SUSTAINABLE OCEANS PROJECT

SPATIO-TEMPORAL ANALYSIS OF MANGROVE ECOSYSTEM

MANGROVE COVERAGE

CARBON STOCKS

FISHERIES

November, 2024.

Ghana's Mangroves

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Ghana's Mangroves

Spatio-temporal Analysis of Mangrove Coverage, Carbon Stocks and Related Fisheries.

This publication is available digitally on the Hen Mpoano's website at *https://www.henmpoano.org*

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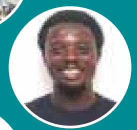

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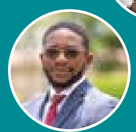

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The full version of technical report on mangrove mapping and carbon stock is available at www.henmpoano.org/mangrovereport

Contents

Guardians *of the* Coastal Eco systems

Welcome!

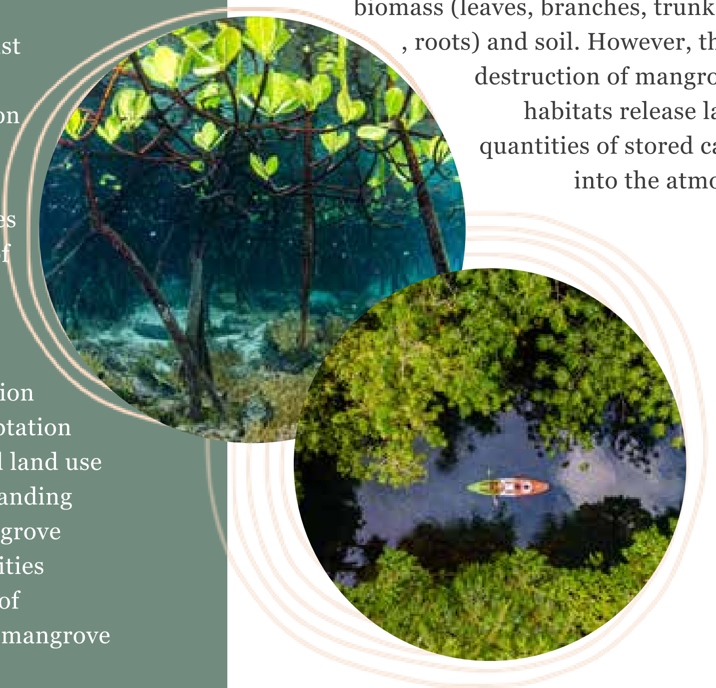
This study aims to throw light on the importance of mangrove forests in Ghana and quantify their changes within the last two decades.

By understanding the significant role mangroves play within the ecosystem, we can grasp their importance for both the environment and humans.
Specifically, the focus is on mapping the mangrove forests, estimating their biomas, carbon sequestration and explore how mangroves impact fishing. Learning more about the mangroves can improve land use, environmental challenges and fishing strategies.

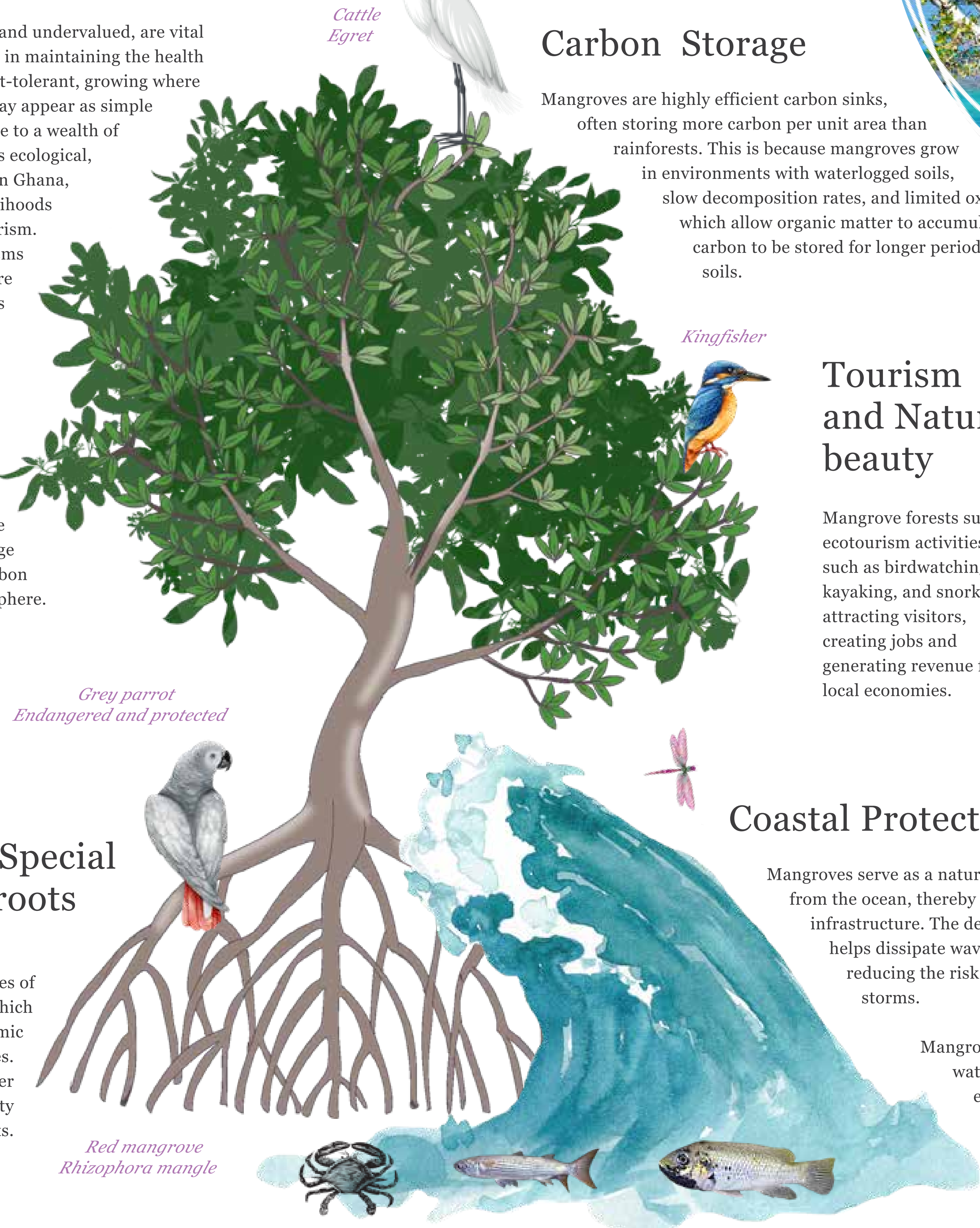
By employing a rigorous and robust methodology, the study provides reliable and up-to-date information on mangrove change, which is critical for decision-making and the formulation of effective policies for the sustainable management of these vital ecosystems.

The expected outcome of this assessment is to provide information to strengthen climate change adaptation in coastal areas through improved land use planning, improve public understanding on the benefits of conserving mangrove ecosystems, help fishing communities make more money by taking care of fisheries resources in and around mangrove ecosystems.

Now, let's dive into the aquatic environments adorned with stunning mangrove habitats.



