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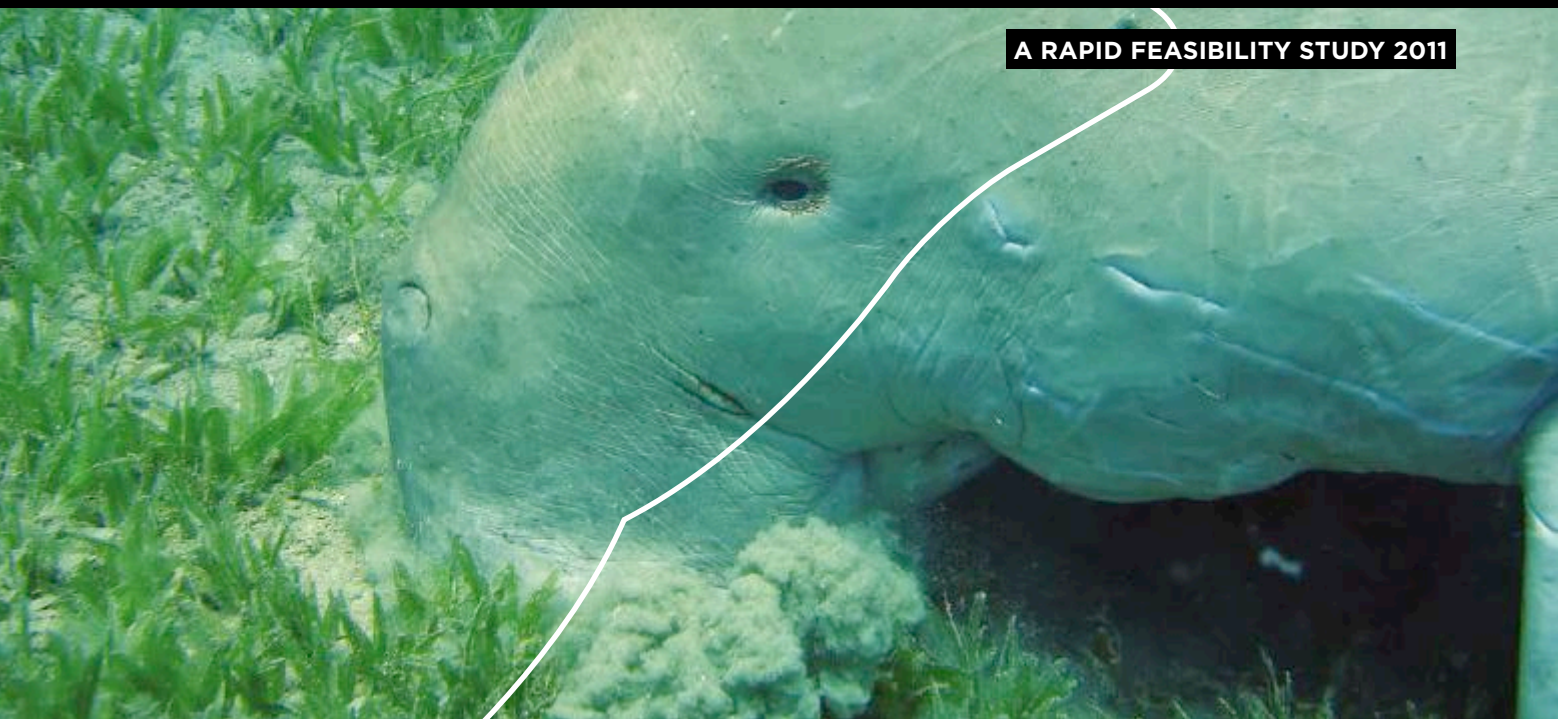
مبادرة أبوظبي العالمية للبيانات البيئية
Abu Dhabi Global Environmental Data Initiative

هيئة البيئة - أبوظبي
Environment Agency - ABU DHABI

BLUE CARBON

FIRST LEVEL EXPLORATION OF NATURAL COASTAL CARBON IN THE ARABIAN PENINSULA (WITH SPECIAL FOCUS ON THE UAE AND ABU DHABI)



A RAPID FEASIBILITY STUDY 2011

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“Our mangroves are an important part of our natural ecosystem; their survival is key to the sustainability of our emirate.”

H.E Razan Khalifa Al Mubarak
Secretary General
The Environment Agency – Abu Dhabi (EAD)

PREFACE

Marine coastal ecosystems, from coral reefs to mangrove forests, deliver essential goods and services to many people throughout the Arabian Peninsula. Vital services include the prevention of coastline erosion caused by wave action and ocean currents, nurseries for many fisheries as well as amenity and recreational services that support lucrative coastal tourism. Yet, these services continue to face threats through water pollution, un-sustainable development and fishing practices and climate change.

Some coastal ecosystems, including mangrove forests, seagrass meadows and saltwater marshland, are gaining increased attention for the carbon stored in their biomass and sediments – a recent concept termed "Blue Carbon". Research indicates that Blue Carbon ecosystems have the potential to hold vast stores of carbon and are important for nature-based approaches to climate change mitigation. Conversely, when disturbed, these ecosystems may be significant sources of greenhouse gas (GHG) emissions.

Blue Carbon - First Level Exploration of Natural Coastal Carbon in the Arabian Peninsula is part of the evolving work on the challenges and opportunities facing the region in the transition to a sustainable, low-carbon, resource efficient economy.

The Arabian Peninsula and particularly coastal areas of States in the Arabian Gulf are closely tied to Blue Carbon ecosystems through cultural heritage, their role as nursery grounds for fisheries, and through coastal development. The importance of mangrove ecosystems in the UAE is already strongly acknowledged, with the total area of mangroves increasing through many afforestation efforts. Seagrass meadows are recognised for their importance as habitat for threatened sea turtles and dugongs, and salt marshes are known as vital rest stops for many international migratory bird species.

The climate change mitigation service that these valuable ecosystems provide in the Arabian Peninsula is currently being explored with a view to ensuring better management of Blue Carbon that will safeguard existing stores of carbon, reduce emissions and maximise the potential of coastal marine ecosystems for removing carbon from the atmosphere.

H.E. Razan Khalifa Al Mubarak

Secretary General
The Environment Agency – Abu Dhabi (EAD)


Caspian Sea
Gaziantep
Mosul
Aleppo
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SYRIA
Tehran
Mashhad
Qom
IRAQ
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UNITED ARAB EMIRATES
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Red Sea
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Kassala
Addis Ababa
Aden
Gulf of Aden
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Djibouti
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(YEMEN)
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Arabian Sea
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FOREWORD

The lack of quality, quantifiable environmental data has proven a major hindrance to the global process of achieving sustainable development. The result is that throughout the world socio-economic and environmental decision makers are being challenged to make vital decisions without the necessary data and information.

Blue Carbon - First Level Exploration of Natural Coastal Carbon in the Arabian Peninsula is part of an AGEDI initiative to explore Blue Carbon in a local, national and regional setting. This report showcases Blue Carbon for the region and identifies preliminary opportunities in advancing coordinated environmental and climate change policy.

Blue Carbon is a new concept with high environmental data demands. A coordinated approach in the assimilation of existing Blue Carbon data, the creation of new data, and in the management and access of data needs to be explored. AGEDI is openly working with partners and stakeholders throughout the world on these and other Blue Carbon issues.

Cathrine Armour

AGEDI Program Manager

SUMMARY

Healthy natural coastal ecosystems, such as mangrove forests, saltwater marshlands and seagrass meadows provide a vast array of important co-benefits to coastal communities around the world, including throughout the Arabian Peninsula. These benefits include ecosystem services such as a rich cultural heritage; the protection of shorelines from storms; erosion or sea-level rise; food from fisheries; maintenance of water quality; and landscape beauty for recreation and ecotourism. In a "Blue Carbon" context these ecosystems also store and sequester potentially vast amounts of carbon in sediments and biomass.

There are risks and uncertainties that need to be considered when advancing Blue Carbon in the region. The carbon stored in coastal ecosystems can be lost through the impact of climate change itself and changes in land use both along the coast and further inland. There is still uncertainty about the amounts sequestered in each Blue Carbon ecosystem – research is required to generate these data and reduce the uncertainty. Methodologies for systematic and verifiable carbon accounting are just emerging. Management regimes vary considerably for Blue Carbon ecosystems and work is needed to understand how best to manage and monitor carbon in each setting.

Implementation of Blue Carbon policies may present great challenges, raising significant institutional and regulatory issues and complex political and socio-economic dilemmas. In particular, an effective policy will need to achieve a balance between coastal livelihoods and carbon management policies. It is crucial that other ecosystem services are not compromised or sacrificed through an unsustainable approach to secure carbon gains.

The multiple benefits of potential Blue Carbon investments include improved livelihoods, with the opening of employment opportunities in areas such as conservation, ecotourism, management, monitoring and rehabilitation. Other benefits could include reversing the rate of biodiversity loss, improving water quality and stabilising coastal sediments. Blue Carbon investments can also contribute to climate change adaptation, for example, through reducing loss of habitat to rising sea levels and increased storm surges. Communities and businesses will also benefit from reduced environmental risks.

Over 40 meetings were held with local, national, and regional authorities and with organisations from three countries in the Arabian Peninsula during the production of Blue Carbon in the Arabian Peninsula. This report primarily focuses on Abu Dhabi and the United Arab Emirates (UAE) but also explores Blue Carbon in a regional context.

"You cannot stop development, but you can do it so that development is sustainable."

Thabit Zahran al Abdessalaam
Director, Management Sector at Environment Agency - Abu Dhabi (EAD)

KEY MESSAGES AND RECOMMENDATIONS

1. **Intense interest exists throughout the region in exploring the management of carbon in natural coastal biological systems.** *This is based on the recognition that managing Blue Carbon can safeguard existing stores of carbon, reduce emissions and maximise the potential of coastal marine ecosystems for removing carbon from the atmosphere.*
2. **It is essential that regional Blue Carbon policy is guided by the best available science concerning ecosystem carbon.** *Decisions should be informed by the overall costs and benefits.*
3. **A primary focus for Blue Carbon in the region should be to establish a baseline** *accounting of the carbon sequestration and storage potential of Blue Carbon ecosystems.*
4. **The valuation of ecosystem services and the potential for a bundled ecosystem services project** *that includes Blue Carbon offsets should be explored.*
5. **The enhancing of local capacity in science and management** *should be included in Blue Carbon strategies for the region.*
6. **Blue Carbon activities, when combined with conservation, ecotourism, management, monitoring and rehabilitation efforts,** *can significantly contribute to the improvement of local livelihoods.*
7. **Blue Carbon activities should complement ongoing regional conservation efforts** *(e.g, through the Ramsar Convention).*
8. **Blue Carbon activities should be coordinated with regional and international interests** *(e.g. IUCN Regional Office for West Asia (ROWA), the Regional Organisation for the Protection of the Marine Environment (ROPME), and the GEF's Blue Forests project).*
9. **Methodologies for monitoring projects and measuring carbon employed on the Arabian Peninsula should be standardised** *with international methodologies.*
10. **National policy opportunities for** *offsetting carbon should be explored.*

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INTRODUCTION

The overwhelming scientific consensus on climate change is that the Earth is in an ongoing phase of global warming caused by human activities and the increased release of carbon dioxide (CO_2) and other greenhouse gases (GHGs) (IPCC, 2007). A range of strategies is required in order to avoid the worst effects of global climate change. To develop and implement these strategies, the vital contribution natural, intact ecosystems make to regulating global and local climate must be understood, valued and protected.

While the conservation and restoration of forests, and recently peatlands, have been highlighted as priorities for climate change mitigation, the role of coastal and marine ecosystems can be as or even more important and needs to be further understood, documented and utilised in strategies to mitigate climate change.

