ENVIRONMENTAL SENSITIVITY ATLAS FOR THE COASTAL AREA OF GHANA

VOLUME II: ENVIRONMENTAL SENSITIVITY RANKING

DECEMBER 2020

FOREWORD

The coastal zone of Ghana, consisting of the sea, the coast (which is about 550 km long), and the adjacent land up to 30m contour, is very important for the people of Ghana and for the economy of the country. Though the coastal area represents only approximately 6.5% of the total area of the country, it houses around 25 % of the population. For instance, high population densities (>500 inhabitants/km^2) are present in the Accra – Tema area, Cape Coast and Sekondi-Takoradi areas. The main economic activities in the coastal zone are oil and gas extraction, fishing, salt production, tourism, farming, and manufacturing. However, this unique and important area is vulnerable to any potential crude oil spill.

The threat from crude oil activities to the coastal zone of Ghana was long realized by Ghanaians in the 1980's. As such in 1986, the country through the assistance of the International Maritime Organisation (IMO), developed a National Oil Spill Contingency Plan (NOSCP) and a paper-based environmental sensitivity atlas (ESA) as a decision-support tool for the NOSCP. In 2004, the Environmental Protection Agency through the support of the Embassy of Denmark and UNOPS, developed a Geographic Information System (GIS)-based ESA for the entire coastline. The discovery of the Jubilee Field, in 2007 with its attendant oil production since 2010, additional discovery and production of Tweneboa-Enyera-Ntomme (TEN) Field and Sankofa-Gye Nyame Field, increased the potential threat of an oil spill to the coastal zone. These later developments hence called for the update of the 2004 environmental sensitivity atlas. The 2020 ESA development is a response to that call.

In the 2020 ESA, the environmental assets (such as important species, both threatened and endemic, habitats, and protected areas) and the socio-economic assets (such as cultural, fisheries, industry, ports, tourism) have been accounted for.

There are many uses to which the sensitivity maps can be put to, ranging from strategic planning at national level to informing a contingency plan for oil spill response within an area. The Agency envisages that the atlas will inform governmental and private sector spatial planning of targeted response strategies that improve the effectiveness of response operations aimed at minimising negative impacts caused by accidental events.

Hon. Henry Kwabena Kokofu

Executive Director

ACKNOWLEDGEMENTS

The environmental sensitivity atlases and associated reports have been prepared by the Ghana Environmental Sensitivity Atlas Team (GESAT). The Agency is grateful to the team, especially the team lead, Mr. Kojo Agbenor-Efunam, the head of the Petroleum Department, for his relentless effort in ensuring that the update of these environmental sensitivity atlases come to fruition. The preparation of these documents, however, has been made possible by the collective efforts of the staff of the Petroleum Department, staff of the GIS Unit (all of the Agency), organisations and individuals, who committed their time and resources to develop, review and complete the documents.

The Royal Norwegian Government, through its Embassy in Ghana and OfD Programme, is acknowledged for the provision of financial and technical support for the development of these documents. The Agency is, particularly, grateful to the Norwegian Environment Agency and the UN Environment Programme World Conservation and Monitoring Centre (UNEP-WCMC) for the technical support provided in the development of these documents. Special mention is also made of the Ghana Oil and Gas for Inclusive Growth (GOGIG) programme, which is funded by DfID-UK, for their immense contribution towards the development of the ESA.

The Agency also wishes to acknowledge the special contribution made by the Deputy Executive Director/Technical Services, Mr. Ebenezer Appah-Sampong, for his technical guidance that ensured that the document is consistent with the framework within which the Agency operates.

Sincere gratitude goes to professionals in the various fields who were involved in the collection, provision, cleaning up and validation of data. Special mention is also made of those who reviewed the documents from time to time until they have been finalized.

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CONTENTS

List of tables

List of figures

INTRODUCTION

The Environmental Protection Agency of Ghana (EPA) is the focal point for coastal zone management activities in Ghana and responsible for the National Oil Spill Contingency Plan. In 2004, in order to strengthen the planning capabilities and support the governments to ensure sustainable coastal zone management, a coastal environmental sensitivity atlas was developed. This was conducted as part of the 'Environmental Sensitivity Map for the Coastal Area of Ghana' project with support from United Nations Office for Project Services (UNOPS) and the Fund for Danish Consultancy Services.

As oil development continues offshore, the risk of oil spill is ever increased for Ghana's coastal zone. As a result, in 2015 the EPA in collaboration with the Norwegian Environment Agency (NEA), identified an update to the 2004 atlas as a priority to further strengthen the capacity to manage the coastal environment effectively. This updated Environmental Sensitivity Atlas for the Coastal area of Ghana (2020), has been developed through a collaboration between EPA, NEA and the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), under the Norwegian Agency for Development Cooperation's (NORAD) Oil for Development programme (OfD).

The atlas incorporates both ecological and socio-economic assets and provides an assessment of sensitivity to oil spill within the coastal area of Ghana. It will support the Ghana National Oil Spill Contingency Plan, to fulfil legislative requirement that *'amenity areas, ecologically sensitive areas and resources should be identified […] and each area described and illustrated on maps. […] priorities for oil spill response actions will need to be decided after consideration of potential conflicts of interests […] and ecological, recreational and economical concerns should be carefully balanced'* (EPA, 2002).

The atlas is comprised of three volumes:

- Volume I: Distribution of Environmental Sensitivity
- Volume II: Environmental Sensitivity Ranking
- Volume III: Coastal Environmental Sensitivity Atlas

This document, Volume II, presents a detailed record of the process for the assessment of environmentally sensitive assets within the coastal area of Ghana. It outlines the assets included as well as the datasets used to identify them. The process and results of each step of the

sensitivity assessment, namely the ranking of assets importance, susceptibility, as well as the combination of these to provide an overall assessment of sensitivity is also detailed within this volume. Finally, the limitations of the approach have been outlined as well as recommendations to address these.

ENVIRONMENTAL SENSITIVITY RANKING

The process for ranking environmental sensitivity is taken from the Mapping Environmentally Sensitive Assets (MESA) Tool (NEA and UNEP-WCMC 2020). The process incorporated the following steps:

1. Identification of assets
2. Assessment of importance at a national level
3. Assessment of susceptibility to oil spill
4. Aggregation of importance and susceptibility assessments to produce overall sensitivity rankings.

IDENTIFICATION OF ASSETS

The asset datasets to be included in the sensitivity atlas have been identified jointly by EPA and UNEP-WCMC. In order to maintain continuity between atlases, the asset types outlined within 'Environmental Sensitivity Map for Coastal Areas of Ghana' (EPA, 2004) have been maintained. Each asset is spatially referenced and included in either point or polygon format depending on the asset type. Additional assets exist within the coastal area, however appropriate datasets of these assets were not identified (see Limitations: Data Availability).