Mangroves, often overlooked and undervalued, are vital ecosystems playing a crucial role in maintaining the health of coastal areas. These trees are salt-tolerant, growing where land and water meet. While they may appear as simple muddy forests, mangroves are a home to a wealth of biodiversity and provide numerous ecological, economic, and social benefits. In Ghana, mangroves are supporting local livelihoods through fisheries and ecotourism. However, these valuable ecosystems are under increasing pressure from human activities such as deforestation, land conversion for agriculture, and urbanization. Despite covering less than 1% of the Earth's surface, mangrove forests store significant amounts of carbon in both above-ground biomass (leaves, branches, trunks , roots) and soil. However, the destruction of mangrove habitats release large quantities of stored carbon into the atmosphere.



Carbon Storage

Mangroves are highly efficient carbon sinks, often storing more carbon per unit area than rainforests. This is because mangroves grow in environments with waterlogged soils, slow decomposition rates, and limited oxygen, which allow organic matter to accumulate and carbon to be stored for longer periods, particularly in their soils.

Tourism and Natural beauty

Mangrove forests support ecotourism activities such as birdwatching, kayaking, and snorkeling, attracting visitors, creating jobs and generating revenue for local economies.

Variety of plant and animal life

Mangroves are biodiversity hotspots, supporting a variety of plant and animal species. These ecosystems provide breeding grounds, nurseries, and feeding areas for numerous fish, crustaceans, and migratory birds.

Special roots

One of the most distinctive features of mangroves is their root systems, which enable them to withstand the dynamic forces of coastal tides and waves. These roots trap sediments and filter pollutants which improves water quality and preserves marine habitats.

Coastal Protection

Mangroves serve as a natural barrier, reducing the force of waves from the ocean, thereby safeguarding coastal communities and infrastructure. The dense network of roots and vegetation helps dissipate wave energy, preventing erosion and reducing the risk of flooding in coastal areas during storms.

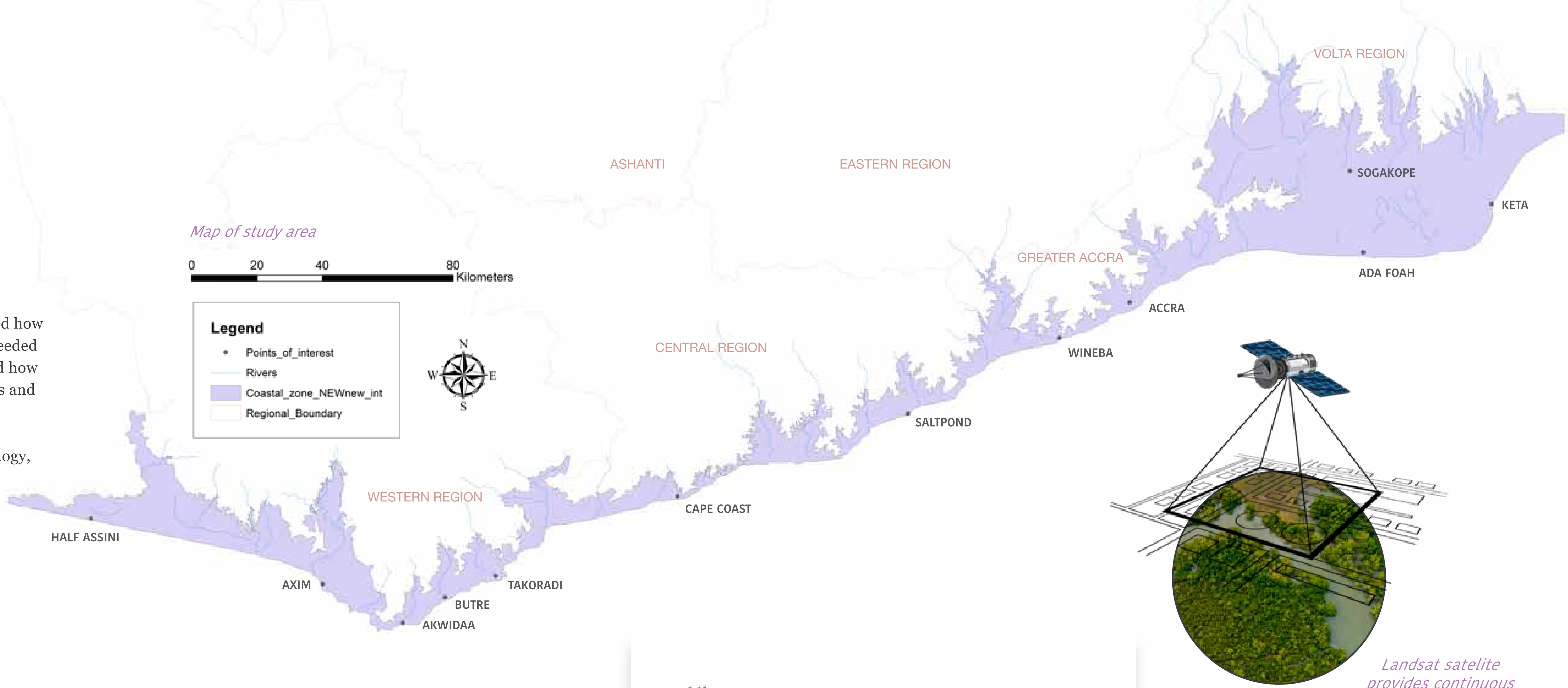
Mangroves have the ability to absorb excess water during high tides and storm events. Their roots and vegetation act like sponges, soaking up water and reducing the volume of water that reaches inland areas, thus mitigating the risk of flooding.

Methodology

To understand how healthy mangroves are and how much they help with climate regulation, we needed to figure out how wide the area they cover and how much biomass (trunks, branches, leaves, roots and other plants) they form.

By employing a rigorous and robust methodology, the study provides reliable information on mangrove change, which is critical for decision-making and the formulation of effective policies for the sustainable management of these vital ecosystems.

Map of study area



Landsat satelite provides continuous space-based record of Earth's land images.

Study area

The study focuses on the coastal zone of Ghana, stretching 550 km from the western to the eastern border. Covering an area of 784,664 hectares, it hosts among others, sandy beaches, rocky shores, lagoons, estuaries, and mangrove forests. The climate is tropical with average annual temperatures of 26°C and bimodal rainfall patterns. Mangroves are concentrated around four main estuaries (Ankobra, Pra, Densu, and Volta River), supporting various species and rich biodiversity including endemic and endangered species.

The coastal population has rapidly grown, with an estimated population density exceeding 200 people per square kilometer, relying on activities like fishing, agriculture, and tourism. These depend on the health of the mangroves. The study aims to provide insights into mangrove dynamics and inform conservation and management strategies.

Mangrove extent Mapping

For estimating the extent of mangrove coverage for both 2000 and 2022, NASA program Landsat was employed. Since 1972, Landsat satellites have continuously acquired space-based images of the Earth's land surface, providing uninterrupted data to help land managers and policymakers make informed decisions about our natural resources and the environment. Furthermore, the use of high-resolution imagery captured by drones, has enhanced the quality of land cover classification.

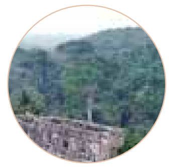
This approach offers a practical and efficient means of obtaining ground truth data, which is often a limiting factor in remote sensing studies, particularly in areas with limited accessibility or resources.

Defining land cover types

Mangrove
Coastal forests of stilted shrubs or trees bordering the ocean or coastal estuaries, composed of one or several mangrove species.

Water
Natural water bodies such as ocean, lakes, ponds, rivers, or streams.

