitation, conservation and sustainable management to be traded within emerging carbon markets.

Table 2.12, continued

No.	Demonstration Projects	Countries/Locations	Partners	Objectives
9.	Saloum Mangrove Reforestation, Senegal	Sine Saloum Delta, Senegal	Face the Future, West African Association for Marine Environment (WAAME)	• To improve local communities' well-being and buffer the effects of climate change through the restoration of mangrove ecosystems of the Sine- Saloum Delta • Climate change mitigation through sustainable sequestration of carbon • Mangrove ecosystem restoration (with positive social, ecological and economic impacts) • Income generation and livelihood improvement for local communities
10.	The Zambezi Mangrove Carbon Project	Tanzania, Mozambique	World Wildlife Fund (WWF), US AID, US Forest Service, Universidade Edudardo Mondlande, Government of Mozambique	• Contribute to the development of Mozambique REDD+ program by providing policy- relevant information necessary to establish baseline for REDD+ and other climate change mitigation activities (e.g., Nationally Appropriate Mitigation Strategies – NAMAS) for mangrove forests. • Build capacity in Mozambique for climate change mitigation and adaptation programs, specifically: o Demonstrate methodologies for conducting a carbon inventory; o Establish Monitoring, Reporting and Verification (MRV) pilot sites in mangrove

2.7.9.2 Feasibility Assessment

Another category of blue carbon projects that are registered under the Blue Carbon Portal are feasibility assessments, whereby every project implemented under this category is a preliminary action to identify the extent of blue carbon potential of selected sites. To date, there are three feasibility assessments that has been carried out, namely at the Arabian Peninsula, the Red Sea and the Gulf of Aden; as well as at the Madagascar. The key points from the feasibility assessments are as presented in Table 2.13.

Table 2.13 Blue Carbon Feasibility Assessment Projects

No.	Feasibility Assessment	Countries/Locations	Partners	Objectives
1.	Blue Carbon – Arabian Peninsula Project	Arabian Peninsula	• Abu Dhabi Global Environmental Data Initiative (AGEDI) • GRID-Arendal	• To explore blue carbon for the Arabian Peninsula in an Environment Agency – Abu Dhabi (EAD), local, regional, and international context, including the production of a Rapid Feasibility Study and the scoping of a regional blue carbon Demonstration Project. • To explore the Eye on the Earth Summit as a milestone event for regional and international blue carbon initiatives.
2.	Blue Carbon In The Red Sea And Gulf Of Aden: Policy Formulation And Regional Approach	Yemen, Abu Dhabi, Somalia, Sudan, Saudi Arabia, Jordan, Egypt and Djibouti.	• UNEP • PERSGA	• Policy analysis and assessments for stimulating application of best policies and management practices to strengthen resilience and improve coastal marine ecosystem having potential for Blue Carbon in the region. • Develop regional capacities for Blue Carbon assessment and policy implementation in the region • Establish synergies/linkages with other global/ regional initiatives on Blue Carbon for exchange of information, expertise and lessons-learned, harmonization, etc. such as UNEP's blue carbon initiative including the GEF "Blue Forest" project.
3.	Realising Madagascar's full blue carbon potential	Madagascar	Blue Ventures	Primarily focussed on REDD+ for mangroves: • Quantification of the greenhouse gas (GHG) emission reductions that can be achieved by mangrove REDD+ • Social impacts of mangrove REDD+

2.7.9.3 Organisations

Based on the information available at the Blue Carbon portal, a total of 25 organisations have registered to date that are involved in the blue carbon assessment or implementation around the world. Below is the summary of the organisation's profile. Summary from the organisations listed in Table 2.14 seems to suggest that a large number of these organisations are interlinked with one another – given their roles, strengths and objectives are complementing one another towards taking the blue carbon mechanism towards implementation.

Table 2.14 List of organisations involved in blue carbon projects as recorded in Blue Carbon Portal

No	Organisation	Country/Region	Type
1.	Abu Dhabi Global Environmental Data Initiative (AGEDI)	United Arab Emirates	Formed to address the local, regional and international need for quality environmental data and information between developing and developed countries. In close collaboration with the Environmental Agency of Abu Dhabi, it has produced an Introductory Guide of the Abu Dhabi Blue Carbon Demonstration Site, together with more than 15 international organisations.
2.	Blue Carbon Indonesia	Indonesia	This is a project under the Research Centre for Coastal and Marine Resources, Research Agency for Marine and Fisheries, Ministry of Marine Affairs and Fisheries – is to facilitate scientific research on blue carbon. It has since developed pilot projects on Banten Bay and have scaled up to larger ecosystems at Derawan Islands, East Borneo. Among its efforts in advancing the blue carbon mechanism in Indonesia includes the organising of a National Forum on Indonesia Blue Carbon, as well as seminar and capacity building workshops.
3.	Blue Climate Solutions	Global	Part of The Ocean Foundation, the Blue Climate Solutions is a non-profit organisation that focuses on policies that promote the roles of coastal and ocean ecosystems as important carbon sinks. It proposes options for the restoration and conservation of these ecosystems.
4.	Blue Ventures	Global	The Blue Ventures is a social enterprise which is focused on REDD+ for mangroves where it facilitates effective coastal community participation and share in the profits.
5.	Conservation International (CI)	Global	One of the three spear headers of the Blue Carbon Initiative, the CI works closely with partners at different levels ranging from top level government to coastal communities. The organisation is also instrumental in championing the blue carbon concept at major climate change meetings such as COPs. The CI has also produced in collaboration the Blue Carbon Policy Framework – outcome from the International Blue Carbon Policy Working Group discussion.
6.	Counterpart International	Global	Provides technical expertise in ecosystem restoration relevant to the Blue Carbon Initiative together with CI and IUCN. Among the aims are to raise awareness on the importance of blue carbon ecosystems, protect livelihoods and food security that depends on these ecosystems as well as to facilitate informed policy and decision makers with sound knowledge and guidelines.

Table 2.14, continued

No	Organisation	Country/Region	Type
7.	Environment Agency – Abu Dhabi	United Arab Emirates	Serves as the country's environmental regulator and advisor to the government on environmental policy. It lead the production of An Introductory Guide of the Abu Dhabi Blue Carbon Demonstration Site in collaboration with more than 15 organisations.
8.	Face the Future	Global	An organisation that focuses on sustainable forestry projects such as the marketing of carbon credits, aside from providing consultancy services. Currently restoring the mangrove at Saloum via reforestation.
9.	Forest Trends	Washington D.C., United States of America	An international non-profit organisation to expand the value of forests to the society while promoting sustainable management. Part of Forest Trends' initiative, the Marine Ecosystem Services (MARES) Programme, along with Katoomba Group (an organisation advocating Payment for Ecosystem Services – PES) are analysing carbon market in collaboration with local partners.
10.	GRID – Arendal	Global	A centre in collaboration with UNEP to support blue carbon projects via assessments, providing information, education, networking and capacity building in areas such as the Coral Triangle Region, West and East Africa and also Arabian Peninsula. GRID-Arendal is instrumental in producing the first introductory guide to building blue carbon demonstration project along with other international organisations.
11.	International Union for Conservation of Nature (IUCN)	Global	The IUCN, together with two other international organisation (CI and IOC-UNESCO) lead the first integrated blue carbon program – serving as the centre-point of understanding for all blue carbon science, knowledge, economics, management, etc. Called the Blue Carbon Initiative, it coordinates the International Blue Carbon Policy Working Group and the International Blue Carbon Scientific Working Group as the two major spheres towards building the blue carbon knowledge.
12.	Mangrove Action Project (MAP)	Global	MAP-Indonesia has embarked on projects focusing on coastal livelihood restoration in South Sulawesi, and partnering with Charles Darwin University, Flora Fauna International and Emerald Planet in rehabilitating abandoned aquaculture ponds to restore the mangrove area to its capacity as a blue carbon sink.

Table 2.14, continued

No	Organisation	Country/Region	Type
13.	National Oceanic and Atmospheric Administration (NOAA)	United States of America	NOAA is a US federal agency which is mandated to oversee the ocean sphere, marine resources and habitat for the nation – but with global influence. The agency is lending its expertise and knowledge to help develop the blue carbon mechanism via facilitating policy incorporation, filling the scientific knowledge gaps, and also to provide support required to develop protocols related to blue carbon implementations.
14.	Nicholas Institute for Environmental Policy Solutions	United States of America	An institute comprise of economists, scientists and policy experts with wide-ranging roles from providing a platform for dialogues between stakeholders and subsequently render neutral evaluations of the strengths and weaknesses of the options taken. The institute is at the forefront in studies relating to the scientific and economic challenges and feasibility of blue carbon as an incentive to conserve coastal ecosystems that are deemed as blue carbon sinks.
15.	Restore America's Estuaries (RAE)	United States of America	A national-based non-profit organisation for the protection of estuaries. It is currently leading the Wetlands Technical Group comprised of scientists and technical experts, which looks into developing requirements for crediting wetland conservation projects.
16.	Sierra Club British Columbia	British Columbia	A non-profit organisation which conserves the environment in the midst of climate change impacts. Its expertise lies in community engagement and mobilization –in collaboration with governmental agencies. Currently the focus of the organisation is on estuaries and seagrass areas.
17.	The Bluecarbon Project	Global	An organisation which focuses on offsetting carbon via conservation and restoration of coastal ecosystems in developing countries. Their objectives are also in line with alleviating poverty in communities by building sustainable business through education, conservation and restoration of these ecosystems.
18.	UNEP World Conservation Monitoring Centre (UNEP-WCMC)	Global	The UNEP-WCMC provides information support for global blue carbon assessments, via a series of online and in-field decision support tools for scientists and local experts. The organisation teams up with GRID-Arendal on various projects that are ongoing globally.

Table 2.14, continued

No	Organisation	Country/Region	Type
19.	United Nations Educational, Scientific and Cultural Organization (UNESCO), the Intergovernmental Oceanographic Commission (IOC) (UNESCO-IOC)	Global	The UNESCO-IOC is a body that promotes international cooperation and coordinate programmes in research and ocean related activities. Involved in the Blue Carbon Initiative under the UNEP, the IOC oversees the International Ocean Carbon Coordination Project (IOCCP) which develops a global network of ocean carbon observation for research.
20.	United Nations Environment Programme (UNEP)	Global	Under the United Nations, it serves as a facilitator and guide in promoting wise use and sustainable development around the world. It has developed a Blue Carbon Initiative to develop a global partnership in promoting sound management of coastal and marine ecosystems as well as to introduce financial instruments and incentives to materialise the baseline and demonstration projects that it is currently involved in.
21.	West African Association for Marine Environment (WAAME)	West Africa	A multi-disciplinary organisations that focuses on sustainable management of mangrove forests, value-add on natural resources, render technical and innovation assistance to local communities, as well as creating platform for community based management activities. Forges partnership with local groups and associations of target group in rehabilitation programmes.
22.	Wetlandcare Australia (WCA)	Australia	Not-for-profit company which undertakes natural resource management projects with landowners and authorities, as well as other national agencies and programs. Currently working with partners to sustainably manage blue carbon sinks and set up voluntary carbon and compliance schemes. The objective of the program is far-reaching beyond capturing of blue carbon but also to protect the nation's food security, as well as the health and productivity of the intertwined coastal ecosystems as a whole.

Table 2.14, continued

No	Organisation	Country/Region	Type
23.	Wetlands International	Global	Not-for-profit organisation for the conservation and restoration of wetlands which includes lakes, marshes and rivers – which special focus on developing nations. Possess technical know-hows on international sustainable coastal resource management policies, while advocating innovative approaches and incentive driven schemes. Extent of work includes Southeast Asia.
24.	World Wildlife Fund for Nature (WWF)	Global	The international non-profit organisation extends its work on conservation and restoration of nature to include blue carbon through the Coral Triangle Initiative. Focusing its attention on mangrove as well as seagrass, WWF is one of the major players to help materialise the implementation of blue carbon concept within the region. The organisation aims also to alleviate poverty and preserve biodiversity through blue carbon. WWF also looks into the REDD+ mechanism for lessons on sustainable financing, inclusion of blue carbon into the existing REDD+ agreements and climate mitigation strategies.

2.7.9.4 Baseline Efforts

To date, there are four baseline efforts reported in the Blue Carbon Portal. Below are the summary of these projects and the key updates:

1 Abu Dhabi Blue Carbon Demonstration Project

The one-year long project involves an extensive field survey along the coastlines of Abu Dhabi, facilitated by the Abu Dhabi Global Environmental Data Initiative (AGEDI). Started in November 2012, this project was focused on data collection to aid policy and financial feasibility analysis, and subsequently contribute towards identifying which options that is the most suitable to incorporate these values into policy and management. The project was supported by a team of expert consisting of GRID-Arendal, UNEP, UNEP-WCMC, Forest Trends, and coastal carbon scientists. This project not only identify the blue carbon pools in mangrove but also in seagrass, salt marsh and algal mats. The project is made up of the following components below:

- Carbon baseline assessment which includes quantifying the stocks of carbon for the coastal ecosystems (i.e. rate of sequestration in association with afforestation)
- Geographic assessment to map the blue carbon ecosystems
- Ecosystem services assessment to identify what are the other goods and services which these ecosystems provide apart from carbon sequestration
- Policy component which determines which is the most viable option for incorporating the blue carbon mechanism in the current policy and governance framework
- Finance feasibility assessment that results in several feasible options for implementing blue carbon in Abu Dhabi – taking into account also the interaction and integration of the components

2 Blue Carbon Baseline In Guinea-Bissau

This project incorporates the mangrove areas functionally as part of the three marine protected areas in Guinea-Bissau which is an important and rich fishery resource area. It plays a crucial role in the food security of the adjacent local communities therefore it is

imperative to ensure the sustainability of this fishery supply. Among some of the actions taken by the authorities are to update the zones and access rules, enhance monitoring and surveillance. Within the marine park, the Orango National Park is one of the most intact and pristine mangrove forest in its region which functions as the centre point of nursery area for fishes, crustaceans and shellfish. However, over the years this area has been degraded due to overfishing and deforestation therefore the patrolling and surveillance is an important component of the baseline effort. Complementary to this baseline effort, there has been studies in this area whereby it establishes a national mangrove C (carbon) reference emissions level (REL) and the assessment of the mitigation potential and expected revenue was done as one of the justifications to enhance the protection of the mangrove in this marine park against degradation.

3 Management Support to the Palau Northern Reefs Area

Consisting mainly of coral reef, seagrass beds, atolls and small volcanic rock islands – the Palau Reef Areas is listed under the Demonstration Site category as it aims to seek a better understanding of the roles of these ecosystems which are not highlighted or known as a significant carbon sequestration sites. Therefore, this demonstration site aims to assess any indicative value of carbon storage and sequestration capacity of these ecosystems to lend to the further understanding of blue carbon in this lesser regarded ecosystems.

4 Sustainable Management of Mangrove Forests in Guatemala, Honduras and Nicaragua.

Located in La Mosquitia which is a shared ecosystem between Honduras and Nicaragua, this project focuses on sustainable mangrove management. This are is occupied predominantly by indigenous population, which is expected to benefit from this baseline programme. This project commenced in 2010 and completed in 2012 with the collaboration of the local communities including the indigenous, local agencies, the Regional Coordinating Unit (RCU) of the Caribbean Environment Programme (CEP). In

line with sustainable management approach, the collaboration aims to encourage the inclusion of mangrove and coastal ecosystems in land use and spatial planning in all the three participative countries. In addition, mangrove restoration and preservation of the livelihood of the vulnerable communities were also the focus of the baseline effort. Among some of the outputs which this effort has put out to achieve is to strengthen the existing Ramsar Convention in Honduras, establish community-based projects on sustainable livelihood (to prevent deforestation of mangrove areas) which include ecotourism, oyster and clam farming, and sales of local products, training of local technicians to facilitate the ongoing capacity-building activities and develop mangrove restoration activities; to name a few. In the effort to prevent further degradation to the mangrove ecosystems through sustainable management, the spill over effect is felt through the preservation of local livelihood and the ecosystem services provided by mangrove – such as its role in carbon sequestration and storage.

2.7.9.5 Initiatives

The projects under the Initiatives category are generally multi-partnered efforts which is focused on blue carbon. Currently there are seven registered Initiatives under the Blue Carbon Portal, some are global-centric while some are localised. Nevertheless, the establishment of such Initiatives are important as it brings together a collaboration among experts on a platform where skills and knowledge can be shared to achieve a common objective. Therefore, these Initiatives extend beyond the confines of a particular nation state but renders their skills and know-hows to blue carbon projects around the world. Table 2.15 presents the key-points that forms the identity and the objectives of these coalition.

Table 2.15 Blue Carbon Initiatives

Initiative	Description
Blue Carbon Coalition	Formed in 2009, the coalition provides advanced policy options for blue carbon which represents conservation groups, environmental stakeholders, scientists from 43 countries. Its objective is to support the inclusion of marine conservation in climate change policy.
Cities and Climate Change in South Pacific: The Lami Town Project	Focused on Lami Town which is exposed to a high risk of erosion and flooding as an impact of climate change, this is part of a UNEP, UN-HABITAT, SPREP and Lami Town Council to design an adaptation plan for the community. Among the steps included is to restore mangrove as part of an ecosystem-based approaches.
International Blue Carbon Policy Working Group	Formed in July 2011, this working group is convened by IUCN and Conservation International. It aims to develop a framework for key policies, activities and financing opportunities. It is also focused on building an integrated Blue Carbon community to support an implementation of Blue Carbon Policy Framework.
International Blue Carbon Scientific Working Group	Started in 2011, this group was to coordinate the establishment of coastal blue carbon by way of providing recommendations to maximize carbon sequestration and avoid emissions by coastal ecosystems. It also plays a role in identifying information and data gaps – all towards facilitating the development of incentives, policies and payment mechanisms through carbon accounting.
Mangrove Restoration Project: Oceanium- Senegal	Due to the constant anthropogenic threat that is degrading and diminishing the mangrove forests in Senegal, this project was to accelerate the resettlement of mangrove in certain areas which needed facilitation. Aside from providing a sustainable natural resource for the local artisanal fishing, the protected and resettled mangrove is also validated under the Voluntary Carbon Standards (VCS) by the UNFCCC Board.
The Blue Carbon Initiative	This initiative brings together governments, NGO, research institutions, and communities globally to develop management approaches, financial incentives and policy mechanisms. It is also involved in developing carbon stock and emission assessments, implement demonstration projects, and support scientific researches. This initiative is headed by Conservation International (CI), the International Union for Conservation of Nature (IUCN), and the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific, and Cultural Organization (IOC-UNESCO).
Wetlands Technical Working Group	The objective of this working group is to develop requirements for quantifying and crediting the carbon assets in wetlands. It also includes considerations of governing issues, establishing baseline scenarios, monitoring and measuring carbon stocks, among some. The carbon standards adopted for this project is the VCS.