The section below outlines the asset types found within the atlas, as well as the source of data for the asset.

ECOLOGICAL ASSETS

Ecological assets were defined in line with 'Environmental Sensitivity Map for Coastal Areas of Ghana' (EPA, 2004). A number of datasets were deemed to be out of date and updated as part of this work under the Oil for Development programme. The datasets for which updates were carried out are highlighted below.

WATER BODIES

The definition of each water body type is provided below.

Datasets for lagoons and estuaries were updated based on remotely sensed data from:

- Sentinel-2MSI: MultiSpectral Instrument, Level 2A (Normalised Difference Water Index (NDWI))
- JRC Global Surface Water Mapping Layers V.1.1

They were supplemented with data from 'Environmental Sensitivity Map for Coastal Areas of Ghana' (EPA, 2004) on importance of sites for birds.

1. Open Lagoons

Open lagoons are defined as coastal water bodies with clear and permanent openings to the marine environment. They are fringed by large intertidal areas of mud flats, marsh or mangrove. Lagoons are sheltered from exposure to wave energy or strong tidal currents. The substrate is flat and dominated by mud.

2. Semi-Closed Lagoons

Semi-closed lagoons are defined as coastal water bodies separated from the marine environment by sandbars. In the rainy season, some of the closed lagoons do open to the sea as a result of floodwaters breaching the sand barrier. This occurs mainly as a result of freshwater seepage through the sandbar which makes it more susceptible to erosion by the sea. Storm surges may also erode sandbars and open up closed lagoons to the sea. Under other circumstances, the sandbar may be opened during the rainy season to reduce the risk of flooding where this is considered a threat.

3. Estuaries

Estuaries are the mouths of rivers as they meet the marine environment. They are usually bounded by areas of mud flats, marsh, or mangrove.

4. Open Lagoons Important for Birds

Open lagoons important for birds are lagoons meeting the description of open lagoons above which are also very important bird sites, providing feeding, roosting and nesting sites for migratory and resident birds.

5. Semi-closed Lagoons Important for Birds

Semi-closed lagoons important for birds are lagoons meeting the description of semi-closed lagoons above, which are also very important bird sites, providing feeding, roosting and nesting sites for migratory and resident birds.

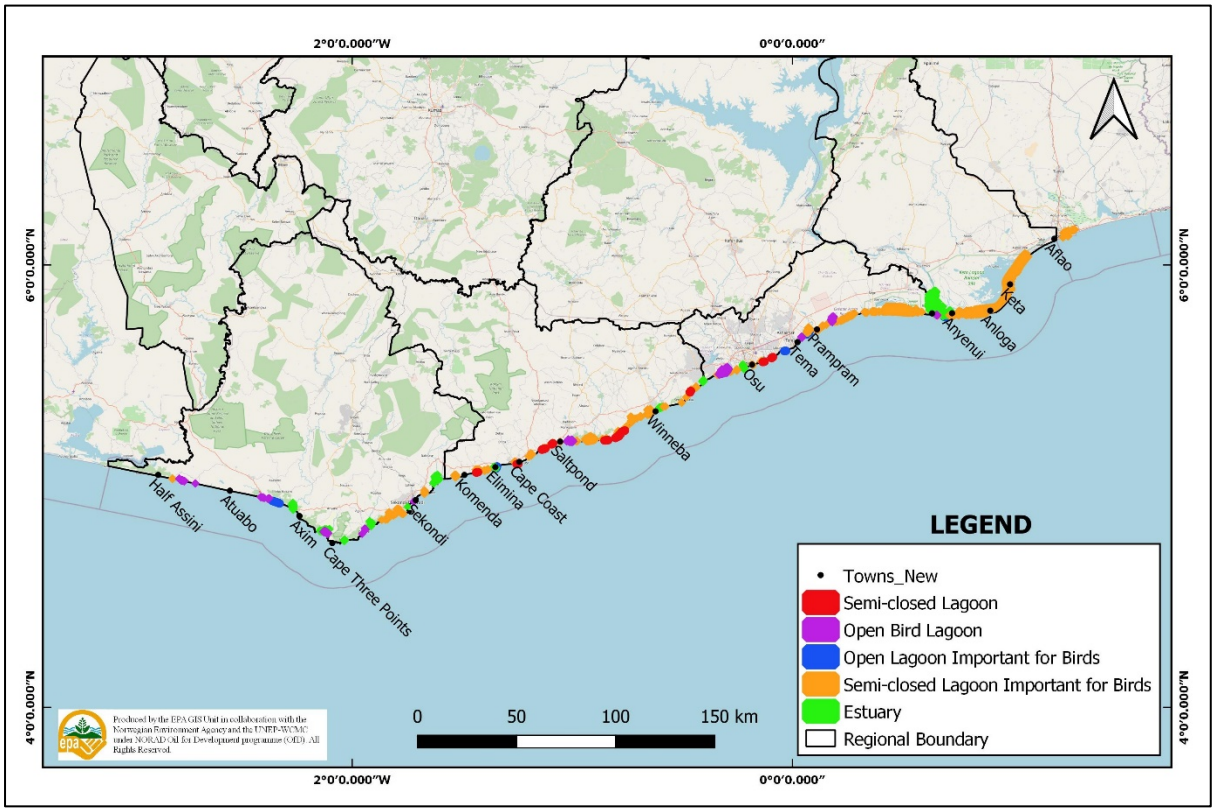

Figure 1: Important lagoons and estuaries.

HABITAT

6. Mangroves

Mangroves are defined in line with that provided by UNEP-WCMC, describing them as trees or large shrubs which grow within the intertidal zone in tropical and subtropical regions and have special adaptations to survive in this saline environment. The term mangrove is applied to both the individual plant and the ecosystem (UNEP-WCMC, 2020). Mangroves are highly productive ecosystems providing food and shelter for a large number of species. They are important breeding and nursery areas for fish and crustaceans, and they are essential habitats for numerous birds.

The 2016 mangrove dataset from Global Mangrove Watch was used as it represents the best globally available records.