Built up
Urban development, extraction or deposition of materials, rural communities, urban settlements, industrial areas, land covered with buildings, bare concrete grounds, roads, bare areas, and other man-made structures.



Non-mangrove Vegetation
Any other vegetation (apart from mangroves), open areas, bushes, fallow lands, wetlands, farmlands.

Above ground biomass and carbon estimation

Above-ground biomass in a mangrove forest was estimated by measuring the height and diameter at breast height of randomly selected trees. Average tree size was derived from the collected data, and biomass per tree was calculated using an allometric equation. This data, along with the total forest area, was input into a random forest model to estimate the total biomass. Carbon content was subsequently calculated as 47% of the above-ground biomass.

The full version of technical report on mangrove mapping and carbon stock is available at www.henmpoano.org/mangrovereport

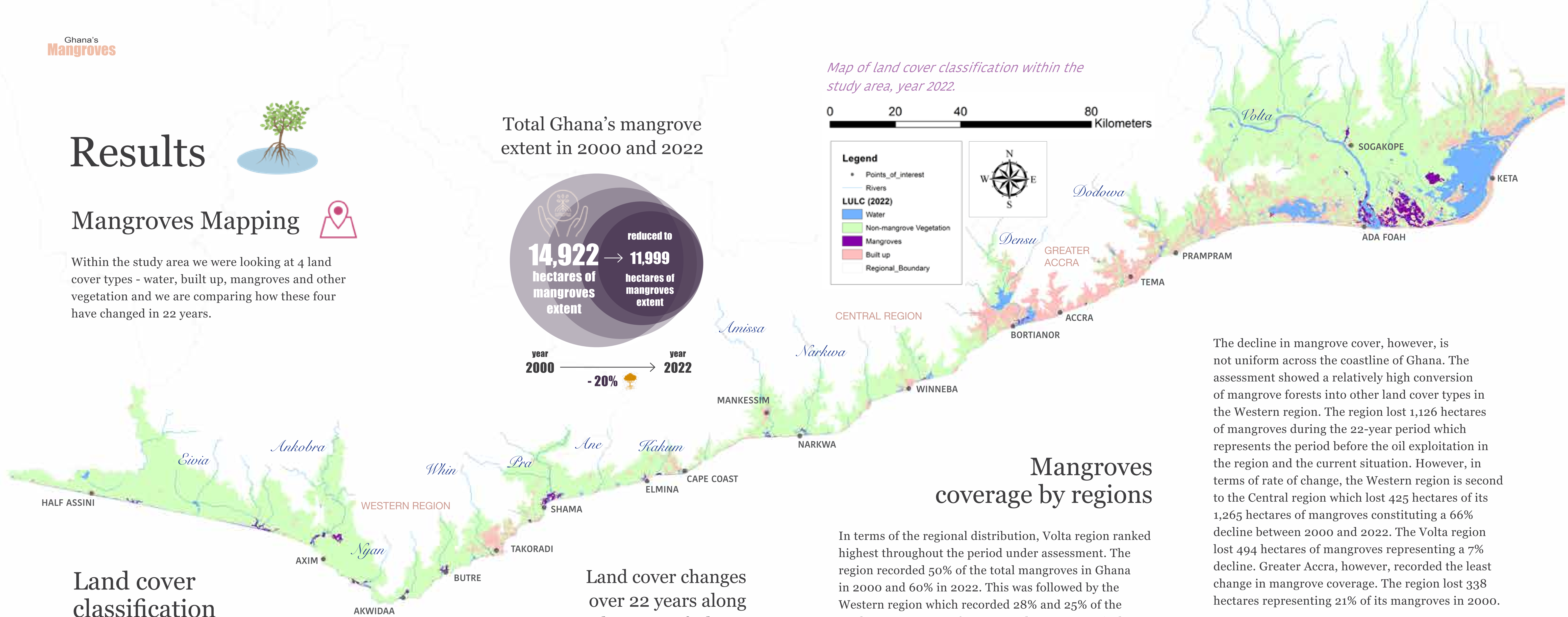
Results

Mangroves Mapping

Within the study area we were looking at 4 land cover types - water, built up, mangroves and other vegetation and we are comparing how these four have changed in 22 years.

Total Ghana's mangrove extent in 2000 and 2022

Map of land cover classification within the study area, year 2022.



Land cover classification

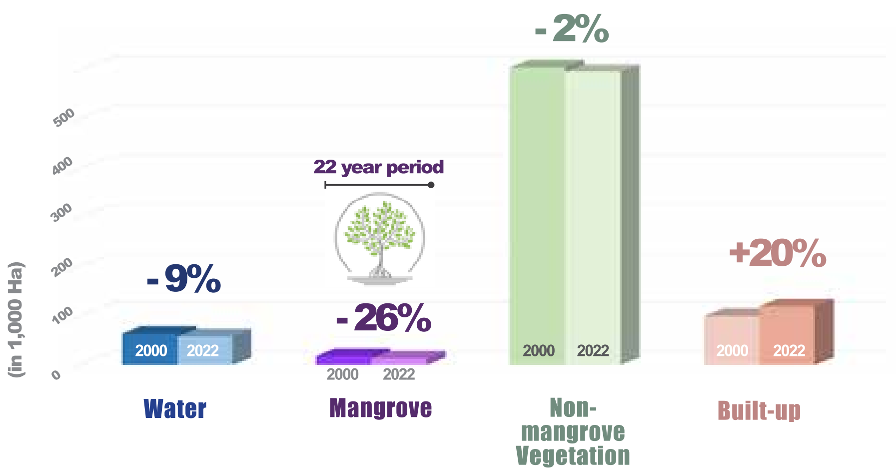
Mangrove forest extent for the entire coastal zone of Ghana for year 2000 was 14,922 hectares and for year 2022, 11,999 hectares, constituting a decline of 19.58%.

The built up is the highest gainer on the landscape throughout the 2 decades, gaining 19,339 hectares (20%) meaning cities and villages grew as population grew and also migrated south to coastal areas from other regions.

Water body has reduced by 9% probably due to conversion of wetlands into other uses like rice farming, salt production and mining.

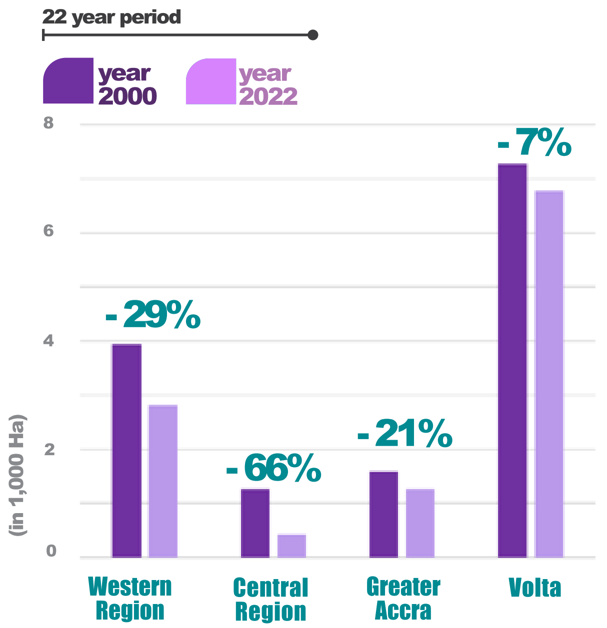
Other non-mangrove vegetation has also reduced by 2%.