Carbon captured by the world's oceans and marine ecosystems represents more than 55 per cent of all the carbon captured by living marine organisms (Falkowski *et al*., 2004; Arrigo, 2005; Bowler *et al*., 2009; Simon *et al*., 2009). The carbon captured by living marine organisms is mainly stored in the form of plankton and fish biomass and in sediments from coastal ecosystems. Marine carbon does not remain stored for decades or centuries (as does carbon in rain forests), but can rather be stored for millennia.

Blue Carbon is a new concept that advances the role some coastal ecosystems play in storing greenhouse gases, thereby helping to mitigate climate change. This concept has stimulated renewed interest in coastal ecosystems including mangrove forests, seagrass meadows and saltwater marshlands, which serve as carbon sinks.

The Blue Carbon concept was introduced by two reports published in late 2009 – *Blue Carbon, the Role of Healthy Oceans in Binding Carbon (*Nelleman *et al.,* 2009*)* and *The Management of Natural Coastal Carbon Sinks (*Lafolley and Grimsditch, 2009*)*. In 2011, reports exploring the science, economics and policy of Blue Carbon, were published *(*Crooks *et al.,* 2011*;* Murray *et al.,* 2011; Climate Focus, 2011*)*. Many international conservation bodies are currently exploring and advancing Blue Carbon, including the United Nations Environment Programme (UNEP), International Union for Conservation of Nature (IUCN), Conservation International, Forest Trends, World Bank, Global Environment Facility (GEF), Linden Trust for Conservation, Blue Climate Solutions and the Blue Climate Coalition, and UNEP/GRID-Arendal.

Blue Carbon - First Level Exploration of Natural Coastal Carbon in the Arabian Peninsula builds on these efforts to bring attention to and explore Blue Carbon in a regional context - for the Arabian Peninsula. This report provides an introduction to Blue Carbon in the region and explores the prospects, opportunities and advantages of binding and keeping carbon in coastal ecosystems.

Setting

The Arabian Peninsula region considered in this report extends from the border of Kuwait and Iraq on the Persian Gulf on the northeast to the border of Saudi Arabia and Jordan on the Red Sea.

Figure 1: The Arabian Peninsula

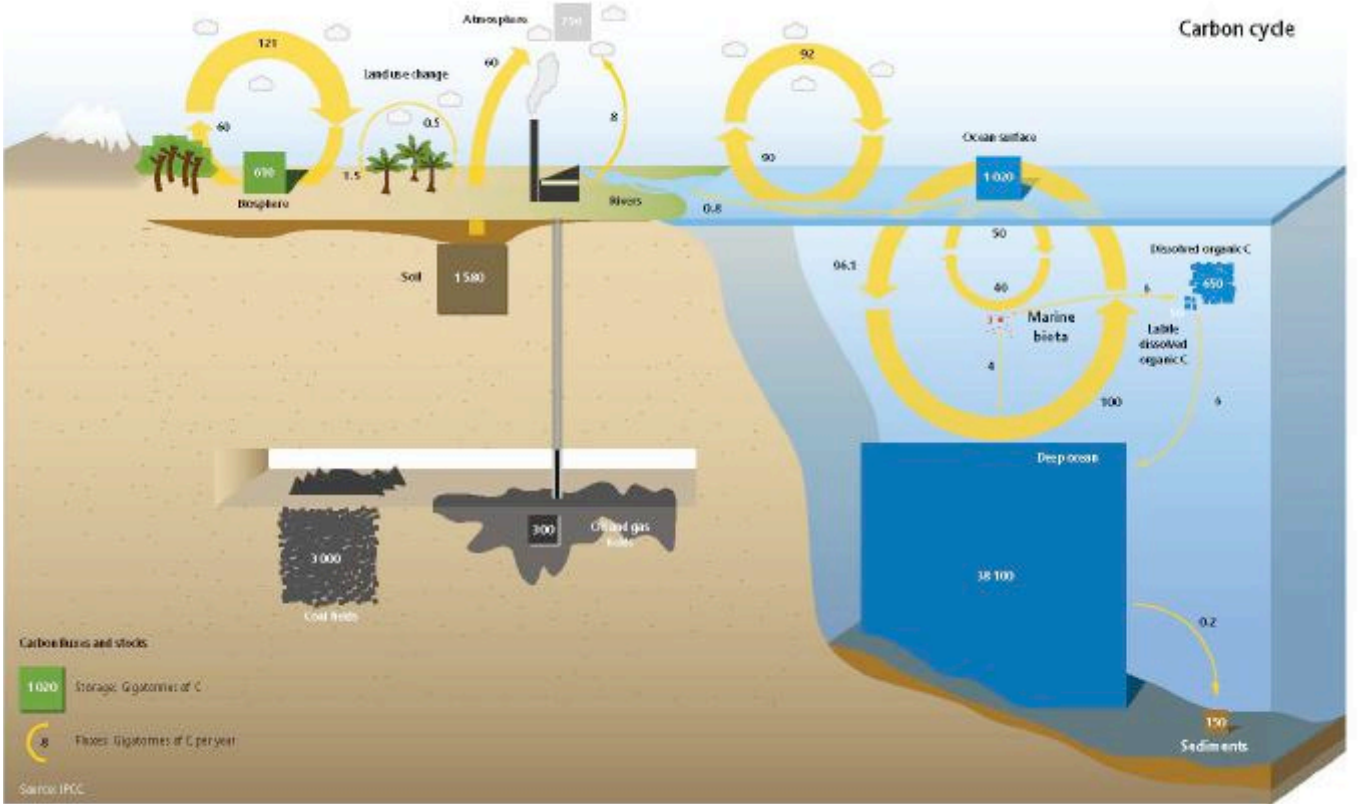


Figure 2: The Carbon Cycle. Oceans are crucial in the global carbon cycle. The living oceans capture over half of all the carbon bound by living organisms through photosynthesis.

THE GLOBAL SETTING OF BLUE CARBON

Blue Carbon ecosystems are found throughout the globe, in all continents except for the Antarctic. Blue Carbon ecosystems are vital to the livelihoods and well being of many coastal communities; these ecosystems, however, face many threats and are being lost at an alarming rate.

Science is critically needed to further understand the sequestration potential of each Blue Carbon ecosystem. Carbon cycles related to forests and peatlands are better understood and have been incorporated into climate change mitigation policies. Coastal ecosystems remain to be considered.

Natural coastal carbon sinks

Mangrove Forests

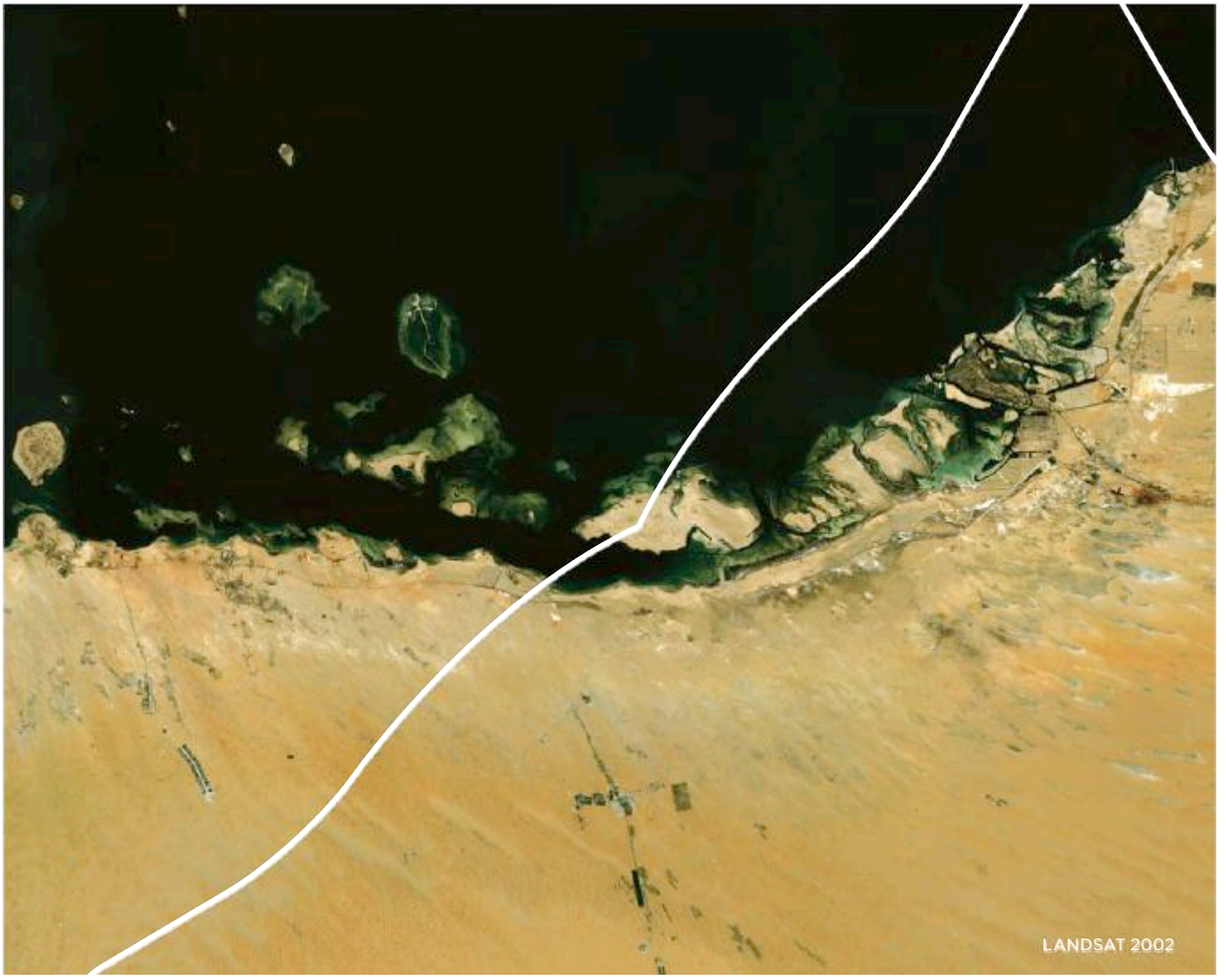
Mangroves are trees, shrubs, palms or ground ferns that commonly grow above mean sea level in the intertidal zone of marine, coastal, or estuarine environments and have evolved many adaptations to life in the salty intertidal zone. They are found in tropical and subtropical zones around the globe.

Mangroves have anaerobic sediments and the organic carbon stored in mangrove soils is not exposed to the atmosphere. Mangroves are among the most carbon-rich forests in the tropics. Including the carbon stocks within the first metre of soil, mangroves contain an average of around 3,754 tonnes of CO_2 per hectare (Donato *et al.,* 2011).

Once these organic-rich soils are exposed to air, decomposition and the release of carbon occurs. Many mangrove forests have thousands of years' worth of carbon sequestered beneath them. The depth of these carbon-rich soils varies according to the location of the mangroves. For example, mangroves in estuaries tend to have greater depths of organic soils than oceanic mangroves, which have a hard sandy or rocky substrate.

Mangroves ecosystem (Mangal) are extremely valuable, providing a wide range of services such as protection of shorelines (from storms, tsunamis or erosion); a range of natural products (wood, honey, medicine); ecotourism activities (birding, kayaking, wildlife viewing); support for fisheries including nurseries for juvenile fish; and improvement of water quality through sediment filtering. However, they are disappearing globally at an alarming rate

Much of the coastline of Abu Dhabi and Dubai has undergone rapid transformation, from deserted coastlines with small fishing villages to high-rise cities, harbors, oil terminals, resorts and artificial islands. Similar changes are occurring in many other Gulf nations.



of 1 to 2 per cent per year, a pace that exceeds the loss of adjacent ecosystems, tropical rain forests and coral reefs. The main causes for the rapid loss of mangrove forests include coastal development, population growth, water diversion, aquaculture and salt pond construction.