2.7.9.6 Pilot Projects

As a critical components in the Blue Carbon Policy, it is imperative to prove the viability of blue carbon as incentive mechanism for conservation is to develop a network of demonstration sites. Various projects have been started globally, some of which are integrated into a larger national-based projects such as disaster prevention measures, poverty eradication and biodiversity conservation initiatives. Malaysia has yet to begin a demonstration site as yet but plans are underway, overlooked by the National Ocean Directorate, under the Ministry of Science, Technology and Innovation (MOSTI). Below in Table 2.16 is the list of countries with pilot Blue Carbon projects:

Table 2.16 Blue Carbon Pilot Projects

No.	Countries	Project Sites	Description
1	Indonesia	4	Supports scientific research into blue carbon in coastal ecosystems as well as the valuable ecosystem services they provide.
2	Australia	2	Mangrove research projects targeting blue carbon at different sites in Australia and Indonesia. More information will follow.
3	Madagascar	1	Building Madagascar's capacity to capitalise on the role that its blue carbon assets and carbon finance could play in both mitigating climate change and in enabling coastal communities to adapt to the impacts of it.
4	Congo	4	Study of the economic values of mangroves of the western central Africa region to make the case for the inclusion of mangrove in REDD+.
5	Abu Dhabi	1	An exploration of blue carbon in the Arabian Peninsula
6	Guinea	1	Promote multi-country agreement on Sub Regional policies and plans for sustainable management of mangrove forests from southern Senegal as far south as Guinea and into Sierra Leone.
7	Tanzania and Mozambique	1	Focus on the mangrove forests in Zambezi delta to provide baseline information for REDD+ and associated climate mitigation projects.
8	Guatemala, Honduras and Nicaragua	1	Implemented through a Joint Programme and with the participation of the Ministry of Agriculture, Food and Environment of Spain and the Ministries of Environment and Natural Resources of Guatemala, Honduras and Nicaragua.

Table 2.16, continued

No.	Countries	Project Sites	Description
9	Vietnam	1	Developing a mechanism enabling investors to responsibly promote mangrove conservation/restoration, carbon emissions reduction and sustainable development through the provision of funding to local communities.
10	Sri Lanka	1	Developing a mechanism enabling investors to responsibly promote mangrove conservation/restoration, carbon emissions reduction and sustainable development through the provision of funding to local communities.
11	Pakistan	1	Developing a mechanism enabling investors to responsibly promote mangrove conservation/restoration, carbon emissions reduction and sustainable development through the provision of funding to local communities.
12	India	1	Extensive program of planting mangroves to protect farmland and villages against extreme climate
13	Kenya	1	Projects with community-based land-use projects with long-term carbon, livelihood and ecosystem benefits
14	Senegal	1	Mangrove reforestation

Source: http://bluecarbonportal.org/

2.7.10 Blue Carbon Projects in Asia

Countries in Asia which have started projects that are related to blue carbon such as Indonesia, Sri Lanka, Pakistan, Vietnam and India. Among them, Indonesia has 4 pilot site studies focused on scientific research on blue carbon; while Sri Lanka, Vietnam and Pakistan are developing a mechanism where investors can fund to local communities for blue carbon projects. India is reducing the loss of mangrove via replanting and development of rural energy to prevent deforestation.

Given that the implementation of a mechanism of such scale and complexities, they are usually done in collaboration with strategic partners which will help in providing technical and financial assistance and also the integration of REDD+ objectives that are presently in place. Therefore, some of the blue carbon projects in Asia are also attempts to streamline REDD+ framework – given that some of the lessons learned from implementation are also relevant to blue carbon; especially those related to community engagement, financing and carbon market, just to name a few.

Malaysia has also begun blue carbon projects, spearheaded by the Forest Research Institute Malaysia (FRIM) whereby carbon stock quantification and measurement studies are being conducted at several mangrove areas around the country. A notable research that has been conducted since 2011 by FRIM is the blue carbon stock quantification at several mangrove forests in Peninsular Malaysia which includes Pulau Langkawi, Merbok, Matang, Sungai Besar and Tanjung Piai (Noraishah et al., 2011).

2.7.11 International Collaborations/Partnership

Having mentioned the blue carbon projects around Asia, it is important to note as well the partnership and collaboration that leads to the materialisation of these projects, given that there will always be a need for technical expertise in launching a relatively new mechanism such as this. For instance, Indonesia has forged a partnership with University of Queensland (Australia), UNEP, Mangrove Action Project (MAP), Operation Wallacea, RIEL Institute, Charles Darwin University and the Alfred Wegner Institute (AWI). As for Sri Lanka, Vietnam and Pakistan – these countries are under the same collaboration with Mangroves for the Future, UNEP, Food and Agriculture Organization of the United Nations (FAO), Regional Fisheries Livelihood Programme for South and Southeast Asia (RFLP). The project in India partnered with IUCN and Danone Group.

2.8 Natural Resource Management

In the discussion about blue carbon as an incentive to encourage better mangrove management and conservation, it is imperative to consider the socio-economic nuances underlying a successful materialisation of blue carbon mechanism. Without due consideration and deliberation of how the current state of natural resource management is functioning or how it could play a role in the future mechanism, it is almost improbable to foresee a successful implementation to a complex incentive system. The following sections describes the relevant literatures relating to natural resource management to

which will be the foundational principles that sets the framework for natural resource management in the context of implementing blue carbon mechanism on mangrove forests.

2.8.1 Payments for Environmental Services (PES)

Ecosystem services has been in the discussion earlier than 1997 as an integral part of environment's life support system (Costanza et al., 1997). Be it the marine, freshwater or terrestrial ecosystems – each one of these play a respective role, which are often interconnected; in regulating the smallest (i.e. microbial) to largest of systems (i.e. climate) that governs the biomes that we have today. Ecosystem services directly and indirectly affects the human welfare, whether it is to provide livelihood and income, basic resource needs, or in influencing local migration, socio-cultural conditions, health and wellbeing (Assessment, 2005). Among the general services that natural ecosystems provide are as displayed in Table 2.17.

Table 2.17 Categories of ecosystem services according to Millennium Ecosystem Assessment 2005 (Assessment, 2005)

Categories	Forests	Oceans	Cultivated/ Agricultural Lands
Environmental Goods	Food Fresh water Fuel Fiber	Food	Food Fuel Fiber
Regulating Services	Climate regulation Flood regulation Disease regulation Water purification	Climate regulation Disease regulation	Climate regulation Water purification
Supporting Services	Nutrient cycling Soil formation	Nutrient cycling Primary production	Nutrient cycling Soil formation
Cultural Services	Aesthetic Spiritual Educational Recreational	Aesthetic Spiritual Educational Recreational	Aesthetic Educational

However, ecosystem services are often undervalued if considered at all- in the high-investment and high-returns developmental plans around the world (Waage, Bracer, & Inbar, 2008). Consequence to this, or perhaps contributed by this –is that the value of ecosystem services are not fully captured in the markets and is usually poorly quantified

in such a way that it is comparable with economic services and manufactured capital (Costanza et al., 1997). As such, ecosystem services are typically not included into policy considerations. Nevertheless, it is imperative to link biophysical aspects of the ecosystem services with human benefits through trade-off approach (i.e. ecological, social, cultural, economic opportunities, and monetary loss due to the loss of ecosystem services) (Kumar et al., 2010).

Among some of the key factors for the payment of ecosystem services to be materialised as a component in policy decisions, is to ensure that the ecosystem services assessments must be spatially and temporally explicit, to enable policy formations and interventions to take place around it (Kumar et al., 2010). An example of the parameters required to ensure that the ecosystem services are viable for payments are as follows (Waage et al., 2008):

- Ecotypes and the services it provide must be mapped
- Mapping the land use and conduct assessment on how these land use activities affects the ecosystem services
- Conduct analysis that quantifies the value (price) of the ecosystem services based on comparable deals in the area

If these parameters are clearly delineated, there is a high potential of creating an economic incentive for conservation as it is expected to – and this should be a solid market- based mechanism so long as the cost for conservation is kept below the payment that will be compensated for delivering the ecosystem services (Gómez-Baggethun, de Groot, Lomas, & Montes, 2010). The payments for ecosystem services does not necessarily come in the form of monetary compensation, but may also be present in various options such as providing financial support for community development (i.e. improving local facilities, healthcare and education), in-kind payments (i.e. skill- training, start-up funds for enterprises or a payment scheme that directly mitigate/compensate

economic losses due to current conditions) and the recognition of rights (i.e. land rights and a participation in decision-makings) (Waage et al., 2008).

In the context of climate change, it is undeniable that ecosystem services will play an integral, if not a pivotal part in the mitigating the impacts. In a clear example, the role of vegetation (i.e. terrestrial and coastal forest systems) in carbon sequestration and storage is imperative as a component to reduce the concentration of CO_2 from the atmosphere, apart from implementing clean development mechanism. In the case of mangrove, not only it is discovered as a pool that is able to store carbon in long periods of time, but also for role as a coastal buffer against storm surges, nursery for marine juvenile species and a source of livelihood for local communities that depends on traditional trade of resource harvesting.

2.8.2 Allocation of Responsibilities

In most discussions pertaining to environmental management, it is crucial to consider importance of a thoroughly planned allocation of responsibilities to ensure that the objectives and goals for the protection and conservation of environment can be achieved and be sustainable in the long run. However such discussions are often centred on systems and institutional arrangements. There is no doubt that the importance of a well-planned institutional arrangement and the delegation of responsibilities, as such management regimes could allocate benefits equitably with limited efficiency losses; as demonstrated as true for local and small user groups and communities (Agrawal, 2001).

Based on a study entitled "*Halting degradation of natural resources: is there a role for rural communities?*" (Baland & Platteau, 1996), it was stated that the "*privatisation or the regulation by central authorities of common-pool resources such as natural resources; often disregard the entitlements and personalised relationships that are characteristic of communal property arrangements*". This essentially means that more often than not, the attempt to manage the environment for its ecosystem services

often leave out an equally important role it plays in the lives of the communities that depends on it for their survival and livelihood, and to a certain extent, one which defines their culture and identity as well. This is addressed partly in Section 2.8.1 (Payments for Environmental Services (PES).

There is a need to pay equal amount of weightage to the underlying rights and power to access, use and management of the natural resource apart from what seems to be granted to the central governing authority (Schlager & Ostrom, 1992). In an overview, some of the themes that are identified for its importance in influencing the success of the natural resource management regime is as follows (Baland & Platteau, 1996):

1 Small size user group
2 Location close to the resource
3 Homogeneity among group members
4 Effective enforcement mechanisms
5 Past experiences of cooperation

Complementing the themes above, there are twelve principles guiding the allocation of responsibilities in order to provide a common point of reference in an situation where there is a high possibility of conflicting interests among the stakeholders and user groups related to the common-pool resource (Mostert, 2015). The summary of the principles are as stated below in Table 2.18:

Table 2.18 Twelve Principles in the Allocation of Responsibilities by Mostert (2015)

No	Principles	Description
1	Capacity	According roles and specific tasks for suitable players to optimally carry out the duties
2	Lowest Social Cost	To ensure that the cost borne by the society is kept at the most minimal
3	Causation	Proper compensation (usually financial) should be borne by defaulters/source of problem
4	Interest	Stakeholders with interests in a management task should invest necessary financial responsibility for the task

Table 2.18, continued

No	Principles	Description
5	Scale	The ability and capacity of the management should be according to the needs required in order to address the management issues
6	Subsidiarity	Management tasks should begin at the lowest level (bottom up approach)
7	Structural integration	To maximize resources, tasks that are related to one another should be managed together
8	Separation	To prevent things from being overlooked, tasks is to be delegated to different stakeholders to ensure there is a 'check and balance' system
9	Solidarity	Shared responsibilities and risks must be cultivated among each member of the group
10	Transparency	Responsibility delegations has to be done in an open manner
11	Stability	The delegation of responsibilities should be able to adapt steadily according to the changing circumstances without major reshuffling
12	Acquired rights	Rights must be respected and rightfully compensated as and when necessary.

CHAPTER 3: METHODOLOGIES

This study used two complementary methods to explore the vulnerability of mangrove forests at the two study sites and the potential of coastal blue carbon mechanism as an incentive to conserve these mangrove forests. The first step was to evaluate the vulnerability of mangrove forests at selected sites using an adapted vulnerability assessment used by the Coral Triangle Initiative, called as the ICSEA-C-Change. This looked into depth the compounding factors that are negatively impacting the current state of mangroves at these sites, so to make a statement that the current management approaches may not be sufficient to protect the mangrove forests.

After establishing the level of vulnerability of the mangrove forests at the study sites, the Rapid Impact Assessment Matrix (RIAM) was used to present a scenario of how the blue carbon mechanism would complement and strengthen the current management approach. This established the understanding of how coastal blue carbon implementation could play a role as a conservation tool apart from being a climate change impact mitigation as it is.

Finally, a comprehensive study of the institutional arrangements, law and policy in context of mangrove forests in Malaysia was done to identify any gaps and challenges; as well as to assess the capacity for integrating the blue carbon mechanism into its present framework.

The outcome from the series of methodology has established the notion that coastal blue carbon could be a viable incentive that could facilitate better mangrove management. Most importantly, the study was aimed at outlining the possibilities and capacity of implementing coastal blue carbon concept in Malaysia's mangrove management by way of identifying the impending gaps and challenges, should this motion is to be materialise beyond just a concept.

3.1 Development of Criteria for the Vulnerability Assessment from Baseline Information

Two mangrove forests in Johor were selected as study sites – Pulau Kukup (Figure 3.1) and Sungai Pulai (Figure 3.2). These sites were selected due to the differences in the mangrove forest types, its management and its adjacent land use; in order to make a comparison between different variables and some similarities which characterizes the two sites. Prior to the vulnerability assessment, a range of baseline information were collected and assessed to provide justification to the criteria which the vulnerability assessment is based. Among the information that were collected include mangrove type and cover, its protection status, characteristics, management, adjacent land use, socioeconomic and prevailing threats.

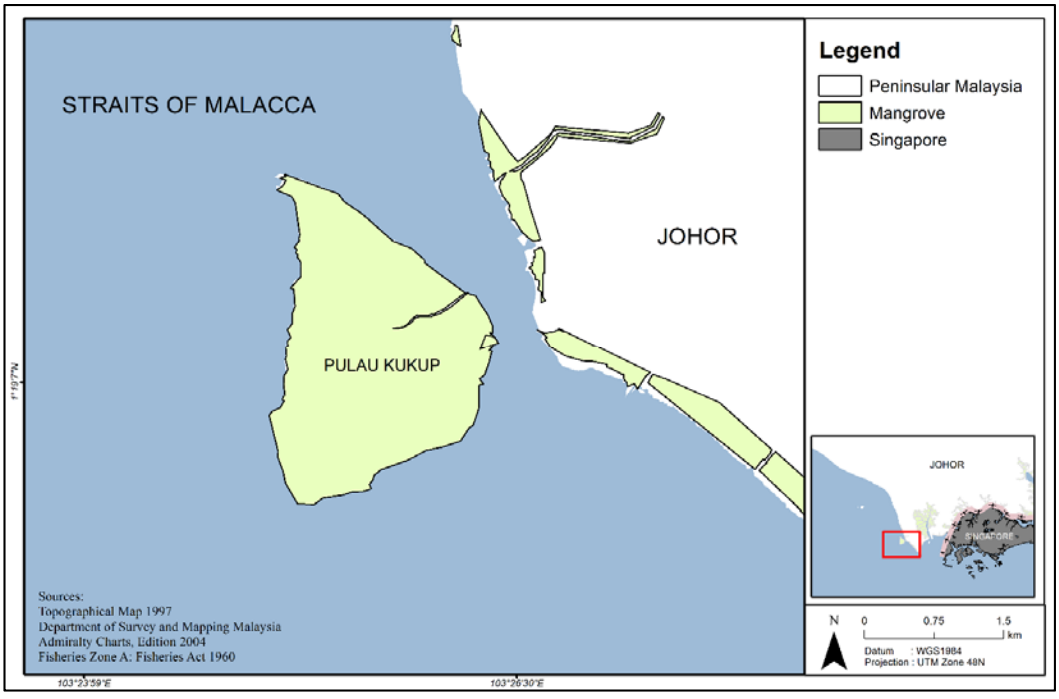


Figure 3.1 Mangrove distribution in Pulau Kukup

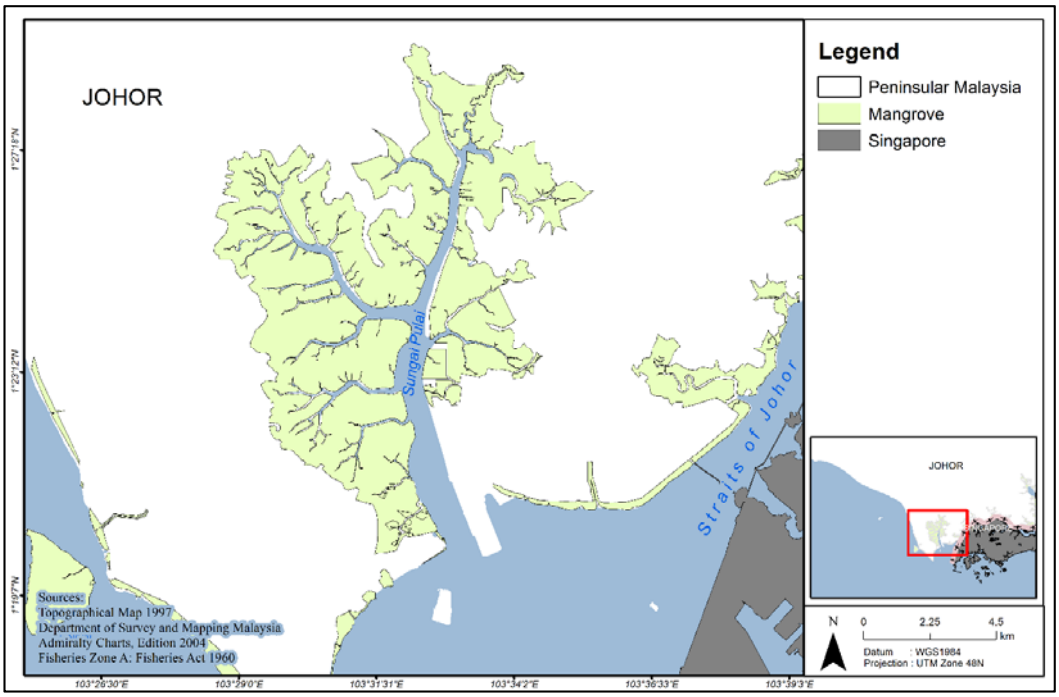


Figure 3.2 Mangrove distribution in Sungai Pulai

3.1 Assessment of Mangrove Areas Vulnerability

The methodology to assess the vulnerability of the mangrove forests at the pilot site is based on an adaptation of the climate change vulnerability assessment tool called the Integrated Coastal Sensitivity, Exposure and Adaptive Capacity to Climate Change Vulnerability Assessment Tool (or ICSEA-C-Change for short). The tool was developed by a large group of Philippine marine scientists, local government units and national governmental agencies, as well as non-government organisations to evaluate climate change impacts, vulnerability, adaptation and resilience- which is now adopted as part of climate change assessment tools by the five other countries in the Coral Triangle Initiative.

