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Studying the Importance of Blue Carbon in Preserving Sustainable Growth in the Red Sea in the Face of Climate Change

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Abstract

The carbon stored in coastal and marine ecosystems is referred to as blue carbon. These habitats, which include mangroves, tidal marshes, and seagrass meadows, also provide important benefits for climate change adaptation, such as coastal protection and food security for many coastal people. However, if ecosystems are degraded or harmed, their ability to absorb carbon is compromised, and stored carbon is released, resulting in carbon dioxide emissions that contribute to climate change (Fouda, 2006). This research aims to safeguard wetland habitats of international and national importance, including threatened and endangered species and biodiversity, as well as to protect coastlines and increase resistance to storm surges and increasing sea levels. The study reveals several findings, including Blue Carbon Ecosystems that are tied to the tourism industry as the principal destination. This study analyzed interviews conducted with 18 officials and experts affiliated to the Ministry of Tourism and Antiquities, the Ministry of Environment, the General Authority for Tourism Development, and the General Authority for Coastal Protection, to examine the environmental consequences of blue carbon systems and their impact on the spread of mangroves on the Red Sea coast. According to the study's findings, there are no mangrove trees except along the shores of the Red Sea Mountain ranges, but their cultivation is limited. Among the recommendations are the participation of residents in projects to protect mangrove forests, reduce the carbon footprint by lowering carbon dioxide emissions, search for clean renewable energy sources and use them as an alternative to fuel and reduce the use of fossil fuels.

Introduction:

Blue carbon refers to carbon that has been collected in coastal and marine ecosystems. Coastal habitats, such as mangroves, tidal marshes, and seagrass meadows, sequester and store more carbon per unit area than terrestrial forests. Their significance in combating climate change is now acknowledged (Pendleton, 2012).

These ecosystems also provide significant climate change adaptation benefits, including coastal protection and food security for many coastal people. However, if ecosystems are degraded or harmed, their carbon sink capacity is lost or reduced, and the carbon stored is released, adding to global warming (Fouda, 2006). Conservation initiatives can assist coastal ecosystems continue to serve as long-term carbon sinks. Mangroves, tidal marshes, and seagrass meadows are coastal ecosystems with large carbon stores that have been accumulated over ages by vegetation and many natural processes (Khalil, 2004).

Per unit area, ecosystems sequester and store more carbon (also known as blue carbon) than terrestrial forests. These vegetative ecosystems are large net carbon sinks due to their ability to absorb Carbon Dioxide (CO_2) from the atmosphere, and they are now being recognized for their role in climate change mitigation (Amin, 2012). However, if ecosystems are degraded or destroyed directly or indirectly by human activities, their carbon sink capacity is lost or negatively impacted, and the carbon stored in soil is released, resulting in CO_2 emissions that contribute to climate change (Pendleton, 2012).

Coastal habitats, which serve as substantial carbon sinks on a global scale, must be protected and restored. Despite their small size in compared to other ecosystems, they trap and store significant amounts of carbon in the soil all over the planet (Al-Ansari, 2012). The continued destruction and loss of these systems contribute to human greenhouse gas emissions (Duarte et al., 2013).

Mangroves, seagrasses, and tidal marshes, collectively known as Blue Carbon Ecosystems (BCEs), are extremely productive ecosystems that provide a variety of Ecosystem Services (ES), including the production of meals, products, and habitat for commercially important species (Pendleton, 2012), coastal protection (Pendleton, 2012), and cultural services. They also help to mitigate climate change by sequestering carbon (Duarte et al., 2013). Despite these advantages, there has been a global decline in coastal resources, owing mostly to conversion to other land uses. The destruction of these habitats can cause CO_2 to be released back into the atmosphere, contributing to global warming. Protecting coastal resources is an effective mitigation method for reducing greenhouse gas emissions and enhancing carbon sinks (Duarte et al., 2013).

Tourism is widely viewed as an essential economic factor that can improve people's quality of life by offering work opportunities, economic diversity, natural and cultural attractions, outdoor leisure and gathering opportunities, and increasing the food and lodging industries (McLeod, 2011).

Cultural services such as recreation and tourism in mangrove, saltmarsh, and seagrass ecosystems are well known and frequently mentioned in scientific studies; yet, these services have received minimal attention (Raddad, 2009).

Although tourism is a crucial economic boost for a community, it can also hurt the environment, particularly on sensitive ecosystems such as BCEs. Water scarcity (particularly on small islands and islets), local resource depletion, land degradation, air, noise, and visual pollution, solid waste and littering, sewage issues, and physical impacts (Development, and land-use changes) are all environmental consequences of tourism. Tourism's negative consequences on BCEs include how developed ports can lead to eutrophication of coastal waterways, which endangers seagrass habitats, as well as mangrove degradation as a result of tourism-related coastal development. In addition to these direct effects, municipal policies and plans may shift their priority to catering to the short-term needs of tourists, frequently missing the long-term (indirect) influence on the environment (Al-Harith, 2006).

There are five reasons why investing in blue carbon ecosystems benefits to the environment:

- Blue carbon ecosystem conservation and restoration also offer habitat for animals and plants, hence supporting biodiversity. Seagrasses, for example, play a vital role in commercial fisheries (UNEP, 2023). giving nursery grounds to one-fifth of the world's greatest fisheries although covering only 0.1% of the ocean floor. Similarly, mangroves are significant and diverse ecosystems that serve as nurseries for a variety of marine animals, including fish and shrimp (IUCN, 2023).

-Nearly 10% of the world's population lives along the coast, which is home to over 680 million people. Floods and storms kill 15 times more people in these villages than in other regions (United Nations, 2023). The restoration or maintenance of blue carbon ecosystems like mangroves and tidal marshes is critical for defending the coast from more destructive storms and floods caused by climate change. As a result, rather than being forced to relocate, coastal communities will be allowed to develop. Furthermore, more than three billion people rely on healthy marine biodiversity for a living, primarily through fishing and ecotourism. As a result, by incorporating local communities from the start, blue carbon initiatives can create additional revenue through improved fishing conditions and sustainable tourism (United Nations, 2023).