Saltwater Marshlands

Saltwater marshes are intertidal ecosystems dominated by vascular plants. They occur mostly in temperate zones, but are known from the sub-arctic to the tropics. Saltwater marshes continuously accumulate sediment. The saline environment of these marshes inhibits the natural creation of methane, a greenhouse gas 25 times more potent than CO_2. Saltwater marshlands contain a range between 900 and 1,700 tonnes of CO_2 per hectare (Sifleet *et al*., 2011).

Photo: © AGEDI

Saltwater marshes are valuable ecosystems that support a particularly high diversity of some groups of species, such as birds and fish, and they provide ecosystem services including fisheries production, pasture lands, protection of coastlines from storms and erosion, ecotourism, and the natural filtering of nutrients. Extensive marsh areas have been lost through dredging, filling and draining and from the construction of roads. Marsh areas are now also threatened by sea level rise.

Seagrass Meadows

Seagrasses are flowering marine plants that form extensive underwater meadows and are distributed throughout the globe. This Submerged Aquatic Vegetation (SAV) is found in the shallow waters of all continents except the Antarctic.

Seagrass meadows store carbon in biomass (leaves) above the sea floor. The majority of carbon storage, however, is below the surface in the form of root structures. Seagrass roots accumulate large stores of carbon through the vertical sub-surface formation of 'mattes.' Over time, these mattes can represent decades and centuries of stored carbon. Seagrass meadows contain around 766.5 tonnes of CO_2 per hectare (Sifleet *et al*., 2011).

Seagrasses supply many valuable ecosystem services - providing food and nursery habitats for commercially important fish and marine invertebrate species; trapping sediments and nutrients, which improves coastal water quality; reducing coastal erosion from storms and waves - and are crucial for the overall functioning of the coastal zone. Seagrass meadows are under serious threat from human activities that cause eutrophication and siltation, such as through coastal development, deforestation on land, and agricultural run-off and sewage. It is estimated that two-thirds of the original global seagrass cover has been lost.

Photo: © EAD

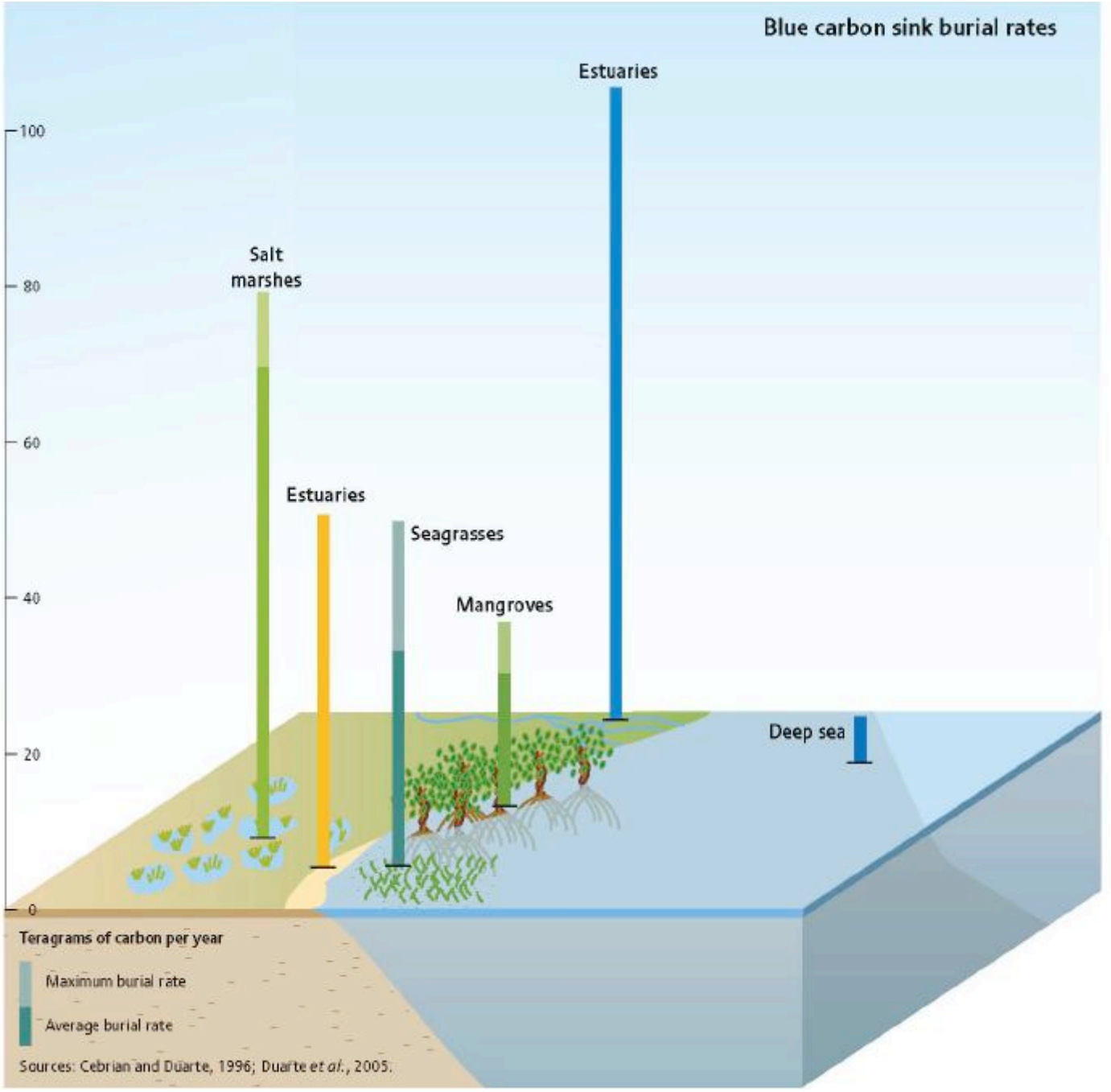


Figure 3: The capacity of the ocean's coastal Blue Carbon sinks.

Current priorities in Blue Carbon science
Scientific priorities for Blue Carbon include:

- Enhance the scientific basis for the understanding of carbon sequestration potential in all Blue Carbon ecosystems, inducing examining the fate of marine carbon from the watershed to the deep ocean;

- The development of a global network of demonstration projects. Priority should be given to demonstration projects in developing countries where large Blue Carbon stocks exist, e.g., tropical Africa and the Coral Triangle region of Asia;

- Support the mapping of Blue Carbon ecosystems, including the assimilation of existing cartography and the creation of new maps and geographic information system (GIS) layers;

- Social science investigations into the role that Blue Carbon ecosystems play in to human health and livelihoods development; and,

- An exploration of co-benefits/ecosystem services associated with Blue Carbon ecosystems and the potential for projects to bundle multiple services.

Capacity building at multiple levels would be necessary to achieve Blue Carbon scientific priorities.

Blue Carbon Policy
Blue Carbon is not yet currently recognised in International Conventions. Blue Carbon science and methodology are not mature enough yet for market-scale investments in Blue Carbon credits, but private companies have begun to support the development of methodologies and demonstration projects. Clean Development Mechanism (CDM) mangrove methodology and Voluntary Carbon Market (VCM) mangrove projects are in development and close to accruing carbon credits. The near-future scenario might involve private agreements for carbon offsets.

Global Blue Carbon Efforts

Numerous stakeholders have been involved in advancing Blue Carbon policy and science at the national and international levels, a sample of efforts include:

- The US National Oceanic and Atmospheric Administration (NOAA) has a Blue Carbon Working Group and is working to advance awareness of coastal Blue Carbon.
- The Republic of Indonesia has a Blue Carbon Working Group, and is interested in 5 demonstration project sites throughout the country.
- Blue Climate Solutions, a non-profit project of The Ocean Foundation, focuses solely on advancing Blue Carbon policy. It has achieved this since 2009 through the Blue Climate Coalition, an international partnership representing over 100 conservation groups and environmental stakeholders from 43 countries around the world. The Coalition has advanced Blue Carbon with the US Government, the GEF, and in international climate change negotiations (e.g., the United Nations Framework Convention on Climate Change (UNFCCC)).
- The GEF recently included Blue Carbon under its recent "Blue Forests" project, which includes advancing methodologies, capacity building and understanding of ecosystem services. A Project Preparation Grant (PPG) is underway.
- UNEP's Blue Carbon Initiative is advancing Blue Carbon projects in developing countries.
- UNEP-WCMC is involved in Blue Carbon ecosystem data and mapping;
- With efforts focussed primarily on developing nations, UNEP/GRID-Arendal, a collaborating UNEP centre and Norwegian foundation, actively works on Blue Carbon capacity building, communications and project management.
- Forest Trends, an international non-profit organisation, focuses on market-based mechanisms to ensuring the maintenance of ecological functions and services, including Blue Carbon, and actively engages a diverse set of partners to facilitate and catalyse innovative solutions.
- The Blue Carbon Project at Duke University's Nicholas Institute for Environmental Policy Solutions examines the economic and scientific challenges Blue Carbon faces.
- Conservation International, IUCN and UNESCO-IOC manage two Working Groups focused on Blue Carbon Science and Policy.
- The Charles Darwin University's Rehabilitating Blue Carbon Habitats proposal includes two demonstration sites for the Republic of Indonesia and explores socioeconomic and environmental benefits associated with rehabilitating and effectively conserving Blue Carbon habitats.

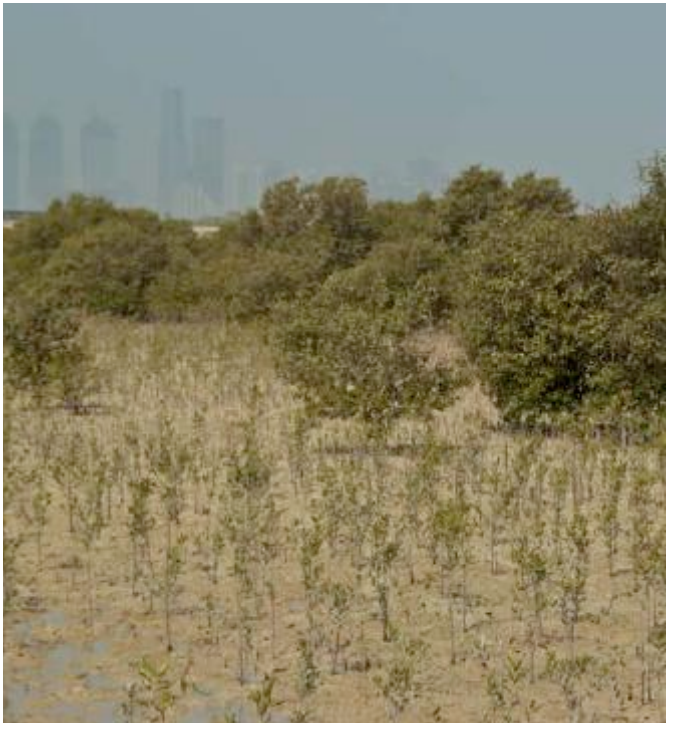
WHY BLUE CARBON IN THE ARABIAN PENINSULA?

Carbon dioxide emissions are those resulting from the burning of fossil fuels and include gasses produced during consumption of solid, liquid, and gas fuels and the manufacture of cement. Since the discovery of oil in the Arabian Peninsula more than 30 years ago, many states have undergone a profound transformation from impoverished small desert principalities to modern states with high standards of living and rapid development of infrastructure and commerce. Rapid economic and population growth and high energy consumption have led to per capita carbon emissions at levels many times that of the world average.

All seven countries of the Arabian Peninsula are signatories to the Kyoto Climate Protocol, a protocol to the UNFCCC, aimed at addressing climate change. Signatory parties are directed to ensure that National Communication reports submitted to the UNFCCC include descriptions of planned mitigation measures.

Many states throughout the region are pursuing a range of options to mitigate their GHG emissions, including solar power, carbon capture and storage and other innovative technologies.