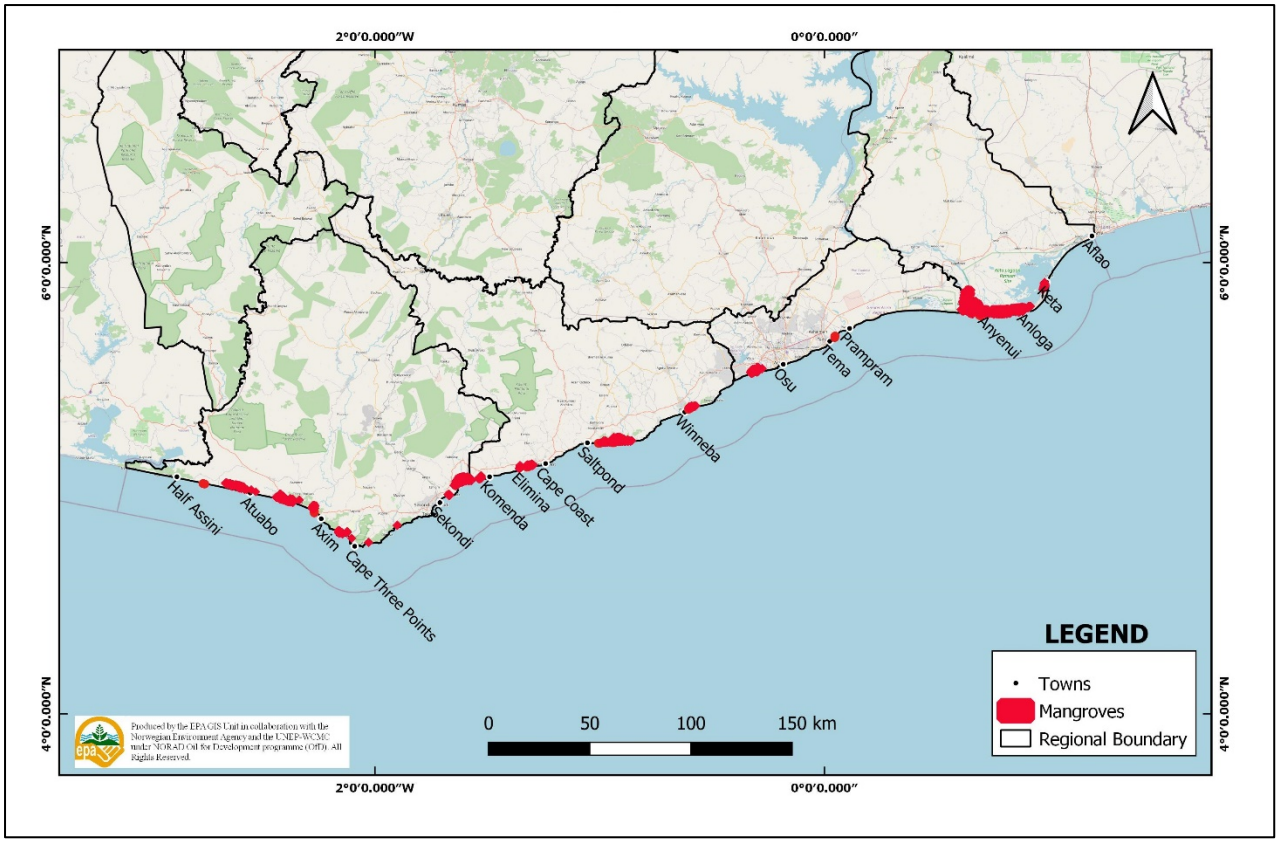

Figure 2: Mangrove stands along the coast.

PHYSICAL ENVIRONMENT

The data and definitions used for the physical environment were taken from 'Environmental Sensitivity Map for the Coastal Area of Ghana' (EPA, 2004).

7. Exposed Rocky Flats with Abundant Crevices

Some rocky flats may contain abundant crevices. On such flats, tide pools form where pools of water collect in hollows and depressions of the rocks at low tide. Tide pools may also form above the zone not normally influenced by the tide. The water in such pools is replenished by wave spray, wave splash or by rainwater. The tide pools house a quite rich vegetation of algae and a diverse fauna of invertebrates and fish.

8. Exposed Rock with Low to Moderate Slope

Exposed rock with low to moderate slope is characterised by regular exposure to high wave energy and strong wave-reflection patterns. The lower slope results in a wider intertidal zone compared to vertical rocks. The intertidal zone can be up to hundreds of meters wide.

9. Intertidal Rocks with Algae Exposed at Low Tide

In some areas intertidal rocks covered by abundant algal growth, which is exposed at low tide, are encountered in a quite wide zone along the coast. This habitat is very important as nursery area for fish.

10. Mixed Exposed Rock and Sandy Beach

Some beaches can be characterised as a mixed rocky and sandy beach. Typically, exposed rocks with low slope are found seawards and sandy areas above the high tide line

11. Steep Exposed Rock

Steep exposed rocks are characterised by regular exposure to high wave energy and tidal currents. The waves are strongly reflected. The slope of the intertidal zone is 30 degrees or greater, resulting in a narrow intertidal and splash zone

12. Sandy Beach with Turtle Nesting Sites

Sandy shores are the most prominent coast type in Ghana. Some sandy beaches of Ghana support the breeding of endangered and protected marine turtles. Female turtles come ashore to nest between August and March. Peak nesting period is from November to January. The female buries the eggs in the sand and then returns to the sea. After 2-3-month incubation period hatchlings emerge and move rapidly to the sea.

13. Sandy Beach with Coarse Sand, Often Mobile Eroding

Sandy beaches with coarse sand are characterised by sand particles ranging from 1-2 mm, intermediate slope of the beach (between 5 and 15 degrees) and relatively high rate of sediment mobility due to coastal sediment transport (i.e., erosion or accretion).

14. Sandy Beach with Fine-grained Sand and Low Slope

Sandy beaches with fine grained sand and low slope are characterised by sand particles ranging in size from 0.06-1 mm, well-sorted and compacted (hard) sediments and a very low slope of the beach (less than five degrees).

