Network of Marine Protected Areas in a Changing Climate in West Africa: An appraisal of Vulnerabilities, Impacts & Adaptive Capacity

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ABSTRACT

West Africa's marine protected area (MPA) network is critical to maintaining environmental resilience and rebuilding declining marine resources. They protect coastal habitats and reduce human vulnerabilities to climate change, including reduction of food insecurity. However, the West African region is challenged to withstand devastating effects of global climate change, despite emitting very little GHG to the atmosphere. We have examined the vulnerability of people and of West African marine protected areas using the IPCC standard vulnerability assessment framework. Our findings reveal that the adaptive capacity of MPAs against climate change in the West African region is only 10% of the actual capacity needed for resilience. This weak capacity can be attributed to climate financing deficit in the region and the degradation of important coastal habitats. Mangrove forests in West Africa have seen net loss of over 980 km^2 over the past five decades. This undermines the capacity of West African states to meet their nationally determined contributions of reducing GHG emissions through sinks. Sea levels for low elevation coastal zones are projected to rise over 1.2m by 2100. This creates livelihoods vulnerability for people inhabiting MPA communities. We found that exposure metrics of torrential rainfall, flooding, marine heatwaves and drought are increasing vulnerability of MPA habitats and ecosystems. We estimated that a CO_2 offset of about 140.05 MtCO2e by mangroves in MPAs are increasing adaptive capacity of people and ecosystems. We recommend tree planting, the upgrade of coastal defenses and early warning systems as sensitive actions against climate vulnerability in West Africa.

PROBLEM STATEMENT AND STUDY OBJECTIVES

The need for marine protected area managers of West Africa to take climate change adaption into account, in the design and management of marine protected areas in is becoming more important. The critical ecosystems within West African marine protected areas and their surrounding communities (towns, villages, and cities) are vulnerable to the effects of global climate change. Additionally, the existing climate adaptation strategic framework developed for protected areas of West Africa are generalized and more concentrated on terrestrial protected areas. It lays more emphasis on the National Adaptation Programs of Action (NAPA) and the National Biodiversity Action Plans (NBSAPS). These plans do not currently address benefit-oriented socio-ecological and socio-economic factors that determine adaptive capacity (Belle E.M.S. et.al, 2016). The residents in low elevation coastal zones (LECZ) of the West African countries within the network of MPAs require effective climate adaptation measures for the resilient of MPA communities, their fisheries and ecosystems. Our study aimed to understand the status of adaptive capacity of West African MPA communities and ecosystems against climate hazards.

The overall objective of this studies was to increase our understanding of the impacts of climate change on MPA communities and their ecosystems and to identify measures that can create climate resilient MPAs. The Specific objectives include:

i) Characterization of climate sensitivity and Vulnerability metrics for West African MPAs and their effects on adaptative capacity of MPA ecosystems and human communities

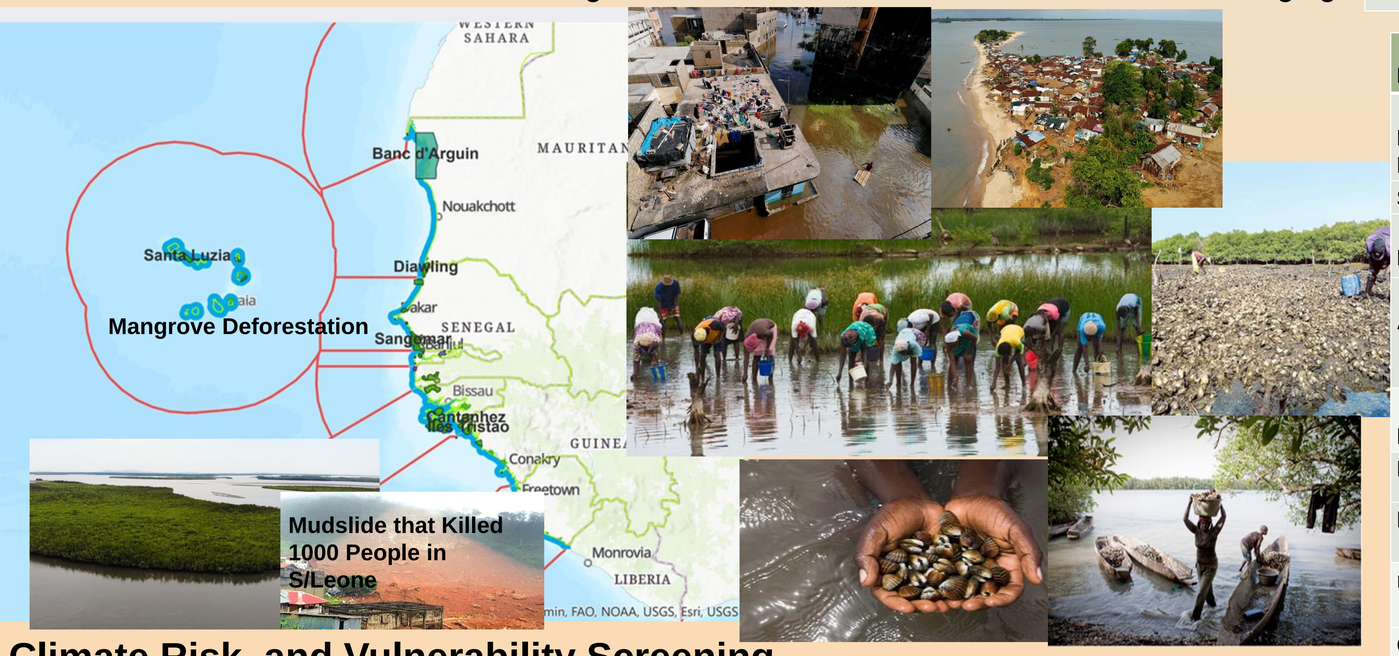
ii) The identification of knowledge gaps in the socio-ecological and socio-economic systems needed to build resilience of MPAs against climate change impacts