The ICSEA-C-Change is essentially a scoping and rapid assessment tool to identify the vulnerabilities of integrated ecosystem services to climate change impacts on the affected coastal communities (MERF, 2013) The key climate change impacts that are referred to throughout the ICSEA-C-Change are sea level rise, sea surface temperature change, waves and storm surges, and rainfall. The method provides a rapid, synoptic

assessment of the acute, immediate impacts of climate change in coastal areas. For the purpose of this study, the ICSEA-C-Change is readapted to determine the level of vulnerability of the mangrove area and the coastal community as a combined entity.

The reason behind utilising vulnerability assessment model by ICSEA-C-Change is to allow the evaluation of vulnerability in a holistic manner as it is able to capture the interlinked relationship between the ecosystem and the coastal community that depends on it. Although the study of coastal blue carbon often focuses on the conservation of mangrove forests for its carbon sequestration and storage abilities, it is imperative to also consider the elements of how the degradation and the conservation of mangrove could affect the coastal communities that depends on it which will add socio-economic weight in policy-making when considering the potential and feasibility of adopting the coastal blue carbon mechanism.

Based on a set of parameters which influences the well-being of mangrove forests and the coastal community that depends on it, the vulnerability will be assessed based on the framework illustrated in Figure 3.3.

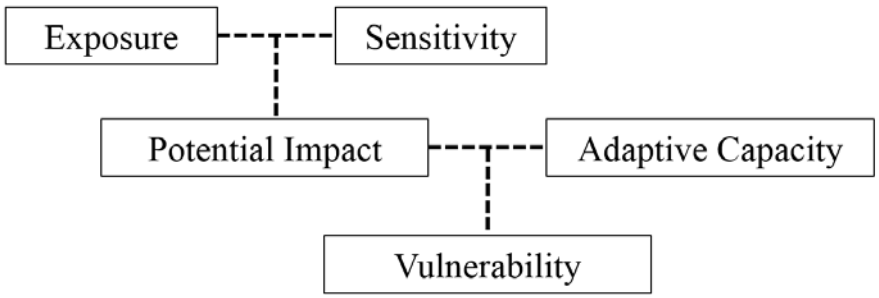


Figure 3.3 Vulnerability as a function of Exposure, Sensitivity and Adaptive Capacity (all known as 'variables') (MERF, 2013)

The ICSEA-C-Change framework is guided by three main variables which are described below:

1 **Exposure**: The intensity/severity of a particular set of physical impacts which are causing physical (and biological) changes in the current state of the biophysical system

2 **Sensitivity**: The current state of the biophysical system, in regards to how a specific property in that system will respond to the Exposure factors arising from a particular physical impact

3 **Adaptive Capacity**: The extent to which the biophysical systems are able to overcome and recover from the impacts of the physical threat. In the rubric scoring system, the Lack of Adaptive Capacity (LAC) is used as the negative representation of the operational definition for Adaptive Capacity. This essentially refers to parameters that assist or prevent the recovery of the system evaluated after being affected by an **Exposure**.

Based on the list above, the general vulnerability criteria that are considered to evaluate the vulnerability of mangrove area of the study sites are identified as shown in Table 3.1.

Table 3.1 Vulnerability criteria for the assessment of mangrove vulnerability

VARIABLES		NO. OF CRITERIA
Exposure		
1	Population Pressure	
2	Adjacent Land Use	
3	Oil Spill Risks	
Sensitivity (5 criteria)		
1	Mangrove Habitat Characteristics	3
2	Mangrove Resources and Ecosystem Services Dependencies	2
Lack of Adaptive Capacity (9 criteria)		
1	Health of mangrove forests	2
2	Habitat restoration and protected areas	3
3	Fish and Fisheries	2
4	Human Activities	2

The ICSEA-C-Change is based on a scoring system to evaluate the criteria under the variables. For this purpose, two sets of rubrics[11] are used to guide the assignment of scores for **Sensitivity** and the **Lack of Adaptive Capacity** variables. It is a five-point, three-level scoring which is Low Sensitivity (1 or 2 points), Moderate Sensitivity (3 or 4 points) and High Sensitivity (5 points). The ICSEA-C-Change scores allows for ranking of several sites based on their vulnerability levels. The following sections explains the Exposure, Sensitivity and Lack of Adaptive Capacity criteria respectively in further detail.

3.1.1 Exposure

Due to the background of which this method was developed (i.e. coastal community vulnerability to impacts of climate change), the Exposure factors used in the ICSEA-C-Change are sea surface temperature, sea level rise, waves, storm surges and extreme rainfall which are acquired from hydraulic and meteorological modelling results. The results from the modelling exercise determined the level of Exposure scores given to the sites being assessed. For the purpose of this study and the loose adaption from the original method, the Exposure factors were determined by the key existing negative impacts which threatens the well-being of mangrove forests. This was done to assess the vulnerability of the mangrove site to anthropogenic threats. These included *Population Density*, *Adjacent Land Use* and *Risk to Oil Spill* (Table 3.2). The categories and assignment of scores were done based on literature review findings in Section 2, and to a lesser extent from personal communication (interview) with Johor National Pack Corporation's Research Officer, Madam Lili bin Tokiman.

[11] The rubric scoring system has been evolved to meet different objectives, usually to rate the quality of performances – with clear definitions and examples (referred to as *descriptors*) to illustrate the attributes being measured, including the rating scale (referred to as *levels*) for each dimension (referred to as *criteria*).
A rubric is an assessment tool or scoring system for communicating expectations of quality. The range of quality for each criterion is divided into an equal number of scores with clear descriptions of each score.

Table 3.2 Key physical exposure in relation to the mangroves at the study sites

No	Physical Impact	Description	Low (1-2 points)	Moderate (3-4 points)	High (5 points)
1.	Population Density within 5km radius (people per km^2)	Mangrove losses are positively related to human population density and growth; the fewer people who live at or near a forest, the less destruction and exploitation is expected (Alongi, 2002). The category of population density and weightage given is based on a study by UNEP (Singh, 2006) which states that the average population density in coastal zones is 115 people per km^2 in year 2010.	< 100	100-300	>300
2.	Adjacent land use (types)	Degradation risks faced by mangrove forests due to adjacent land use includes possible deforestation due to land use conversion and expansion (e.g. agriculture, aquaculture, settlements, industry, etc.) (Polidoro et al., 2010), (Alongi, 2002), (Sasekumar, 1990) . The weightage is given based on the extent of impact from the land use and activities on mangrove forests. Mangrove reclamation projects such as clearing for heavy industry, ports, etc receive the highest weightage while low impact residential and tourism footprint receive the lowest weightage.	Residential and low impact tourism	Rural Agriculture and Aquaculture	Heavy industries and ports

Table 3.2, continued

No	Physical Impact	Description	Low (1-2 points)	Moderate (3-4 points)	High (5 points)
3	Distance to marine navigation – risk to oil spill exposure	The location of the study sites are in close vicinity of the Straits of Malacca, a busy international navigational route. Incidences of oil spill are not uncommon and there has been cases where the fringing mangrove areas at Tanjung Piai, Pulau Kukup and to a lesser extent, Sungai Pulai. (Ahmad, 2012) (BERNAMA, 2005). There are various ways to model the oil spill transport, along with many of the seasons, meteorological conditions, weathering factors, the type of oils, the current speed and direction, etc (Reed et al., 1999). However, the distance to which the mangrove forests are exposed to oil spill considered as an important indicator on how much time the oil spill emergency team are able to arrive at the scene and deploy remediation actions. The average current speed at the Straits of Malacca ranges from 1 to 1.25 knots (1.8 to 2.3km/hr) (Kamaruzaman, 1998). Therefore, it is assumed that if a spill happens at more than 2km away from the mangrove forests, it would take approximately an hour to reach the shore – translating to one hour of deploy time for the emergency response team to act. Hence, the closer the mangrove forests to the risk of oil spill area, the higher the exposure weightage it is accorded.	> 2km	> 1km	< 1km

3.1.2 Sensitivity

Based on the original ICSEA-C-Change method, Sensitivity of an area is based on how the area responses to the climate change impacts based on characteristics which may influence the degree of sensitivity such as whether there are temperature-sensitive coral reefs, extend of seagrass meadows which provides for the local fishery stocks, the extent of mangrove cover, how important fishery is for the community and how prone are the coastlines to erosions.

To include this in the study, the Sensitivity criteria being assessed for the vulnerability of the mangrove and the adjacent community are; 1) the extent of the natural mangrove cover still existing in the area; 2) the location of which the mangrove forests are found compared to the navigational route (to assess the level of exposure to potential oil spill); and 3) the adjacent population that is heavily dependent on mangrove resources and ecosystem services, especially fisheries. The following Table 3.3 provides the rubrics for Sensitivity in details:

Table 3.3 Sensitivity Rubrics

Criteria				Low	Medium	High
				1-2	3-4	5
Mangrove Habitat Characteristics	What is the existing natural extent of the mangrove areas left?	1	A larger extent of mangrove areas would have a higher chance of survival when experiencing degradation.	More than 50% of natural mangrove areas	Between 25-50% of natural mangrove areas	Less than 25% natural mangrove areas
	How exposed are the mangrove area to the risk of oil spill?	2	The further and more sheltered the mangrove areas are from navigational routes, the lower the risk of oil spill impacts	> 5km	4-2km	< 2km
	Are there existing coastal erosion/accretion?	3	Coastlines are constantly in the process of seasonal or long-term erosions/accretion, which affects the mangrove colonization capacities over time.	Accretion	Moderate seasonal accretion and erosion	Long-term trend of erosion
Mangrove Resources and Ecosystem Services Dependencies	What is the fisheries ecosystem dependency?	4	Mangrove areas are juvenile fish nursery grounds, which are crucial to ensure the constant replenishment of fish stocks of the area to which fishermen rely on as livelihood. The loss of this area will severely impact the fishery stock and depending on the number of fishers in a population, it would negatively impact the livelihood of the community.	35% or less of the population are fishers	36% to 60% of the population are fishers	More than 60% of the population are fishers
	What is the mangrove ecosystem services dependencies	5	The role of the mangrove areas determines the type of dependencies of the local community on the mangrove area.	Recreational	Livelihood	Livelihood and coastal buffer zone

3.1.3 Lack of Adaptive Capacity (LAC)

The final criteria of the ICSEA-C-Change method is the Lack of Adaptive Capacity (LAC), which functions as a negative representation of the operational definition of Adaptive Capacity as described earlier. In the original method, this criteria assesses the health of the coastal habitats, the water quality and the presence of any habitat restoration efforts to identify how low is the adaptive capacity (coping/recovery ability) of the area assessed. To assess the vulnerability of the mangrove areas at the sites in this study, the assessment are based on the health of the mangrove forests, mangrove restoration and protection, fisheries and mangrove natural resource extraction in the area and adjacent land use activities. The Lack of Adaptive Capacity rubric is as detailed in Table 3.4.

Table 3.4 The Lack of Adaptive Capacity Rubric

Criteria			Scoring				Notes
			Low 2	Moderate 3	Moderate 4	High 5	
Health of mangrove forests	1	Are the slow growing, slow colonizing species most common in the area?	Presence of more than 5 mangrove species capable of colonizing newly available habitat	Presence of 3 to 4 mangrove species capable of colonizing newly available habitat	Presence of 1 to 2 mangrove species capable of colonizing newly available habitat	Yes, all species are slow growing, slow colonizing	Recruitment potential
	2	Are there more large trees than small propagules (in terms of density)?	Seedlings and propagule observed between 8 to 12 months every year	Seedlings and propagule observed between 4 to 8 months every year	Seedlings and propagule observed between 1 to 4 months every year	Yes, all trees are large, seedlings and propagules are absent	Recruitment potential
Habitat restoration and protected areas	3	How much of the degraded mangrove area remain to be rehabilitated?	Less than 50% of the degraded habitats	Between 50 to 70% of the degraded habitats	Between 70 to 90% of the degraded habitats	More than 90% of the degraded habitats remain to be rehabilitated	Extent of degradation affects the recuperating ability of the mangrove to restore its area cover
	4	How much is the need to expand as part of the Ramsar/National Parks boundary is to cover the mangrove area?	Almost none; Ramsar/National Parks boundary is covering almost all of the mangrove areas at the site	Ramsar/National Parks boundary is covering at least 80% of the mangrove areas at the site	Ramsar/National Parks boundary is covering at least 50% of the mangrove areas at the site	Ramsar/National Parks boundary is covering at less than 20% of the mangrove areas at the site	Presence/absence of sustainable management intervention from authorities
	5	Was the Ramsar/National Parks design and management focused on mangrove enhancement alone?	Yes	No, biodiversity and tourism aims also considered	Fisheries and tourism were considerations	Tourism was the only consideration	Determines the type of management priorities

Table 3.4, continued

Criteria			Scoring				Notes
			Low 2	**Moderate 3**	**Moderate 4**	**High 5**	
Fish and Fisheries	6	What is the average fishing experience per fisher?	Less than 5 years	Between 5 to 10 years	Between 10 to 20 years	More than 20 years	The longer the fishing experience, the harder for fishers to shift livelihood
	7	Is fishing and mangrove natural resource extraction the only source of livelihood of the adjacent community?	No, more than 3 other sources of livelihood	Fishing plus two other sources of livelihood	Fishing plus another source of livelihood	Yes	Assessing if there are alternative livelihood for the community should the mangrove area depletes
Human Activities	8	How much does the present land use pattern deviate from the land use plan?	No deviation	Between 1 to 25%	Between 25 to 50%	More than 50%, or there is no land use plan	Presents an impression of the land use/conversion trend at the area
	9	What is the most extensive conversion of the coastal lands to rural agricultural, residential, commercial and industrial use, at the adjacent area of the mangrove forests?	Rural Agriculture	Residential	Commercial	Industrial	Determines the extent of impact of the land use activities on mangrove areas

3.1.4 Vulnerability Ratings

The method to which the scores from the Sensitivity, Exposure and the Lack of Adaptive Capacity (LAC) rubrics are integrated determines the final Vulnerability of the mangrove area at the study sites. These scores are averaged and converted to three scales, Low, Moderate and High. Based on the original ICSEA-C-Change method, the component scores are combined based on the following rules:

- When at least one of the three components is a moderate (score of 3-4), the final vulnerability rating for that site is Moderate
- When two components have a score of at least moderate and the third component's score is high (score of 5), the final rating for that site is High Vulnerability
- Other than what is stated above (i.e. two low scores between 1-2), the site receives a Low Vulnerability rating

The points above are further demonstrated in Table 3.5 to explain the integration of scores between the three components (Exposure, Sensitivity and Lack of Adaptive Capacity).

Table 3.5 Integration of score to obtain Vulnerability rating

		SENSITIVITY				
		L (1-2)	M (3-4)	H (5)		
EXPOSURE	L (1-2)	LLL	MLL	HLL	L (2)	**LAC**
	M (3-4)	LMM	MMM	HMM	M (3-4)	
	H (5)	LHH	MHH	HHH	H (5)	
Sensitivity and Exposure Subcore Conversion					Lack of Adaptive Capacity	
- Low is an average of 1.0 to 2.0					- Low is an average of less than 3.0	
- Moderate is an average of more than 2.0 up to 4.0					- Moderate is 3.0 to 4.0	
- High is an average of more than 4.0					High is more than 4.0	

The final results of the vulnerability assessment for the mangrove at the study sites were evaluated and discussed in Section 4.1.

3.2 Application of Rapid Impact Assessment Matrix (RIAM) to Justify Blue Carbon Mechanism

The RIAM is a method developed for the use in Environmental Impact Assessment (EIA) that enables quick scoping of the expected key impacts in the event of a particular scenario. RIAM is a system of scoring within a matrix that is designed to allow subjective judgements to be quantitatively recorded in multidisciplinary theme. It functions as a screening tool that considers both negative and positive impacts stemming from a known 'cause and impact' scenario (Pastakia & Jensen, 1998).