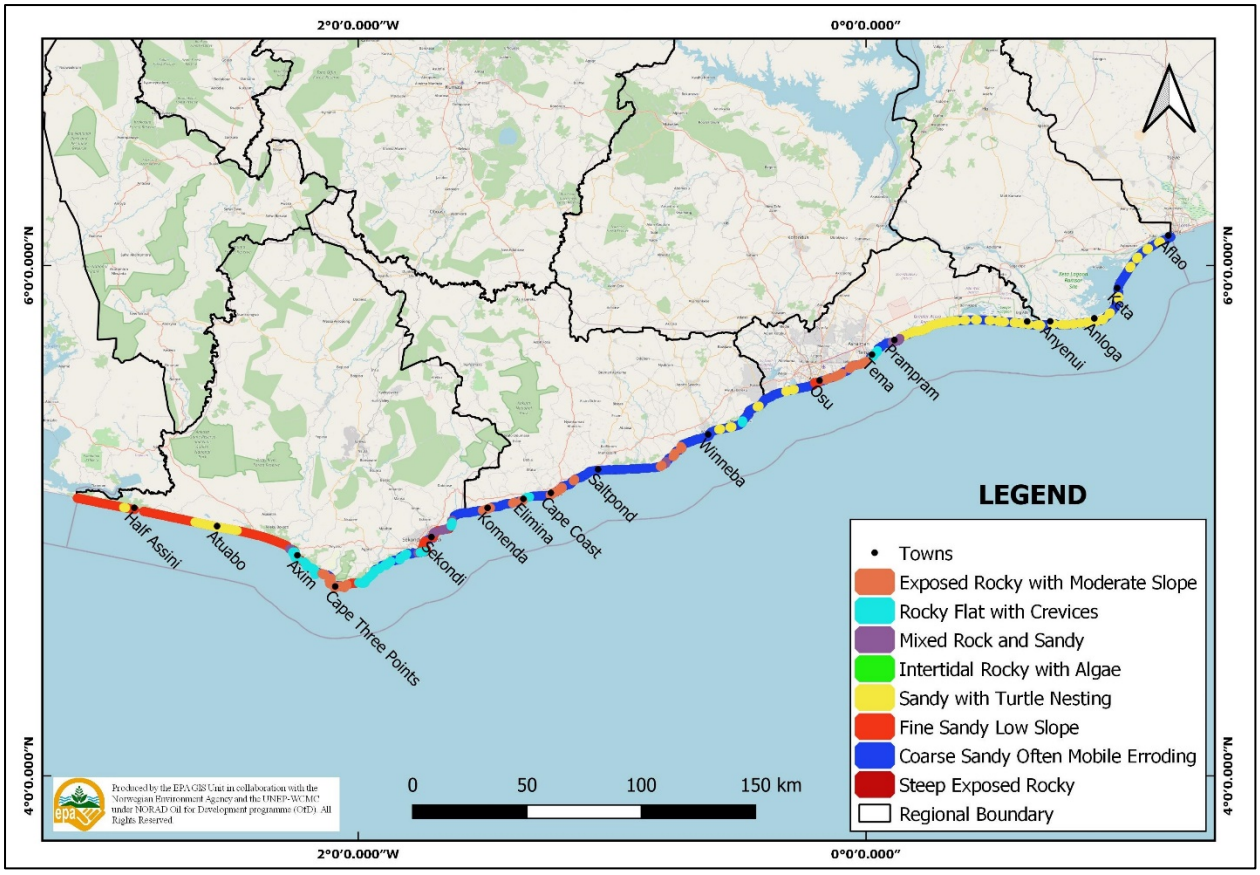

Figure 3:Types of coastlines.

SOCIO-ECONOMIC ASSETS

The definitions used for the socio-economic asset were taken from 'Environmental Sensitivity Map for the Coastal Area of Ghana' (EPA, 2004). Data for 2004 was included and supplemented by additional data collected through ground-truthing surveys in 2016 and 2019.

FISHING

1. Fish Landing Sites

The majority of the 10,000 canoes and vessels along the coast are hauled up on sandy beaches when not in operation or moored in sheltered lagoons, and the catch is carried to the beach.

2. Fishing Communities

Fishing communities occur along the coast, often closely associated with fish landing sites. In addition, they may have a small number of canoes landed within the community itself.

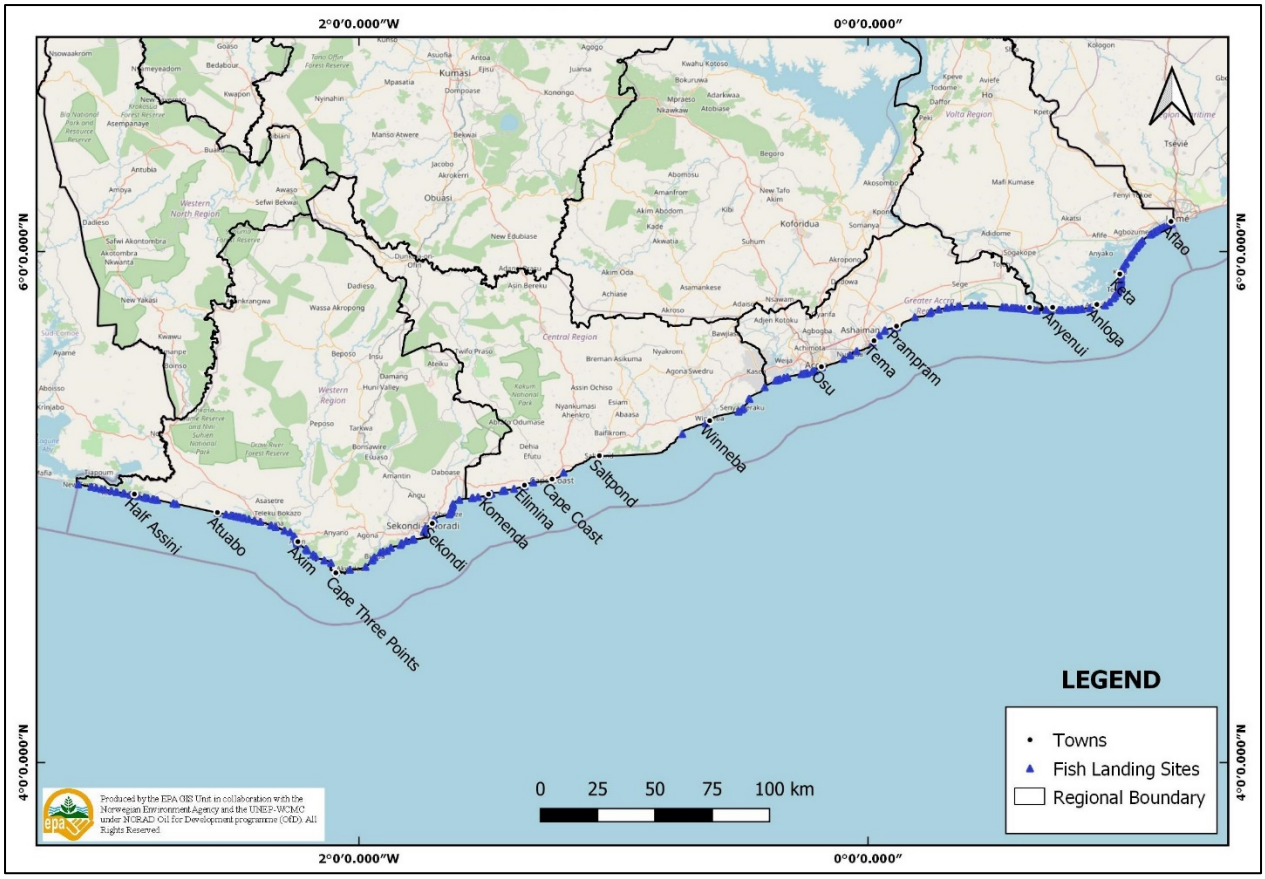

Figure 4: Fish landing sites.

TOURISM

3. Coastal Hotels

The coastal area of Ghana offers varied opportunities for tourism and holds potentials for growth into a major income-earner for the nation. Hotels located next to the shoreline depend to an extent on the natural amenities of the coast (relaxation, water sports, etc) and scenery sea view.