METHODS

Study Area: Regional Network of Marine Protected Areas in West Africa

The study area for this research comprised of the regional network of marine protected areas (MPAs) in West Africa (RAMPAO), established in 2007. This MPA network covers 16,858 km^2 of 41 MPA areas from seven member states:: Sierra Leone, Guinea, Guinea Bissau, Gambia, Senegal, Cape Verde and Mauritania (See http://www.rampao.org/?lang=fr). The network is located in the northern part of the West and Central African Region. Important reasons for Regional MPA Network include the conservation of biodiversity, Protection and management of fisheries resources, protection of cultural heritage and Promotion of tourism.

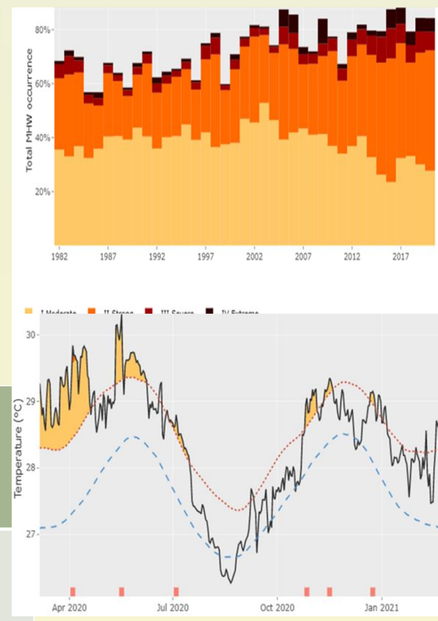
Senegal St. Louis & Sierra Leone Plantain Island Submerging



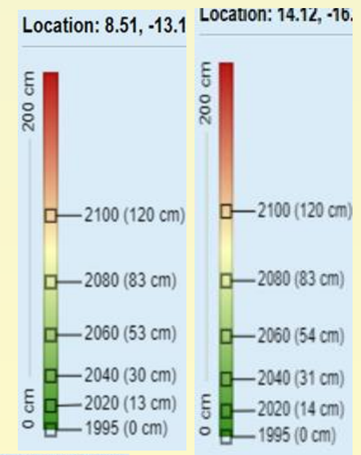
RESULTS

Climate Stressors & Livelihoods of West Africa MPAs

Livelihoods Group	Key Actors	Climate S stressors
Agriculture	MPA Managers/NGOS/ Civil society/Government	Temperature Warming up to 40 ºC
Sediment and Minerals	Fishermen, Local Leaders, Environment/MPA Managers	GHG Emission
Fishing & Fish Processing	Fishing Industry, Local Leaders/Government/NGOs/ Civil Society/ Women Fish Processors,	Flooding/ Torrential Rains, Tropical Storms/ Seasonal Upwelling
Mineral Mining	Fishermen, Transporters, Local Leaders/ Youths, MPA Managers/ Government/NGOs	Torrential rainfall of 800mm/yr
Sea Transport	Fishermen/Transporters/Youths/Women Fish processors/	SST up to 30 ºC/Torrential Rains/Flooding/Storms/
Mangrove	Fishermen/Transporters/Youths/Fish Processors/Marine resources Department	Coastal erosion /Flooding /Torrential Rain/Landslide
Petty Trading/Salt Processing	Fish processors//Transporters/ Government/NGOs	Landslide/Flooding/S Torrential Rains/Storms
Healthcare	Doctors/Healthcare Givers/Nurses	Torrential Rains/Flooding/ Sea Level Rise/Landslide