Land cover changes over 22 years along the coast of Ghana



Mangroves coverage by regions

In terms of the regional distribution, Volta region ranked highest throughout the period under assessment. The region recorded 50% of the total mangroves in Ghana in 2000 and 60% in 2022. This was followed by the Western region which recorded 28% and 25% of the total mangrove cover for 2000 and 2022 respectively. Central region, on the other hand, had the least amount of mangrove forest in both periods. The region recorded 9% (in 2000) and 4% (in 2022).

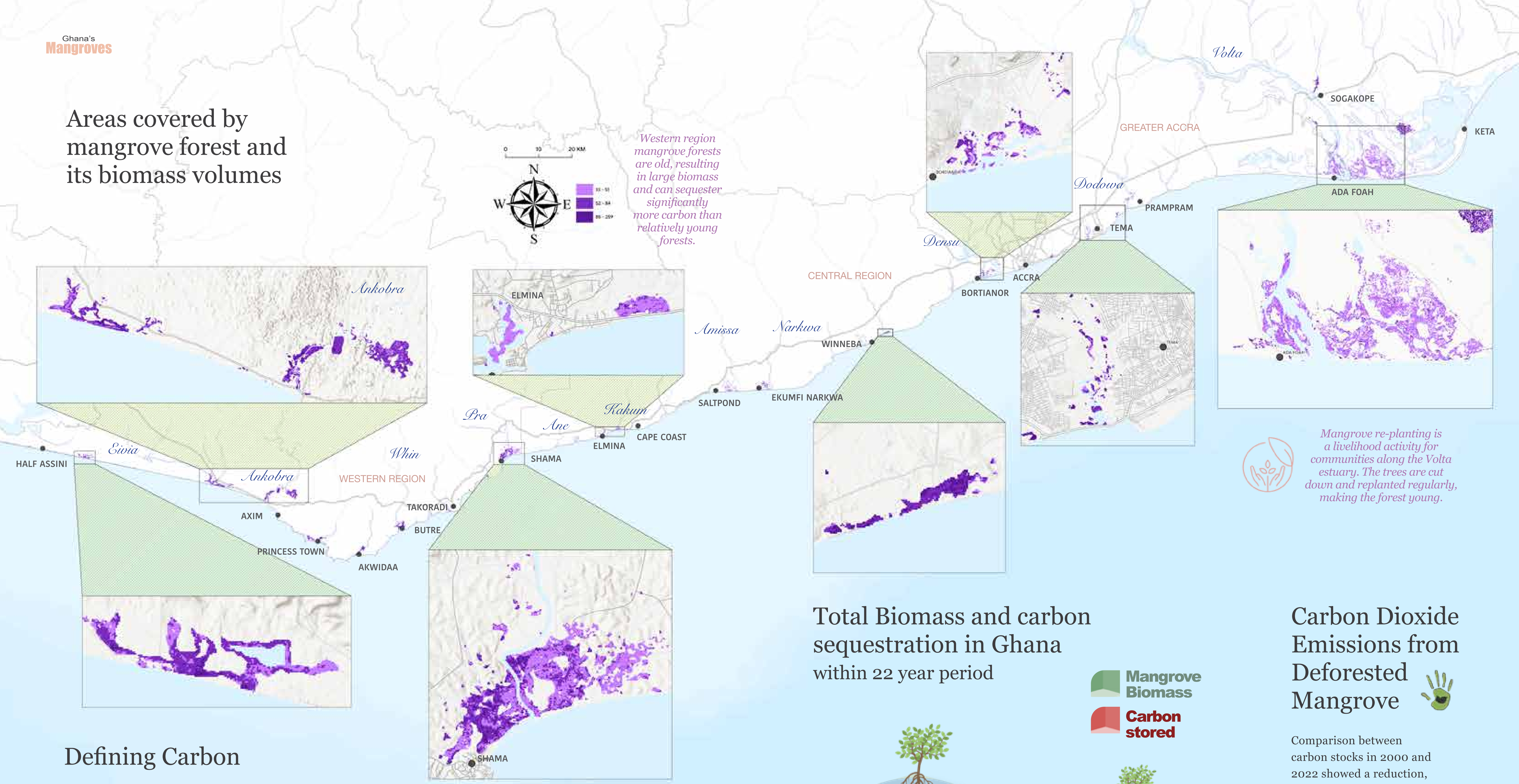


The decline in mangrove cover, however, is not uniform across the coastline of Ghana. The assessment showed a relatively high conversion of mangrove forests into other land cover types in the Western region. The region lost 1,126 hectares of mangroves during the 22-year period which represents the period before the oil exploitation in the region and the current situation. However, in terms of rate of change, the Western region is second to the Central region which lost 425 hectares of its 1,265 hectares of mangroves constituting a 66% decline between 2000 and 2022. The Volta region lost 494 hectares of mangroves representing a 7% decline. Greater Accra, however, recorded the least change in mangrove coverage. The region lost 338 hectares representing 21% of its mangroves in 2000.

Mangrove Biomass Distribution

In the year 2000 and 2022 the total mangrove biomass for the entire area was 45,842 tonnes per hectare and 37,388 tonnes per hectare, respectively. The distribution of biomass across the four coastal regions showed clear patterns. The Western Region, including areas around Axim, had the highest biomass values exceeding 200 tonnes per hectare. Moving eastward, biomass gradually decreased, with areas around Cape Coast and Accra showing moderate values ranging from 44 to 84.6 tonnes per hectare. The northeast corner, particularly around the Volta River, had the lowest biomass values, less than 31 tonnes per hectare. These findings highlight significant spatial differences in mangrove biomass distribution along the Ghanaian coast.

Areas covered by mangrove forest and its biomass volumes



Defining Carbon

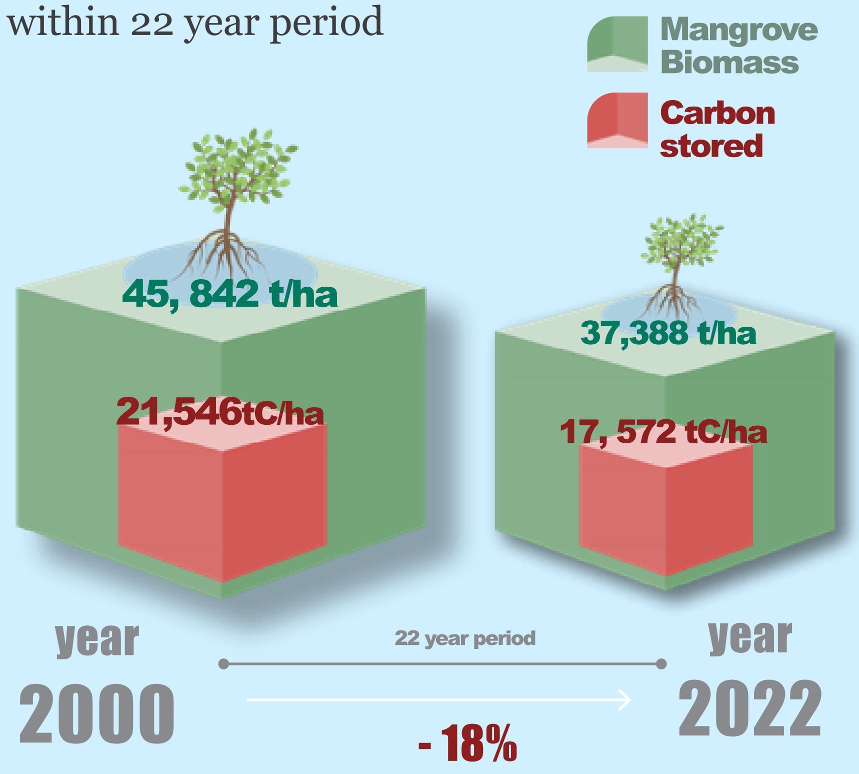
Carbon is a chemical element with the symbol 'C'. It is one of the most abundant elements on Earth and plays a crucial role in the chemistry of life. Carbon is the building block of organic molecules found in all living organisms. It helps keep the planet warm by trapping some of the heat from the sun. This is called the greenhouse effect. But when there's too much carbon dioxide and other gases in the air, it can make the planet too warm. This is called global warming, and it causes problems like hotter temperatures, more extreme weather, rising sea levels, and harm to plants and animals.Mangroves are incredibly efficient at capturing (sequestering) and storing carbon dioxide within their biomass (trunks branches, leaves and roots) through photosynthesis.