4. Coast Used for Recreational Purposes

In certain sections of the coast, often near the urban centres, recreational activities are concentrated utilising sites with pleasant sea view due to the coastal scenery, swimming for recreational purposes or water sports. Popular recreational sites can host commercial activities (e.g., restaurants and trade stalls).

5. Historical Monuments Near Waterfront

There are numerous forts and castles in various state of preservation along the coast of Ghana. The forts have a unique place in an unfortunate chapter of the world history, and many of them are listed as UNESCO's World Heritage Sites.

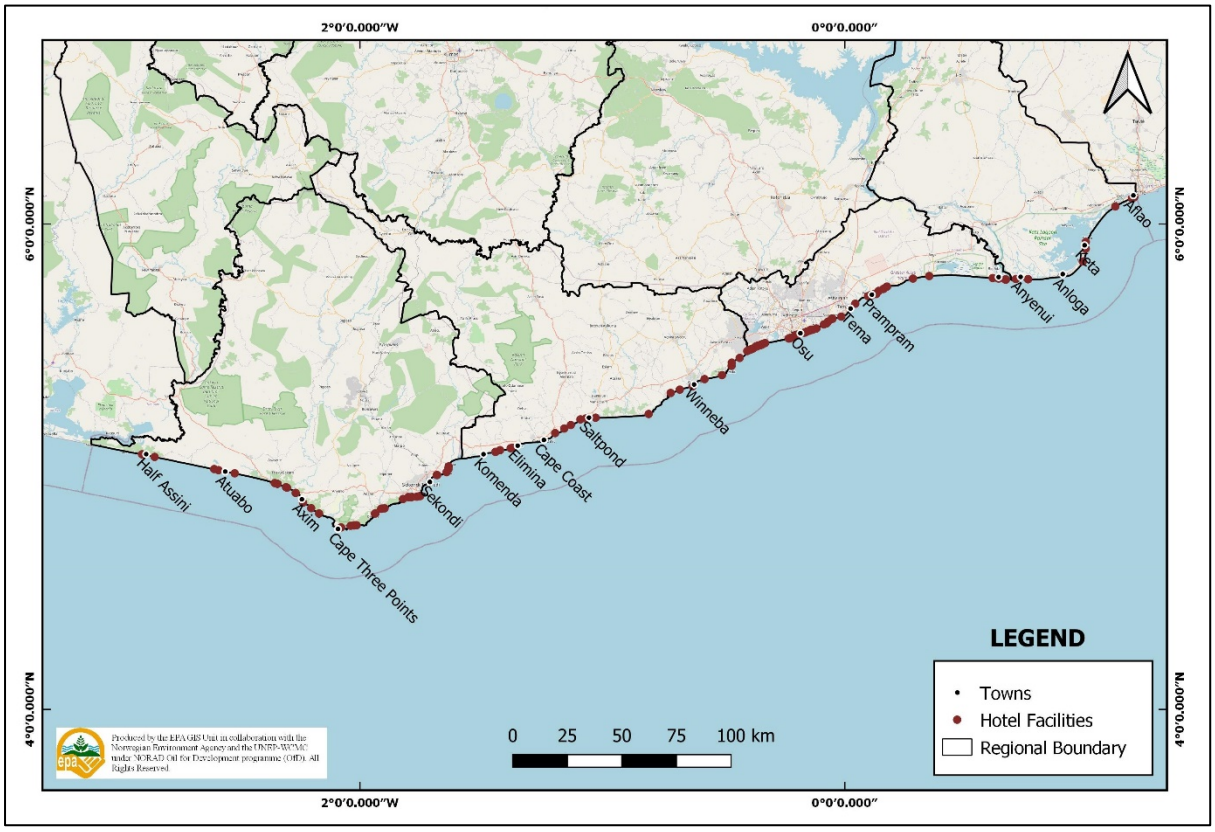

Figure 5: Lodging facilities.

INDUSTRIAL ACTIVITY

6. Major Ports

Ghana has only two major ports for receiving cargo and merchant vessels. The ports are thus important export/import gates for trade.

7. Industrial Plant Relying on Marine Water Intake

Although the majority of the industries in Ghana are located in the coastal area, only a few rely on marine water for cooling water purposes or for processes by means of water intakes (except for salt production).

8. Salt Production Using Marine Water

Salt production takes place within or on the edges of coastal lagoons utilising the flat contours as large areas required for water evaporation. Extensive salt production occurs in about 14 lagoons along the coast and the industry is considered to be important as it provides employment and contributes to the national economy. The traditional method of salt production is simply to collect salt from the lagoon flats in the dry season when salt crystallises out of the super-saturated lagoon water. The more advanced method is to establish dedicated saltpans encircled with low dikes constructed from mud or concrete walls. The pans are filled with lagoon water at high tides, the dikes are closed, and the water left for weeks to evaporate. The third method involves pumping water from the lagoon to salt concentration pans located at some higher levels. As the water evaporates increasingly more saline water is conveyed to lower lying saltpans.