For this study, the RIAM method will be used to assess: 1) the key impacts from the current threats faced by mangroves in the two study sites and 2) the key impacts on these mangrove forests when the coastal blue carbon concept is adopted into the current mangrove management. The result from this matrix essentially determines the consequence between two scenarios; where coastal blue carbon is not adopted, and when coastal blue carbon is adopted. The matrix comprise of five criteria (i.e. Importance, Magnitude, Permanence, Reversibility and Cumulativity) and three environmental components (i.e. Physical, Ecological and Socioeconomic) with further descriptions as presented in Table 3.6.

Table 3.6 Criteria, its scales and descriptions in the RIAM assessment (Pastakia & Jensen, 1998)

Criteria	Scale	Description
A1. Importance of the impact	4	Important to national interests: area of coverage can be defined as the country as a whole, or the impact target has national/international significance.
	3	Important regionally: area of coverage can be defined as a single region of the country with its immediate surroundings, e.g. Central Finland as a whole.
	2	Important to areas outside the local context: area of coverage can be defined as a part of the region, but nevertheless is bigger than in local impacts. For example, a municipality as a whole.
	1	Important only in the local context: area of coverage is small and can be defined as point-formed, for example a single village inside a municipality.
	0	No geographical or other recognised importance.

Table 3.6, continued

Criteria	Scale	Description
A2. Magnitude of change	3	Major positive benefit
	2	Significant improvement in status quo
	1	Improvement in status quo
	0	No change in status quo
	-1	Negative change in status quo
	-2	Significant negative change in status quo
	-3	Major negative change in status quo
B1. Permanence of impact	3	Permanent or long-term where the impact is intended to be a permanent one or will last for more than 10–15 years
	2	Temporary and short-term: the impact will last only for a short period of time (from a few weeks/months/<9 years)
	1	No change/not applicable
B2. Reversibility of impact	3	Irreversible impact: impact has changed the environment permanently or the restoration will last at least 10–15 years.
	2	Reversible impact: the original state of the environment will be restored quickly (from a few weeks to months) after the activity finishes.
	1	No change/not applicable
B3. Cumulativity/ synergism of impact	3	Cumulative and/or synergistic impacts exist in the project environment with the other projects or activities occurring in the same area
	2	Impact can be defined as single (not interacting with other impacts)
	1	No change/not applicable

After placing a scale at the potential issues, the Environmental Score (ES) is calculated based on the following formula:

$$\mathbf{ES = A1*A2\ (B1+B2+B3)}$$

The ES are then compared against the range values as stated below in Table 3.7.

Table 3.7 Environmental Score, Range Value and the respective descriptions (Pastakia & Jensen, 1998)

RIAM Environmental Score (ES)	Range Value (RV)	Description of RV
72 to 108	+E	Major positive impact
36 to 71	+D	Significant positive impact
19 to 35	+C	Moderate positive impact
10 to 18	+B	Minor positive impact
1 to 9	+A	Slight positive impact

Table 3.7, continued

RIAM Environmental Score (ES)	Range Value (RV)	Description of RV
0	N	No change to status quo
-1 to -9	-A	Slight negative impact
-10 to -18	-B	Minor negative impact
-19 to -35	-C	Moderate negative impact
-36 to -71	-D	Significant negative impact
-72 to -108	-E	Major negative impact

3.3 Assessment of Policy and Management

The purpose of assessing the current policy and management relating to mangrove forests protection in Malaysia is for identifying its capacities, gaps and challenges in order to assess how the coastal blue carbon mechanism can best fit into the present management of mangrove forests of this country. This framework and results from this assessment has been presented at the International Conference on Mangroves of Asia-Pacific Countries in view of Climate Change (MAPCVCC-2014) (Teh, 2014).

A method commonly adopted in deliberating the multi-faceted public policies, is the analycentric approach (Hoppe, 1999). It provides a comprehensive study of the institutional systems and context of the issue pertaining to mangrove forests in Malaysia. It is a qualitative assessment of the relevant management and legislative mechanisms that influences the level of mangrove forests protection in Malaysia. It also takes into considerations the political, economic and socio-cultural factors influencing the policy process and management approaches in the current mangrove conservation. Among the points that the policy and management analysis aim to address are:

1 Level of protection accorded to mangrove forests in Malaysia;

2 The institutional arrangement that contributes to the mangrove management;

3 The extent of provision of laws or enactment that protects mangrove; and

4 Gaps or challenges of current management approach

CHAPTER 4: RESULTS

4.1 Baseline Information of Study Site

4.1.1 Site Characteristics

The mangrove forests at Pulau Kukup and Sungai Pulai are both natural mangrove areas and the two sites were selected due to the differences in their characteristics. Comparisons were made in terms of its management and land uses (Table 4.1):

Table 4.1 Descriptions between the Sungai Pulai and Pulau Kukup mangrove area[i]

Descriptions	Pulau Kukup	Sungai Pulai
Mangrove Cover	Approx. 6.7km^2	Approx. 9.13km^2
Mangrove Type	• 18 'true' mangrove plant species recorded • Zone 1: *Rhizophora apiculata* and *Brugueira cilindrica* • Zone 2: *Avecinnia alba and Sonneratia alba* • Zone 3: Diverse mature mangrove, dominated by *Rhizophora, Bruguiera* and *Avicennia* • Zone 4: Mixed forest dominated by *Rhizophora apiculata,* and *Bruguiera-Avecinnia marina* • Zone 5: Mixed forest dominated by *Rhizophora,* and *Bruguiera parviflora-Rhizophora apiculata-Xylocarpus granatum* • Zone 6: A rich diverse area dominated by *Rhizophora apiculata* • Zone 7: An area of mature tall trees mixed with *Rhizophora-Brugueira-Avicennia-Xylocarpus granatum-Ceriops tagal* • Zone 8: Unvegetated Intertidal mudflat area	• 24 'true' mangrove plant species and 21 mangrove associated species recorded • Four vegetation types: – *Avicennnia* forests at the seaward side at the estruary fronting Tanjung Piai – *Rhizophora-Bruguiera* forests at large areas within Sungai Pulai – *Luminitzera-Scyphiphora* forests occurs landward as a transition to the hinterland, inundated only during spring high tides – Dryland mangroves which occurs landward and inundated during occasional hightides • Noteworthy mangrove species include *Avicennia lanata, Bruiguiera sexangula* and *Podocarpus polystachus*

Table 4.1, continued

Descriptions	Pulau Kukup	Sungai Pulai
Protection Status	• State and National Park • Ramsar Site • Entire island is gazetted • Environmentally Sensitive Area Rank 2** • Primarily conserved for scientific research and wise use of marine biodiversity and resources • Open for visitors (boardwalk)	• Mangrove Forest Reserve • Ramsar Site • Undefined official boundary • Environmentally Sensitive Area Rank 1*
Characteristic	• Island with mudflat of 8km^2, concentrated at north-west coast • Uninhabited • Mature mangrove in the interior • Rapidly accreting zones on the west coast, eroding at south-east coast • Important Bird Area (IBA)	• Lowland tropical river basin • Extensive river network • Presence of associated seagrass beds, intertidal mudflats and inland freshwater riverine forest • Settlements at upstream areas • Not listed as Important Bird Area (IBA) but has threatened (IUCN Red List) avian species recorded in the mangrove forest
Management	• Johor State Park Corporation • Pontian District	• Johor State Park Corporation • Forestry Department of Malaysia • West side of Sungai Pulai falls under the district of Pontian while the left region is under Johor Bahru District
Adjacent Land use	• International marine navigational route • Artisanal fishery • Mariculture (cage culture) • Residential areas	• Cargo port at estuary • Predominantly surrounded by agriculture • Small scale fishery in rivers • Residential areas
Adjacent Socioeconomic	• Aquaculture • Shellfish harvesting • Fisheries • Tourism service providers (e.g. seafood restaurants, chalets, shops, boat tours, ferry rides, etc) • Agriculture in the outskirts	• Villages located at the fringes of Sungai Pulai is highly dependent on mangrove resources, whether by way of natural resource extractions (e.g. wood, shellfish, etc), fisheries, aquaculture and eco-tourism.

Table 4.1, continued

Descriptions	Pulau Kukup	Sungai Pulai
Threats	• Exposed to the risks of oil spill incidences • Illegal wood harvesting for subsistence by local community • Illegal harvest of resources from mangrove and mudflat • Unregulated tourism on the island • Water quality degradation due to usage of chemicals from the marine cage culture	• Port development within the estuary causing increased wave energy – resulting in accelerated coastal erosion • Water quality pollution (e.g. increased total suspended solids, sediment plume, heavy metal suspension and toxic organics) from coastal areas, likely caused by Tanjung Pelepas Port development (dredging and reclamation activities) • Exposed to the risks of oil spill incidences

Source of information derived from Information Sheet on Ramsar Wetlands (RIS) (Pillai, 2003a) and (Pillai, 2003b) and via desktop search
** ESA Rank 1: No development, agriculture or logging shall be permitted except for low-impact nature tourism, research and education.*
*** ESA Rank 2: No development or agriculture. Sustainable logging and low-impact nature tourism may be permitted subject to local constraints.*
Source: Environmental Impact Assessment (EIA): Procedure And Requirements In Malaysia by the Department of Environment Ministry of Natural Resources & Environment (DOE, 2007)

4.1.2 Present and Future Site Conditions

This section contains general descriptions of the conditions at the two study sites (Pulau Kukup and Sungai Pulai) mainly relating to the human-interaction point of view. The following information serve as basis to justify the scores given in the vulnerability assessment. In this Section, the current and future (proposed) Local Structure Plans[12] were compared to identify the future land use trend for the mangrove vulnerability assessment.

4.1.2.1 Pulau Kukup

At present, Pulau Kukup is a fully protected island which is designated as a State Park since March 1997, and in 31st January 2003 it was accepted as the 1287th Ramsar site. Given its unique feature as a mangrove island, it is recorded as one of the largest in

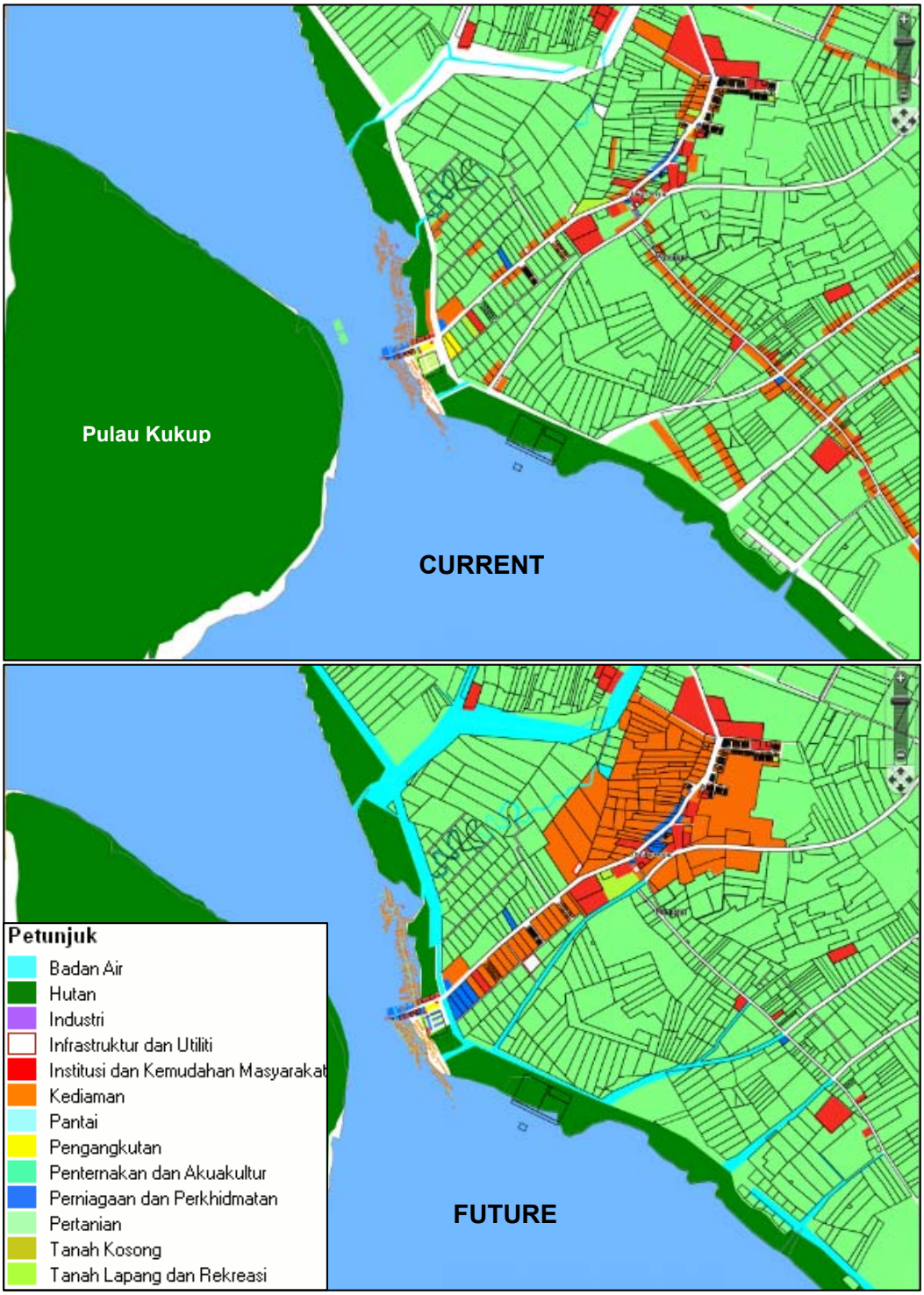
[12] Local Structure Plans are prepared under the provision of Section 12, Act 172, where it formulates a detailed proposal for the development and use of land in the area of local plan. It typically includes measures for the improvement of physical environment, the improvement of communications and management of traffic.

the world that are still intact. Currently the uninhabited mangrove island is separated from the mainland, i.e. Pekan Kukup by a mere 500 meters of narrow strait. However, the marine culture cages are less than 100 meters away from the coastline of Pulau Kukup. The local mariculture industry has benefitted from the location of Pulau Kukup as it provides shelter from the wave action in the larger Strait of Malacca (Figure 4.1).

Figure 4.1 Google Earth map displaying the present distribution of marine cage culture in the vicinity of Pulau Kukup

Apart from that, the local community also depends on the island for the thriving tourism industry where services such as seafood restaurants, homestays, shops and boat tours as a form of livelihood. Figure 4.2 shows the current development plan of the area

around Pulau Kukup vis –a –vis to the future development plan based on the Local Structure Plan as derived from the Town and Country Planning portal



Source: JPBD Portal

Figure 4.2 Current and future development at the adjacent land area of Pulau Kukup based on Local Structure Plan

As shown on Figure 4.9, the adjacent settlement lots (orange regions) at Pekan Kukup and Kampung Permas Kecil will expand along with slight expansion for businesses and

services (dark blue regions) mostly at Pekan Kukup. Therefore, population pressure is projected to increase in future with a likelihood of higher domestic waste discharge from the expanded settlements. There is also a potential for mariculture industry expansion which will increase the nutrient/chemical loading into the waters as production volume increases. Nevertheless, larger scale development such as land reclamation, port and heavy industries development that presents detrimental effect on the mangrove ecosystem of Pulau Kukup are not expected to occur at the area.

4.1.2.2 Sungai Pulai

With a total of 9,126 hectares, the riverine mangrove area at Sungai Pulai is recognized as an important biodiversity spot. The extensive mangrove stretches from Jeram Batu to Tanjung Piai and Tanjung Pelepas (Figure 4.3). It is managed as a mangrove forest reserve (MRF) under the National Forestry Act 1984 by the Johor State Forestry Department. Split by the main river (Sungai Pulai), the mangrove area that falls under the Pontian District (west) is notably larger than that which is found under the Johor Bahru District (east).

Source: JPBD Portal

Figure 4.3 The extent of Sungai Pulai mangrove area as a sensitive coastal ecosystem demarcated in IP10 in the National Physical Plan

The Sungai Pulai extensive riverine mangrove is also a conducive place for various ongoing research activities conducted by the local academic institutions, as well as the collection of annual waterbird counts by local non-governmental agencies to feed into the Asian Waterfowl Census report. Aside from its biodiversity, Sungai Pulai is also an important ecosystem that sustains the stocks for the local fishery and shrimp industry. There are about 38 villages located in Sungai Pulai MRF which are highly dependent on mangrove natural resources, inshore fishery, aquaculture and eco-tourism.

There was no eminently significant threat that poses the mangrove forest of Sungai Pulai until in 1997 when the 800 hectare Tanjung Pelepas Port (TPP) started construction at its river mouth (Figure 4.4). A significant area of mangrove forest were cleared for this development and local fishing villages at Tanjung Pelepas were evicted from the area. The port is still in its five phases of development up until year 2020.