Carbon Stock Distribution

Carbon stock distribution across the studied regions varied, with minimum, maximum, mean, and standard deviation values indicating distinct characteristics. In 2000, carbon stocks ranged from 0 to 161 tonnes per hectare, with a mean of 21.81 tonnes per hectare and a standard deviation of 28.36. For 2022, carbon stock ranged from 4 to 121 tonnes per hectare. The western region had the highest carbon stocks, especially in the Southwestern part, while the Volta region had the lowest.

Total Biomass and carbon sequestration in Ghana

within 22 year period



Carbon Dioxide Emissions from Deforested Mangrove

Comparison between carbon stocks in 2000 and 2022 showed a reduction, indicating carbon release into the atmosphere rather than sequestration. The deforested mangrove areas emitted approximately 729.10 tCO_2 per hectare annually over the 22-year period, totaling 2,093,455.07 tCO_2/year, suggesting a net release of carbon into the atmosphere.

Limitations

Sampling timeframe

The fisheries survey was conducted between September and November 2023, a limited period that did not encompass the full annual cycle. This timeframe restricts the assessment's ability to account for seasonal variations that influence fish abundance, species composition, and distribution within mangrove habitats. As a result, the data may not reflect shifts in population dynamics that could occur across different seasons, particularly those driven by spawning, recruitment, and seasonal migration.

Sampling techniques

Fish sampling relied solely on the cast net method, which inherently constrained the diversity of species captured. This method is effective mainly for finfish species, leading to an underrepresentation of the full spectrum of biodiversity present in the mangrove ecosystem. Key invertebrate species, including shellfish such as bivalves, crabs, and shrimps, were excluded, limiting insights into the abundance of these groups and their contributions to local fisheries and the mangrove food web.

Drivers of mangrove deforestation

The assessment focused exclusively on quantifying changes in mangrove cover over the last two decades, without investigating the underlying direct and indirect drivers of deforestation. Consequently, insights into the socio-economic, environmental, and policy-related factors contributing to mangrove loss—such as coastal development, aquaculture expansion, and land use changes—are absent from this assessment.

Land use lancover timeframe

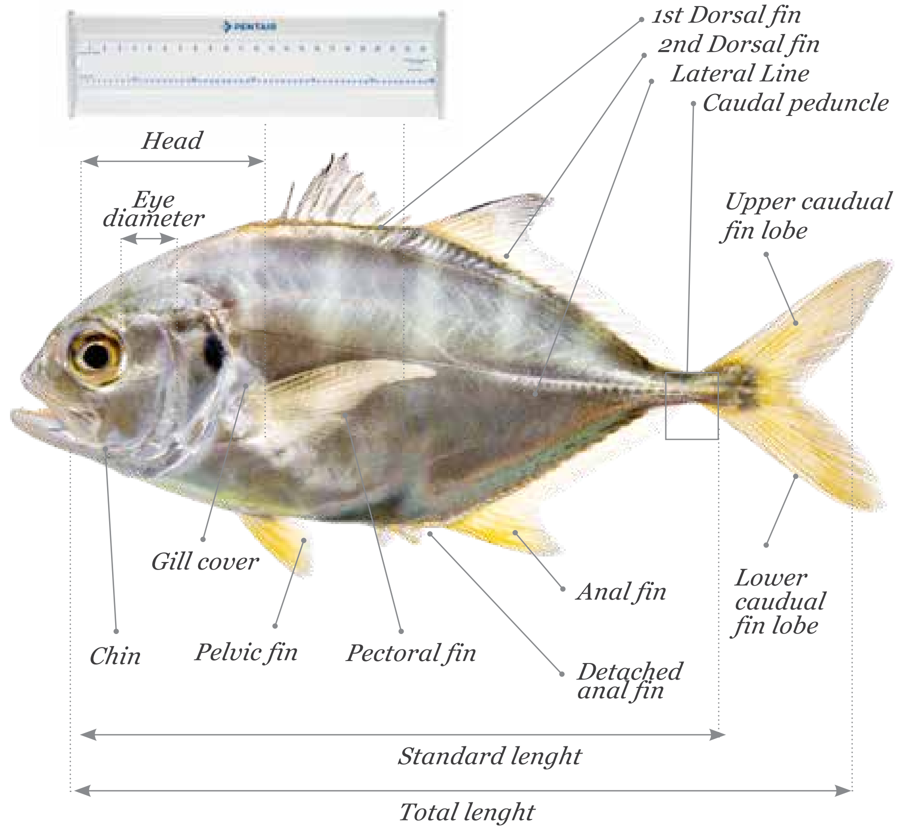
The two-decade time period does not allow for the observation of changes during the period. This extended duration may have missed the dynamics of transitions occurring within the timeframe. A shorter time stamp, like 10 years, could provide more detailed insights into the transition in land use and land cover, capturing changes that might have gone unnoticed over a longer period.

Fish breath through the gills, located near the head. Disolved oxygen passes through thin membranes in the lamellae of the gills and enters fish's blood. At the same time carbon dioxide is eliminated.

Fisheries in mangrove ecosystems

External features of a fish Pictured below is Carranx Hippos, one of Ghana's dominant species.

Credit: www.ncfishes.com.



This study aims to promote a resilient and sustainable ocean economy by improving how coastal communities manage their coastal resource areas.

The key objectives are to reduce fishery declines, enhance sustainability, manage fish populations, and ensure that fishermen have access to sustainable resources. To achieve this, the study focuses on improving governance of coastal areas and actively involving communities in decision-making.

To understand how to protect fish populations and the environments they inhabit, we conducted research across various coastal sites in Ghana. These sites were selected along the entire coastline and divided into three geographical zones based on specific criteria. The report covers activities carried out in September to November 2023. These activities included determining water quality, assessing the composition and diversity of fish species.

Criteria for site selection

- Presence of an estuary
- Tidal flooding and drainage
- Presence of pristine mangrove ecosystem
- Evidence of mangrove degradation
- Active fishing

Fish sampling, identification and measurement of morphometric parameters

Fishes were caught by local fishermen using a cast net with a stretched mesh size of approximately 30 mm. Also, fishing was done within the hours of 6 – 8 am to reduce variations in temperature and tidal influence. Fish samples from all station were then obtained from fishermen immediately after fishing, stored on ice in a Coleman cooler to ensure preservation of samples for further analysis. Furthermore, fish samples were identified using key developed by Dankwa et al. (1998).