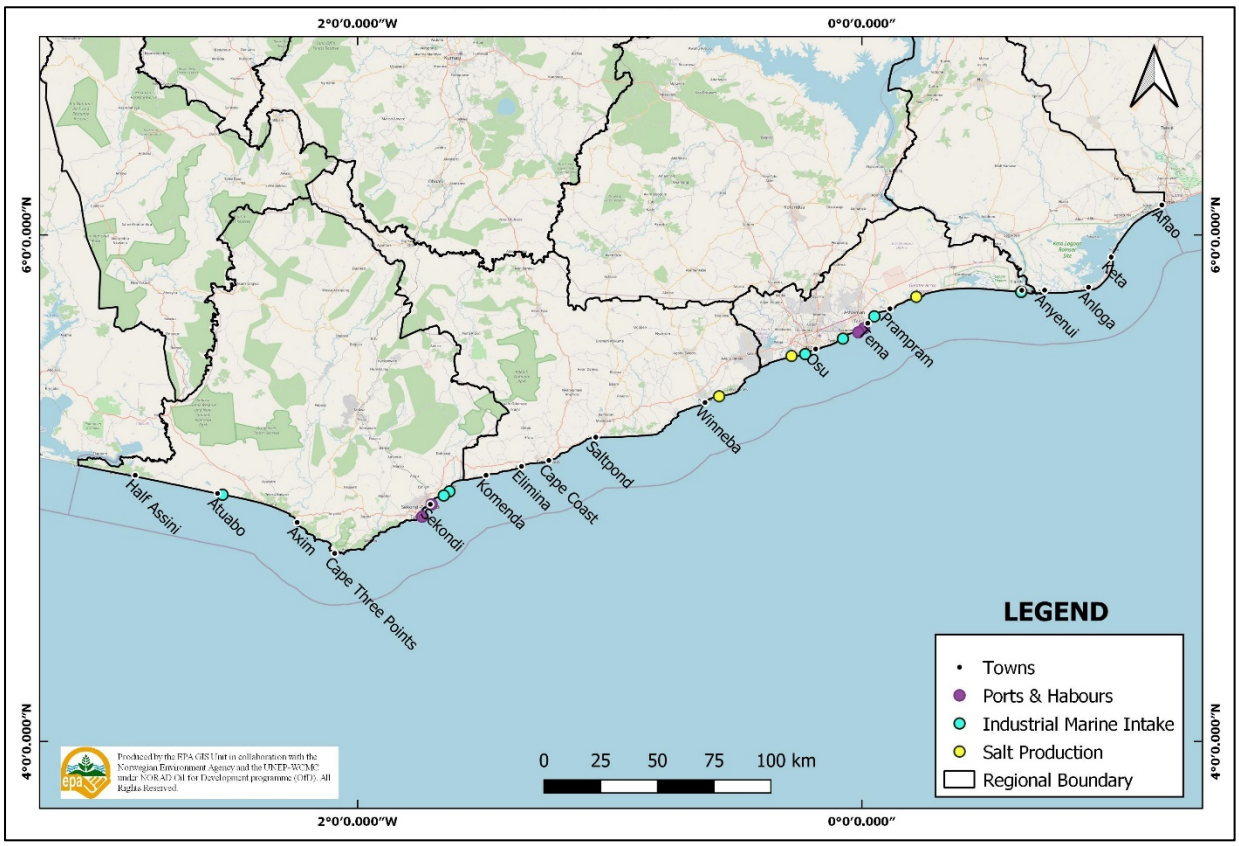

Figure 6: Industrial facilities.

ASSESSMENT OF IMPORTANCE AT NATIONAL LEVEL

The importance assessment identifies the relative conservation significance and priority of the identified assets based on national, and local conditions. It incorporates aspects of legal protection, threat status and irreplaceability. Assets are assigned a score between 1 (lowest) and 5 (highest) based on their importance.

As stakeholders may have differing opinions with regards to importance, a workshop was convened in April 2020 in order to inclusively assign importance rankings to each of the asset types through engagement with a wide range of government officials, NGO (s) and academic stakeholders. As the Environmental Sensitivity Atlas for the Coastal Area of Ghana (2020) is designed to inform national oil spill response plans, it focuses on importance at a national level.

Stakeholder consensus at the April 2020 workshop supported the ranking of all assets at the highest level of importance. However, based on the information provided in Schedule 5 of the Environmental Assessment Regulations 1999, the importance rankings of ecological assets were further refined as laid out in Table 1.

Table 1: Importance rankings for environmental assets with the coastal region of Ghana.

Asset Type	Importance ranking rationale	Importance
Mangrove	Qualifies as environmentally sensitive areas under Schedule 5 as "*Mangrove area*"	5
Open-Lagoons Important for Birds	Qualifies as environmentally sensitive areas under Schedule 5 as "*water which support wildlife and fishery activities*"	5
Semi-closed Lagoons Important for Birds	Qualifies as environmentally sensitive areas under Schedule 5 as "*water which support wildlife and fishery activities*"	5
Estuaries	Qualifies as environmentally sensitive areas under Schedule 5 as "*water which support wildlife and fishery activities*"	5

Open Lagoons	Qualifies as environmentally sensitive areas under Schedule 5 as "*water which support wildlife and fishery activities*"	5
Intertidal Rocks with Algae Exposed at Low Tide	Qualifies as environmentally sensitive areas under Schedule 5 as "*water which support wildlife and fishery activities*"	5
Sandy Beach with Turtle Nesting Sites	Qualifies as environmentally sensitive areas under Schedule 5 as "*areas which constitute the habitat of any endangered or threatened species of indigenous wildlife*"	5
Semi-Closed Lagoons	Was identified as important during the April 2020 stakeholder workshop, but is unlikely to qualify as environmentally sensitive areas under Schedule 5	3
Exposed Rocky Flats with Abundant Crevices	Was identified as important during the April 2020 stakeholder workshop, but is unlikely to qualify as environmentally sensitive areas under Schedule 5	3
Exposed Rock with Low to Moderate Slope	Was identified as important during the April 2020 stakeholder workshop, but is unlikely to qualify as environmentally sensitive areas under Schedule 5	3
Mixed Exposed Rock and Sandy Beach	Was identified as important during the April 2020 stakeholder workshop, but is unlikely to qualify as environmentally sensitive areas under Schedule 5	3
Steep Exposed Rock	Was identified as important during the April 2020 stakeholder workshop, but is unlikely to qualify as environmentally sensitive areas under Schedule 5	3
Sandy Beach with Coarse Sand, Often Mobile Eroding	Was identified as important during the April 2020 stakeholder workshop, but is unlikely to qualify as environmentally sensitive areas under Schedule 5	3
Sandy Beach with Fine-grained Sand and Low Slope	Was identified as important during the April 2020 stakeholder workshop, but is unlikely to qualify as environmentally sensitive areas under Schedule 5	3

Fish Landing Sites	Qualifies as environmentally sensitive areas under Schedule 5 as associated with "*water which supports wildlife and fishery activities*"	5
Fishing Communities	Qualifies as environmentally sensitive areas under Schedule 5 as associated with "*water which supports wildlife and fishery activities*"	5
Coastal Hotels	Qualifies as environmentally sensitive areas under Schedule 5 as "*areas with potential tourist value*"	5
Coast used for Recreational Purposes	Qualifies as environmentally sensitive areas under Schedule 5 as "*areas with potential tourist value*"	5
Historical Monuments near Waterfront	Qualifies as environmentally sensitive areas under Schedule 5 as "*areas of unique historic, archaeological, or scientific interests*"	5
Major Ports	Was identified as important during the April 2020 stakeholder workshop, due to strategic role in national industries	5
Industrial Plant Relying on Marine Water Intake	Was identified as important during the April 2020 stakeholder workshop, due to strategic role in national industries	5
Salt Production using Marine Water	Was identified as important during the April 2020 stakeholder workshop, due to strategic role in national industries	5

ASSESSMENT OF SUSCEPTIBILITY TO OIL SPILL

The susceptibly assessment identifies the degree to which assets are likely to be affected by exposure to oil spill. Assets are assigned a score between 1 (lowest) and 5 (highest) based on their susceptibility.