- Blue carbon ecosystem projects are nature-based projects that aim to restore the natural balance of marine ecosystems. Blue carbon is particularly defined as carbon absorbed and deposited in marine ecosystems such as tidal marshes, mangroves, and seagrass beds (Carbon Credits, 2023). This is in contrast to traditional green carbon derived from terrestrial ecosystems such as tropical forests. The intriguing part is that studies have shown that these marine ecosystems can store three to five times as much CO_2 as mature tropical forests and sequester carbon at a pace ten times greater. One square meter of seagrass removes more than 200 grams of carbon from the atmosphere, which is more than three times the rate of storage in a comparable area of tropical rainforest and more than seven times the rate of storage in temperate forests (United Nations, 2023).

- Despite their importance in terms of carbon absorption, biodiversity, and coastal protection, blue carbon ecosystems are among the most vulnerable habitats on the planet as a result of human activity. Excessive fertilizer run-off into coastal waterways has resulted in algal blooms, dead zones, fish kills, ocean acidification7, and overfishing, to name a few anthropogenic causes of habitat deterioration. Your organization will be able to have a meaningful and positive impact on the natural world's equilibrium by investing in blue carbon ecosystem projects (Baghdadi,2015).

-Blue carbon projects go beyond the conservation of specific marine ecosystems to include the restoration of wetlands, seagrass beds, and other natural regions like tidal marshes. As natural areas are restored, the number of square meters reserved for natural ecosystems increases, potentially removing more CO_2 from the atmosphere than efforts focused on conservation (UNEP, 2023).

Blue Carbon can Help Address Climate, Biodiversity, and Development Issues

Coastal habitats such as mangroves, seagrass meadows, and salt marshes provide critical services to coastal populations, ranging from sustaining local diets and fishing industries to protecting homes and infrastructure from erosion and storm damage. However, the advantages are not limited to coastal places. Healthy coastal ecosystems can be a valuable ally in dealing with global climate, biodiversity, and development concerns (WRI, 2023).

Blue Carbon Ecosystems Can Benefit People and the Environment

Ecosystems offer a variety of "co-benefits" to both humans and nature, such as food, water, and economic security, as well as protection from the effects of climate change.

- Storm, flood, and erosion protection for coastlines: Rising global temperatures are creating more catastrophic coastal storms, Mangrove forests serve an important role in safeguarding coasts from wave action and storm surges in tropical locations around the world (Storm, Flood and Erosion Protection, 2023).

- Keeping coastal economies alive: Along with local fisheries, blue carbon ecosystems offer recreational and leisure activities that can attract tourists, providing new jobs in the ecotourism industry and increasing adjacent industries such as food and accommodation (UNEP, 2023).

-Blue carbon ecosystems are important biodiversity hotspots. They provide habitat for a diverse range of marine and coastal species, including birds, fish, and mammals, as well as invertebrates, algae, and bacteria. Many of these species are critical not just to ecosystem health, but also to local food production and fishing operations. Mangroves, seagrasses, and salt marshes protect coastal streams from land contaminants including nutrient-rich agricultural and wastewater runoff, which can lead to excessive algal growth and low-oxygen "dead zones." In blue carbon environments, dense vegetation acts as a filter, delaying the flow of coastal water and allowing plants and animals to retain and absorb more nutrients (Carbon Better, 2023).

- Local blue carbon ecosystems can help with water quality and food security. They protect local communities from weather-related risks such as flooding and storm surges, preventing salt water from invading freshwater supplies like groundwater. Mangroves and seagrass beds, for example, serve as critical nursery grounds for a varied spectrum of marine and coastal life (Local Blue Carbon Ecosystems, 2023).

Blue Carbon Ecosystems are in jeopardy

Blue carbon habitats are rapidly disappearing, despite their inherent value and significance. Climate change (such as sea level rise and extreme weather events) and coastal development have combined to put a "coastal squeeze" on these habitats. Climate change has increased the power of hurricanes and storms that batter coastlines and natural structures, while sea level rise is diminishing the amount of area available for these ecosystems to thrive. Large sections of these ecosystems have also been destroyed or degraded as a result of urbanization and commercial activities like aquaculture and farming. These acts not only harm blue carbon habitats, but they can also induce the release of stored carbon in specific situations (WRI, 2023).

The significance of protecting coastal and marine environments

When conserved or restored, blue carbon ecosystems trap and store carbon. However, when these ecosystems are degraded or destroyed, the carbon they have stored for Millenia is released into the atmosphere and oceans, becoming sources of greenhouse gases. Mangroves, tidal marshes, and seagrasses are critical for coastal water quality, fishery health, and storm and flood protection. The ocean has immense potential to halt global warming while simultaneously providing food, increasing biodiversity, and protecting local beaches from storms and tides (SIWI, 2023).

-Seagrasses and mangroves absorb carbon from the atmosphere via photosynthesis and trap organic carbon-containing sediment around their roots. Because of their potential to retain carbon and provide important habitat for many species, it is critical to halt the loss of tropical ecosystems and promptly restore more of them (OCEANNETS, 2023).

- Marshes form on the borders of bodies of water, storing carbon in sediments in coastal soils and the ocean floor. Furthermore, these wetlands can catch suspended sediments from land-based activities (For more information check: https://impakter.com/bluecarbon, accessed on 25 November 2023).

-Seaweed forests and farms can quickly capture enormous amounts of CO_2. Seaweeds sequester carbon by breaking fronds that are carried to the deep ocean by current. Seaweed farms collect carbon similarly, but perhaps not as much because they are harvested regularly for food production and other human needs. Seaweed is an excellent source of food and nutrients. Certain seaweed products sequester more CO2 than others (WRI, 2023).

-Trails on the open ocean: Whales, huge fish, and millions of microscopic fish that live in the deeper, mesopelagic waters beneath the ocean's surface can all contribute to keeping carbon out of the atmosphere. The survival of these species can help to make the ocean more adaptable to the effects of climate change while still supporting human lives. Unfortunately, over the last 200 years, hunting and fishing have significantly reduced the population of these larger animals, and new commercial fishing methods have been developed to target mesopelagic fish (For more information check: https://bluenaturalcapital.org/bcaf, accessed on 26 June 2023).

-Millions of fish and invertebrates reside in the ocean's mesopelagic depths, which range from under the sunlit ocean surface layer to approximately 1000 meters. Many of these fish and other mesopelagic organisms, such as zooplankton (e.g., copepods and krill), engage in "diel vertical migration," a massive, coordinated daily movement within the sea, in which the organisms rise to the ocean's surface at night to feed on phytoplankton and smaller animals, then retreat to mesopelagic depths during the day (SIWI, 2023).