As the Arabian Peninsula contains no major terrestrial forests, Blue Carbon may provide options for carbon sequestration and storage in natural coastal ecosystems.



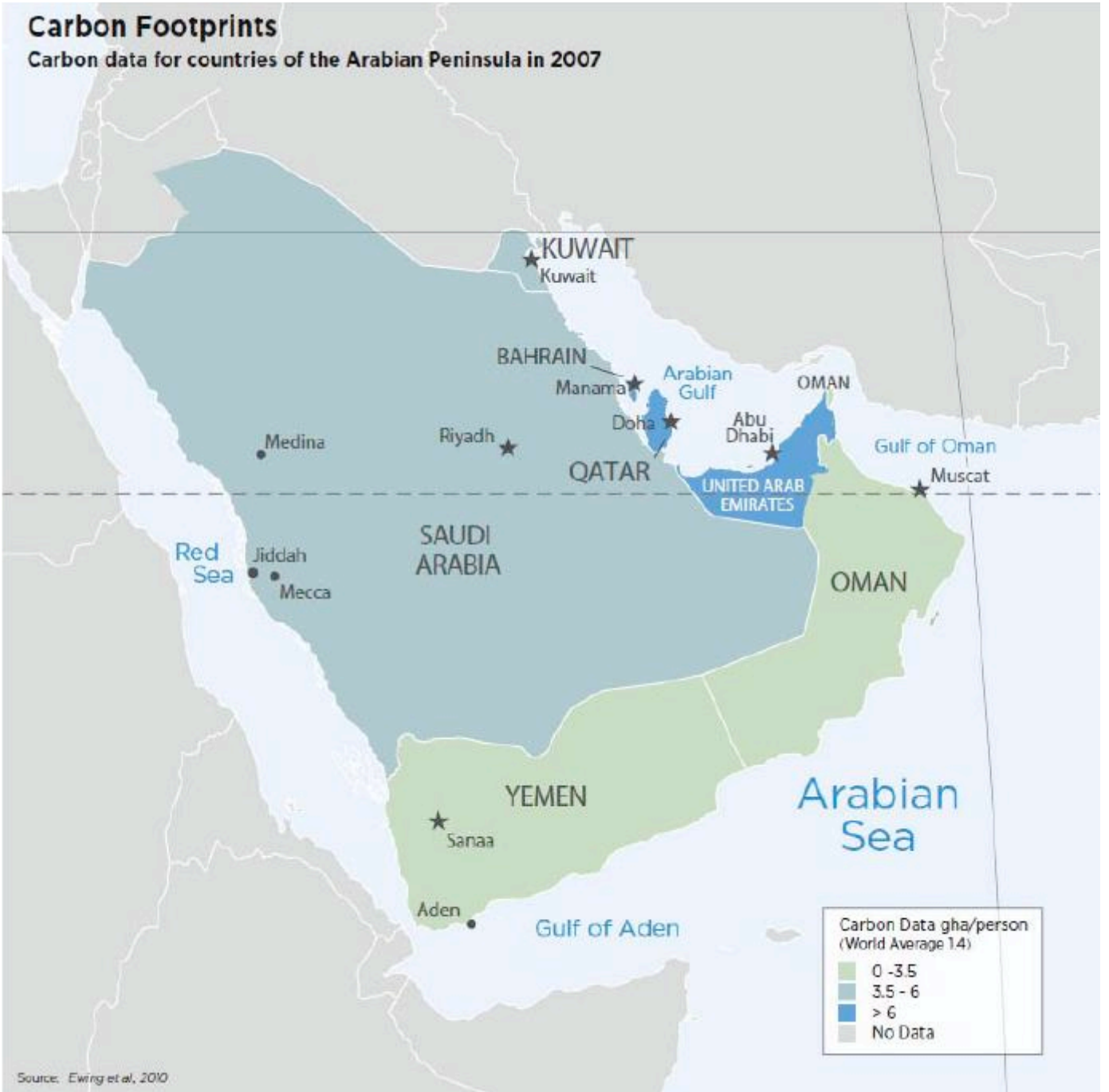
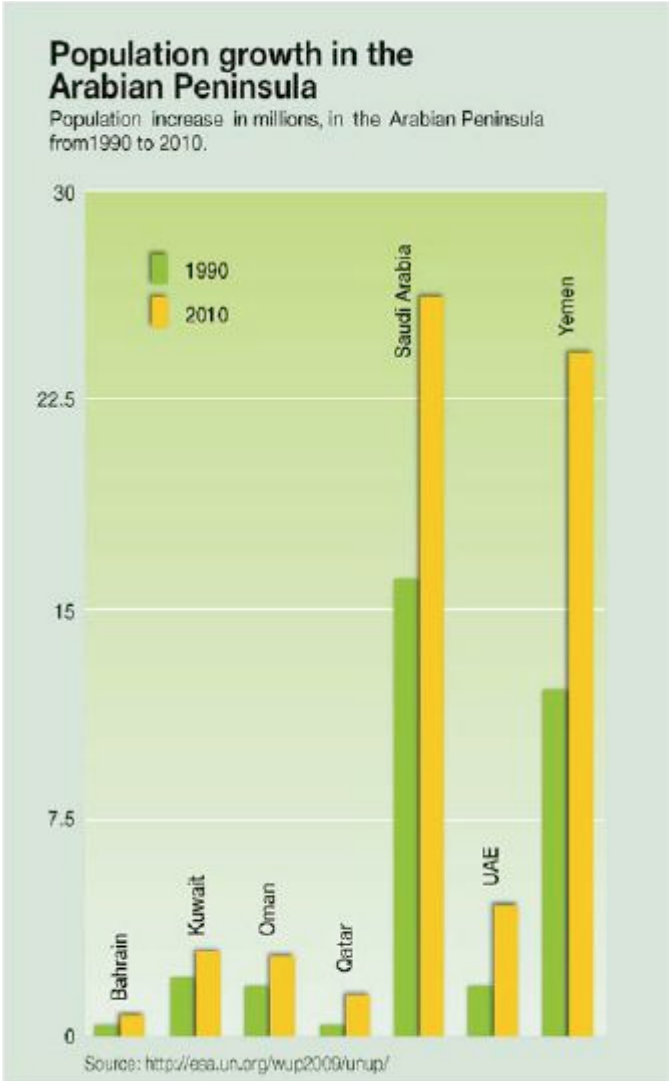


Figure 4: Regional carbon footprints.



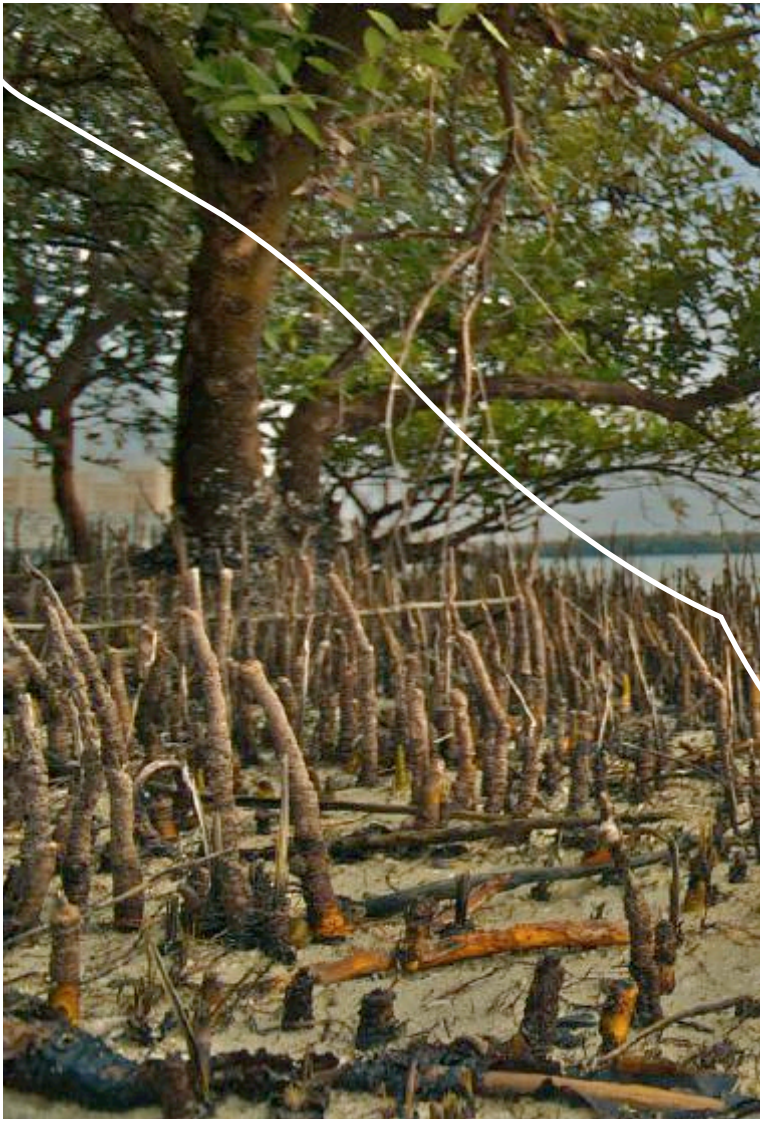


Figure 5: Regional population growth.

"It will take a concerted effort by committed Gulf leaders to involve the international research community and build effective and long-term collaborative relationships with regional and local universities so that local expertise in environmental science can set root."

Van Lavieren *et al.*, 2011

BLUE CARBON ECOSYSTEMS OF THE ARABIAN PENINSULA

Despite their high ecological, economic and societal values, the coastal ecosystems of the Arabian Peninsula, including coral reefs and mangrove forests, are subjected to continued degradation (Burke *et al.,* 2011**). Blue Carbon ecosystems exist in all seven regional nations.**

Regional natural coastal carbon sinks

Mangroves

Known as 'Qurum' in Arabic, four species are recorded from the region, with *Avicennia marina* being dominant. Despite low diversity and a mostly irregular distribution with many stands (Mangal) relatively small in size, mangroves throughout the region are regarded as ecologically significant (Spalding *et al.,* 2010). In the Arabian Gulf mangroves reach their northern limit in Asia, grow under hyper saline conditions and are represented by a single species, *Avicennia marina*. Mangroves are reported to be widespread in Yemen and irregular throughout the rest of the region. Notable areas of mangroves can be found near Muscat in Oman and Abu Dhabi in the UAE. Mangroves do not normally occur in Kuwait, but efforts have been made to introduce them there. Only two species have been recorded along the Red Sea coast of Saudi Arabia, *Avicennia marina*, which is widespread, and *Rhizophora mucronata*.

Mangroves are known to have been more extensive both in the recent and long-term past. The historical causes for reduction are generally accepted to be clearance, primarily from fuelwood (charcoal), collection and livestock grazing (camels). The largest current impact to regional mangroves is conversion for development.