The assessments of sensitivity for 'Environmental Sensitivity Map for Coastal Areas of Ghana' (EPA, 2004) identified the fate of oil and its impact upon each asset. As such, this aligns closely with the concept of susceptibility as defined within MESA as a combination of impact severity and potential to recover. It was therefore decided that these detailed assessments of the assets can be directly incorporated into the susceptibly assessment as follows:

Table 2: Susceptibility of assets to oil spill

Asset Type	Susceptibility ranking rationale		Susceptibility
	Impact severity	**Potential to recover**	
Mangrove	5 – based on impacts outlined in EPA (2004): "*The oil clogs the pores in the aerial roots and if many roots are oiled, the respiratory system collapses and the trees die […] Mangroves can also be killed due to toxic effects of oil components, especially low boiling aromatics*."	5 – based on fate of oil outlined in EPA (2004): "*Oil easily gets trapped in the mangroves and usually persist for a very long time*." And based on Conolly *et al* (2020): "*complete recovery of mangroves to pre-oiling cover will take 55 years".*	5
Open-Lagoons Important for Birds	5 - based on impacts outlined in EPA (2004): *"Stains of oil on the plumage may destroy the insulating and water repelling property which may ultimately cause the death of the bird […] Toxic effects after the ingestion of oil […] Indirect effects resulting from destruction of bird habitats or food resources*".	3 – based on fate of oil outlined in EPA (2004): "*If oil enters into an open lagoon natural removal rates are very slow […] oil may persist for years on the flats".*	4
Exposed Rocky Flats with Abundant Crevices	5 – based on impacts outlined in EPA (2004): "*biological impacts can be immediate and severe"*	2 - based on fate of oil outlined by EPA (2004): "*The oil will be removed by wave action and natural*	4

		degradation […] oil can be trapped in the pools"	
Semi-closed Lagoons Important for Birds	3 – based on impacts for Open Lagoons Important for Birds (as detailed by EPA (2004)), but with lower severity due to reduced ability for the oil to enter	3 – based on fate of oil outlined in EPA (2004): "*If oil enters into an open lagoon natural removal rates are very slow […] oil may persist for years on the flats".*	3
Estuaries	3 – based on impacts outlined in EPA (2004): "*Severe impacts on the fauna can be expected"* but *"Toxic concentrations of oil may develop on the shallow water".*	3 – based on recovery outlined in EPA (2004): "*recovery of a sensitive benthic amphipod Ampelisca took more than ten years".*	3
Open Lagoons	3 – based on impacts outlined in EPA (2004): "*Severe impacts on the fauna can be expected"* but *"Toxic concentrations of oil may develop on the shallow water".*	3 – based on recovery outlined in EPA (2004): "*recovery of a sensitive benthic amphipod Ampelisca took more than ten years".*	3
Intertidal Rocks with Algae Exposed at Low Tide	5 – based on impacts outlined in EPA (2004): "*severe biological impacts".*	1 – based on fate of oil outlined in EPA (2004): "*Oil may be trapped in the algal mat during low tide*"	3
Sandy Beach with Turtle Nesting Sites	5 – based on impacts outlined in EPA (2004): "*Young turtles, which have been exposed to oil in water, may suffer a wide number of injuries […]*	1 – based on oil fate outlined in EPA (2004): "*low penetration and low potential for burial [of oil]";* and the temporary nature of turtle presence on	3

	These injuries may eventually cause the death of the animal […] Fresh crude oil on the sand surface, significantly affects the hatching success of eggs"	the beaches: *"the hatchlings are especially at risk when they dig their way out of the nest and enter the water […] during their first period in the sea the young juveniles stay in surface waters"*	
Mixed Exposed Rock and Sandy Beach	5 – based on impacts outlined in EPA (2004): "*Inverebrates on rocky shores often suffer heavy casualities if coated with fresh crude oil […] Large numbers of limpets were killed on heavily oiled rocky shores with up to 90% mortality recorded."*	1 – based on fate of oil outlined by EPA (2004): "*high wave energy tend to remove oil"*; and on recovery: "*usually repopulated once the oil has been substantially removed".*	3
Semi-Closed Lagoons	2 – based on impacts for Open Lagoons (as detailed by EPA (2004)), but with lower severity due to reduced ability for the oil to enter	3 – based on recovery outlined in EPA (2004): "*recovery of a sensitive benthic amphipod Ampelisca took more than ten years".*	3
Exposed Rock with Low to Moderate Slope	5 – based on impacts outlined in EPA (2004): "*Inverebrates on rocky shores often suffer heavy casualities if coated with fresh crude oil […] Large numbers of limpets were killed on heavily oiled*	1 – based on fate of oil outlined by EPA (2004): "*high wave energy tend to remove oil"*; and on recovery: "*usually repopulated once the oil has been substantially removed […] Recovery*	3

	rocky shores with up to 90% mortality recorded."	*can occur within 6-12 months".*	
Steep Exposed Rock	1 – based on the impacts outlined by EPA (2004): "*risk of organisms being affected by oil is quite small on vertical rocks"*	1 – based on the fate of oil outlined by EPA (2004): "*Stranded oil remains on surface because the substrate is impermeable, resulting in quick removal of oil by natural degradation process.";* and on recovery: "*Any detrimental impact on benthic invertebrates in shallow waters near the shoreline is expected to be of short duration due to the high recovery potential of benthic fauna"*	1
Sandy Beach with Coarse Sand, Often Mobile Eroding	1 – based on the impacts outlined by EPA (2004): "*Species diversity on sandy beaches with coarse grained sand is low […] significantly less potential for ecological damage"*	1 – based on the recovery outlined by EPA (2004): "*Any detrimental impact on benthic invertebrates in shallow waters near the shoreline is expected to be of short duration due to the high recovery potential of benthic fauna."*	1
Sandy Beach with Fine-grained Sand and Low Slope	1 – based on the impacts outlined by EPA (2004): "*low species diversity […] low penetration and low potential for burial [of oil]"*	1 – based on the recovery outlined by EPA (2004): "*Any detrimental impact on benthic invertebrates in shallow waters near the shoreline is expected to be*	1

		of short duration due to the high recovery potential of benthic fauna."	
Major Ports	5 – based on the impacts outlined by EPA (2004): "*economical losses and claims from ship owners and firms relying on harbour operations […] unemployment for workers"*	2 – based on the duration of impact outlined by EPA (2004) as *"temporary"*	4
Industrial Plant Relying on Marine Water Intake	5 – based on the impacts outlined by EPA (2004): "*closure of the intake might impact the entire operation of the plant and thus vital economic interests"*	2 – based on the duration of impact outlined by EPA (2004) as *"temporary closure"*	4
Salt Production Using Marine Water	5 – based on the impacts outlined by EPA (2004): *"salt produced might be directly affected by deposits of oil in the pans or the production might be hampered because the water intakes to the salt production plants has to be closed"*	2 – based on the duration of impact outlined by EPA (2004): "*until the oil is removed"*	4
Fish Landing Sites	5 – based on the impacts outlined by EPA (2020): *"stranded oil on the land sites will hamper or make*	1 – based on the recovery outlined by EPA (2004): *"time span is likely to be in the order of weeks to several months"*	3