- Whales and massive fish forage deep in the sea, eating smaller fish and crustaceans such as krill, storing much of the carbon contained in these smaller species, and then recycling the remaining carbon and nutrients throughout the ocean, including near the surface, where it can help drive photosynthesis, which absorbs carbon dioxide from surface waters (For more information check: https://impakter.com/bluecarbon, accessed on 02 July 2023)

The Carbon Footprint

Because the carbon footprint accounts for half of the global environmental impact, reducing the carbon footprint is vital to protecting the surrounding ecosystem for future generations. (Al-Nish, 2001) The term "carbon footprint" refers to the amount of carbon emitted by any activity (usually measured in tons). Carbon emissions represent the quantity of carbon dioxide absorbed by forest regions. The use of fossil fuels and biofuels, particularly ethanol, has an environmental impact (Obaid, 2000). The indices of ecological footprint and carbon budget follow a similar logic according to Al-Ansary (2009):

-The carbon footprint is the amount of land needed to absorb CO2 emissions.

-CO2 emissions have a tremendous impact on the environment.

-The ecological footprint can round out the field of carbon budgeting by including the concept of land and allowing comparison with biological capacity.

-The carbon budget can be used to demonstrate one's environmental footprint.

The carbon footprint is a measure of the quantity of carbon dioxide emissions created by the combustion of fossil fuels, which include (petroleum, natural gas, and coal) used in the generation of electrical energy, various modes of transportation, industrial activities, and so on. The carbon footprint is used. Carbon dioxide emissions rates are usually expressed in tons of CO_2 per year when expressed at the level of activity (individuals, countries, and institutions) or even at the level of the process of creating or manufacturing specific goods. (Al-Nish,2001)

Methods for lowering our Carbon Footprint

It must lower our carbon footprint by reducing carbon dioxide emissions, paying attention to, and monitoring all everyday activities, whether tourism, agricultural, or industrial, as well as the behaviors that lead to this. One of the most important tactics for reducing carbon footprint is to hunt for sources of clean renewable energy and use them as a fuel substitute. Reduced use of fossil fuels, reduction of gaseous waste, monitoring of all waste generated by industrial activities, recycling, and waste treatment. Agricultural activities can be monitored and compelled to convert to environmentally friendly organic crops, exploit and develop mass transportation to reduce the use of individual modes of transportation that emit harmful gases daily, rationalize electricity and water consumption, use them more effectively, and recycle recyclable materials and reuse them in manufacturing processes (Amin, 2012).

In addition to employing highly efficient and environmentally friendly tools, gadgets, equipment, and projects, extending tree and forest planting, increasing vegetation and natural cover, and focusing on constructing green structures in construction operations. Priority must be given to the search for alternative energy sources that do not contaminate the environment and contribute to sustainability. This includes innovative energy sources that use cutting-edge technology, such as solar energy, wind energy, hydropower, and other ecologically friendly renewable energy sources (Al-Ansary,2009).

Climate Mitigation

The Land Use, Land-Use Change, and Forestry (LULUCF) component of the GHG inventory allows governments to calculate and account for greenhouse gas emissions and removals from terrestrial lands. Depending on how a country defines terrestrial land, this could include coastal wetlands. Many countries are tackling LULUCF. Until a country specifies the environment, reviewing these submissions does not provide a clear indication of whether coastal wetlands are included or not (Amin, 2012).

According to Crooks (2010) Asia LULUCF includes

- Bahrain's Mangrove Transplantation Project, which began in 2013, seeks to restore degraded coastal zones by producing and planting mangrove seedlings as an adaptation strategy with mitigating benefits. Bahrain understands the need of proper management of crucial habitats that serve as critical natural carbon sinks. It adds that seagrass beds, which serve as an important carbon sink, are dispersed along Bahrain's southeast and west beaches, and refers to them as "blue carbon."

- The Philippines understands that marine ecosystems, particularly blue carbon, can play a key role in both mitigation and adaptation initiatives. The Philippine National Strategy and the recently updated Philippine Biodiversity Strategy and Action Plan outline some of these ecosystem contributions.
- Australia wants to use the IPCC 2006 Guidelines and the IPCC 2013 Revised Supplementary Methods, which include coastal wetlands, to reduce CO2 emissions by 26 to 28 percent below 2005 levels by 2030.

- China intends to boost carbon sinks and sequestration in natural ecosystems, including stronger conservation and restoration of wetlands, however it is unclear whether this includes coastal wetlands and would involve a more thorough study of national operations.

-Sri Lanka is expanding its forest cover, which includes protecting and preserving Oceania's mangrove and wetland environments.

- The United Arab Emirates' National Development Plan includes a section on "Wetlands, Coastal, and Marine Environment Conservation (Blue Carbon)." The UAE is also carrying out large mangrove and seagrass restoration and plantation programs, which will help with both ecosystem-based adaptation and climate mitigation. The Abu Dhabi Blue Carbon Demonstration Project, which quantified and mapped blue carbon policy applications in the Emirate of Abu Dhabi, has evolved into a National Blue Carbon Project.

- Bangladesh's LULUCF mitigation efforts include "continuation of coastal mangrove plantation." It is worth noting, however, that the agreement does not specify how the plantation will be established.

According to Wetlands (2014) Africa LULUCF includes

- The Comoros want to use protected areas to mitigate climate change, particularly in the marine environment. Mangrove restoration is an essential part of Senegal's forestry operations. Senegal, in particular, has committed to preserving and rehabilitating 4,000 acres of mangroves year beginning in 2017.
- Despite not accounting for the offsetting capability of ocean biomass and marine ecosystems (or blue

carbon) in their mitigation assessment and calculation, the Seychelles recognize blue carbon and leave ample room for future efforts and ambition in their next NDC.

- Angola's concept of LULUCF includes mangroves and wetlands. Afforestation and replanting in degraded forest regions and mangrove ecosystems have high mitigation potential and are included in Angola's Forest Carbon Options.
- Brunei's Forestry and Land Use Sectors help to mitigate climate change by capturing carbon dioxide from the atmosphere.
- To promote sustainable management and a more systematic reforestation effort, the Republic of Guinea will reduce anthropogenic deforestation pressures on mangroves as part of a revised mangrove management plan.