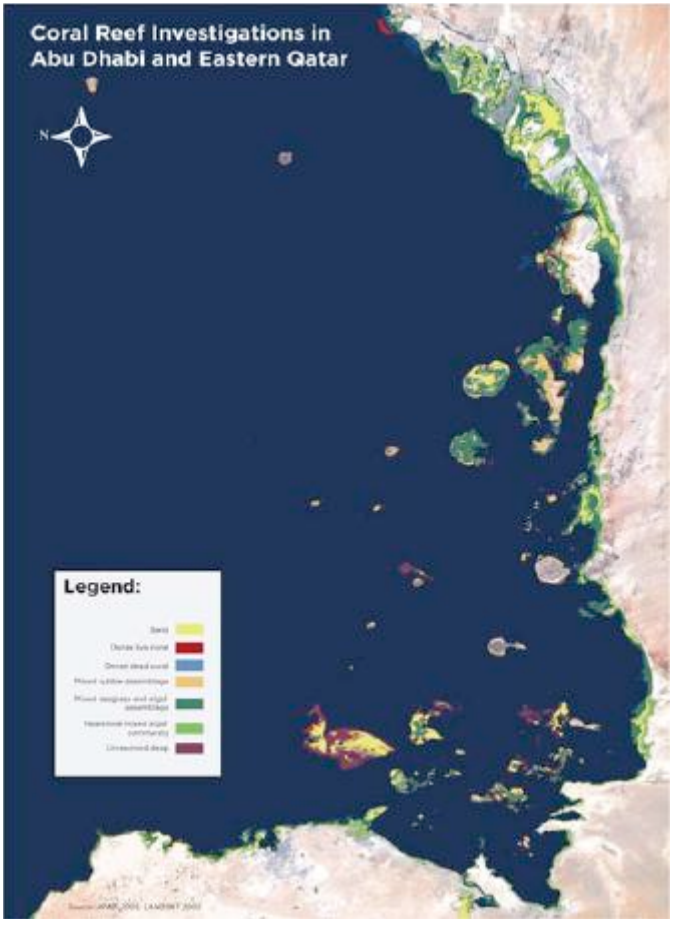


Figure 6: Marine ecosystems of the UAE.

Figure 7: Blue Carbon ecosystems of the Arabian Peninsula.

Mangrove nurseries are known from the UAE and Oman. Due to the legacy of the late Sheikh Zayed Bin Sultan Al Nahyan, who instituted a massive reforestation campaign, mangroves have been planted in many locations throughout the UAE since the 1970's. The Environment Agency-Abu Dhabi (EAD) recently reintroduced the mangrove species "*Rhizophora mucronata*" which was previously recorded in the UAE. It is largely unknown how much carbon sequestration and storage would result from mangrove afforestation.

A good review of mangroves throughout the region can be found in the 2010 World Atlas of Mangroves (Spalding *et al.,* 2010), published by UNEP-WCMC.

Seagrasses

Eleven species of seagrass are reported from the Arabian Peninsula. The highest diversity is reported from the Red Sea (11 species) and the lowest in the Arabian Gulf (3 species). Seagrasses are reported from Kuwait, western and eastern Saudi Arabia, Bahrain, Qatar, and the UAE (Phillips, 2002).

Mangrove Carbon...

Seagrass Carbon...

Photo: © EAD - Xavier Eichaker

> *"Studies needed are those on density, biomass, primary productivity, and growth rates of the seagrasses. Until these studies are done, there is no real way to quantity their contribution to the Gulf fisheries...This work is badly needed for the Arabian Gulf."*
>
> (Phillips, 2002).

Photo: © EAD

Approximately 42 per cent of Yemen's Red Sea coastline supports seagrass communities (Rouphael *et al*., 1998).

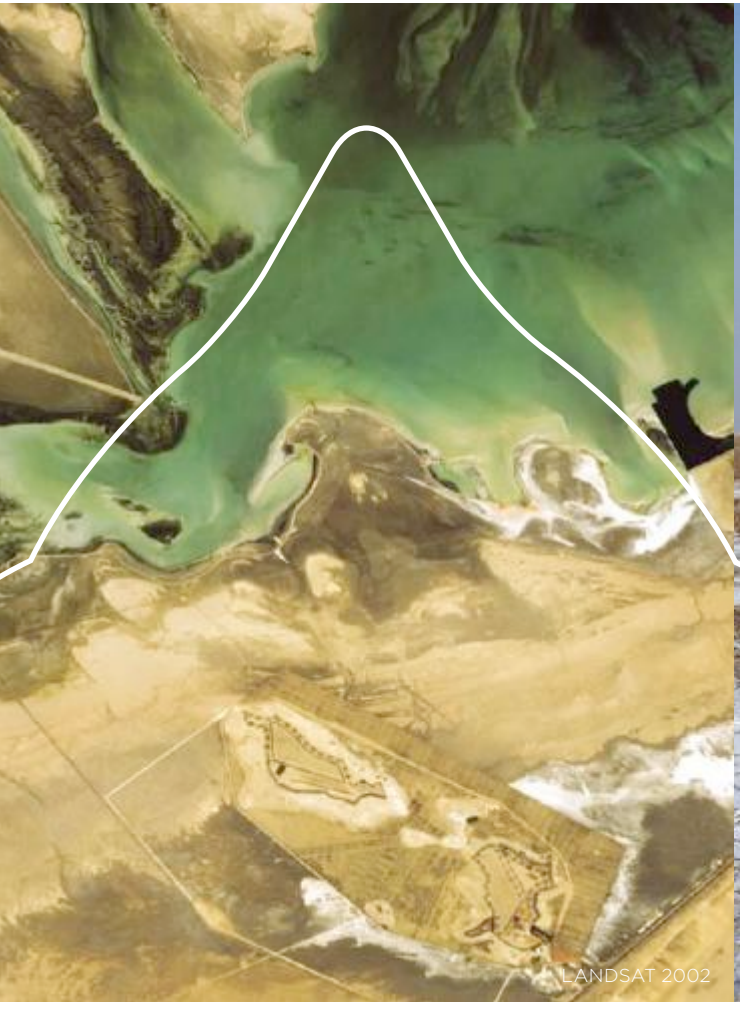
In 2002, the late Dr. Ronald Phillips, a pioneer in seagrass research, noted an almost total lack of research on seagrasses in the Arabian Gulf (Philips, 2002);

Research on regional seagrass density, biomass, primary productivity, and growth rates are also paramount for Blue Carbon.

Salt marshes

Commonly found in the more sheltered regions of the Arabian Gulf coast, salt marshes are intertidal

Saltmarsh Carbon...



biologically diverse sand and mud flat habitats. They support large numbers of invertebrates and foraging shorebirds. These rich ecosystems also provide valuable breeding and stopover habitat for a number of regionally and internationally important populations of migrant waterfowl (Arkive, 2011).

Sabkha Carbon ?

Sabkha is the Arabic term for a salt flat. Sabkha "are flat and very saline areas of sand or silt lying just above the water-table" (West, 2007). They are characterised by flat plains with "algal mats" a few centimetres thick, beneath which are layers of minerals. Coastal Sabkha may experience occasional wetting of sea water. In the summer months, the mats dry and flake. Sabkha are known throughout the region. Large areas are found in the UAE, the Bar al Hiskmann peninsula in Oman, and much of the Saudi Arabian Red Sea coast.

The carbon sequestration and storage potential of Sabkhas has not yet been explored.

A good reference for regional saltwater marshes is the 1995 A Directory of Wetlands in the Middle East (Scott, 1995), published by UNEP-WCMC.

Photo: © UNEP

REGIONAL IMPORTANCE OF BLUE CARBON ECOSYSTEMS

Services produced and supported by healthy Blue Carbon ecosystems provide a great benefit to coastal populations throughout the Arabian Peninsula.

Valuable services include supporting fisheries by providing crucial habitat for many fish species; underpinning tourism opportunities such as snorkelling over seagrass beds, diving among coral reefs, kayaking in mangroves and bird watching in saltwater marshes; maintaining global biodiversity such as the millions of migratory birds that use regional wetlands annually; adding to the foundation of culture and heritage throughout the region; sustaining endangered and threatened species such as habitat for sea turtles and dugongs; and, providing coastal protection and adaptation to climate change through mangroves stabilisation of shorelines during storms, high tides, and the subsequent risk of flooding.

Services provided by regional Blue Carbon ecosystems

Dugongs

Dugongs *(Dugong dugon)* are large marine mammals that live in warm, shallow waters. They are herbivores (plant-eaters), whose diet consists mainly of seagrass.

These mammals often graze in herds and can be found at the same location for weeks to months. A dugong's foraging techniques include 'cultivation grazing,' where a patch of seagrass is cropped short by frequent grazing (Preen, 1995).

Photo: © Yusuf Thakur

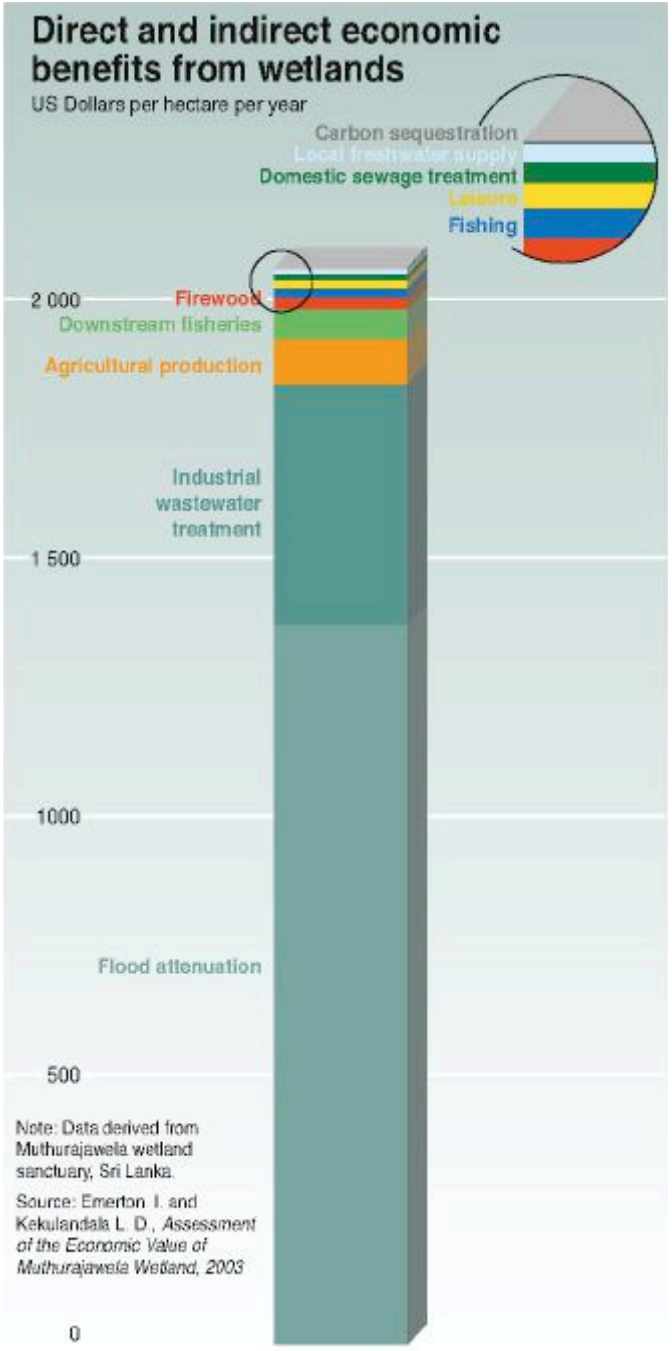


Figure 8: Benefits from wetlands.

Dugong carbon?

A dugong's diet consists mainly of seagrass. They are known to forage by 'cultivation grazing,' where a patch of seagrass is cropped short by frequent grazing. This method promotes the faster growth of young leaves. The impact this unique foraging technique has on the carbon sequestration efficiency of seagrass meadows (via faster leaf growth) is yet to be understood."

Dugongs are found in 43 countries in tropical and sub-tropical zones, along the western Pacific and Indian Oceans (also known as the Indo-Pacific), with populations ranging from the coastal waters of East Africa to Japan, Australia, and the Vanuatu islands (Western Pacific Ocean).

In the Arabian Peninsula, they are found in the waters of the Arabian Gulf and Red Sea. The dugong population in the Arabian Gulf is believed to be the second largest in the world after Australia. In the Arabian Gulf, dugongs are restricted to the southern and south western coastline between Ras Tannurah in Saudi Arabia and Abu Dhabi in the United Arab Emirates.

Preen (1989) identified four core areas as being the most important areas for dugongs in the Arabian Gulf:

- Between Bu Tinah shoal and Abu al Abyad Island in the UAE.
- The coastal territory Saudi Arabia between Qatar and the United Arab Emirates.
- Between Bahrain and Qatar, south of Fasht Adhm and north of the Hawar Islands.
- Between Saudi Arabia and Bahrain, south of the Saudi Arabia-Bahrain Causeway and north of Uqair.