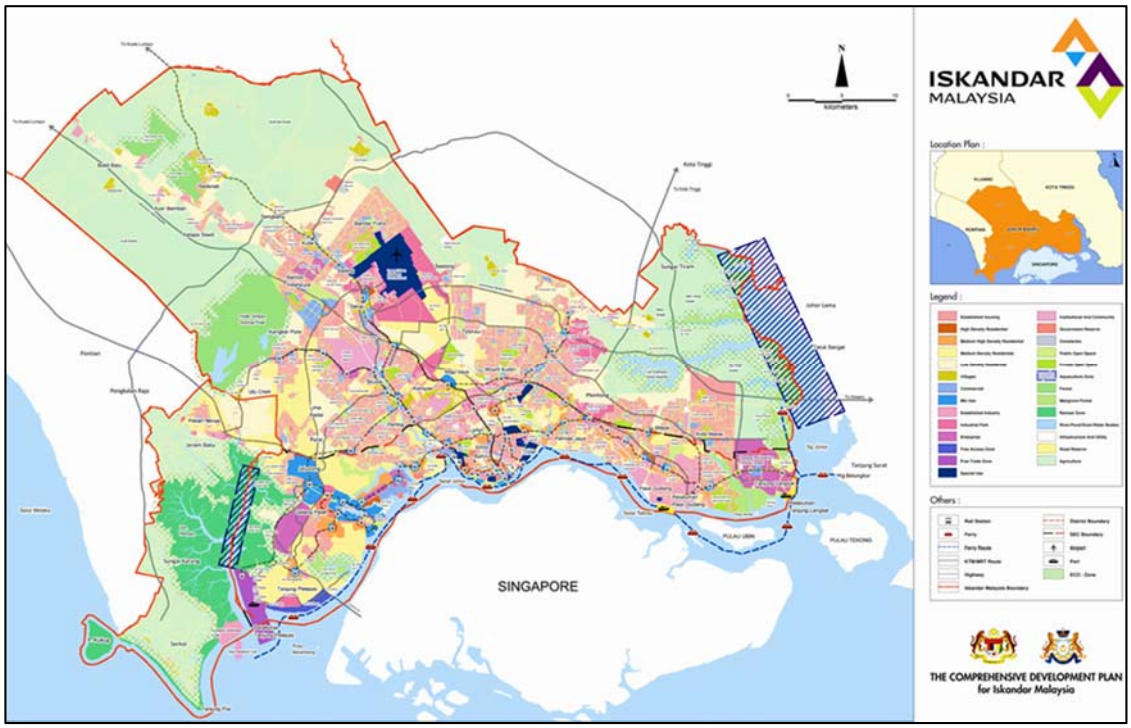
Figure 4.4 Google Earth map displaying the present layout of the Tanjung Pelepas Port at the estuary of Sungai Pulai (Imagery date: July 2011)

The development of the TPP could have deteriorated the level of water quality due to the extensive dredging and reclamation activities over the long period (Pillai, 2003b). Among some of the impacts that may arise due to this are changes in the sediment

transport and water current. The physical act of dredging may also suspend heavy metals and toxic organics into the water column due to suspended sediment.

As Sungai Pulai straddles on two districts, the east side and west side of mangrove forest are subjected to different Local Structure Plans, which ultimately decides the future land use in the adjacent area. Unlike Pulau Kukup, the mangrove forest in Sungai Pulai is not uninhabited. There are small villages that are settled at the fringes of the forest, and accounts of indigenous community known as Orang Seletar who is known as a nomadic group of people which has been occupying the area for centuries. They are spread out along Sungai Pulai, Sungai Johor and the Johor Strait, depending on the natural resources around them for livelihood and sustenance. To a large extent, these indigenous people has been affected by the scale of the various development (especially the Iskandar project) on the mangrove forest of Sungai Pulai and the adjacent areas to which they highly depend on (Star, 2011).

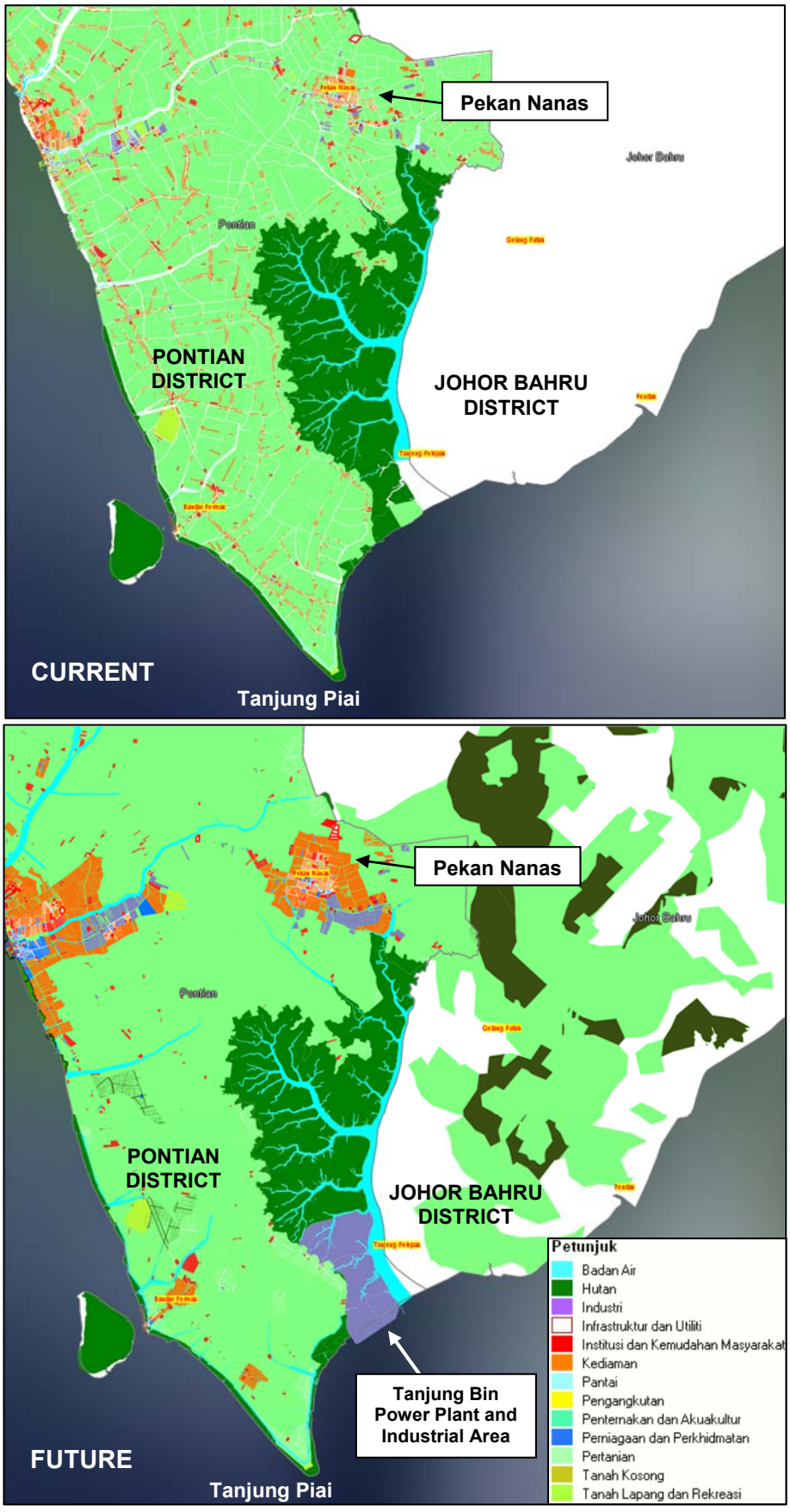
The mangrove forest at Sungai Pulai has been facing threats from a line of large scale development projects, starting from Danga Bay to TPP and currently Iskandar Malaysia, a mixed development which sprawls 2,217km^2, stretching from Pontian to Pasir Gudang (Figure 4.5).



Source: Medini Iskandar

Figure 4.5 Iskandar Development Map

Notably, the extent of urban development affecting the mangrove forests at Sungai Pulai is more significant on the east (Johor Bahru District) compared to the west side (Pontian District). The following figures compares the current land use and future development at the land adjacent to the mangrove forests at both districts (Figure 4.6 and Figure 4.7).



Source: JPBD Portal

Figure 4.6 Current and future development at the adjacent land area of Sungai Pulai at the east side based on the Pontian District Local Structure Plan

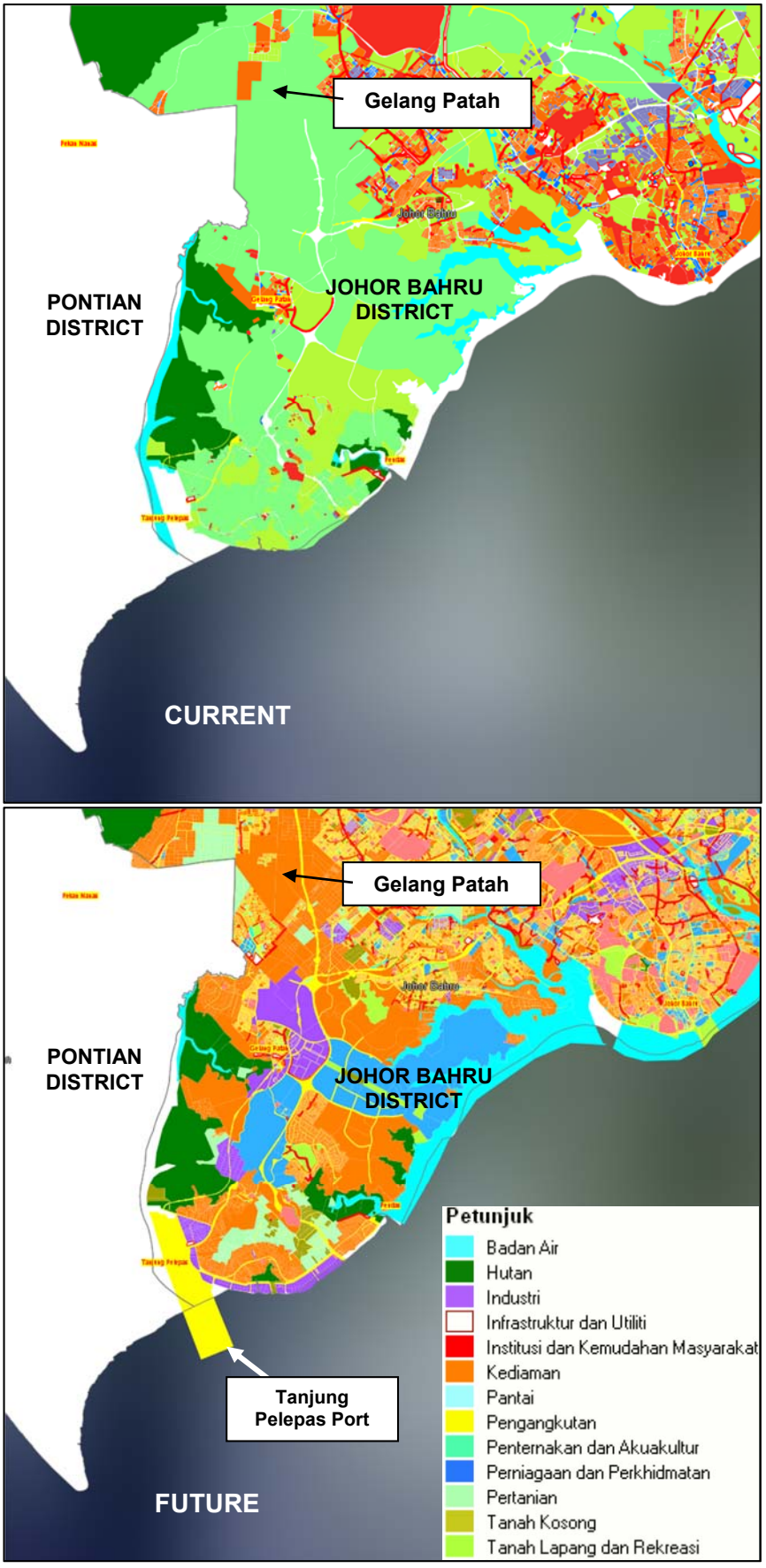


Figure 4.7 Current and future development at the adjacent land area of Sungai Pulai at the east side based on the Johor Bahru District Local Structure Plan

Based on Figure 4.6, there is an expected residential area expansion in the northwest side of Sungai Pulai mangrove area at Pekan Nenas. At the southwest region, at Tanjung Bin, a power plant is presently in operation but not captured in the figure depicting the current land use of the area. The industrial zone at Tanjung Bin is expected to expand towards inland, which inevitably involve physical clearance of significant cover of mangrove area at the estuary. Meanwhile on Figure 4.7, widespread development is expected around the fringes of the east side of Sungai Pulai mangrove area (Johor Bahru district). Compared to the current Local Structure Plan, there will be a widespread establishment of residential settlements, industrial zones, as well as business and services conurbations in the future plan. Note should be taken that the current Local Structure Plan did not include the presently existing and fully operational Tanjung Pelepas Port (TPP) which was constructed since 1997 and are still developing in phases up to year 2020.

4.2 Study Sites Mangrove Vulnerability

Following the adaptation of the ICSEA-C-Change method for this study as deliberated in Section 3.2, the following table presents the results of the Exposure scores (Table 4.2), Sensitivity scores (Table 4.3), the Lack of Adaptive Capacity scores (Table 4.4) and finally the Vulnerability results) for the mangrove areas in Pulau Kukup and Sungai Pulai.

Table 4.2 Exposure Scores between the mangrove area in Pulau Kukup and Sungai Pulai

Study Site	Population Pressure	Land Use	Oil Spill Risk
Pulau Kukup	3	3	5
Sungai Pulai	4	5	4

* *Scoring is based on Table 3.2*

Table 4.3 Sensitivity Scores between the mangrove area in Pulau Kukup and Sungai Pulai

	Sensitivity Criteria	Pulau Kukup	Sungai Pulai
Mangrove Habitat Characteristics	What is the existing natural extent of the mangrove areas left?	More than 50% of natural mangrove areas	More than 50% of natural mangrove areas. Potential risks due to port expansion
		Score: 1	Score: 3
	How exposed are the mangrove area to the risk of oil spill?	< 2km	4-2km
		Score: 5	Score: 3
	Are there existing coastal erosion/accretion?	Moderate seasonal accretion and erosion	Moderate seasonal accretion and erosion
		Score: 4	Score: 3
Average Score		**3.3**	**3.0**
Mangrove Resources and Ecosystem Services Dependencies	What is the fisheries ecosystem dependency?	36% to 60% of the population within 5km radius are fishers	35% or less of the population within 5km radius are fishers
		Score: 4	Score: 2
	What is the mangrove ecosystem services dependencies	Livelihood and wave buffer	Livelihood and coastal buffer zone
		Score: 5	Score: 5
Average Score		**4.5**	**3.5**
GENERAL MEAN		**3.9 ≈ 4**	**3.3 ≈ 3**

** Scoring is based on Table 4.1 and Table 3.3*

Table 4.4 Lack of Adaptive Capacity (LAC) scores between the mangrove area in Pulau Kukup and Sungai Pulai

Criteria			Pulau Kukup	Sungai Pulai
Health of mangrove forests	1	Are the slow growing, slow colonizing species most common in the area?	2	2
	2	Are there more large trees than small propagules (in terms of density)?	3	3
		Average	**2.5**	**2.5**
Habitat restoration and protected areas	3	How much of the degraded mangrove area remain to be rehabilitated?	2	3
	4	How much is the need to expand as part of the Ramsar/National Parks boundary is to cover the mangrove area?	2	2
	5	Was the Ramsar/National Parks design and management focused on mangrove enhancement alone?	2	4
		Average	**2**	**3**

Table 4.4, continued

Criteria			Pulau Kukup	Sungai Pulai
Fish and Fisheries	6	What is the average fishing experience per fisher?	4	5
	7	Is fishing and mangrove natural resource extraction the only source of livelihood of the adjacent community?	3	5
		Average	**3.5**	**5**
Human Activities	8	How much does the present land use pattern deviate from the land use plan?	2	4
	9	How extensive is the conversion of the coastal lands from rural agricultural to residential, commercial and industrial use at the adjacent area of the mangrove forests?	3	5
		Average	**2.5**	**4.5**
		GENERAL MEAN	**2.6 ≈ 3**	**3.75 ≈ 4**

Table 4.5 Vulnerability of the mangrove areas

	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Population Density Pressure				
Pulau Kukup	3	4	3	**Moderate**
Sungai Pulai	4	3	4	**Moderate**
Adjacent Land Use Impacts				
Pulau Kukup	3	4	3	**Moderate**
Sungai Pulai	5	3	4	**High**
Oil Spill				
Pulau Kukup	5	4	3	**High**
Sungai Pulai	4	3	4	**Moderate**

** Vulnerability level is based Table 3.2 and Table 3.5*

Based on Table 4.5, it shows that the Vulnerability level of the two mangrove study sites are similar, except for the land use impact and oil spill vulnerability. The extent changes to the land use in the near future for the adjacent land area of Sungai Pulai is significant, especially with the expansion of TPP development on the west (Johor District), coupled with the Tanjung Bin Power Plant and industrial zones at the southwest (Pontian District); and both developments are concentrated at the estuary of Sungai Pulai. Despite the Ramsar designation, large areas of mangrove forest at the estuary has been cleared and

will continue to be replaced with the expansion of heavy industry development, as stated in the Local Structure Plan. A significant amount of lots are also allocated for residential and mixed development (Pekan Nanas, Gelang Patah, Nusajaya, Iskandar) which will eventually contribute to the increase of domestic and commercial waste outfall and affect the water quality. Meanwhile, Pulau Kukup is an island directly exposed to the busy navigational route of Strait of Malacca, therefore making the exposure very high. Although the risk is high, the frequency of oil spill happening is relatively low and therefore, the threat perceived is not significant – as long as adequate and efficient oil spill response measures are established.

4.3 Rapid Impact Assessment Matrix (RIAM)

The RIAM assessment compares two scenarios which are stated earlier in the methodology section; 1) key impacts from the current threats faced by the two study sites and 2) key impacts on mangrove when the coastal blue carbon concept is adopted into the current mangrove management. These impacts are assessed based on three main receiving components: physical/chemical, biological/ecological and socio-cultural/economy. The RIAM assessment is done based on the premise that the mangrove forest is now a valuable commodity for carbon trading, therefore the implementation of blue carbon shall endeavour to take all possible actions to preserve the sustainability of the mangrove growth and survival by way of stricter laws, strengthened enforcements and a more mindful planning and monitoring.

4.3.1 Pulau Kukup

Results from the RIAM assessment for Pulau Kukup is as shown on Table 4.6 and Table 4.7, where it shows the current condition faced by the mangrove forest in Pulau Kukup and the impact/changes from implementing the blue carbon mechanism respectively.