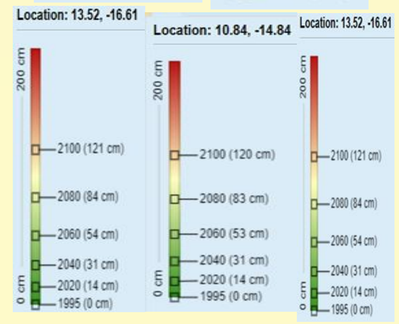


SEA LEVEL RISE PROJECTIONS



GHG Emission & CO2 Offset by the MPA Network

Country	GHG Emission $MtCO_2e$	Mangrove Coverage Hectares	CO_2 Offset $MtCO_2e$
Sierra Leone	10.57	105,200	22.54
Guinea	41.17	203, 900	32.061
G. Bissau	4.44	299,900	30.630
Gambia	3.31	58,100	7.3494
Senegal	34.36	157,137	22.812
Mauritania	12.99	1,240,600	24.66
Cape Verde	0.77	534	Limited Information



Non-Climatic Stressors	Habitat Type	Comment
Nutrient and River Discharge of Sediment	Estuaries/Bays/Creeks/Lagoons	Critical Concern
	Coastal land/Estuaries/Wetlands	
Sewage Pollution		Critical Concern
Eutrophication	Wetlands/ Mudflats/Estuaries	
Anoxia and Hypoxia	Mangroves/Coastal forest/ Seagrass beds	Critical Concern
	Bays/Coves/Lakes/Estuaries	Major Concern
Sand Mining from Beaches	Coastal Land/Estuaries/Bays/Lagoons	Critical Concern
Farming and Gardening	Mangrove Forest/Wetlands	Major Concern
Fishing	Mangrove Forest/Estuaries/Bays/Creeks	Major Concern
mangrove Harvest	Mangrove Forest/Estuaries/Creeks/Bays/Lagoon	Critical Concern
Oil/Gas Refining	Estuaries	Critical Concern

Climate Risk and Vulnerability Screening

Our Climate Risk and Vulnerability Screening was based on the IPCC Vulnerability Framework and the use of the **World Bank Climate Knowledge Portal, Rapid Vulnerability Assessment (RVA) and the CLIMsystems Sea Level Rise App** For the extreme sea warmings causing marine heatwave, we used the marine heatwave tracker (http://www.marineheatwaves.org/tracker.html), using coordinates of MPAs in West Africa, to investigate the occurrence of MHW and their implications for ecosystem functioning of MPAs in West Africa. The identification of MHW of West Africa was based on the hierarchical approach described by Alistair J. Hobday et.al., (2016), where observed sea surface temperatures greater than the 90th percentile of the local climatological average of West Africa region was sustained for a period of at least 5 consecutive days on a 30 years base period..

Ecological Risk Screening and Analysis of CO_2 Offset

We used the ecological risk screening approach in order to fully understand the interactions of stressors with MPA ecosystems and the human livelihoods which is useful for future adaptation planning. The CO2 offset by mangroves in the region was examined to understand the contribution of mangrove forests to sequester CO_2 from the atmosphere and contribute towards climate adaptation. We calculated the ratio of CO_2 to Carbon based on the atomic weights of each molecule., using the biomass of 840 metric tons of carbon sequestered by 1 hectare of matured mangroves (Fatoyinbo T, et. al.,2017). Using the relationship: **CO_2:C=ArCO_2/ArC.** Where Ar represent relative atomic mass (atomic weight), C represents Carbon and CO2 represent Carbon dioxide. Mangroves can sequester C at a rate two to four times greater than mature tropical forests and can store three to five times more carbon per unit area than terrestrial forests.

Critical Climate Change sensitivity metrics increasing vulnerability and **reducing adaptive capacity include:** 1) Low Literacy Rate, 2) Low human development and economic status, 3) High rural urban migration 4) Poor access to water, sanitation and electricity, 5)Weak infrastructure and coastal defense system, 6) malleable land tenure systems, 7) Weak Early Warning and Disaster Response System

Climate Change Exposure Metrics for MPAs in West Africa	
Climate Change Stressor	**Time Scale and Proxy**
Tropical Storm	2020 to 2030; 2031-2061; >30yrs till 2100
Changing Rainfall Pattern	1983- 2100, RCP 8.5
Flooding	projections 2030-2100), Flood Event/SLR
Coastal Erosion	2000 to 2100, vertical land movement @RCP8.5
Thunderstorm/Lightening	1983- 2100
Storm surges	1983-2100, inundation maps,
Sea Level Rise (SLR)	2035- 2100, water marks, Water Level returns

CONCLUSIONS

Our analysis of climate change risks, vulnerability and adaptive capacity shows that the network of marine protected areas in West Africa are sensitive and vulnerable to climate change impacts. Guinea Bissau MPAs have the largest mangrove cover with significant CO_2 offset of 32.061 million metric tons of CO2 equivalent(22.9%) in the region. This provides a significant potential for increasing adaptive capacity of MPAs. The weak infrastructure and poor early warning and response systems is increasing vulnerability to climate change impacts. The occurrence of strong marine heatwaves in coastal waters of the MPAs in Sierra Leone within the network is critical for ecosystem functioning and fisheries. More