According to Crooks (2010) Americas LULUCF includes

- The United States intends to include all categories of emissions from sources and removals from sinks as reported in the Inventory of US Greenhouse Gas Emissions and Sinks; to account for the land sector using a net-net approach; and to account for harvested wood products using a "production approach" consistent with IPCC guidance.

- As part of its mitigation efforts, Haiti plans to protect and expand 19,500 hectares of mangrove forest by 2030.

-Antigua and Barbuda's remaining wetlands and watershed zones with carbon sequestration potential will be protected as carbon sinks under 2030 conditional mitigation targets.

-Guyana's avoided deforestation component of the Emission Reduction Program includes mangroves.

- Belize will protect existing mangroves and rebuild those that have been destroyed. Between 2020 and 2030, restoration and protection will remove current CO_2 emissions of roughly 11.2 Gg per year, as well as an extra 2.2 to 35 Gg CO_2 per year. Between 2015 and 2030, emissions are projected to decrease by up to 379Gg CO_2.

- Suriname's Forest Mitigation division is drafting legislation to safeguard mangrove forests along the country's North Atlantic coast. It promotes both adaptation and mitigation by enhancing sedimentation and subsequent mangrove regeneration, resulting in increased mangrove forest stock and carbon sequestration.

- In Ecuador, ecosystem and forest protection, as well as the strengthening of national protected area systems, are viewed as critical to preventing climate change.
-The Bahamas enacted the Forestry Act, which creates specific management zones subject to an environmental conservation management plan. Mangrove ecosystems are predicted to function

better and have a greater ability to store carbon with proper management. The Bahamas may be considered for inclusion activities, subject to additional examination.
-Mexico's Ecosystem-Based Adaptation component emphasizes the significance of boosting carbon capture while also enhancing coastal protection through the conservation and recovery of coastal and marine ecosystems like as coral reefs, mangroves, seagrass, and dunes.

Oceania includes (Research article, Ocean governance in Bangladesh,2021)

- Kiribati is looking to restore mangrove forests, which might save 7,080 tCO2e by 2025.

-Saudi Arabia considers constructing blue carbon sinks to be an adaptation activity with large mitigation co-benefits, and it prioritizes deploying coastal management measures to achieve this.

-The Cook Islands regard coastline preservation, forestry, and marine conservation as projects that will cut and offset carbon emissions while enhancing resilience.

-The Marshall Islands see mangrove regeneration as an adaptation measure with mitigation benefits, such as increased carbon sinks.

Europe

- Iceland incorporates wetland restoration and probably other LULUCF activities as part of its climate change programs, but whether this includes coastal wetlands is unknown and would take a further analysis of national activity (Iceland, 2008).

Mangrove growth lines:

Because it appears at a low latitude, we only see it on the Red Sea shores between Egypt, Saudi Arabia, and the Arab Gulf states, as well as other latitudes around the world. Still, temperatures in Africa and the Arab world are much higher than in Mediterranean countries, so its growth limits remain in that belt. As a result, it has a closer relationship with the Red Sea, which has coasts in Egypt, Saudi Arabia, and the Gulf states (Al-Mansi,1999).

Egypt's Mangrove Expansion Obstacles

Returning to the agricultural and climatic environment of mangroves in Egypt, we find separate attempts over nearly 15 years and mobilized efforts to save the mangroves from extinction, even though Egypt has more than one long-lived mangrove tree, one of which is more than 200 years old, located in the waters of the Red Sea in the Al-Alqan area within the waters of Wadi El Gemal Reserve in Marsa Alam attracts large numbers of tourists and Egyptians. Egyptian initiatives to safeguard mangroves, on the other hand, have lagged in their expansion and development strategy for mangrove farming (Raddad, 2009).

Mangrove is only found along the beaches of the Red Sea Mountain ranges, but its cultivation volume is limited. Mangrove is concentrated on beaches where salt water is prevalent, providing that the water level is low and not very deep, because these locations are compatible with its environmental needs, as the tree does not need to be completely buried in water, and it is sufficient. Plant roots, on the other hand, sprout above the water's surface on occasion, covering 1-2 meters of trees and their roots (Abdo, 2008).

Its cultivation demands the availability of suitable environmental conditions. The plants flourish in salty oceans and can survive saline levels of 40-50 thousand parts per million. As a result, locations on the Red Sea with salty water of up to 30-40 thousand parts per million are most suitable for its cultivation. Mangroves secrete Secretions around their roots, which aid in the growth of fish resources, resulting in a symbiotic link between them and the fish, and planting these trees outside of the water is usually ineffective (El-Hussieny, 2012).

The fundamental reason for the delay in moving forward with the agricultural expansion of mangroves till today is that reproduction of these plants is difficult, and they must be grown in their surroundings under suitable conditions for good growth. The second issue is that most scholars do not visit mangrove-growing areas to study them and contribute to their development due to their remoteness. The third reason for its recent decline is that it has deteriorated as a result of camel grazing and logging operations by locals living near densely forested areas. Furthermore, mangroves are natural forests that have been developing on the Red Sea coast since ancient times, beginning to the south of the city of Safaga and continuing to the north to our international borders in Sudan. They are located in the Ras Muhammad and Nabq Reserve in the Gulf of Aqaba, south of Sinai. The entire area of naturally growing mangroves on the Red Sea beaches is 5 km2 (about 1,500 acres) (ElHussieny, 2012).

Mangrove agriculture offers various advantages and has a positive environmental impact

Only camels and Bedouins realize their leaves are a water desalination plant. Camels make their way through the trees to the sea, catching water drops on the backs of the plant's leaves. Mangrove

leaves absorb sea salt and convert it to fresh water, which condenses on the leaves. The salt is depicted at the top of the paper as a freshwater station for migratory animals and birds (Abdo, 2008).

The "Ramsar Convention" was established globally in 1975 to preserve wetlands that had been threatened by global deterioration for decades, and it includes mangrove forests in the Red Sea, indicating that Egypt is one of the countries that has signed and committed to this agreement. In 2002, intensive efforts were made to cultivate mangroves from north to south, beginning with the Nabq and Ras Muhammad areas in South Sinai, El Gouna, South Safaga, Hamata, Wadi Gamal, Marsa Alam, Shalatin, Halayeb, and some clusters on islands such as Abu Minqar, and focusing on the condition of mangrove plants in Hurghada (Al-Mansi, 1999). The ecological significance of mangrove forests in Egypt

1-Measuring environmental quality: Mangrove plants are sensitive to environmental conditions because they are influenced by environmental elements in the vicinity of where they are grown. In the event of pollution, they are also regarded as clear environmental proof. In addition to their role in mitigating the consequences of climate change, certain plants stunt when exposed to pollution, and others are unable to adapt and perish (Al-Mansi, 1999).