Table 4.6 Issues and impacts of the current threats faced by mangroves in Pulau Kukup

	ISSUES/THREATS	CURRENT GENERAL STATE OF MANGROVE	A1	A2	B1	B2	B3	ES	RV	DESCRIPTION
Physical/Chemical	Oil Spill	Oil spill from leakage or collision between shipping vessels due to increased marine traffic navigation along the Strait of Malacca and insufficient emergency response plans that could contain the spill in the shortest time possible	3	-2	2	2	3	-42	-D	Significant negative change/impact
	Illegal harvesting	Uncontrolled and unsustainable removal of natural resources from the mangrove- even at a subsistence level by the local community will inevitably cause a steady depletion of mangrove area cover, hence diminishing its ecosystem services as a wave buffer zone	2	-3	3	2	3	-48	-D	Significant negative change/impact
	Pollution	Pesticides, fertilizers, and other chemical load originating from the upstream agriculture plots, coastal aquaculture cages and dumping of untreated domestic wastes could negatively impact the water quality beyond the tolerable threshold of the mangrove	2	-2	3	2	3	-32	-C	Moderate negative change/impact
Biological/Ecological	Oil Spill	Spills of light fuels could be absorbed by roots and cause mortality of mangrove. Crude oil coverage reduces the ability of roots to exchange gases. Sensitive propagules/seedlings covered in oil may have lower chance of survival.	3	-3	2	2	3	-63	-D	Significant negative change/impact
	Overharvesting	Unsustainable harvesting of wood causes extensive and often irreversible loss of mangrove cover area which consequently affect other organisms that depends on this ecosystem to survive	2	-2	3	2	3	-32	-C	Moderate negative change/impact

Table 4.6, continued

	ISSUES/THREATS	CURRENT GENERAL STATE OF MANGROVE	A1	A2	B1	B2	B3	ES	RV	DESCRIPTION
Biological/Ecological	Solid waste and toxic chemicals	Leachate from the untreated domestic waste (especially detergents) and the use of chemicals in the aquaculture cage industry could potentially poison the roots of the mangrove, affect benthic organisms and fishes	2	-3	3	2	3	-48	-D	Significant negative change/impact
Socioeconomic/Cultural	Oil Spill	Deterioration of water quality affects the fishing areas and subsequently affects fish stocks as the polluted waters may drive existing fish population away or negatively impact the fish reproductive processes	2	-2	2	2	2	-24	-C	Moderate negative change/impact
	Overharvesting	An unsustainable source of income over time as it is a finite natural resource, coupled with the fact that Pulau Kukup is a no-take mangrove island.	2	-2	3	2	3	-32	-C	Moderate negative change/impact
	Land based Pollution	Long term pollution from settlements and agricultural plots will cause degradation and mortality of mangrove, affects the ecosystem where the people derive their fishery resource as livelihood	2	-2	3	2	3	-32	-C	Moderate negative change/impact

Table 4.7 Impacts on mangrove when the coastal blue carbon concept is adopted into the current mangrove management in Pulau Kukup

	ISSUES/THREATS	WITH COASTAL BLUE CARBON IMPLEMENTED	A1	A2	B1	B2	B3	ES	RV	DESCRIPTION
Physical/Chemical	Oil Spill	Revision shall be made on the current emergency response plans of oil spill to not only address the spread of the spill but also place adjacent mangrove as one of the first priorities to be protected by the ERP team	3	2	2	2	3	42	D	Significant positive impact
	Illegal harvesting	Increased enforcement and heavier penalty on defaulters as each mangrove tree has value in terms of carbon stored. Regular measurement of the carbon stock at the mangrove forest will indirectly provide a more continuous presence of monitoring authorities	2	2	3	2	3	32	C	Moderate positive impact
	Pollution	Increased monitoring and enforcement with heavier penalty on defaulters to prevent degradation of water quality that may undermine the growth of propagules. Ensure that the coastal settlements does not release domestic outfalls into the sea and set stringent rules to monitor the level of pollution contributed by the adjacent aquaculture cage industry.	2	2	3	2	3	32	C	Moderate positive impact

Table 4.7, continued

	ISSUES/THREATS	WITH COASTAL BLUE CARBON IMPLEMENTED	A1	A2	B1	B2	B3	ES	RV	DESCRIPTION
Biological/Ecological	Oil Spill	Part of the implementation of coastal blue carbon demonstration site would have to include a revised emergency response plan to specifically address the issue of oil spill prevention from affecting the mangrove areas that are prone to such incidences	3	3	2	2	3	63	D	Significant positive impact
	Illegal harvesting	Increased enforcement and heavier penalty on defaulters as each mangrove tree has value in terms of carbon stored. Regular measurement of the carbon stock at the mangrove forest will indirectly provide a more continuous presence of monitoring authorities	2	2	3	2	3	32	C	Moderate positive impact
	Solid waste and toxic chemicals	Increased monitoring and enforcement with heavier penalty on defaulters to prevent degradation of water quality that may undermine the growth of propagules. Ensure that the coastal settlements does not release domestic outfalls into the sea and set stringent rules to monitor the level of pollution contributed by the adjacent aquaculture cage industry.	2	3	3	2	3	48	D	Significant positive impact

Table 4.7, continued

	ISSUES/THREATS	WITH COASTAL BLUE CARBON IMPLEMENTED	A1	A2	B1	B2	B3	ES	RV	DESCRIPTION
Socioeconomic/Cultural	Oil Spill	Improve emergency response plans of oil spill to not only address the spread of the spill but also place adjacent mangrove as one of the first priorities to be protected by the ERP tea. This should prevent the deterioration of fishing areas that may affect fish stocks which local fishermen depend on as a source of livelihood	2	2	2	2	2	24	C	Moderate positive impact
	Illegal harvesting	The implementation of blue carbon demonstration sites calls for a more sustainable harvesting of wood such as the model used in Matang Forest Reserve.	2	2	3	2	3	32	C	Moderate positive impact
	Land based Pollution	Enhancing monitoring activities of the mangrove areas to ensure that any land based pollution are identified and mitigated. This is to prevent the mortality of mangrove where people derive their resource and livelihood from	2	2	3	2	3	32	C	Moderate positive impact

Based on the impacts between the current situations of mangroves in comparison with the implementation of coastal blue carbon displayed on Table 4.6 and Table 4.7, the cumulative impact of the assessment is presented in the bar graph below (Figure 4.8).

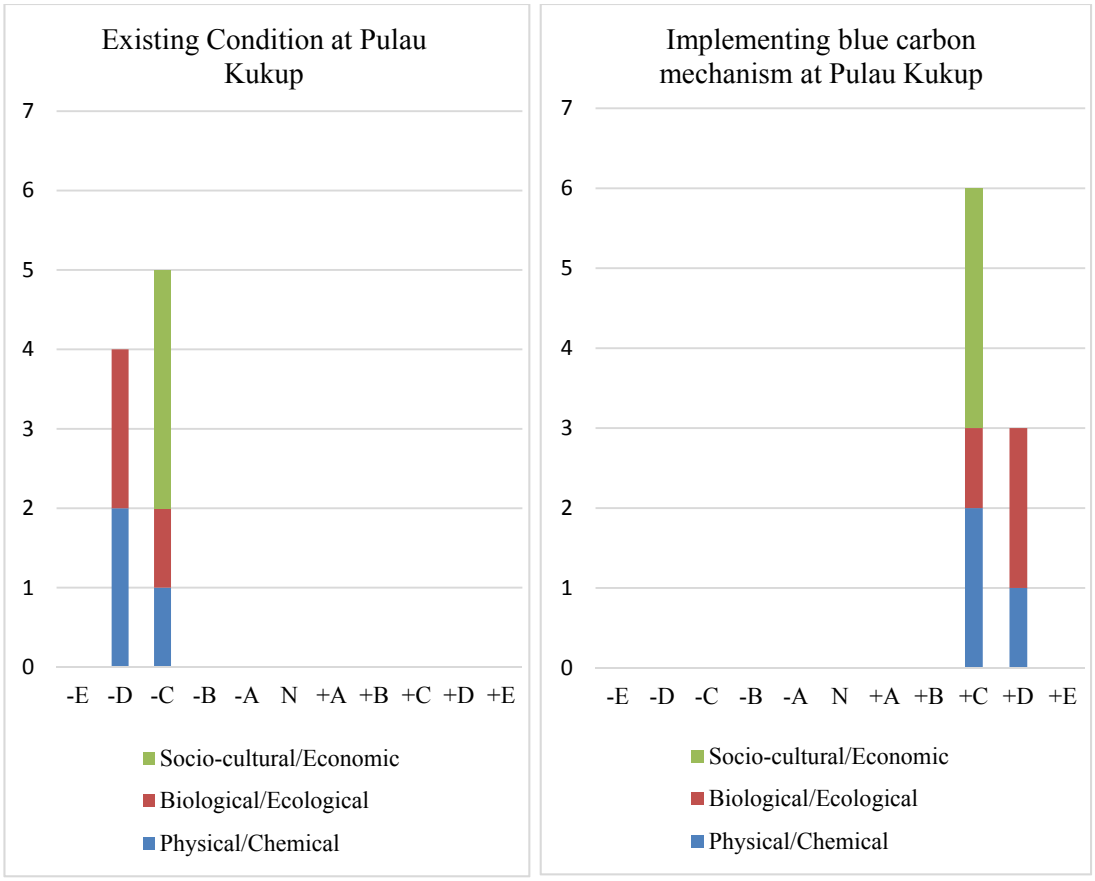


Figure 4.8 Cumulative impacts from the RIAM assessment between the current conditions vs. implementing blue carbon at the mangrove forest at Pulau Kukup

Based on the cumulative impacts above, the current conditions of the mangrove forest at Pulau Kukup will be improved with the implementation of the blue carbon mechanism. *Significant Negative Impacts* (score –D) from situations such as oil spill and illegal harvesting could be mitigated via stricter laws and enforcement which serves to protect and conserve the mangrove forest from deterioration and loss. While existing laws that conserves natural resources typically aim towards the same objective, the difference lies in the new role of mangrove in sequestering and storing carbon - one which adds greater value to the ecosystem service of mangrove than previously acknowledged.

Most of the *Moderate Negative Impacts* (score –C) in the RIAM assessment for Pulau Kukup came from the impacts that affect the socioeconomic condition of the local community. Contributed by the combined impacts of oil spills, illegal mangrove harvesting and long term water quality pollution (from the nearby settlements and agricultural plots), the condition of the mangrove in Pulau Kukup will deteriorate further and subsequently affects its ability to provide ecosystem services for the local population's livelihood – especially fishery. In addition, studies have shown that Pulau Kukup is faced with increasing sea level rise since 2006 due to extreme flooding such as the one caused by Typhoon Utor that occurred in 2007 (Jeofry & Rozainah, 2013) . The rise of sea level further increase the vulnerability of the mangroves at Pulau Kukup as the inundated mangrove fringes may not retreat in time. However, given the implementation of blue carbon mechanism, it should ideally put a stop to illegal harvesting through stricter laws and enforcement (given also that it is a no-take mangrove forest), and improve land use and waste management through a more holistic planning which takes into account the impact of adjacent land use on the mangrove forest in Pulau Kukup.

Most of the *Significant Positive Impact* (score +D) arising from the implementation of blue carbon mechanism will be experienced from mitigating the impact of oil spill and dumping of solid waste and toxic chemicals into the coastal waters. The role of mangrove forest as carbon sequester and storage bears national importance in the effort to mitigate the effect of climate change, thus making it a compelling factor to review the national oil spill emergency response plan (ERP). All efforts from the ERP must strive to ensure that the mangrove at Pulau Kukup receive the utmost importance in terms of preventing the spill from arriving and contaminating the mangrove areas. This is especially important as Pulau Kukup is in close proximity to the busy navigational Strait of Malacca and have been subjected to the impacts of several oil spill incidences over the years. In addition to that, implementing the blue carbon mechanism would also

encourage devising a solution which is designed to overcome the frequent and consistent outfall from domestic and solid waste from the nearby population through blue carbon mechanism would bring about a significant positive impact to the health of the mangrove in the long term basis.

4.3.2 Sungai Pulai

The results from the RIAM assessment for the mangrove forest in Sungai Pulai are shown on Table 4.8 and Table 4.9, where it shows the current conditions faced by the mangrove at Sungai Pulai and the impacts/changes after implementing blue carbon mechanism. Arguably, the mangrove forest in Sungai Pulai experiences more threats by way of its geographical characteristics, which is an extensive network of river surrounded by a large area of non-mangrove and populated land mass. Among some of the key threats highlighted in the RIAM assessment for Sungai Pulai mangrove are deforestation/land clearing, overharvesting, river changes, oil spill and land based pollution.

Table 4.8 Issues and impacts of the current threats faced by mangroves in Sungai Pulai

	ISSUES/THREATS	CURRENT GENERAL STATE OF MANGROVE	A1	A2	B1	B2	B3	ES	RV	DESCRIPTION
PHYSICAL/ CHEMICAL	Deforestation/ Clearing	Clearing of mangrove for other land uses such as ports, agriculture, property development, aquaculture and the likes causing the loss of buffer zone from coastal erosion and sediment trap	2	-3	3	2	3	-48	-D	Significant negative change/impact
	Oil Spill	Source from leakage or collision between vessels due to increased marine traffic navigation along Sungai Pulai (Tanjung Setapa) and insufficient emergency response plans that could contain the spill in the shortest time possible	3	-2	2	2	3	-42	-D	Significant negative change/impact
	Overharvesting	Uncontrolled and unsustainable removal of natural resources from the mangrove, especially for firewood, construction wood, wood chip and pulp production, charcoal production, and animal fodder causes depletion of mangrove area cover, hence diminishing its ecosystem services	2	-3	3	2	3	-48	-D	Significant negative change/impact
	River Changes	Redirection of flow water due to land reclamation and settlement irrigation reduces the amount of water reaching the mangrove - hence changing also the salinity of the water and may affect the physical-biology (especially growth) aspects of the mangrove in the long term basis	2	-2	3	2	3	-32	-C	Moderate negative change/impact
	Land deforestation	Inland deforestation/land clearance for urban development causes erosion increases the level of sedimentation in the water flowing to mangrove forests. It may overcome the mangrove's filtering ability and eventually smothering the mangrove forest	3	-2	3	2	3	-48	-D	Significant negative change/impact

Table 4.8, continued

	ISSUES/THREATS	CURRENT GENERAL STATE OF MANGROVE	A1	A2	B1	B2	B3	ES	RV	DESCRIPTION
PHYSICAL/ CHEMICAL	Deforestation/ Clearing	Load of pesticides, fertilizers, and other chemicals carried from upstream and dumping of untreated waste (especially industrial waste) could severely impact the water quality beyond the tolerable threshold of the mangrove	2	-2	3	2	3	-32	-C	Moderate negative change/impact
BIOLOGICAL/ ECOLOGICAL	Deforestation/ clearing	Loss of biodiversity from flora, macrobenthos, fishes to avifauna. The loss of mangrove also increases turbidity of water and may impact the planktonic community that depends on light penetration in water for primary productivity	2	-2	3	2	3	-32	-C	Moderate negative change/impact
	Oil Spill	Light fuels can be absorbed by roots and cause mortality by certain mangrove species, while crude oil reduce the ability of roots to exchange gases. Sensitive propagules/seedlings covered in oil will be negatively affected.	3	-3	2	2	3	-63	-D	Significant negative change/impact
	Overharvesting	Unsustainable harvesting of wood causes extensive and often irreversible loss of mangrove cover area which consequently affect other organisms that depends on this ecosystem to survive	2	-2	3	2	3	-32	-C	Moderate negative change/impact
	Foreshore protection structures	Tidal barriers, drainage and flood mitigation works (foreshore structures) at Tanjung Setapa may prevent the usual tidal patterns that ensure the floodplains are not drained. The structures would also be a physical barrier that prevents the seedlings from dispersing and repopulate other areas	2	-3	3	2	3	-48	-D	Significant negative change/impact

Table 4.8, continued

	ISSUES/THREATS	CURRENT GENERAL STATE OF MANGROVE	A1	A2	B1	B2	B3	ES	RV	DESCRIPTION
BIOLOGICAL/ ECOLOGICAL	Deforestation/ clearing	Mangroves often become dumping ground for waste and harmful chemicals from the nearby urban areas. Leachate from the untreated waste, especially industrial waste could potentially poison the roots of the mangrove, benthos and fishes and may even cause mortality	2	-3	3	2	3	-48	-D	Significant negative change/impact
SOCIOECONOMIC	Deforestation/ Clearing	Loss of livelihood for those who depend on the forest resources to survive, especially the orang asli seletar. The excessive loss of mangrove area would also cause coastal erosion and subsequently lead to loss of coastal areas which will affect the community living along the coastline. This will also increase sediment plume and may affect international boundary (i.e. Singapore).	3	-3	3	3	3	-81	-E	Major negative change/impact
	Oil Spill	Deterioration of fishing areas and may affect fish stocks as the polluted waters may impact the fish reproductive processes.	2	-2	2	2	2	-24	-C	Moderate negative change/impact
	Overharvesting	An unsustainable source of income over time as it is a finite natural resource	2	-2	3	2	3	-32	-C	Moderate negative change/impact
	Land based Pollution	Pollution causing the mortality of mangrove will affect the ecosystem where the people derive their resource and livelihood	2	-2	3	2	3	-32	-C	Moderate negative change/impact

Table 4.9 Impacts on mangrove when the coastal blue carbon concept is adopted into the current mangrove management in Sungai Pulai

	ISSUES/THREATS	WITH COASTAL BLUE CARBON IMPLEMENTED	A1	A2	B1	B2	B3	ES	RV	DESCRIPTION
PHYSICAL/ CHEMICAL	Deforestation/ Clearing	Increased enforcement and heavier penalty on defaulters. Change in land use planning at the policy level with the collaboration of State government and the Town and Country Planning Department	2	2	3	2	3	32	C	Moderate positive impact
	Oil Spill	Improve emergency response plans of oil spill to not only address the spread of the spill but also place adjacent mangrove as one of the first priorities to be protected by the ERP team	3	2	2	2	3	42	D	Significant positive impact
	Overharvesting	Implement Matang Mangrove models on gazetted mangrove forests. Form a group of experts and rangers to oversee and monitor the mangrove forests from encroachment	2	2	3	2	3	32	C	Moderate positive impact
	River Changes	Redirection of flow water due to damns and irrigation must not be approved without a detailed water catchment and river network assessment which takes into account the mangrove forests which would be affected	2	0	3	2	3	0	N	No change/status quo/not applicable
	Land deforestation	Inland deforestation must take into account its sedimentation impacts on mangrove and implement best mitigation measures to prevent negative impacts to mangrove in the downstream as much as possible	3	2	3	2	3	48	D	Significant positive impact
	Pollution	Increase enforcement and heavier penalty on defaulters	2	2	3	2	3	32	C	Moderate positive impact