	usual operation impossible"		
Coastal Hotels	5 – based on the impacts outlined by EPA (2004): *" direct access to the shore and the options for swimming, fishing or utilising water sport facilities will be hampered or made impossible"*	1 – based on the recovery outlined by EPA (2004): *"time span is likely to be in the order of weeks to several months"*	3
Fishing Communities	3 – based on the impacts outlined by EPA (2004): *"fishery will be difficult or impossible in areas directly affected […] alternative and nearby fishing grounds free of oil can be utilised in the period"*	1 – based on the recovery outlined by EPA (2004): *"impacts are limited in time (hours to days)"*	2
Coast Used for Recreational Purposes	2 – based on the impacts outlined by EPA (2004): *"amenity value is reduced and commercial activities might suffer but without being detrimental in a socio-economic context"*	1 – based on the recovery outlined by EPA (2004): *"time span is likely to be in the order of weeks to several months"*	2
Historical Monuments near Waterfront	1 – based on the impacts outlined by EPA (2004): *"no direct impact on the sites and visitors are not directly influenced by the spill"*	1 – based on the recovery outlined by EPA (2004): *"time span is likely to be in the order of weeks to several months"*	1

ENVIRONMENTAL ASSET SENSITIVITY

Environmental assets are assigned a sensitivity ranking by applying the formula outlined in Figure 7 to combine the values assigned to the asset for importance and susceptibility.

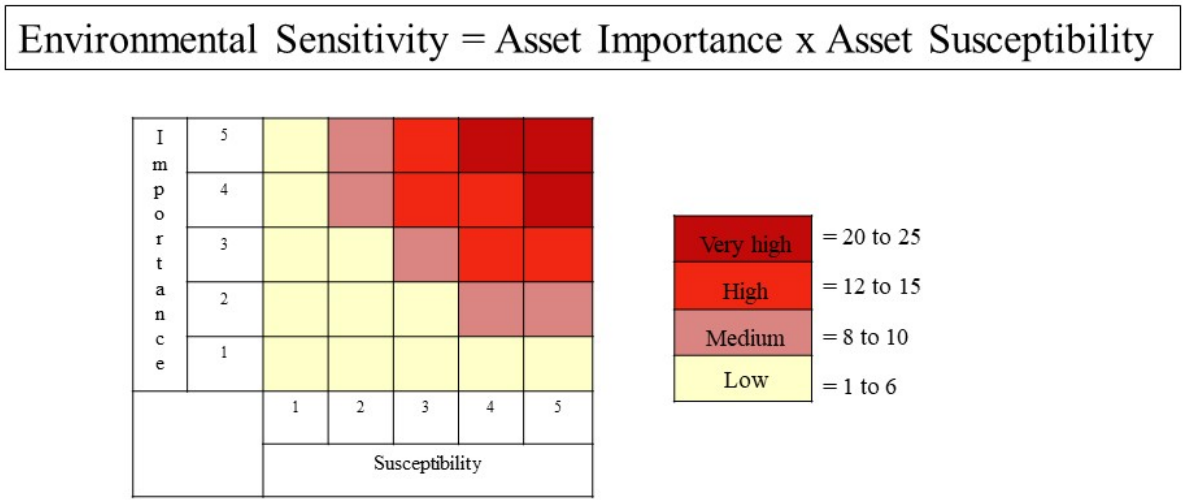

Figure 7 : Approach for combining importance and susceptibility rankings into an overall assessment of sensitivity.

The results of this process provide an assessment of sensitivity for each asset type as shown in Table 3.

Table 3: Overall sensitivity assessments for each asset type based on their importance and susceptibility.

Asset	Importance	Susceptibility	Sensitivity Assessment	Sensitivity Ranking
Mangrove	5	5	25	Very High
Open-Lagoons Important for Birds	5	4	20	Very High
Semi-closed Lagoons Important for Birds	5	3	15	High
Estuaries	5	3	15	High
Open Lagoons	5	3	15	High
Exposed Rocky Flats with Abundant Crevices	3	4	12	High

Intertidal Rocks with Algae Exposed at Low Tide	5	3	15	High
Sandy Beach with Turtle Nesting Sites	5	3	15	High
Mixed Exposed Rock and Sandy Beach	3	3	9	Medium
Semi-Closed Lagoons	3	3	9	Medium
Exposed Rock with Low to Moderate Slope	3	3	9	Medium
Steep Exposed Rock	3	1	1	Low
Sandy Beach with Coarse Sand, Often Mobile Eroding	3	1	1	Low
Sandy Beach with Fine-grained Sand and Low Slope	3	1	1	Low
Major Ports	5	4	20	Very High
Industrial Plant Relying On Marine Water Intake	5	4	20	Very High
Salt Production Using Marine Water	5	4	20	Very High
Fish Landing Sites	5	3	15	High
Coastal Hotels	5	3	15	High
Fishing Communities	5	2	10	Medium
Coast Used for Recreational Purposes	5	2	10	Medium
Historical Monuments Near Waterfront	5	1	5	Low

LIMITATIONS OF THE METHODOLOGY

There are a number of limitations to the outlined approach to sensitivity mapping that should be considered when interpreting the resulting atlas.

Data Availability

The assets included within this atlas are those for which sufficient, spatially referenced data were available. While these capture a range of ecological and socio-economic assets within the coastal area of Ghana, they are by no means exhaustive. In particular, datasets for the marine environment are greatly lacking. The following assets should be prioritized for data collection and integrated into future updates as data become available:

- **Fish spawning and feeding grounds:** areas in which fish congregate in large numbers, either for spawning or feeding.
- **Areas important for marine mammals:** areas that are important for cetaceans within the coastal area of Ghana. These may be feeding, breeding or resting grounds.
- **Areas of high biodiversity value:** areas within the coastal area that have high biodiversity value that would be impacted by exposure to oil spill (e.g., coral reefs and saltmarshes).

Data Quality

Datasets used to identify physical environment assets, as well as lagoons important for birds were drawn directly from 'Environmental Sensitivity Map for Coastal Areas of Ghana' (EPA, 2004). As a result, the data are over 15 years old and may not reflect current conditions on the ground. Where possible, every effort has been made to ensure changes have been captured, but a degree of validation with local stakeholders should be conducted as part of the integration of the atlas into decision-making processes.

Visualisation of Sensitivity

The sensitivity displayed in this atlas is drawn from the most sensitive asset within each grid cell. It does not differentiate between cells with multiple assets and cells with only one. The data on the number of assets per cell are maintained within the geopackage file for the atlas and should be consulted where further information is required in order to best prioritise areas for oil spill response.

Asset Importance

Asset importance was determined based on the inclusion of assets in Schedule 5 of the Environmental Assessment Regulations, 1999 of Ghana (LI 1652) and stakeholder input from the April 2020 workshop. However, no other global or national priorities were incorporated into this assessment.

REFERENCES

EPA (1999), Environmental Assessment Regulations, LI 1652.

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