MANGROVE BLUE CARBON STOCK ASSESSMENT

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Internationale Vereinigung der Vermessungsingenieure

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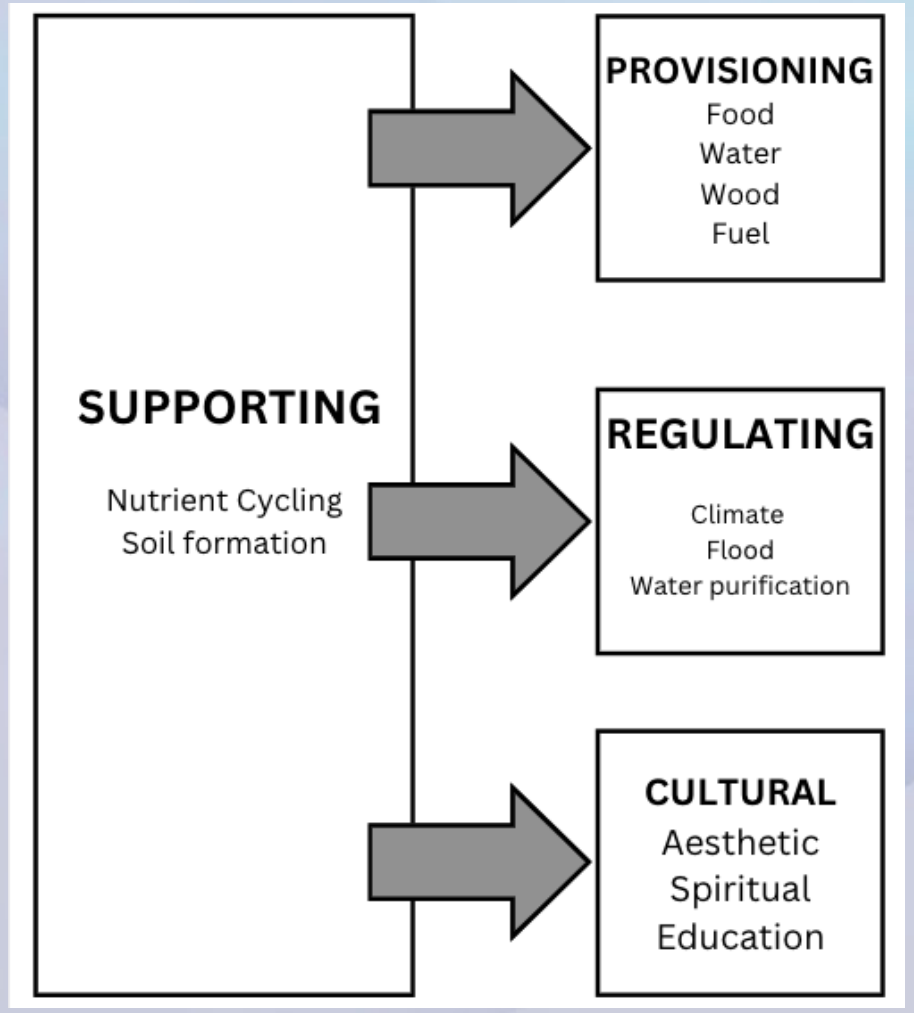
Contents