The International Union for the Conservation of Nature (IUCN) lists the dugong as Vulnerable on a global scale. Dugongs in UAE waters are protected by Federal Law No. 23 (Article 28), which prohibits the taking of dugongs in UAE waters. The Environmental Agency (EAD), Abu Dhabi, conducts summer and winter aerial dugong surveys of UAE waters.

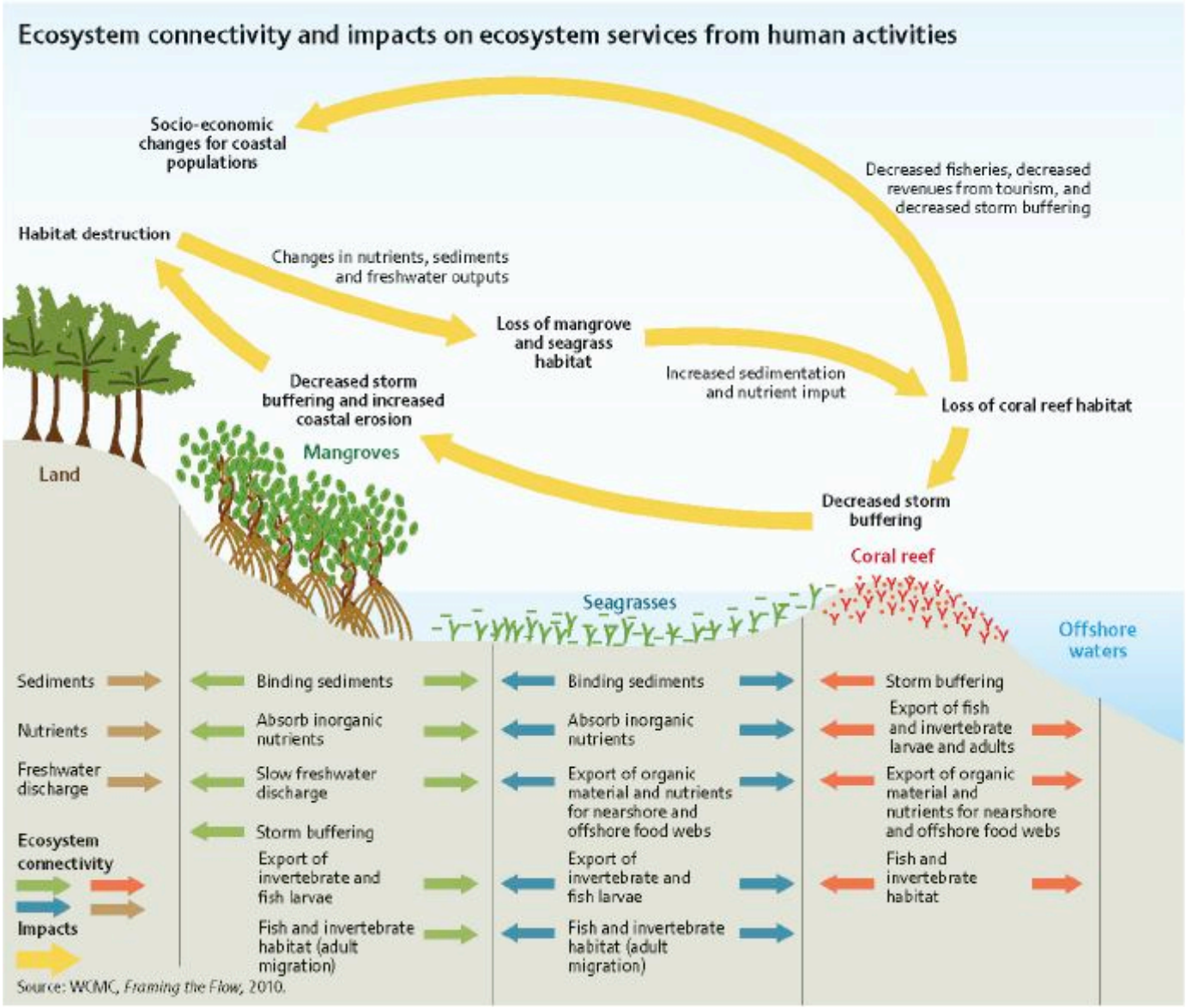


Figure 9: Ecosystem connectivity and impacts on ecosystem services from human activities.


Photo: © Yusuf Thakur

In the waters surrounding the Arabian Peninsula, as in the rest of their distribution range, the dugong faces numerous threats to its survival. Regional threats include the loss of sea grass habitats caused by dredging, coastal land clearing and filling, as well as water and oil pollution. Abandoned ropes and fishing nets also threaten dugongs.

Dugongs are iconic species that are known around the world. Many visitors to the region and local residents might be interested to participate in wildlife tours that involve dugong viewing. Evidence for the potential in revenue generated from iconic marine species has been well documented in costal areas involving species such as Cetaceans (whales and dolphins). This connection could also potentially support the creation of locally owned wildlife tourism businesses that would then increase livelihoods and entrepreneurial business engagement throughout the region. Community-based tourism (CBT) is well linked to areas that have iconic species populations.

Sea Turtles

Sea Turtles are ancient marine reptiles that inhabit all of the world's oceans except the Arctic.

Five of the planet's seven marine turtle species are found in the waters of the Arabian Peninsula; the hawksbill (*Eretmochelys imbricata*), green (*Chelonia mydas*), loggerhead (*Caretta caretta*), olive ridley (*Lepidochelys olivacea*) and leatherback (*Dermochelys coriacea*) sea turtles. The hawksbill and green turtles are common in the waters of the Gulf and Arabian Sea. The loggerhead, olive ridley, and leatherback occur occasionally. All species, other than the leatherback, nest on beaches in the region.

Green sea turtles are the only sea turtles that are strictly herbivorous as adults. Adult green sea turtles often consume seagrasses, mangrove leaves and algae.


Photo: © Hanne & Jens Eriksen

Nesting beaches are found throughout the region, in Kuwait, Oman, UAE, Qatar, and Yemen. Significant nesting populations are found on the coastlines of Oman and Yemen. An estimated 30,000 loggerhead turtles nest annually on Masirah Island, Oman.

IUCN lists all five regional turtle species as endangered or critically endangered categories.

Sea turtles in UAE waters are protected by Federal Law No. 23 (Article 28), which prohibits the taking of sea turtles in UAE waters and the collecting of sea turtle eggs. EAD conducts aerial sea turtle surveys of UAE waters.

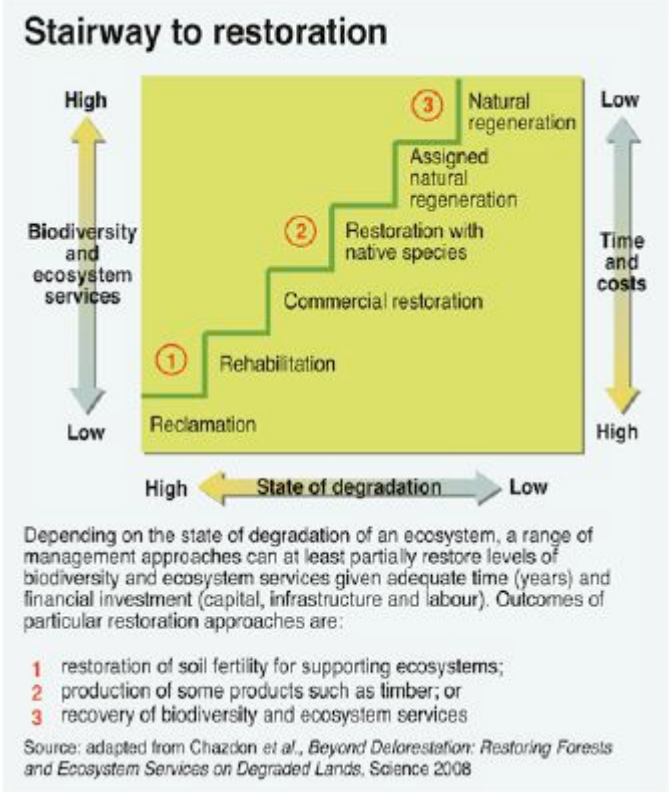


Figure 10: Biodiversity and ecosystem services within a restoration model.

In regional waters surrounding the Arabian Peninsula, as in the rest of their distribution range, sea turtles face numerous threats to their survival. Significant threats include the loss of nesting beaches due to coastal development, illegal fishing, and by-catch.

Sea turtles are also an iconic marine species that hold great significance in tourism development in costal areas. As with any tourism development, sustainable strategies need to be implemented in order to not disturb wildlife breeding and viability. Costa Rica, for example, has benefited significantly both socially and economically from sea turtle viewing and conservation.

Fisheries

Due to its role in food security, fisheries are the next most important natural resource in Arabian Peninsula, second only to oil. Blue Carbon ecosystems are vital to fisheries throughout the region. Mangrove habitats serve as critical nurseries for many commercially important marine species and therefore play a crucial economic well being for fishermen.

Mangroves and seagrasses produce a large amount of leaf litter per acre per year, which is broken down by bacteria and fungi and eventually provides food for sea-life. Mangrove habitats provide a rich source of food while also offering refuge from predation for many fish species. Mangroves and seagrasses serve as essential habitat for the commercially important Hamour (*Epinephelus coioides*), Aqalah (*Lutjanus fulviflamma*), Badah (*Gerres longirostris*) and Faskar (*Acanthopagrus bifasciatus*). Fisheries throughout the region would suffer a dramatic decline without access to connected and healthy seagrass and mangrove habitats.

Regional fisheries are currently threatened by a multitude of impacts, including habitat destruction, overfishing and water pollution. Over 70 per cent of the Abu Dhabi Emirate's fisheries are currently classified by EAD as 'over-exploited.' The stocks of 8 popular species (including the Hamour and Farsh) are heavily over-exploited. Re-building fish stocks is a high priority environmental goal for the Emirate.

High quality, local food sourcing is imperative for discerning high end tourism market. The provision of unique/region specific, local fish to restaurants and the hospitality industry could provide economic incentive to ensure long-term fishery health. In addition, the fishery industry is critical for economic propriety of local communities.