2-Food for marine organisms: Mangrove trees provide some marine organisms with food rich in organic protein as a result of the fall of their leaves, flowers, and fruits, as well as the decomposition of these leaves and branches in the form of sediments and decomposed organic materials that collect with each other and become a good and renewable source of supplying water with organic materials and fertilizers daily with Tides movement. Thus, marine life is preserved, future generations profit from it, and both local inhabitants and tourists enjoy healthy meals (El-Hussieny, 2012).

3- Coastal erosion protection: Mangrove trees preserve the environment and decrease coastal erosion by trapping sediments accumulated in valleys that flow into the Red Sea. The roots of mangrove plants help to stabilize the soil and sediments around them, reducing the influence of wave sculpting. As a result, the beaches and coasts will be preserved for future generations, as will the overall sustainability of the surrounding environment (Zayed, 2013).

4- Living organism shelter: Mangrove Forest settings serve as a natural nursery for fish and crustaceans, as fish lay eggs in the shallow waters around mangrove forests, and are also good for feeding and raising economic fish like mullet and crustaceans like shrimp. This promotes fishing tourism and the pleasure of marine life, as well as benefits the local community through the sale of various types of fish, resulting in economic recovery and an improvement in the level of living in the surrounding area (Abdo, 2008).

5- A location for birds to stay and feed: Some wild birds feed on the fruits of mangrove trees, while others feed on small fish found under mangrove trees. It is also regarded as a haven and home for many birds and a good setting for nesting various seabirds and migratory birds during certain seasons. The Red Sea's location is crucial in migration paths—birds from Europe and Asia to Africa. Regarding the tourism patterns linked with them, we discover that tourists are interested in witnessing the migration of various birds, which increases the means of accommodation near the mangrove region, employment there, the number of tourist nights, and tourist income (El-Hussieny, 2012).

The Causes of Mangrove Damage in Recent Years

Natural factors such as decreased rainfall in recent decades compared to the past, increased salinity levels in the Red Sea, and overgrazing by camels and goats as a result of a decline in alternative vegetation in the southern Red Sea region and the exposure of trees to felling have been blamed for mangrove damage in recent years. It is unfair to Bedouins and residents in some areas, and she pointed out that there are plant-related factors, such as the need for seedling care in the early stages of growth. She added that the Desert Research Center is now working on a project in the southern Red Sea to produce mangroves and enhance the number of trees in the area. She stressed that mangrove cultivation has a long history in Egypt, claiming that there are ancient relics of this plant dating back to before 400 AD. Between 400 and 700 AD, archeological investigations yielded the first plant samples (Abdo, 2008).

Abu Shaar, a stronghold on the Red Sea coast, was discovered. This fortress was connected to the harbor and served as a major stop for commercial caravans traveling from Europe to the beaches of East Africa and India, as they traveled across the Mediterranean to Alexandria, then the Nile River, then the castle on the sea coast, and finally south to Africa and India. Caravans frequently traveled to Africa to transport slaves and to India to trade. This port was also the main stop for African Christian pilgrims heading to Palestine after crossing the Red Sea to the port of Kilani, which is located opposite the port of Abu Shaar in Sinai's Al-Tur district (Zayed, 2013).

The relevance of this castle in mangrove history originates from the fact that the castle's columns, doors, walls, and stairs were made from mangrove trees, namely the Shura plant (one of the species of mangrove). Some of the stems used for this purpose are up to 40 centimeters in diameter. This diameter may be for a tree with a vegetative development volume of 25 cubic meters, according to scientific estimations. This growth, however, is already available in this place and may also be found in Shalatin. Several plants were also spotted in this location. The weak one was identified in 1991 and was later removed from the region's tourism operations (El-Hussieny, 2012).

Between 400 and 700 AD, mangroves flourished at a density hitherto only seen in southern Egypt. Historians discovered that between 1000 and 1300 AD, the bark of the Rhizophora plant (a type of mangrove) was widely used in dyeing and woodworking processes. Mangrove stems were also used to make furniture and boats since their wood is resistant to weevils and can withstand the passage of time (Zayed , 2013).

Egypt's Economic Relevance of Mangrove Forests

1- Apiary work: Mangrove Forest areas are exploited at Safaga and Hamata on Egypt's Red Sea coast to obtain clean and natural honey (Baghdadi, 2015).

2- Fish farming: Mangrove forests are used as farms for many sorts of commercial fish, shellfish, shrimp, and crustaceans. They serve as a natural hatchery for some sorts of economically significant fish, such as several farms in Qusayr (Zayed , 2013).

3- A natural component of eco-tourism: Mangrove forests and their beautiful aesthetic perspective on the coasts assist in attracting tourists interested in this type in Egypt's reserves of Nabq, Ras Muhammad, Wadi El Gemal, and Elba, as they draw diving, safari, and bird watching lovers (Abdo, 2008).

4- Wood source: Mangrove forests are an important source of wood, which is used in the construction of homes, especially in coastal areas due to its resistance to humidity, as well as in the construction of ships and boats, and as fuel for heating, building fences, and making sculptures. Some locals dwell in the woodlands of Al-Qusayr and Wadi El-Gimal. They utilize mangrove wood to build their houses and for warmth (Zayed , 2013).

5- Animal feed: Because of the high protein content of its leaves, fruits, and branches, mangrove forests are used as fodder for livestock, particularly camels and sheep, in Qusayr, Wadi El Gemal, and Elba (Baghdadi, 2015).

6- A medicinal plant: Many medicinal compounds are produced from the leaves of mangrove fruits and used to treat gum and liver problems. Coastal ikat plants are also planted as a source of hormone components such as steroids and terpenes, as well as the coumarin chemical, which is used in the manufacture of pharmaceuticals and medicines (Shaltout, 2003).