The total length (TL) and standard length of fishes were measured using a fish measuring board along with a meter rule to the nearest 0.1 cm. The body weight of each species was measured using the Sensor Disc SF-400 weighing scale, rounded to the nearest 1g. Data obtained was used to estimate species composition, diversity, evenness and richness for various coastal zones. We used this data to figure out the different types of fish in each area, how many there were and how evenly distributed they are in various coastal zones.

The chosen communities for this study were: Azulenoano, Ankobra, and Edobo for the Western zone, Akwidaa, Anlo Beach, and Duakor for the Central zone, and Anyanui, Dzita, and Galosota for the eastern zone.

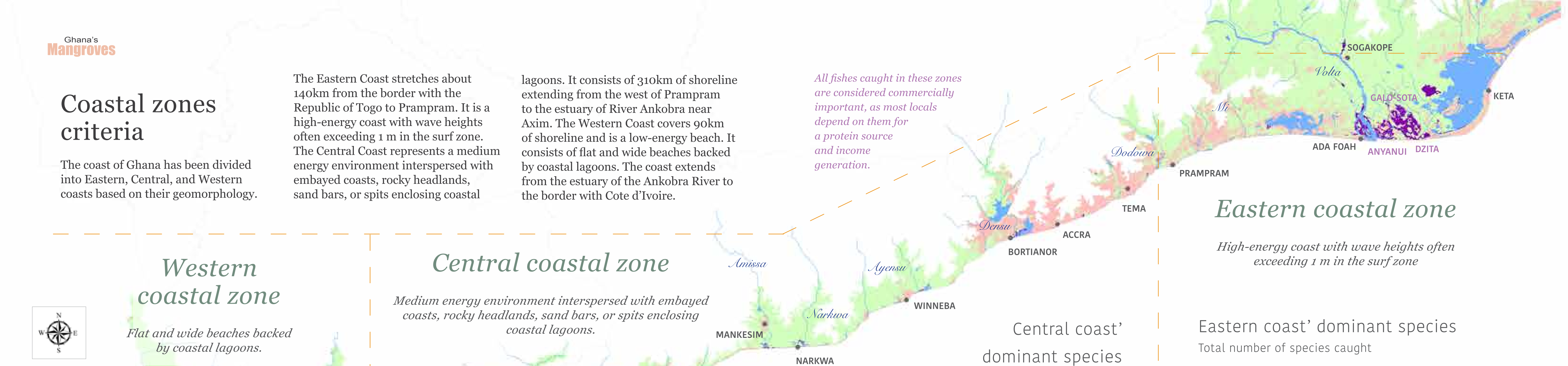
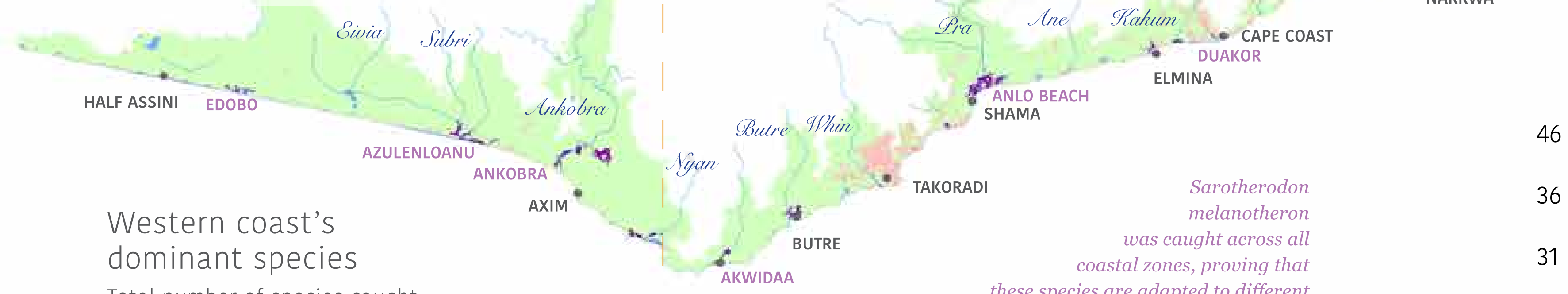
(Refer to the map on page 14-15)

Coastal zones criteria

The coast of Ghana has been divided into Eastern, Central, and Western coasts based on their geomorphology.

The Eastern Coast stretches about 140km from the border with the Republic of Togo to Prampram. It is a high-energy coast with wave heights often exceeding 1 m in the surf zone. The Central Coast represents a medium energy environment interspersed with embayed coasts, rocky headlands, sand bars, or spits enclosing coastal lagoons. It consists of 310km of shoreline extending from the west of Prampram to the estuary of River Ankobra near Axim. The Western Coast covers 90km of shoreline and is a low-energy beach. It consists of flat and wide beaches backed by coastal lagoons. The coast extends from the estuary of the Ankobra River to the border with Cote d'Ivoire.

All fishes caught in these zones are considered commercially important, as most locals depend on them for a protein source and income generation.

Western coastal zone

Flat and wide beaches backed by coastal lagoons.

Central coastal zone

Medium energy environment interspersed with embayed coasts, rocky headlands, sand bars, or spits enclosing coastal lagoons.

Eastern coastal zone

High-energy coast with wave heights often exceeding 1 m in the surf zone

Western coast's dominant species

Total number of species caught

58	FORKTAIL CATFISH	*Chrysichthys nigrodigitatus*
18	BLACKCHIN TILAPIA	*Sarotherodon melanotheron*
12		*Caranx hippos*

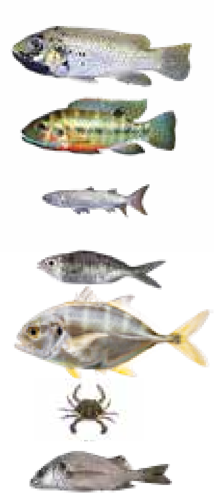
DIVERSITY 1.22
EVENNESS 0.69
RICHNESS 1.65

0 - 3.5 HIGH DIVERSITY
(RANGE 0 - 1)

Sarotherodon melanotheron was caught across all coastal zones, proving that these species are adapted to different coastal environments, especially in brackish waters. Additionally, Chrysichthys nigrodigitatus and Sarotherodon melanotheron showed greater abundance in the Western, Central, and Eastern Coasts. Reasons for their population in such zones could be related to certain physiological and biological behaviors such as reproduction, favorable environmental conditions, food availability, etc.

Central coast' dominant species

Total number of species caught



46	BLACKCHIN TILAPIA	*Sarotherodon melanotheron*
36	REDBELLY TILAPIA	*Coptodon zillii*
31	GREY MULLET	*Mugil Cephalus*
17	FLATFIN MOJARRA	*Eucinostomus melanopterus*
13	CREVALLE JACK	*Caranx hippos*
10	SWIMMING CRAB	*Callinectes pallidus*
9	BIGEYE GRUNT	*Brachydeuterus auritus*

DIVERSITY 1.61
EVENNESS 0.84
RICHNESS 1.66

0 - 3.5 HIGH DIVERSITY
(RANGE 0 - 1)

Eastern coast' dominant species

Total number of species caught

230	BLACKCHIN TILAPIA	*Sarotherodon melanotheron*
26	NILE TILAPIA	*Oreochromis niloticus*
14	REDBELLY TILAPIA	*Coptodon zillii*
10	BANDED JEWELFISH	*Hemichromis fasciatus*

DIVERSITY 0.63
EVENNESS 0.62
RICHNESS 0.41

0 - 3.5 HIGH DIVERSITY
(RANGE 0 - 1)

Why do we measure diveristy?