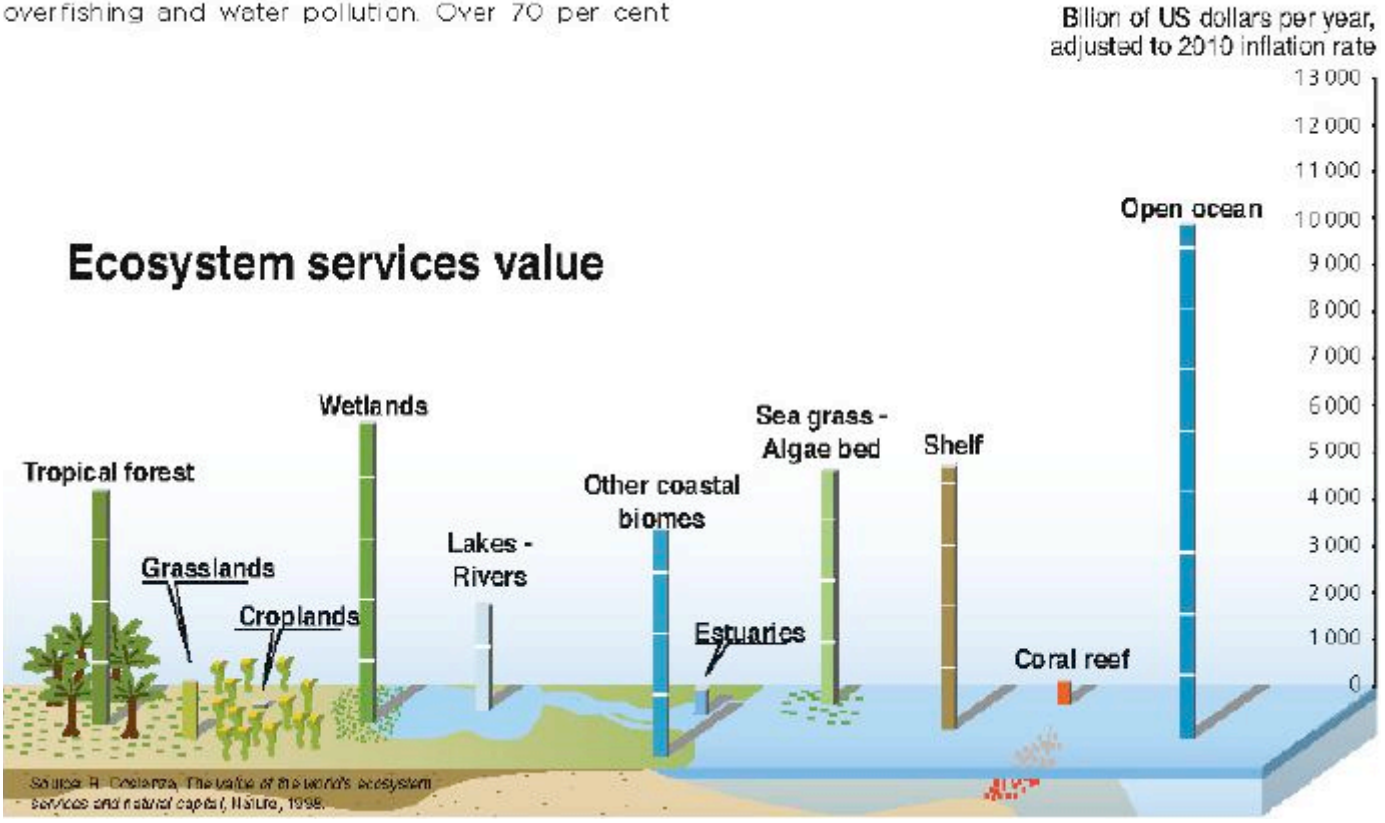


Figure 11: The value of ecosystem services.

Cultural Heritage

Archaeological evidence indicates a close relationship between man and mangroves. Early man utilised mangrove associated species for food, such as the mollusc shell (*Trebrelia palustrus*) and the mud mangrove crab (*Scylla serata*). The oldest occupied island with mangroves in Abu Dhabi, Murawa Island, has been inhabited for 7500 years and two Neolithic settlements are located on it. Early man likely over exploited mangroves for wood and fuel, and multiple species disappeared during the early Islamic period (Beech, 2011).

Mangroves have traditionally been used for wood, fuel, and livestock grazing (camels). Abu Dhabi's mangroves have been used for centuries for honey production (EAD, 2006). Mangroves also feature in regional folklore, Jinn, or genies, are said to inhabit mangrove areas (Beech, 2011).

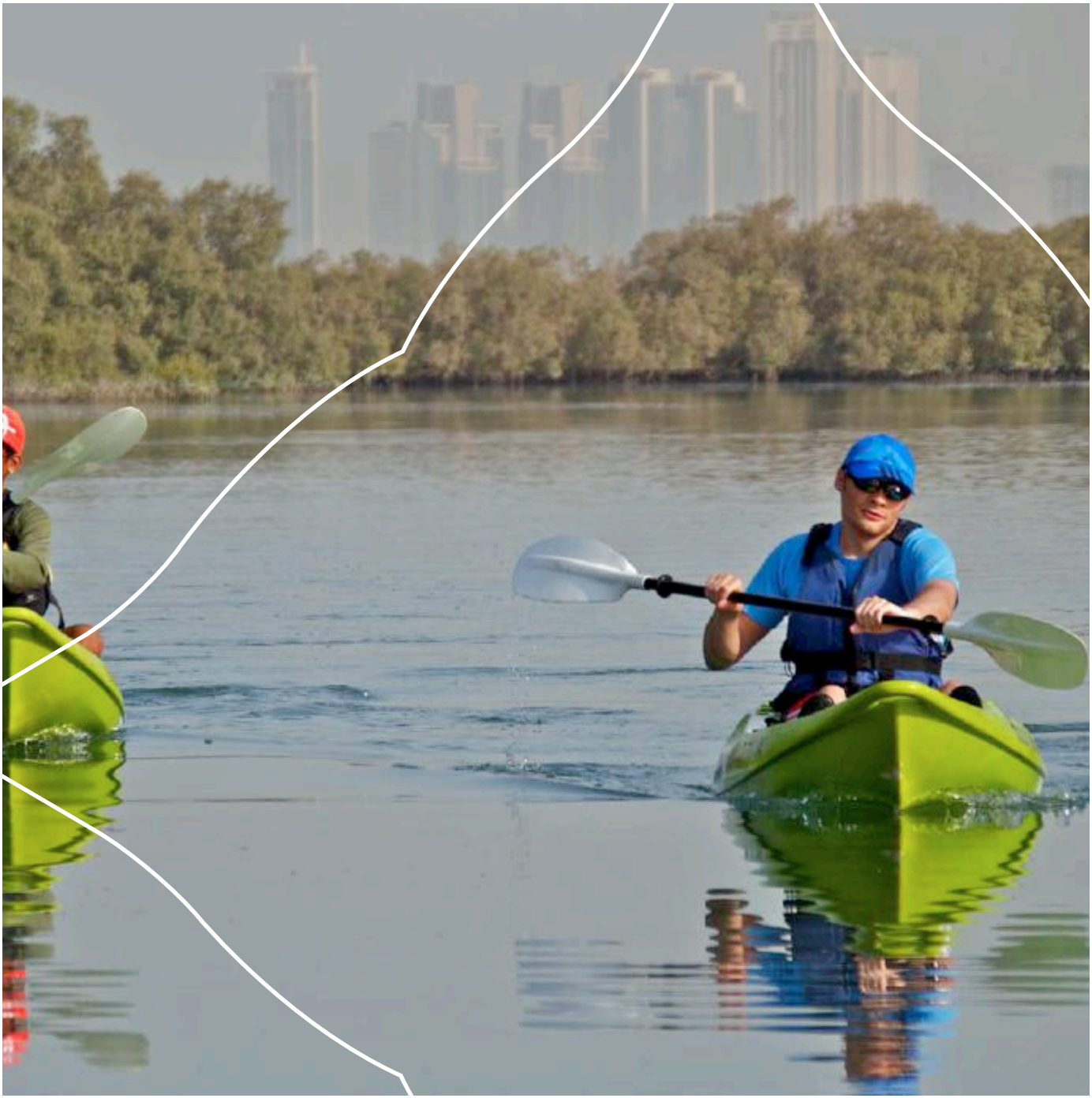
Tourism

Tourism is arguable the world's largest industry and the largest sector supporting protected areas. Sustainable tourism incorporates positive economic, socio-cultural, environmental and climate considerations and impacts during planning and implementation. More than 50 per cent of all tourists visiting a foreign country make use of protected areas. Experiences in these areas can lead to tourists becoming engaged in conservation serving as a conduit for socio-cultural conservation and having a major potential to raise investments for conservation.

Tourism in the states of the Arabian Gulf is a rapidly growing industry (Khan, 2007). A wide range of mass tourism activities are available, from scuba diving and beach going to desert safari tours, auto racing and concerts. Ecotourism, defined as tourism in natural areas that conserves the environment and the well being of local people, is relatively new in the region and may offer opportunities to advance Blue Carbon. Ecotourism when seen within the context of UNEP's Green Economy Initiative can help promote transitions to sustainable planning and development.

Ecotourism is the tourism industry's fastest growing sector globally. Well planned sustainable tourism can support conservation efforts such as marine protected areas (MPA). During MPA planning and implementation, positive economic, socio-cultural, environmental and climate considerations are incorporated. Healthy intact landscapes are the most desirable for sustainable marine tourism, and they also store the most Blue Carbon.

'Blue Carbon' tourism activities in the Arabian Peninsula include a variety of nature-based options. Examples include kayaking in the mangroves of Abu Dhabi, fishing for crabs at night in the mangroves of Emirate of Umm Al Quwain, and bird watching for Greater Flamingos on the inter-tidal mudflats as well as inshore and seagrass beds at Ras Hayan on the southeast coast of Bahrain. Much sport fishing could be considered a 'Blue Carbon' activity, as many popular fish species, and their food sources depend on healthy Blue Carbon habitats.



REGIONAL CONSIDERATIONS ON ADVANCING BLUE CARBON

Blue Carbon is a new concept however its core strategy - the conservation of coastal ecosystems - is not.

A Blue Carbon initiative for the Arabian Peninsula should explore and coordinate with ongoing local, regional and international environmental frameworks, networks and organisations, and initiatives. Examples include the following:

- IUCN ROWA - IUCN's Regional Office for West Asia covers all regional countries and is interested in advancing Blue Carbon throughout the region.
- ROPME - The Regional Organisation for the Protection of the Marine Environment's mission involves the protection of the marine environment and the coastal area the Arabian Gulf (ROPME Sea Area). Regional members include Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the UAE. ROPME is involved in the regional conservation and management of mangroves and has expressed interest in Blue Carbon.
- National carbon accounting - All regional members are UNFCCC signatories and are required to report emissions and descriptions of planned mitigation measures. Carbon stored in natural coastal ecosystems could be included.
- CBD - The Convention for Biological Diversity is an international treaty with a focus on the conservation of biological diversity. All regional countries are parties to the Convention. In 2010, at the 10th Conference of the Parties to the CBD, a number of targets were adopted relevant to Blue Carbon; to reduce the rate of loss of all natural habitats by half, to enhance ecosystem resilience and the contribution of biodiversity to carbon stocks, and to improve and apply science and technologies relating to biodiversity conservation (targets 5, 15 and 19 respectfully).
- World Heritage Listing - A World Heritage Site is a place listed by the UNESCO as of special cultural or physical significance. The list is maintained by the international World Heritage Programme and administered by the UNESCO World Heritage Committee. Qatar and the UAE are committee members along with 19 other states.
- EAD Wetland Mapping Project – EAD's Mapping and Characterization of Coastal Wetlands project aims to classify and characterize coastal wetlands, map coastal wetlands including mangroves, salt marshes and seagrass meadows, and to develop conservation and management plans for the coastal wetlands of the Emirate.
- Ramsar Convention on wetlands - (see page 38).

Additionally, a regional Blue Carbon initiative could explore innovative approaches for securing the financing of the sustainable management of coastal ecosystems, including the valuation of ecosystem services (see page 39).

Estidama and the Pearl Rating System

Estidama, which means "sustainability" in Arabic, is an Abu Dhabi Urban Planning Council (UPC) sustainable development initiative, which aim is to balance development with environmental, economic, cultural and social needs (the four pillars of Estidama).

One of Estidama's key initiatives is the Pearl Rating System, which provides design guidance and detailed requirements for rating a construction project's potential performance in relation to the four pillars of Estidama. The Pearl Rating System is organized into seven categories, including "natural systems," which advances the conservation, preservation and restoration of the region's critical natural environments and habitats. Mangroves and seagrasses are included in the system as priority habitats, those which are of exceptional value and are highly threatened.

The Pearl Rating System may offer a unique opportunity to preserve the full value of Blue Carbon ecosystems in the Abu Dhabi Emirate, though the incorporation of carbon stored and other services provided in the rating of a construction project's performance.

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Ramsar

The Ramsar Convention is "an intergovernmental treaty that embodies the commitments of its member countries to maintain the ecological character of their Wetlands of International Importance and to plan for the "wise use", or sustainable use, of all of the wetlands in their territories" (Ramsar, 2011). Coastal wetlands of the Arabian Peninsula considered under Ramsar, include sabkha, salt pans, mangrove forests, tidal flats, coral reefs and seagrass beds.