Situational Analysis (SWOT Analysis) of Mangrove Forests in Egypt

The use of SWOT analysis is vital for improving the process of building blue carbon strategies since it examines the strengths, weaknesses, opportunities, and threats (Peter Rauch, et al, 2015, P.88), which can be stated as follows:

Strengths Points

- Egypt's unique ecological richness, with coral reefs, fish, and seaweed available in particular sections of the Red Sea in Egypt (Nabq - Ras Muhammad - Hurghada - Wadi El Gemal - Elba - Marsa Alam) (Al-Harith, 2006).

- The presence of some mangrove trees within the boundaries of natural reserves, such as (Nabq, Ras Muhammad, Hurghada, Wadi El Gemal, and Elba), which helps safeguard the mangrove areas there (Abdo, 2008).

- Local community participation in protecting mangrove trees and attempting to grow them in several Red Sea places, such as (Nabq - Safaga - Qusayr - Wadi El Gemal - Elba) (Al-Harith, 2006)

Weaknesses

- Increased population numbers in areas surrounding the sites, particularly in Safaga, Al-Qusayr, and Marsa Alam, have led to urban and tourism growth. In addition to the increase in tourism activities, the spread of tourist development activities, tourist communities, and others has helped to eliminate some mangrove forests, which severely impact seedlings and very sensitive roots, exposing them due to walking on them (Amin, 2012).

- Camel and sheep overgrazing as a result of the existence of some tribes and local inhabitants near mangrove locations, as well as a lack of environmental knowledge among some of them in areas such as Safaga and Al-Qusayr (Al-Harith, 2006).

Opportunities

-Develop plans to gain from mangrove forests in the Red Sea region.

-Creating plans and planned activities for environmental management through the state's adoption of sustainable development mechanisms and scientific investment in projects with a green environmental economy (Baghdadi, 2015).

-Involving the local people in projects to protect mangrove forests.

In collaboration with the Academy of Scientific Research and the Red Sea and South Sinai Governorates, the Egyptian government is focusing on rehabilitating and expanding mangrove forests in the Red Sea, pointing out that audited technical studies of the tree development process took about two years, and then seedlings were planted in the heart of the saltwater the Red Sea. Because they operate as a defense wall against tidal processes and are one of the natural techniques for preventing beach erosion processes on the Red Sea coast, expanding the development of these natural forests is critical. By launching models of projects that focus on beekeeping in mangrove growth areas, as it produces one of the finest types of Honey bees, the Desert Research Center and the Academy of Scientific Research seek to reduce the negative interaction of residents of mangrove areas, to stop using these trees for wood and harming them during overgrazing, so the residents of the surrounding areas knew the importance of mangrove trees, and thus began their mission to preserve them (Kholeif, 2007).

Threats

External threats or risks to mangrove forests in the Red Sea region include:

-Pollution from industrial and sewage drainage, as mangrove plants are affected by sewage and industrial wastewater that flows directly into the coastal marine environment, and pollution from solid and petroleum wastes in some mangrove areas in the Red Sea, such as (Nabq - Ras Muhammad - Hurghada -Marsa Alam) (Al-Harith, 2006).

-Unsystematic investment in some mangrove sites and unsustainable resource depletion, especially given Egypt's richness and natural resources diversity (Baghdadi, 2015).

-Conflict of laws and jurisdictions between concerned authorities, such as jurisdiction over lands and overlapping jurisdictions of some agencies responsible for mangrove sites, such as the Ministry of Environment, the General Authority for Tourism Development, the General Authority for Coastal Protection, the General Authority for Fisheries Resources, and the security authorities of border guards in mangrove areas in Egypt (Awari, 2013).

Mangroves hold economic value in Egypt (Baghdadi, 2015)

Mangrove trees have direct and indirect economic values, including those for future generations.

1. Benefits of using mangrove forests directly: Mangrove forests provide economic benefits through grazing, tourism, and fish aquaculture, among other things. Mangrove trees contribute to the Red Sea coast's annual output of more than two million kg of fish. These values may be marketable, such as tourism or awareness.

2. Values of indirect use of mangrove forests: These values indicate the indirect use of environmental resources, such as coastal protection, climate preservation, and medical purposes.

3. Future worth of mangrove forests, including direct and indirect uses like medical and fish farming.

4. Legacy and presence values include economic benefits for future generations, biodiversity, landscape, cultural, and religious values.

The economic value and benefits of mangrove trees significantly benefit the national economy through the current and expected future financial flows they provide in the event of sustainability, confirming the importance of the role they play in protecting these areas and increasing their future economic value (Baghdadi, 2015).

Blue Carbon discussion

Mangroves are natural forests that have been developing on the Red Sea coast since ancient times, beginning to the south of the city of Safaga and continuing to the north to international borders in Sudan.

The comparative advantages of Blue Carbon (Al-Harith,2006)

-Enhancing regional economies and coastal livelihoods through fisheries, aquaculture, and tourism.

-Preserving wetland ecosystems with worldwide and national significance, especially those for threatened and endangered species and biodiversity.

-Preserving shorelines and increasing resistance to storm surges and rising sea levels.

-Improving and sustaining water quality.

-Looking after a marine nation with enduring and continuing cultural value.

-Providing seaside enjoyment and connecting communities with nature.

Methodology

Due to the lack of documents on studies for Blue Carbon, the study relied mainly on interviews with officials from the Ministry of Tourism, the Ministry of Environment, the General Authority for Tourism Development, and the General Authority for Coastal Protection, The following themes are discussed :

- The planning of increasing the Mangrove trees and its impact on the rate of tourism development in Red Sea Coast

- Blue Carbon Ecosystems Benefit People and the Environment.

- The significance of protecting coastal and marine environments.

- The obstacles to tourism development in the Red Sea Region and the means of dealing with deal with concerned authorities responsible for mangrove sites.

- The problems that affect the development of Mangrove sites in the Red Sea Coast.

- The means of overcoming the problems of investors face in the Red Sea Region.

Data analysis

Personal interviews with 10 officials and 8 experts of the Ministry of Tourism, the Ministry of

Environment, the General Authority for Tourism Development, and the General Authority for Coastal Protection, to discuss What is the Blue Carbon Ecosystems (BCEs) and their impact on increasing the Mangrove trees on the Red Sea Coast. These personal interviews were analyzed with the research sample from the public tourist sectors through qualitative analysis of the main topics raised by the officials during their dialogue.