Imagine, if there was only one species in the river. Species diversity would be zero, meaning no variety. What do we call species diversity and why it matters? Diversity (or variety) refers to the number of different species represented in a given location and it also incudes volume of each species. Ecosystem with higher diversity tend to be more resilient and it leads to greater stability. It is more likely to be able to handle weather disturbances, disease and pollution.

Species diversity

In our study, the highest diversity observed in the Central coast can be attributed to extensive mangrove covers along the fringes of water bodies, providing breeding grounds and habitats for various aquatic organisms. Additionally, the abundance of food in this area could be a major driver of higher species diversity since food attracts fish. Similar reasons could be attributed to the Western coast, which recorded a relatively high diversity. However, issues of water pollution due to illegal mining activities in this area could be a factor that led to the observed value.

Lower species diversity observed in the Eastern Coast could be ascribed to lower mangrove covers, shallow water depths in sampling locations based on observations, and limited availability of food. Shallower waters are mostly characterized by extreme temperatures with less dissolved oxygen, which could lead to the death of many aquatic species. Hence, fish seeking better refuge to ensure survival.

Species evenness and richness

The term "evenness" simply refers to how similar the abundances of different species are in the community. This value ranges from 0 to 1 where 1 indicates complete evenness. For instance 30 Tilapias, 30 Crevalle Jack and 30 Grey Mullets in a water body indicates complete evenness. Zero evenness would mean large differences in how many fish of each species are present in a water body, for example 1 Tilapia, 500 Crevalle Jacks and 4,000 Grey Mullets shows almost zero evenness.

In our study the higher evenness recorded in the Central coast can be attributed to habitat diversity and favorable conditions that ensure the survival of species. Furthermore, food availability encourages mutualistic interactions, creating a more even distribution of species to occupy different niches. This pattern can further explain why the Western coast also experienced higher species evenness. However, lower species evenness observed in the Eastern coast could be linked to lower habitat diversity, as most mangroves within these areas are being depleted. Subsequently, leading to unfavorable habitat conditions such as extreme temperatures and limited food supply.

Species richness refers to the number of different species in an area. In this study, species richness is highest on the Central coast, followed by the Western coast, while the Eastern coast has the lowest richness. Factors like food availability, ecosystem health, and habitat diversity influence species distribution. The Eastern coast's lower richness is linked to a lack of these factors, as well as human impacts like mangrove depletion and overfishing. Effective management is needed to conserve these important habitats.

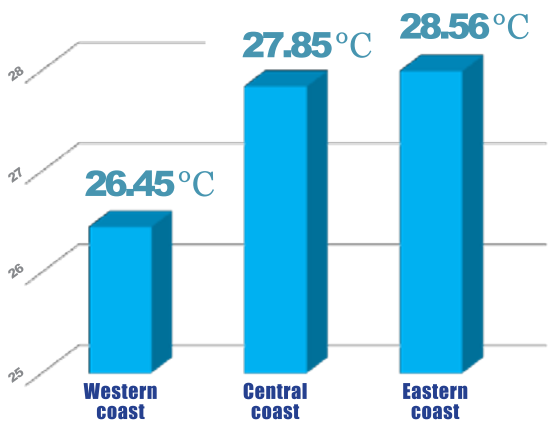
Estimating water quality

Using a Horiba U-5000 water quality checker temperature, pH, electrical conductivity (EC), dissolved oxygen (DO), total dissolved solids (TDS), and salinity were measured at different coastal zones. Readings were taken three times at each location to ensure accuracy.

Physiochemical parameters including temperature, pH, electrical conductivity (EC), dissolved oxygen (DO), total dissolved solids (TDS), and salinity were measured using the Horiba U-5000 multiparametric water quality checker.

Temperature

Tropical fish thrive within an optimal temperature range of 25°C to 35°C, which is essential for their survival and health. Deviations from this range either higher or lower can lead to stress and, potentially, increasing death among these sensitive species.
Temperatures on the Eastern coast are higher due to shallow water depths, which warm up faster. Additionally, reducing mangrove cover along waters of the eastern coast exposes it to direct sunlight, causing temperatures to rise further. To help manage this, farming near waterbodies and the cutting of mangroves should be minimized. Overall, the temperatures measured in this assessment are within a range suitable for supporting aquatic life in these zones.

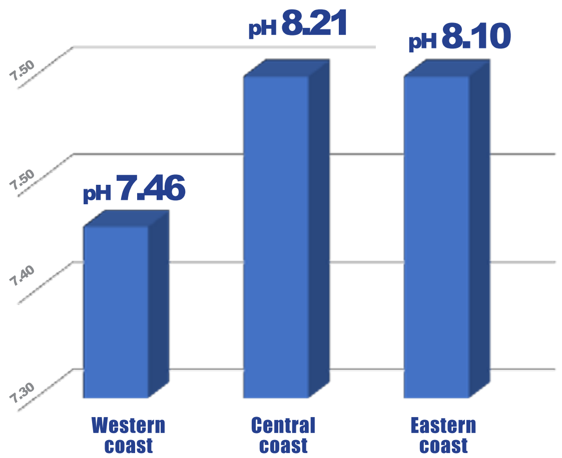


pH

pH indicates a waterbody's acidity or alkalinity; this plays a critical role in aquatic health.

Research shows that notable fluctuations in pH can affect how fish respond to chemical signals, feeding behaviors, and impact on their ability to detect and evade predators. These pH changes are often caused by fertilizer and pesticide runoff from nearby farms and decomposition of organic material.

For healthy aquatic life, an optimal pH range is between 6.5 and 8.5. This study recorded values between 7.46 and 8.21, a



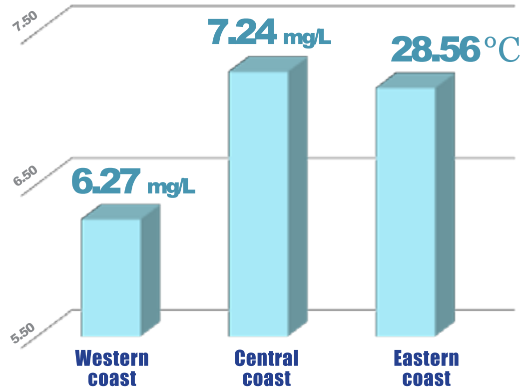
range that supports the well-being and survival of fish in this ecosystem.

Disolved oxygen

Dissolved oxygen (DO) levels indicate the amount of oxygen available in the water, a vital factor for aquatic life. An optimal concentration is at least 5 mg/L; levels below this threshold can lead to suffocation and death among fish and other species. Higher DO levels are generally linked to enhanced photosynthesis, water movement, and air-water interactions.

In this assessment, DO levels across various coasts were within optimal ranges for aquatic species, though the Western coast exhibited the lowest levels. This reduction is likely due to illegal mining activities, which have introduced high levels of suspended particles into the water. These particles obstruct sunlight penetration, slowing down photosynthesis in aquatic plants and consequently reducing oxygen production.