Table 4.9, continued

	ISSUES/THREATS	WITH COASTAL BLUE CARBON IMPLEMENTED	A1	A2	B1	B2	B3	ES	RV	DESCRIPTION
BIOLOGICAL/ ECOLOGICAL	Deforestation/ clearing	Land use planning especially when it affects the coastal areas where mangroves are, must place a heavy emphasis on ensuring that mangroves are not to be cleared for development. In relation to this, the NPP-CZ must review its provision that allows for development to take place over ecological sensitive areas should the economic benefits outweigh the environmental benefit. Carbon storage should be regarded as having both environmental and economic importance. It is imperative as well to increase enforcement on monitoring the illegal activities as part of the blue carbon habitat boundary protection	2	2	3	2	3	32	C	Moderate positive impact
	Oil Spill	Part of the implementation of coastal blue carbon demonstration site would have to include a revised emergency response plan to specifically address the issue of oil spill prevention from affecting the mangrove areas that are prone to such incidences	3	3	2	2	3	63	D	Significant positive impact
	Overharvesting	The implementation of blue carbon demonstration sites calls for a more sustainable harvesting of wood such as the model used in Matang Forest Reserve.	2	2	3	2	3	32	C	Moderate positive impact
	Foreshore protection structures	The construction of tidal barriers, drainage and flood mitigation works (foreshore structures) would require hydraulic modelling before it can be approved at areas where mangrove are found and warrants the approval of the state and federal DOE and Forest Department.	2	3	3	2	3	48	D	Significant positive impact

Table 4.9, continued

	ISSUES/THREATS	WITH COASTAL BLUE CARBON IMPLEMENTED	A1	A2	B1	B2	B3	ES	RV	DESCRIPTION
BIOLOGICAL/ ECOLOGICAL	Deforestation/ clearing	Mangroves often become dumping ground for waste and harmful chemicals from the nearby urban areas. The implementation of coastal blue carbon sites would require the mangrove areas to be accurately defined to ensure that the mangrove boundaries are defined for better management	2	3	3	2	3	48	D	Significant positive impact
SOCIOECONOMIC	Deforestation/ Clearing	Coastal blue carbon project often involve the participation of locals and therefore strive to restore the livelihood of those who depend on the forest resources to survive. The prevention of mangrove loss may reduce the risk of coastal erosion which could subsequently lead to loss of coastal areas, to which affects the community living along the coastline.	3	3	3	3	3	81	E	Major positive impact
	Oil Spill	Improve emergency response plans of oil spill to not only address the spread of the spill but also place adjacent mangrove as one of the first priorities to be protected by the ERP team. This should prevent the deterioration of fishing areas that may affect fish stocks which local fishermen depend on as a source of livelihood	2	2	2	2	2	24	C	Moderate positive impact
	Overharvesting	The implementation of blue carbon demonstration sites calls for a more sustainable harvesting of wood such as the model used in Matang Forest Reserve.	2	2	3	2	3	32	C	Moderate positive impact
	Land based Pollution	Enhancing monitoring activities of the mangrove areas to ensure that any land based pollution are identified and mitigated. This is to prevent the mortality of mangrove where people derive their resource and livelihood from	2	2	3	2	3	32	C	Moderate positive impact

Based on the results on Table 4.8 and Table 4.9, the Figure 4.9 below shows the cumulative impacts from the difference between the current condition at the mangrove forests at Sungai Pulai compared to when blue carbon is implemented.

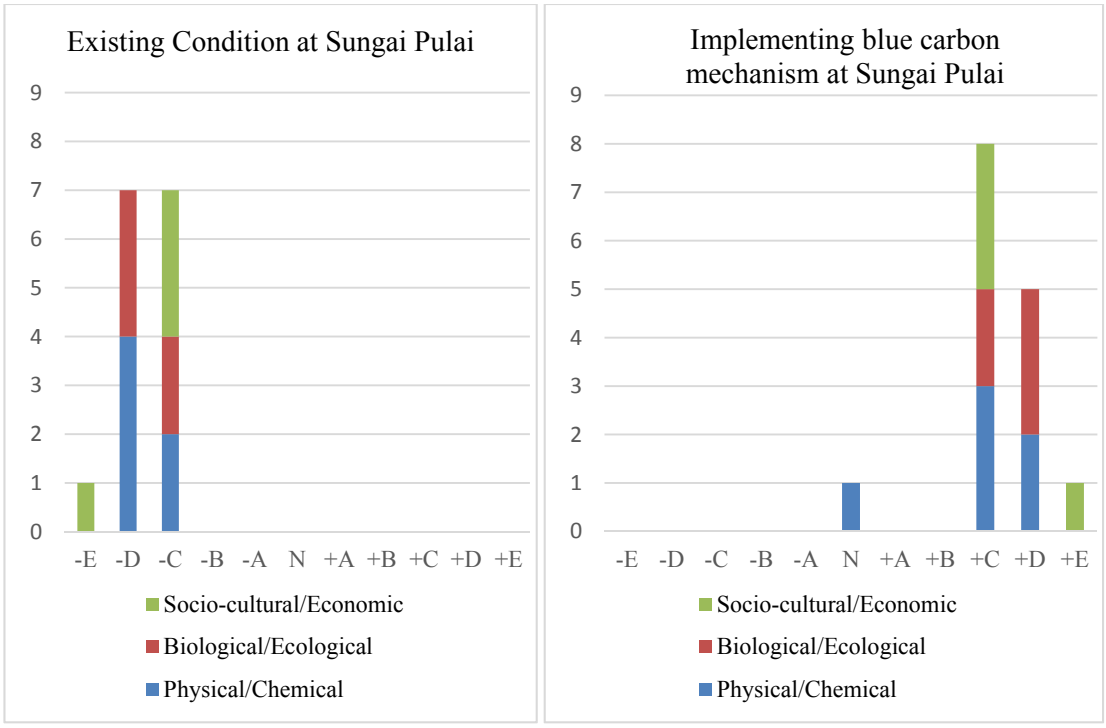


Figure 4.9 Cumulative impacts from the RIAM assessment between the current conditions vs. implementing blue carbon at the mangrove forest at Sungai Pulai

It is expected that there will be a shift from negative impacts in the Existing Condition to positive impacts in the three components (i.e. socio-cultural/economic, biological/ecological and physical/chemical) when Coastal Blue Carbon is implemented (Figure 4.9). Similar to the assessment for Pulau Kukup, the blue carbon mechanism bears a double function where it preserves the mangrove forest's role in sequestering and storing carbon, and mitigate the impact of the threats which the mangroves are currently facing. The RIAM assessment is based on the principle of taking every necessary and appropriate measures to protect the mangrove and its role as a carbon sink and sequester.

The *Major Negative Impact* (score –E) in the assessment for Sungai Pulai came from the loss of livelihood for those who depend on the forest resources to survive, especially the orang asli Seletar who depends heavily on fishery as their main source of

livelihood, to which Sungai Pulai is regarded as their customary waters and land. The excessive loss of mangrove area would also cause coastal erosion and subsequently lead to loss of coastal areas which will affect the community living along the coastline. This will also increase sediment plume and may affect international boundary (i.e. Singapore) – which will then become a serious issue of transboundary pollution. However, if the oil spill emergency response plan could be revised to place high priority on protecting the mangrove forest from the spread of the oil spill, then the chances of the mangrove forests from being a collateral damage which then diminishes its role as a carbon sequester.

4.4 Policy and Management Assessment

4.4.1 Protection of Mangrove Forests in Malaysia

In Malaysia, mangrove forests are categorised under the Environmentally Sensitive Areas (ESA) Rank 1[13] and their buffer zones are Rank 2[14] under National Physical Plan 2 (NPP2). In Peninsular Malaysia, the only two mangrove areas that are gazetted as Permanent Reserved Forest (PRF) are some parts of Matang Mangrove Forest Reserve, Perak and the mangroves in Che Mat Zain and Tengah Islands, Selangor. In PRF, the respective State Forestry Departments shall prepare a specific management plan of the protected area that includes these aspects below:

- Biophysical attribute
- Land use
- Planning
- Socio-economic
- Resource, etc

National Forestry Council (NFC) has divided mangroves in forest reserves into 4 categories under National Forestry Policy (NFP):

- Protection Forest
- Production Forest
- Amenity Forest
- Research and Education Forest

To date, these are the top four states with highest mangrove area gazetted in Malaysia:

- Sabah 328, 658ha (1,400km coastline)
- Sarawak 73, 000ha (750km coastline)
- Perak 43, 500ha (230 km coastline)
- Johor 17, 832ha (400km coastline)

[13] Rank 1: No development, agriculture or logging shall be permitted except for low-impact nature tourism, research and education.
[14] Rank 2: No development or agriculture. Sustainable logging and low-impact nature tourism may be permitted subject to local constraints.

The management of mangrove forests in Sabah, Sarawak and Johor are further supported by its respective state ordinances and enactments, which will be elaborated further in the following Section 4.4.3. Nevertheless, Perak state which does not have its own enactment boasts a good management of the Matang Mangrove Forest Reserve (Perak), whereby it is able to strike a balance between wood resource demand and preservation of the mangrove ecosystem through a sustainable management plan ever since it was gazetted as forest reserve in 1906.

4.4.2 Institutional Arrangement for Mangrove Management in Malaysia

Mangrove management practices in Malaysia vary from state to state although the central federal agency, the Forestry Department oversees the management of forest throughout the country. Generally, the management and protection of mangroves come under the jurisdiction of the respective State Forest Departments – which maintains a close affiliation with the federal Forest Department. However in Johor, Sabah and Sarawak, these states possess their own National Park authority and manage their parks via their respective enactments, on top of what is already in place by the State Forestry Department. Conservation initiatives, mainly mangrove replanting and monitoring programmes are often shared between government agencies, non-governmental organisations (NGO) and private sectors (Table 4.10). Research on blue carbon mechanism, especially on carbon measurement studies have just recently gained traction but not widely available in Malaysia.

Table 4.10 Collaborations between government agencies, NGO and private sectors

Parties	Main Focus
Government	Intensified R&D and budget for mangrove replanting
NGO	Local community engagement and awareness programmes
Private Sectors	Corporate Social/Environmental Responsibilities (CSR/CER)

4.4.3 Laws and Enactment for Mangrove Protection in Malaysia

It is imperative to note that the management of mangrove forests and its resources in Malaysia are covered as a subset under forestry management. As for the overall management of forest in Malaysia, be it protection or conservation, is closely tied to the policies that directs the industrial development of the country; one which outlines the National Vision 2020's objectives. In this aspect, the forest (which essentially includes the mangrove) plays a role in materialising the objectives in terms of conservation, socio-economic and industrial development of Malaysia (ITCC, 2004). Below the overarching umbrella of Vision 2020, the policies that relates to biodiversity and forest resource management are as listed as below:

1 National Environmental Policy 2002
2 National Conservation Strategy (Draft) 1993
3 State Conservation Strategies
4 National Policy on Biodiversity 1998
5 National Agriculture Policy
6 Master Plans for Protected Areas in Peninsular Malaysia
7 Sarawak Wildlife Master Plan
8 National Forestry Policy (NFP) 1978

Influenced by the fact that the State Governments have the primary jurisdiction in managing their forest areas, the forestry policies in Malaysia are categorised into three regions, namely the National Forestry Act 1984 which is observed in Peninsular Malaysia, the Forest Enactment 1968 in Sabah and the Forest Ordinance 1958 in Sarawak. In addition to this, States also implement various amendments that are prepared from time to time. Table 4.11 presents the summary of regulations and Table 4.12 presents the policies and acts that also affects the implementation of the three regional legislations in relation to forestry as discussed earlier.

Table 4.11 Regulations related to forestry in different regions of Malaysia

Peninsular Malaysia	Sabah	Sarawak
• Aboriginal Peoples Act 1954 • Land Conservation Act 1960 • National Land Code 1965 • Protection of Wildlife Act 1972 • Environmental Quality Act 1974 • National Parks Act 1980 • Forest Rules 1985 • Occupational Safety and Health Act 1994	• Land Ordinance 1930 • Forest Rules 1969 • Wildlife Conservation Enactment 1977 • Environmental Quality Act 1974 • Sabah Parks Enactment 1984 • Conservation of Environmental Enactment 1996 • Cultural Heritage (Conservation) 1997 • Water Resource Enactment 1998 • Biodiversity Enactment 2000	• Land Ordinance 1952 • Land Code 1958 • Forest Rules 1962 • Native Code 1992 • Natural Resource and Environment Ordinance 1993 • Occupational Safety and Health Act 1994 • Water Ordinance 1994 • Native Code Rules 1996 • Native Custom Declaration 1996 • The Forests (Planted Forest) Rules 1997 • Natural Resources and Environment Ordinance 1997 • Sarawak Biodiversity Centre Ordinance 1997 • Sarawak Biodiversity (Access, Collection & Research Regulations) 1998 • Wildlife Protection Ordinance and Rules 1998

Table 4.12 Policy, acts and plans in direct relation to mangrove protection

Document	Description
National Forest Policy 1992	Emphasized on sound management, conservation, utilization, development and protection of mangroves
Environment (Protection) Act 1996	Coastal Regulation Zone restricts discharge of industrial effluents to protect mangrove
Section 4(b) of the National Forestry Act 1984 (Amended 1993)	Every State Forestry Department to prepare forest management and working plan
National Coastal Zone Physical Plan (NPP-CZ)	To ensure coastal biodiversity and a dynamic coastline are conserved, where industrial/development activities shall not harm natural ecosystems, i.e. mangrove.

4.4.4 Challenges Faced by the Current Management Approach in Malaysia

Despite the presence of authority and management, threats from unsustainable exploitation continues to be one of the major causes for mangrove forest loss and degradation. Encroachments from illegal timber logging are still reported in some areas such as Pulau Che Mat Zin in Klang, Selangor[15]. In addition, there is a lack of sustainable exploitation and management implemented throughout the mangrove forests in Malaysia liken to that of Matang Mangrove Forest Reserve. Also despite of Ramsar designation, the mangrove forests at Sungai Pulai continues to face threats from the large-scale urban and industrial development around and on its sensitive ecosystem.

Having mentioned this, there is a concern on budgetary issues as such management approaches will inevitably incur substantial costs to maintain and preserve the environment - those which does not immediately translate tangible and quantifiable economic returns. Table 4.13 below presents the summary of issues facing the effort in managing the mangrove areas in Malaysia.

Table 4.13 Main issues in mangrove management in Malaysia

Issues	Description
Un-gazetted mangrove areas	Stateland mangrove which are not gazetted are usually cleared for aquaculture and agricultural industry (stateland mangrove accounts to about 15% of total mangrove area in Malaysia)
Conflicting management approaches	While mangrove is categorised as ESA Rank 1, management of PRF allows for utilisation in the principle of sustainable forest management. Same goes for Ramsar designation, where it does not have the capacity to deter mangrove clearance for other land use.
Lack of community engagement or endorsement	Lack of buy-in by the local community due to communication, consultation, and collaboration gaps/barriers

[15] Based on a news report from The Star, "*Selangor loses RM100mil in revenue to mangrove thieves*" dated 30th August 2010, it was found that illegal loggers and smugglers cut down about 200,000 mangrove trees every month. This translates to more than 24 million trees would have been felled over the 10-year period.

Table 4.13, continued

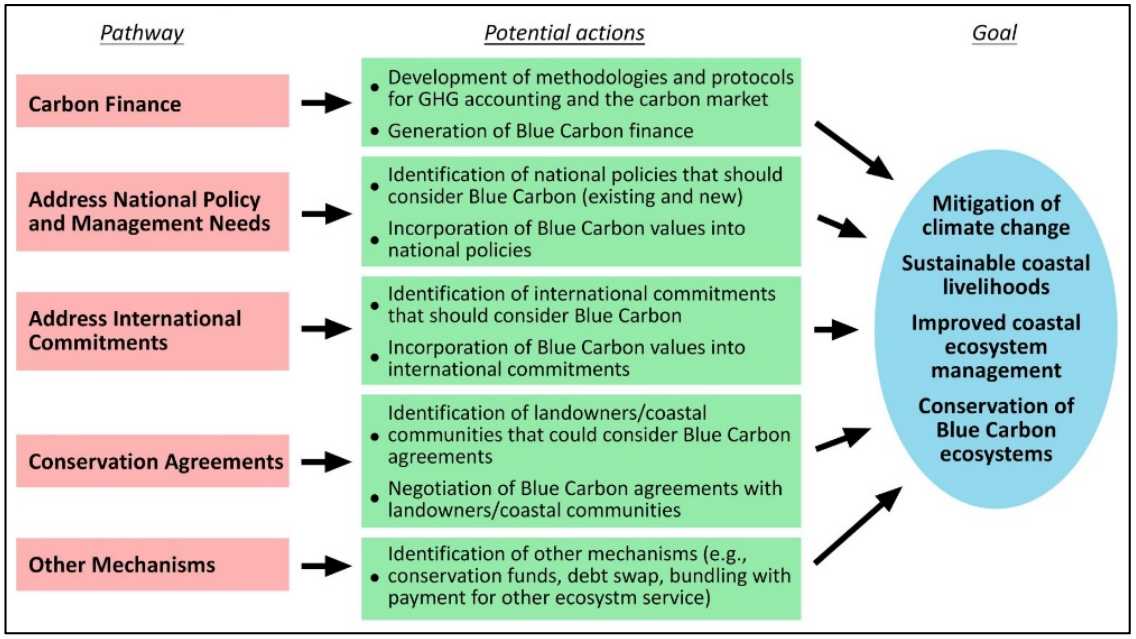
Issues	Description
Lack of international commitments or partnerships	Presence of regional/international commitments for mangrove protection could have increased funding opportunities. Ramsar in this case is not an international commitment, as it could be degazetted by the state at any time.
Distribution budget allocation	Budget allocation under Malaysia Plan 9 (2006-2010) for Mangrove Rehabilitation Project may not be adequate to be distributed throughout the country to enable multipronged approach in mangrove rehabilitation

Among some of the important points worth taking note of is that although the Federal Constitution, under Article 94(1), ninth schedule, empowers the federal government to formulate forestry legislation to promote uniformity between two or more states; Article 74(2) of the Federal Constitution also provides the States a virtual monopoly over their respective forest land, with full powers of disposal. Due to this, occasions do arise whereby conflicting land use and environmental management between the Federal and State agencies.