Results and discussion

A set of personal interviews were conducted with some officials and experts in tourism at the Ministry of Tourism and Antiquities , the Ministry of Environment, the General Authority for

Tourism Development, and the General Authority for Coastal Protection and their number was 18 people to identify their views on the possibility of benefiting from the natural and cultural elements to increase the tourist flow, preparing tourist nights, identifying obstacles and trying to solve them, the interviews were held between June 2023 and January 2024. The meetings resulted in the extraction of the main research results, which represent important obstacles and problems of Blue Carbon in Red Sea Coast:

-Increasing techniques of sequestering and storing blue carbon to counteract climate change

90% of experts agreed that blue carbon, or carbon deposited in coastal and marine ecosystems such as mangroves, tidal marshes, and seagrass meadows, is one of the most important methods for sequestering and storing carbon, thereby mitigating climate change. Experts also confirmed that if ecosystems deteriorate or are destroyed directly or indirectly as a result of human activity, they lose their ability to absorb carbon, and the carbon stored in the soil is released, contributing to climate change through carbon dioxide emissions.

-Mangroves' importance as blue carbon sinks

All the interviewees agreed that mangroves are critical for maintaining beaches and coastal people's food security, in addition to their long-term role as carbon sinks and consequently the survival of coastal ecosystems due to the vast amounts of carbon stored in their soil.

-Benefits provided by mangrove trees

Blue carbon environments, which include mangroves, seaweeds, and tidal marshes, are highly productive ecosystems that offer a range of benefits including food production and tourism. 80% of experts agreed that these ecosystems can provide job opportunities because mangroves are natural, cultural, and recreational attractions, as well as services for supplying food to hotels and eco-tourism, which are frequently mentioned in scientific studies, but these services have received little attention.

-The effects of tourism on blue carbon ecosystems

Tourism hurts blue carbon ecosystems, as confirmed by 85% of experts. This includes depletion of local resources, land and air degradation, noise, visual pollution, and waste related to sewage. Coastal development projects may also be undertaken to meet tourist needs, but only in the short term. As a result, it fails to consider the long-term environmental impact. Mangroves serve as incubators for a range of marine species, including fish and shrimp, which improves fishing conditions and promotes sustainable tourism.

-The importance of mangroves in protecting beaches from erosion

90% of experts reported that mangroves, seagrass meadows, and salt marshes protect homes and the underlying environment from erosion and storm damage, addressing global climate and biodiversity challenges, which include birds, fish, mammals, invertebrates, algae, and microorganisms, and that various blue carbon ecosystems preserve coastal water quality while slowing global warming.

-The effect of carbon footprints on climate

90% of experts believe that we must reduce our carbon footprint by lowering carbon dioxide emissions, monitoring all daily activities, whether tourism, agricultural, or industrial, seeking clean renewable energy sources and using them as an alternative to fuel, reducing the use of fossil fuels, and reducing, recycling, and treating gaseous waste. Rationalizing power and water consumption while utilizing cutting-edge energy technology such as solar, wind, and hydroelectric energy.

-Obstacles to expanding mangrove cultivation

70% of experts confirmed that Egypt has more than one perennial mangrove tree located in the Alqan area within the waters of the Wadi El Gemal Reserve in Marsa Alam, which attracts many number of foreign and Egyptian tourists; however, the volume of cultivation of this type of tree is still limited, and its cultivation requires the availability of appropriate water. It is salty at a low level and not deep, as these trees do not require to be entirely covered in water, but there are now initiatives to plant them in clean, climate-friendly regions such as Marsa Alam. Furthermore, the reproduction of these plants is challenging, and most scientists do not visit mangrove growing areas to do research. Finally, camel grazing and trees are being cut by locals, but the Desert Research Center is currently working on a project to grow mangrove trees in the southern Red Sea.

Results

-90% of experts agreed that blue carbon, or carbon stored in coastal and marine ecosystems including mangroves, tidal marshes, and seagrass meadows, is one of the most significant ways to sequester and store carbon, thereby mitigating climate change and the planning of increasing the Mangrove trees and its impact on the rate of tourism development in Red Sea Coast.

-All interviewees agreed that mangroves are critical for maintaining beaches and coastal people's food security, in addition to their long-term role as carbon sinks and Blue Carbon Ecosystems Benefit People and the Environment.

-80% of experts agreed that these ecosystems can provide job opportunities because mangroves are natural, cultural, and recreational attractions, as well as services for supplying food to hotels and eco-tourism.

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- Tourism hurts blue carbon ecosystems, as confirmed by 85% of experts. This includes depletion of local resources, land and air degradation, noise, visual pollution, and waste related to sewage. Coastal development projects may also be undertaken to meet tourist needs, but only in the short term.

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-70% of experts confirmed that Egypt has more than one perennial mangrove tree located in the Alqan area within the waters of the Wadi El Gemal Reserve in Marsa Alam, which attracts a large number of foreign and Egyptian tourists; however, the volume of cultivation of this type of tree is still limited, and its cultivation requires the availability of appropriate water.

- Blue Carbon Ecosystems (BCEs) are associated with the tourist sector as the primary destination site or as an added feature.

- Mangroves, Tidal Marshes, and Seagrass Meadows are examples of ecosystems that provide important benefits for climate change adaptation, such as coastal protection and food security for many coastal people.

-Tourism is commonly regarded as an important economic aspect that can improve people's quality of life by providing job possibilities, economic diversity, natural and cultural attractions, outdoor leisure and get-together chances, and strengthening the food and hotel businesses.

- Although tourism is an important economic booster to a community, it can also negatively impact the environment, particularly the vulnerable ecosystems including BCEs.

- Tourism's environmental implications include water scarcity (especially on tiny islands and

islets), local resource depletion, land degradation, air, noise, visual pollution, solid waste and littering, sewage concerns, and physical impacts (e.g., developments, land-use changes) and mangrove destruction as a result of tourism-related coastal development.

- Mangroves, seagrass meadows, and salt marshes provide vital services to adjacent residents, ranging from sustaining local diets and fishing industries to protecting homes and infrastructure from erosion and storms.

-The spread of tourist development activities, tourist communities, and others has helped to eliminate some mangrove forests, which severely impact seedlings and very sensitive roots, exposing them due to walking on them.

- Large swaths of these ecosystems have also been destroyed or degraded as a result of urban development and commercial uses such as aquaculture and agriculture.

- Camel and sheep overgrazing as a result of the existence of some tribes and local inhabitants near mangrove locations, as well as a lack of environmental knowledge among some of them in areas such as Safaga and Al-Qusayr.