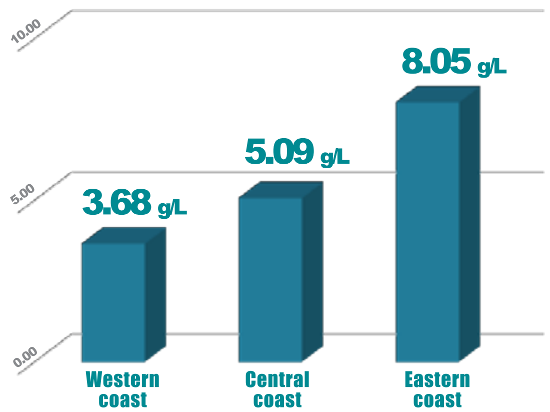
Mitigating illegal mining is essential to restoring DO levels, which will not only support aquatic survival but also enhance fish productivity, food availability, and the livelihoods of local communities.



Total disolved solids

Total dissolved solids (TDS) measure the concentration of dissolved substances in water, including salts, minerals, and organic matter. TDS levels play a critical role in the health and behavior of aquatic species, as many are sensitive to changes in water chemistry. Optimal TDS levels for aquatic life in moving waters should not exceed 1000 g/L; values above this can lead to physiological stress or even death in aquatic organisms.

In this study, lower TDS levels in the Western and Central coasts can be attributed to greater freshwater inflow, diluting dissolved substances. On the other hand, the Eastern coast exhibited higher TDS levels due to increased salt concentration, driven by seawater influx and high temperatures. Elevated temperatures in this region lead to higher evaporation, concentrating salts further—a pattern consistent with recorded salinity and temperature data from the Eastern coast.

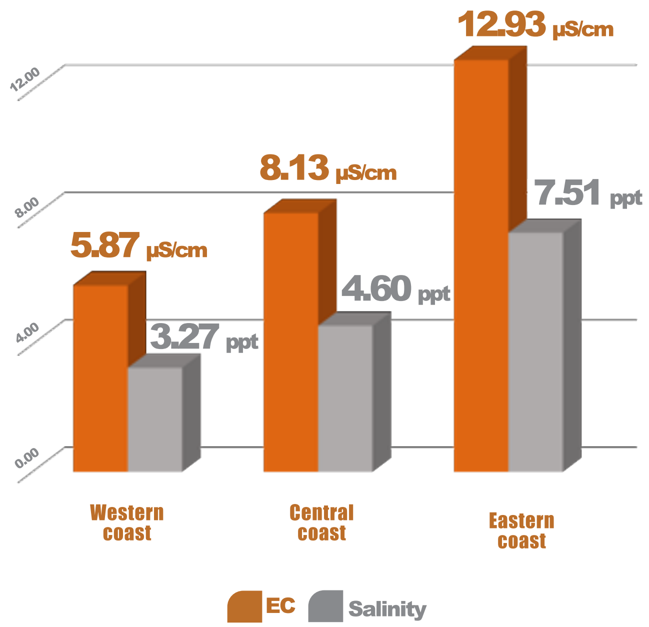


Electric conductivity and Salinity

Electrical conductivity (EC) measures water's capacity to conduct electricity and is directly related to salinity; higher salt concentrations lead to increased EC. Salinity and EC in water bodies are primarily influenced by the influx of freshwater or seawater, as well as by evaporation and temperature. Aquatic organisms maintain salt and water balance through osmoregulation, adapting to their environment's salinity.

Fish that enter water with unsuitable salinity levels may not survive due to osmosis, where water molecules move from areas of lower to higher solute concentration. For example, freshwater fish entering saltwater will lose internal water to the saltier environment, resulting in dehydration, while saltwater fish in freshwater will absorb excess water, leading to cellular swelling and death.

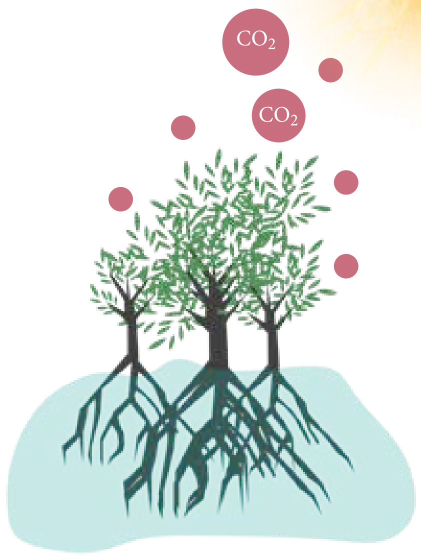
For brackish water species, the optimal salinity range is 0.5 – 30 ppt, with EC levels ideally between 10–1000 µS/cm. Salinity levels recorded in this study were within the optimal range for brackish species. Lower EC and salinity in the Western coast were likely due to significant freshwater influx, while higher EC and salinity levels in the Eastern coast were influenced by shallow depths and warmer



temperatures, leading to increased evaporation and salt concentration.
All water quality parameters measured in this study are considered optimal for survivalww of aquatic life.

Recommendations

The findings of this study offer valuable insights into the dynamics of mangrove ecosystems along the Ghanaian coast, shedding light on critical spatial variations in biomass distribution and carbon stocks. To translate these insights into effective conservation and management strategies, several recommendations are proposed.



Measurment of water quality parameters.
Mangrove restoration at Southwest Ghana.

Continuos Monitoring

Firstly, the establishment of an integrated monitoring system is paramount. Leveraging remote sensing technologies, particularly Landsat 8 OLI and SAR polarizations, in an ongoing monitoring framework would enable real-time assessments of changes in biomass, carbon stock, and land cover. This continuous monitoring approach would provide a foundation for prompt intervention strategies and adaptive management practices.

Strategy

Building on the identified influential variables, such as land surface temperature and vegetation indices, targeted conservation strategies should be developed. Focused efforts on areas exhibiting high biomass and carbon stock, notably the Western Region, can significantly enhance the effectiveness of conservation initiatives. These strategies should be informed by a nuanced understanding of regional characteristics, including mangrove species diversity, age, and other factors contributing to spatial heterogeneity.

Engaging local comunities

Community engagement is a crucial component of successful mangrove conservation. Establishing educational programs that communicate the importance of mangroves, their role in climate regulation, and the potential impacts of deforestation is essential. Engaging local communities in conservation efforts fosters support and participation, making them key stakeholders in preserving these vital ecosystems.

Adaptation to climate change

Recognizing the correlations between land surface temperature and biomass, incorporating climate-resilient mangrove species in restoration projects is recommended. This adaptive approach contributes to the resilience of mangrove ecosystems to temperature variations, ensuring their long-term sustainability in the face of changing environmental conditions.

Sustainability

Governments and environmental agencies should work towards developing robust policy frameworks for the sustainable management of mangrove ecosystems. These frameworks should encompass regulations on deforestation, land-use planning, and climate change adaptation strategies. Policies that prioritize the conservation of mangroves contribute to the broader goals of biodiversity preservation and climate change mitigation.

Better understanding of mangrove ecosystem

Ongoing research efforts should focus on enhancing the accuracy of biomass and carbon stock estimation models. Incorporating new satellite data, refining vegetation indices, and exploring emerging technologies will provide more nuanced insights into mangrove health and dynamics. This continual improvement in research methodologies contributes to a more comprehensive understanding of mangrove ecosystems.

In conclusion, the implementation of these recommendations is vital for the sustainable management and preservation of mangrove ecosystems along the Ghanaian coast. By incorporating these strategies into conservation initiatives, stakeholders can contribute to the broader global effort to conserve and restore mangroves, ensuring their continued ecological significance.

SUSTAINABLE OCEANS PROJECT

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