Three countries in the region are parties to Ramsar - Bahrain, UAE and Yemen. The UAE presently has one coastal wetland site with Blue Carbon habitat designated as a Wetland of International Importance - the Ras Al Khor Wildlife Sanctuary in Dubai, which includes mangrove and salt marsh habitat. Other Emirates are interested in Ramsar designation. Yemen's Detwah Lagoon on Socotra Island is a Wetland of International Importance that includes seagrass habitat. Bahrain has two 'Blue Carbon' sites designated as a Wetland of International Importance, Hawar Islands which, contains extensive seagrass beds, and Tubli Bay, which includes mangroves and seagrasses.

Interest in and experience with Ramsar throughout the region may offer opportunities for advancing Blue Carbon. For a site to be declared a Wetland of International Importance the wetland has to be protected and declared a nature reserve under national policy. For this to occur, a clear legal mandate must exist for the site, including designation of ownership, property lines, etc. Similar documentation must occur for Blue Carbon (especially if financial transactions are expected). A Blue Carbon initiative for the region should closely follow and coordinate with Ramsar and its network of wetland professionals.

Photo: © Sheikh Ahmed bin Hamdan

Blue Carbon and Ecosystem Services (ES)

We only take care of that which we value. The recognition and valuation of ecosystem services can help ensure their consideration in policies as they move forward.

A combined Blue Carbon and Ecosystem Services (ES) approach may be necessary to secure the sustainable management of Blue Carbon ecosystems. Blue Carbon by itself may not generate enough funds to support the sustainable financing of conservation efforts, due to potentially high opportunity costs associated with coastal land, high transaction costs associated with these types of projects (development, verification, and monitoring costs may outweigh carbon revenue), and a relatively low current price of carbon on the voluntary carbon market. A bundled or combined approach with payments for other ecosystem services may be necessary to ensure long-term sustainable financing and management.

Additionally, many costal communities are connected to and depend on the services that Blue Carbon ecosystems provide. These can include cultural heritage, food security through essential habitats for harvested fish species, water security through desalination of coastal waters, and revenue from tourism (e.g., kayaking in mangroves and bird watching in salt marshes).

Pursuing a Blue Carbon agenda without considering a community's connection to its local coastal ecosystems may cause economic hardship and generate political ill will. Conversely, if ecosystem services are considered, valued, and incorporated, Blue Carbon projects could gain political support and enhance local economies.

Blue Carbon and Packaged Ecosystem Services

Carbon sequestration, supporting ecotourism, providing fisheries habitat, and filtering water of sediments and pollutants, are four key ecosystem services that healthy Blue Carbon habitats provide. These services may be supported in a synergetic way, through a 'bundled' (one payment for multiple services) or 'stacked' (multiple payments for different services) payment for ecosystem services (PES) scheme enabling service users to package payments to service providers. Combining ecotourism with the restoration of coastal habitats for fisheries and coastal water quality and payments for carbon sequestration may offer an innovative and attractive source of financing for the sustainable management of coastal and marine ecosystems. In addition, a combined approach can support the socio-cultural and livelihoods development strategies of countries throughout the region.

What could be purchased?

Options for generating revenue include:

- Payments for carbon sequestration and storage by the conservation of Blue Carbon ecosystems (e.g, an energy company paying for the protection and conservation for the sustainable management of mangrove forests or seagrass meadows as carbon mitigation, or coastal development projects compensating for and rehabilitating the Blue Carbon ecosystems they impact);

- Conservation fees, taxes, payments for ecosystem services by dependent businesses, and biodiversity offsets directed towards ecological conservation and restoration (e.g., entrance fees for coastal and marine protected

areas, “green” tourist taxes, voluntary payments by tourism operators for specific management activities, biodiversity offsets for unavoidable impacts from coastal development, and oil and gas operations);

- Conservation fees, taxes, or payments for ecosystem services directed towards the restoration of fisheries habitats (e.g., taxes on unsustainable fisheries, fees for the mitigation of coastal development activities that impact fisheries and payments by the commercial fishing industry to safeguard nursery habitats for their harvested species); and,

- Conservation fees, taxes, payments for ecosystem services and biodiversity offsets directed towards the conservation and restoration (e.g., taxes on water utility bills, payments by water utilities, especially those using desalination, and biodiversity offsets for unavoidable impacts from coastal development and oil and gas operations).

Fees, payments, investments derived from carbon, fisheries, coastal water quality, and tourism could be used to support coastal protected areas and MPAs, address water quality and water security issues, and compensate local communities for supporting the sustainable use of coastal resources. Managing and protecting coastal wetlands and marine ecosystems for their carbon and these other ecosystem services will also provide additional co-benefits such as shoreline protection, supporting biodiversity, and reducing vulnerability to climate change.

Mangrove planting in the Emirate of Abu Dhabi

Abu Dhabi possesses extensive mangrove areas on its islands and coastal regions, with mangroves currently covering around 72 square kilometres, the largest area of mangroves in the UAE.

Developers in Abu Dhabi are encouraged to plant mangrove saplings to alleviate the effects of property development on vulnerable coastal habitats. A ratio of two mangroves planted for every one lost to development is recommended by EAD.

EAD and the Abu Dhabi Tourism Authority (ADTA) recently planted over 800,000 mangrove saplings close to the Capital, continuing a tradition started back in the late 1970s, when the late Sheikh Zayed Bin Sultan Al Nahyan initiated massive mangrove plantation programmes.

Photo: © EAD

CONCLUSION

Blue Carbon may offer many exciting opportunities throughout the Arabian Peninsula to protect coastal ecosystems and ensure long-term benefits from the services they provide while mitigating climate change. Much has to be accomplished in science, management, policy and related capacity. However the potential benefits to livelihoods, human well being, biodiversity, the economy, and climate change may stimulate societal support for advancing Blue Carbon policies.

Key opportunities to advance Blue Carbon in the region:

- The recognition of the contributions of Blue Carbon ecosystems in national Greenhouse Gas Emissions accounting.
- The formation of a regional Blue Carbon Working Group and the undertaking of dedicated regional workshops.
- A primary focus of demonstration projects should be the establishment of a baseline for carbon accounting of regional Blue Carbon ecosystems. Demonstration projects should be coordinated in order to collect high quality comparable data. Consideration should be given to data management and accessibility.
- A secondary focus of regional demonstration projects should be an exploration of other co-benefits/ecosystem services, the potential for projects bundling multiple services, and the production of peer-reviewed economic valuations for coastal ecosystems in the region.
- The enhancing of local capacity in science and management should be included in all strategies and projects under the Blue Carbon initiative for the region.
- Blue Carbon activities should complement ongoing regional conservation efforts (e.g., Ramsar and Convention on Biological Diversity (CBD)).
- Blue Carbon activities should be coordinated with and complement regional and international conservation interests (e.g., ROPME, IUCN ROWA, and the GEF Blue Forests project).
- General education programmes could also be considered with the aim of informing the public of the positive outcomes and accomplishments in policies that potentially benefit a wide range of stakeholders.

ACRONYMS

AGEDI	Abu-Dhabi Global Environmental Data Initiative
CBD	Convention for Biological Diversity
CDM	Clean Development Mechanism
CO_2	Carbon dioxide
EAD	Environment Agency-Abu Dhabi
ES	Ecosystem Services
GEF	Global Environment Facility
GHG	Greenhouse gases
GRID	Global Resource Information Database
IUCN	International Union for Conservation of Nature
IUCN ROWA	IUCN Regional Office for West Asia
MPA	Marine protected area
NOAA	US National Oceanic and Atmospheric Administration
PES	Payment for Ecosystem Services
PPG	Project Preparation Grant
UAE	United Arab Emirates
UNEP	United Nations Environment Programme
UNEP-WCMC	UNEP-World Conservation Monitoring Center
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESCO-IOC	UNESCO International Oceanographic Commission
UNFCCC	United Nations Framework Convention on Climate Change
VCM	Voluntary Carbon Market

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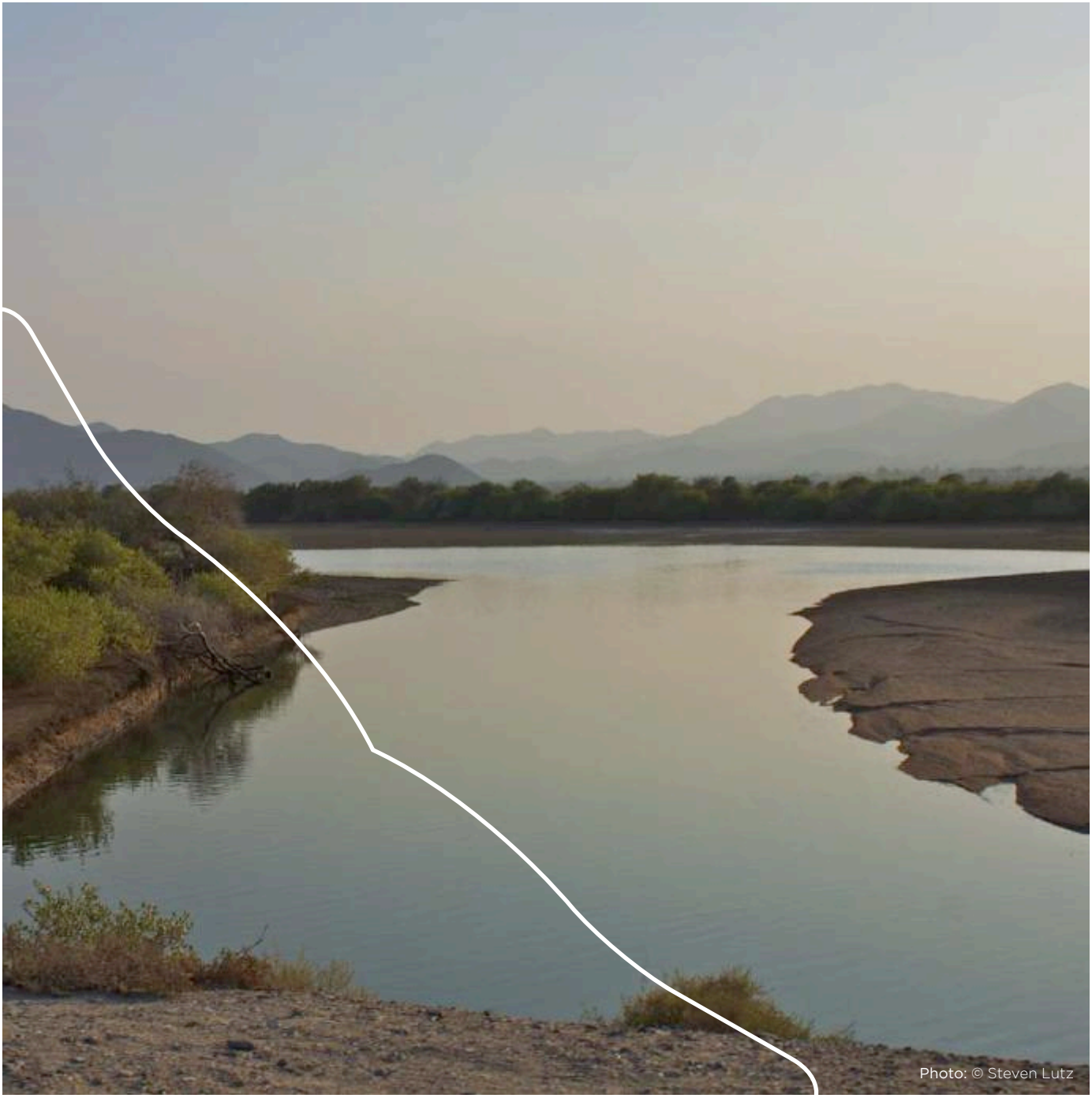

Photo: © Steven Lutz

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