- The carbon footprint accounts for half of the global environmental impact, reducing the carbon footprint is vital to protecting the surrounding ecosystem for future generations.

- Mangrove is only found along the beaches of the Red Sea Mountain ranges, but its cultivation volume is limited.

- Mangrove appears at a low latitude, we only see it on the Red Sea shores between Egypt, Saudi Arabia, and the Arab Gulf states, as well as other latitudes around the world. Still, temperatures in Africa and the Arab world are much higher than in Mediterranean countries, so its growth limits remain in that belt.

- The fundamental reason for the delay in moving forward with the agricultural expansion of mangroves till today is that reproduction of these plants is difficult, and they must be grown in their surroundings under suitable conditions for good growth.

-Pollution from industrial and sewage drainage, as mangrove plants are affected by sewage and industrial wastewater that flows directly into the coastal marine environment, and pollution from solid and petroleum wastes in some mangrove areas in the Red Sea, such as (Nabq - Ras Muhammad - Hurghada -Marsa Alam).

-Unsystematic investment in some mangrove sites and unsustainable resource depletion, especially given Egypt's richness and natural resources diversity.

-Conflict of laws and jurisdictions between concerned authorities, such as jurisdiction over lands

and overlapping jurisdictions of some agencies responsible for mangrove sites, such as the Ministry of Environment, the General Authority for Tourism Development, the General Authority for Coastal Protection, the General Authority for Fisheries Resources, and the security authorities of border guards in mangrove areas in Egypt.

Recommendations

- Develop plans to gain from mangrove forests in the Red Sea region.

- Creating plans and planned activities for environmental management through the state's adoption of sustainable development mechanisms and scientific investment in projects with a green environmental economy.

- Involving the local people in projects to protect mangrove forests.

- Reduce our carbon footprint by lowering carbon dioxide emissions, monitoring all daily activities, whether tourism, agricultural, or industrial, seeking clean renewable energy sources and using them as an alternative to fuel, reducing the use of fossil fuels, and reducing, recycling, and treating gaseous waste.

- Increase mangroves, seagrass meadows, and salt marshes to provide critical services to neighboring residents, such as sustaining local diets and fishing industries and protecting homes and infrastructure from erosion and storm damage.

- Develop the awareness of some tribes and local inhabitants near mangrove locations inform them of their importance, and prevent camels and sheep from eating these ecosystems.

- Reducing the carbon footprint is vital to protecting the surrounding ecosystem for future generations.

- Creating suitable conditions for the planting and growth of mangrove trees along the Red Sea coast and the continued interest of scientists and agriculturalists in monitoring their growth and reproduction.

- Reducing industrial sewage and sewage pollution, as mangrove plants are affected by sewage and industrial sewage water that flows directly into the coastal marine environment, and pollution from solid and petroleum wastes in some mangrove areas in the Red Sea, such as (Nabq - Ras Muhammad - Hurghada - Marsa Alam).

- Organized investment in some mangrove sites and setting a sustainable rate of resource consumption, especially in light of Egypt’s richness and diversity of its natural resources, replacing them with renewable resources, and trying to recycle spent resources to reuse them again.

- Reconciliation of laws and jurisdictions between concerned authorities, such as jurisdiction over lands, and coordination ofthe jurisdictions of some authorities responsible for mangrove sites, such as the Ministry of Environment, the General Authority for Tourism Development, the General Authority for Coastal Protection, the General Authority for Fisheries Resources, and the security authorities of border guards in mangrove areas in Egypt.

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أهمية الكربون الأزرق في الحفاظ على التنمية المستدامة بالبحر الأحمر في مواجهة التغير المناخي

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ملخص اللغة العربية

يسمى الكربون المخزن في النظم البيئية الساحلية والبحرية بالكربون الأزرق حيث توفر أشجار المانجروف، ومستنقعات المد والجزر، ومروج الأعشاب البحرية أيضًا فوائد بالغة الأهمية للتكيف مع تغير المناخ، وخاصة حماية السواحل والأمن الغذائي للعديد من المجتمعات الساحلية. (فودة، ٢٠٠٦). يتطلب تحقيق السياحة المستدامة في المناطق الساحلية تضمين إدارة وحماية الكربون الازرق على المدى الطويل؛ وفهم كيف تؤثر السياحة على هذه الموارد لإيجاد حلول مناسبة أفضل ومخصصة للمواقف المحلية. (عبدو، ٢٠٠٨) تهدف هذه الدراسة إلى الحفاظ على موائل الأراضي الرطبة ذات الأهمية الدولية والوطنية، بما في ذلك الأنواع المهددة بالانقراض والتنوع البيولوجي، وحماية الشواطئ، وتعزيز القدرة على التكيف مع هبوب العواصف وارتفاع منسوب مياه البحر. تظهر الدراسة بعض النتائج مثل النظم البيئية للكربون الأزرق المرتبطة بقطاع السياحة كموقع الوجهة الرئيسي ، وقامت الدراسة بتحليل المقابلات التي أجريت مع ١٨ مسؤولاً وخبيراً من وزارة السياحة، والبيئة، والهيئة العامة للتنمية السياحية، والهيئة العامة لحماية السواحل، لمناقشة وسائل النظم البيئية للكربون الأزرق وتأثيرها بشأن زيادة أشجار المانجروف على ساحل البحر الأحمر ، ومن نتائج الدراسة لا يوجد أشجار المانجروف إلا على طول شواطئ سلاسل جبال البحر الأحمر، إلا أن حجم زراعته محدود ، و تعارض القوانين والاختصاصات بين الجهات المعنية مثل الاختصاصات الخاصة بالأراضي ومواقع أشجار المانجروف ، ومن ضمن التوصيات إشراك السكان المحليين في مشاريع حماية غابات المانجروف ، وتقليل بصمتنا الكربونية من خلال خفض انبعاثات ثاني أكسيد الكربون، ومراقبة جميع الأنشطة اليومية سواء كانت سياحية أو زراعية أو صناعية، والبحث عن مصادر الطاقة المتجددة النظيفة واستخدامها كبديل للوقود، والتقليل من استخدام الوقود الأحفوري، ومعالجة النفايات الغازية.

الكلمات المفتاحية: الكربون الازرق- النظم البيئية- التغيرات المناخية- اشجار المانجروف