CHAPTER 5: DISCUSSION

5.1 Framework on the Implementation of Coastal Blue Carbon

Given the benefits of implementing the blue carbon mechanism in the current management of mangrove forests as anticipated in Section 4.3, the following discussion is about proposing a rudimentary blue carbon framework for Malaysia, as the nation prepares to implement the blue carbon mechanism into its current mangrove management practices. Based on the case studies, the key to materialising blue carbon as an incentives is to merge the Blue Carbon Pathway Actions[16] (Figure 5.1) with the lessons learned from REDD+ (Section 2.6.2).



Source: (AGEDI, 2014)

Figure 5.1 Coastal Blue Carbon Pathways

According to the Blue Carbon Pathway Actions and the key lessons from REDD+, the components to which Malaysia must first consider before implementing any projects are listed on the concurrent list in Table 5.1.

[16] The Blue Carbon Pathway Actions was first proposed by NOAA (Habitat Conservation) and later developed further by the Abu Dhabi Global Environmental Data Initiative (AGEDI) study in 2014.

Table 5.1 Key components to be considered in the implementation of blue carbon projects in Malaysia

Blue Carbon Pathway Actions	REDD+ Key Lessons
The workings of carbon financing through voluntary market and its value	Requirement for long historical data on mangrove
Addressing the national policy and management needs	Community and stakeholders must be well-defined with similar objectives
Address international commitments related to climate change and biodiversity protection	Economic interests of stakeholder groups must be complemented
Existing conservation agreements	Ensure no conflicting land and natural resource use
Consideration of the REDD+ readiness plan as a foundation for blue carbon implementation	Identify the direct and indirect dependents on the mangrove
	Effective awareness programmes

In essence, the Blue Carbon Pathway Actions addresses the higher management issues which concerns national and international policies, agreements, market prices and funding avenues. Equally as important, the REDD+ represents the lower management issues where on-ground project implementation is concerned. Nevertheless, there should not be disconnect between the two management hierarchy but should foster an effective communication and manage expectations in order to achieve the common goal. Taking the key components from the previous list (Table 5.1), these pathway actions were assessed against the current condition of the pilot study sites (Pulau Kukup and Tanjung Piai) as discussed in the following Section 5.1 to Section 5.5.

Strategy I: Carbon Financing

The ultimate value that can be derived from the blue carbon captured in mangrove forests are heavily dependent on various interlinked features of the mangrove; such as the age of the tree, biomass (above and below ground), photosynthetic rate of the leaves, species of mangrove, location of the mangrove forest and so forth. Based on a research by FRIM (Noraishah et al., 2011), it was found that the mangroves at their study sites recorded a carbon stock of 20 to 210 tC/ha – a wide range due to the various features of

the mangrove influencing the carbon stocks. A similar study has yet to be conducted in the study site of this dissertation – therefore a crude estimate value of burial rate by mangrove is used instead, whereby a conservative estimate is about 1.39 tonne/ha/yr (Caraco et al., 2005). Meanwhile, the EU emissions trading scheme (highest estimate in the market) priced the value of carbon as USD19.18/tonne (Ullman, Bilbao-Bastida, & Grimsditch, 2013). Table 5.2 below presents an objective assessment to determine the status of the pilot sites against the carbon financing pathway.

Table 5.2 Carbon financing readiness of the pilot study sites

Pathways	Actions	Pulau Kukup	Sungai Pulai
Carbon Financing	Methodologies/ protocols for measurement	• No record of study is currently available. • Crude estimate of carbon storage potential value: USD 17,255/year	• FRIM and local universities are undertaking blue carbon measurement research in their respective capacities. • Remote sensing mapping research is available. • Crude estimate of carbon storage potential value: USD243,300/year
	Generation of blue carbon finance	No record of study is currently available. Nevertheless, the beneficiaries of the blue carbon incentives must be identified from the early stage.	No record of study is currently available. Beneficiaries of the blue carbon incentives must be identified from the early stage.

Strategy II: National Policy and Management Needs

The following Table 5.3 illustrates the key policy and management approaches that governs both study sites, at the state and national level. As land matters are under the state jurisdiction, it is imperative that the state government revisit the land use policies as mangrove forests' main threat is deforestation. Incorporating the blue carbon mechanism into decision making will increase the likelihood of mangrove being considered fairly based on the value of its ecosystem services. In a wider scope, the integration of the blue carbon mechanism at the national level takes on a more interlinked presence throughout

the spectrum of natural resource management – from the highest level at the Prime Minister's Department to the Economic Planning Unit, as well as from the Ministry of Natural Resources and Environment to the Department of Marine Park Malaysia; in a collaborative effort which also includes the state agencies.

Table 5.3 Policy and management needs of the pilot study sites

Pathways	Actions	Pulau Kukup	Sungai Pulai
Address National Policy and Management Needs	Determine the policies and natural resource managers which should incorporate blue carbon into their decision making	• *Policies, strategies, plans, etc*: – State Level: Johor National Park Corporation Enactment 1989, State land use policies – National Level: National Environmental Policy 2002, National Conservation Strategy (Draft) 1993, State Conservation Strategies, National Policy on Biodiversity 1998, National Agriculture Policy Master Plans for Protected Areas in Peninsular Malaysia, National Forestry Policy (NFP) 1978 • *Relevant natural resource managers*: Forestry Department, Forestry Research Institute Malaysia, Department of Environment, Department of Town and Country Planning Malaysia, Ministry of Natural Resource and Environment, Economic Planning Unit, Department of Prime Minister, Department of Fisheries, Department of Marine Park Malaysia, Johor National Park Cooperation	
	Consolidate existing data and build on gathering crucial information needs, which includes all aspects of carbon measurement in order to monitor and place value on carbon as realistically accurate as possible.	• *A national repository of mangrove data is required:* Baseline data and information collected on both study sites should be consolidated and updated under a repository which could be accessed and collaboratively build at the national level. There is a crucial need to share information (in all forms including GIS, remote sensing, blue carbon research and results, etc) across board to ensure that there are sufficient knowledge and data to make informed policy and management decisions.	

Strategy III: International Commitments

The next pathway that shall play a big role in the implementation of blue carbon projects in Malaysia is the existing international and regional commitments that are related to mangrove forests. This is to ensure that the approaches taken for blue carbon mechanisms can merge or streamline with the current action plans from these commitments to avoid redundancy of efforts, to ensure a more optimised use of resources and manpower, as well as to complement the common objective towards the preservation of mangrove forests in Malaysia. Given that the blue carbon mechanism involves a form of incentives, a more thorough planning is required to ensure that related commitments are aware of the concept and the components involved in the blue carbon mechanism so to avoid any potential conflicts of interests. Table 5.4 presents some of the existing key commitments relevant to Malaysia's mangrove forests.

Table 5.4 International/Regional Commitments related to the pilot sites

Pathways	Actions	Pulau Kukup	Sungai Pulai
International/Regional Commitments	Determine the relevant commitments which must take into consideration and incorporate blue carbon into their roadmap	• Ramsar Convention • Convention of Biological Diversity (CBD) • Coral Triangle Initiative (CTI) • Sulu-Sulawesi Marine Ecoregion Programme (SSME)	

Strategy IV: Conservation Agreements

Conservation agreements are defined as the mutual understanding and common ground to which each and every layer of the stakeholders, ranging from resource managers such as the governmental agencies and NGO agencies, the landowners of the mangrove forest and the coastal communities that depend on the wellbeing of the mangrove either for livelihood or socio-cultural reasons – must be established and

achieved in order to foster a solid collaboration across the spectrum. Due to the different needs and perceptions of the different layer of stakeholders, the conservation agreements must be holistic but realistic at the same time (Table 5.5).

While this is a relatively challenging task to undertake, conservation agreements should be the go-to document when conflict arises or when changes to the approach needs to be reviewed in order to improve the implementation of blue carbon. All in all, this is part and parcel of ensuring that the blue carbon mechanism's framework in Malaysia is established with a long-term goal in mind.

Table 5.5 Conservation agreements planning in relation to the pilot sites

Pathways	Actions	Pulau Kukup	Sungai Pulai
Conservation Agreements	Resource managers, landowners and coastal communities should consider working towards blue carbon project agreements	Although the island is fully gazetted and not inhabited – the stakeholders and communities (e.g. those at Kukup town) related to the mangrove area must be identified and defined.	Seeming more complex due to the multi-use and dependency on the mangrove area from the Orang Asli Seletar to the fishermen downstream of Sungai Pulai, must be acknowledged as stakeholders.

5.2 Other Mechanism

Last but not least, other mechanisms that should be involved in the establishment of blue carbon framework in Malaysia may include other approaches such as utilising available conservation fund to initiate blue carbon projects and bundling the incentives from the blue carbon mechanism together with the other ecosystem services that it provides (e.g. fishery nursery ground, storm surge buffer zones, water purification, etc) (Table 5.6). Having state so, the valuing of ecosystem services would have to be in place as well before the incentives can be bundled together. Nevertheless, the action of valuing ecosystem services will lend more weight to the incentive in conserving the mangrove

forests of which could be one of the factors that could ensure the sustainability of the blue carbon mechanism compared to if it was a stand- alone mechanism.

Table 5.6 Other mechanism in relation to the study sites

Pathways	Actions	Pulau Kukup	Sungai Pulai
Other Mechanism	Conservation funds and bundling payment with other ecosystem services.	Studies on ecosystem services are available but data may need updating. However, conservation funds and payments has yet to be looked into in detail. The dearth of quality baseline data and the consolidation of existing information must be prioritised.	

CHAPTER 6: RECOMMENDATIONS

This section presents a checklist (Table 6.1) with the essential components that builds the blue carbon mechanisms, otherwise called as a *preparedness checklist towards blue carbon implementation*. The list features four major steps; Scoping, Planning, Demonstration and Implementation – each accompanied by recommendations for the country and the stakeholders involved. This is by no means a definitive checklist but it aims to serve as a starting point to which future amendments will be made to strengthen the checklist further. The purpose of this checklist is to ensure that the foundations that supports the blue carbon mechanism in Malaysia is firmly grounded before it becomes a national template which could be emulated throughout the country.

Table 6.1 Checklist for Setting up Coastal Blue Carbon Projects in Malaysia

No.	Steps	Components	Recommended Actions for Malaysia	Potential/Relevant Stakeholders
1.	**Scoping**	• Develop understanding of the concept • Build interest and participation among stakeholders • Identify target areas and key threats • Evaluate existing management practices and scientific capacity • Identify information and data gaps; in the effort of gathering quality baseline data which decision making are based upon.	• Conduct workshops and trainings that are catered for different groups and levels of the stakeholders involved to ensure that the training objectives which are unique to different stakeholder groups are achieved • Training and reference materials has to be localised in terms of language, culture, topics of concern, issues and objectives • Foster active and interactive discussions to ensure that every member of the stakeholder group training are well informed and fully understand the mechanism • Engage the stakeholders in mock scenario activities e.g. planning process, decision making, resource allocation, conflict resolution, and debate – to simulate possible situations that may take place to pre-empt solutions.	• Trainers: IUCN, Wetlands International, UNESCO-IOC, UNEP, FRIM, Forestry Department, academicians • Participants: Officers from related governing agencies (Forestry Department, FRIM, DOE, JPBD, etc), policymakers (MNRE, EPU, DPM), resource managers (Department of Fisheries, Department of Marine Park Malaysia, Johor National Park Cooperation, Sabah Parks Authority, Sarawak Forestry), scientists, academicians, economists, indigenous community leaders

Table 6.1, continued

No.	Steps	Components	Recommended Actions for Malaysia	Potential/Relevant Stakeholders
2.	**Planning**	• Measureable goals and objectives • Potential project partners • Potential sources of funding • Science methodologies for coastal blue carbon assessment	• Prepare a roadmap based on the outcome from the Scoping feedback and discussions, guided by measureable goals and objectives • Based on the roadmap, identify the potential project partners that would include the key stakeholders, as well as project financiers and technical experts in the various facets of the blue carbon implementation • Thoroughly planned allocation of responsibilities, integration with the current management to encourage integration and avoid conflicts and redundancy • Roles and responsibilities must be clearly defined and delineated to ensure that expectations are managed, facilitate proper monitoring and reporting systems • Prioritise the gathering of quality data by allocating a dedicated team to build up a repository of database.	• Planners: FRIM, Forestry Department, academicians • Researchers/Technical Experts: IUCN, Wetlands International, FRIM, Forestry Department, academicians • Project Managers: Department of Fisheries, Department of Marine Park Malaysia, Johor National Park Cooperation, Sabah Parks Authority, Sarawak Forestry • Partners: IUCN, Wetlands International, UNESCO-IOC, UNEP, FRIM, Forestry Department

Table 6.1, continued

No.	Steps	Components	Recommended Actions for Malaysia	Potential/Relevant Stakeholders
3.	**Demonstration**	Identify suitable sites for demonstration/pilot projects and conduct pilot site studies	• Choose mangrove area that has good historical baseline data, inventory data, and good governance, have been included as part of the national REDD+ studies, among some. A site suggestion to begin a demonstration project is the Matang Mangrove Forest Reserve, Perak. • Establish a sustainable financial backing either from internal (national funds) or external (international aids) • Derive and apply lessons learned and best practices from case studies from international blue carbon projects • Monitor and assess the parameters to be measured and maintain a good database system to record all the information collected. • Adopt technological approaches to assess the temporal and spatial changes in mangrove area cover and land use using remote sensing. • Take stock and evaluate the effectiveness and gaps from the demonstration projects from time to time.	Same stakeholder group as Planning

Table 6.1, continued

No.	Steps	Components	Recommended Actions for Malaysia	Potential/Relevant Stakeholders
4.	**Implementation**	Take the evaluation results from the demonstration projects and implement on other mangrove sites.	• Finalise and utilise the best measurement of carbon above and below ground, monitoring and reporting practices • Set milestones and track constantly • Evaluate the efficiency of the implementation, assess and address challenges, review status of implementation and make necessary changes to adapt to changing times • Adhere to local and international commitments	Same stakeholder group as Planning

A more accurate, representative and measurable coastal blue carbon potential requires extensive data on the area cover, species, age and soil distribution of mangrove forests to accurately determine the figure. For this purpose, the existing research outcomes from measuring blue carbon undertaken by FRIM and universities could be collated into a shared repository, whereby it is merged with data from National Forestry Inventories.

An ideal demonstration site as proposed by Ammar, Dargusch and Shamsudin (Ammar, Dargusch, & Shamsudin, 2014) is the Matang Mangrove Forest Reserve – which already have a good management model that has been established for decades. The management model can be modified to cater to the objectives of blue carbon and then demonstrated at other study sites around Malaysia.

However, it is crucial to take note that any blue carbon action and programme implemented must be supported by a deep interest and participation of the different stakeholders – all aiming towards mutual benefits to sustain a long term engagement. As important as local engagement, the presence of regional partnerships and collaboration will enhance the success-rate of demonstration projects due to knowledge transfer and funding opportunities.

The long- term goal of piloting blue carbon is not only to demonstrate its advantage of reducing ecosystem vulnerabilities but also to improve policies that will underscore the role of mangroves in climate change mitigation and adaptation. Such policies serves as platform for creating responsive and sustainable programmes and projects.

CHAPTER 7: CONCLUSION

Malaysia has a potential in coastal blue carbon given its current extent of mangrove cover amounting to 577, 558 hectare (FAO, 2002). Despite the substantial area, the actual coastal blue carbon sequestration and storage potential of the mangrove forests in Malaysia still requires more extensive data on the area distribution of these ecosystems to accurately determine the figure. The Forest Research Institute of Malaysia (FRIM) and National Ocean Directorate (NOD) has begun discussions and studies on coastal blue carbon potential in Malaysia as a crucial step forward in harnessing this opportunity. To strengthen this opportunity further, Malaysia could establish extensive network of collaborations among the relevant agencies within the country, with concerting efforts from non-governmental organisations and academic institutions. With a stronger proposal and implementation team for materialising the blue carbon mechanism in the country, international grants will be easily made available for blue carbon projects (e.g. from UNDP, GEF and USAID).

In summary, the four objectives set out in the Introduction (Chapter 1) has been fulfilled. Based on the first objective of this study, the presence of information gaps is revealed when establishing the baseline information for the two selected mangrove sites. The lack of collated and comprehensive baseline data (e.g. updated mangrove area cover, density and distribution, species richness, land-use, etc) continues to be a hampering factor that would have given due importance to the actual magnitude and impact of its loss, especially in terms of ringgit and cents. To facilitate this, every necessary information and data required in formulating informed policies must be collected and utilised in order to conserve these ecosystems.

Addressing the second objective of this study, it is shown that the vulnerability level of the mangrove sites are high despite the current management and policies that are in place today. This calls for a revisit and review of the current approach in mangrove

management throughout Malaysia. Tied closely to the second objective, the third objective was fulfilled via demonstrating how blue carbon mechanism could bring about a change in creating more responsive and sustainable mangrove rehabilitation and protection programmes.

The fourth objective of the study is to produce recommendations on how Malaysia can prepare for the implementation of coastal blue carbon concept in its current management approach on mangrove forests. Based on the findings, the key focus is on a policy change which could ensure that the protection of mangrove areas can be stipulated more distinctively in the current policies and legislations.

In conclusion, the conservation priority for mangrove can be significantly increased as the importance of mangrove is made quantifiable in terms of carbon credits and climate change mitigation. Among the suggested further studies to expand this dissertation is to expound further and fine-tune the vulnerability assessment of mangrove in Malaysia and conduct a thorough study on institutional governance in environment, in order to promote a sustainable and effective blue carbon programme in the country.

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