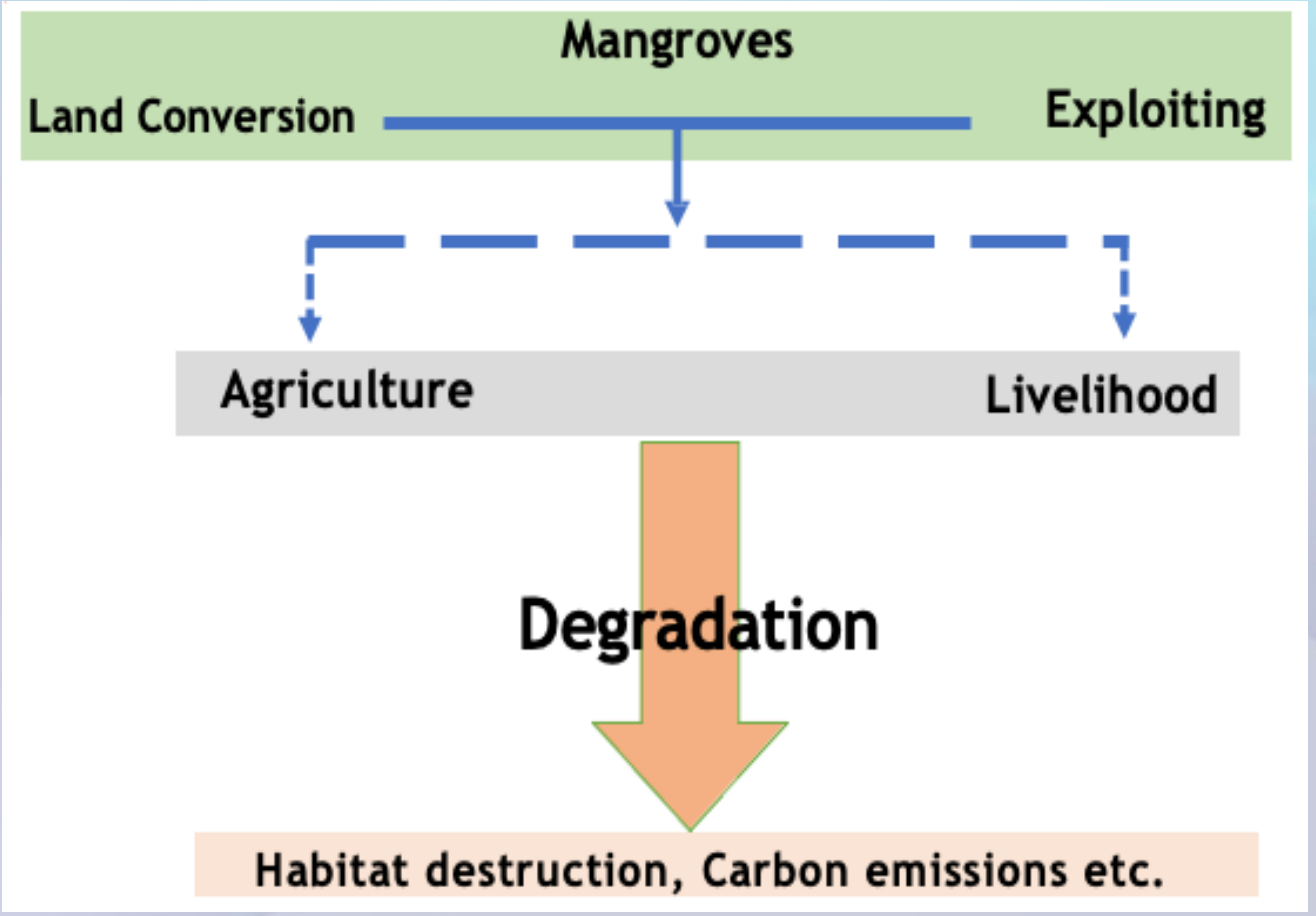
Introduction

- Coastal ecosystems
- Mangroves (Spalding et al., 2024)
- Ecosystem services
- Blue carbon modelling (Mcleod et al. 2011)



Problem statement

- Declining mangrove area (Nunoo & Agyekumhene, 2022)
  - Decrease by 24% in Ghana from 181km2 - 137km2
  - Rate of 8.1 km2/yr
- Population pressure (Awuku-Sowah et al., 2023)
  - Behavior and perception
  - Intensified exploitation of mangrove resources
- Carbon emission threat (Adotey, 2022)



Aim & Objectives

- **Aim**

Assess the ecological and socio-economic value of mangrove ecosystems, focusing on spatial dynamics, carbon sequestration, local perceptions, and drivers of degradation.

- **Specific objectives**

1. Determine land cover cover change over the past 10 years (2015, 2020, 2025)
2. Model the amount of carbon stock sequestered using the InVest Blue Carbon Model over the past 10 years.
3. Assess the perception of change by the local community in the mangrove area.
4. Identify socio-economic factors that drive mangrove exploitation by local community
5. Assess the willingness of local community to utilize alternative energy sources

Methodology

- **Location**
  - Woarabeba, Central Region, Ghana
  - Beach barrier separating an open coastal lagoon
- **Study area** – 14 km2
- **Population** – 552 (GSS, 2010)
- **Mangrove conservation challenges**
  - Sea-level rise (Sagoe-Addy & Appeaning Addo, 2013)
  - Salt mining
  - Mangrove harvesting (Awuku-Sowah, 2023)

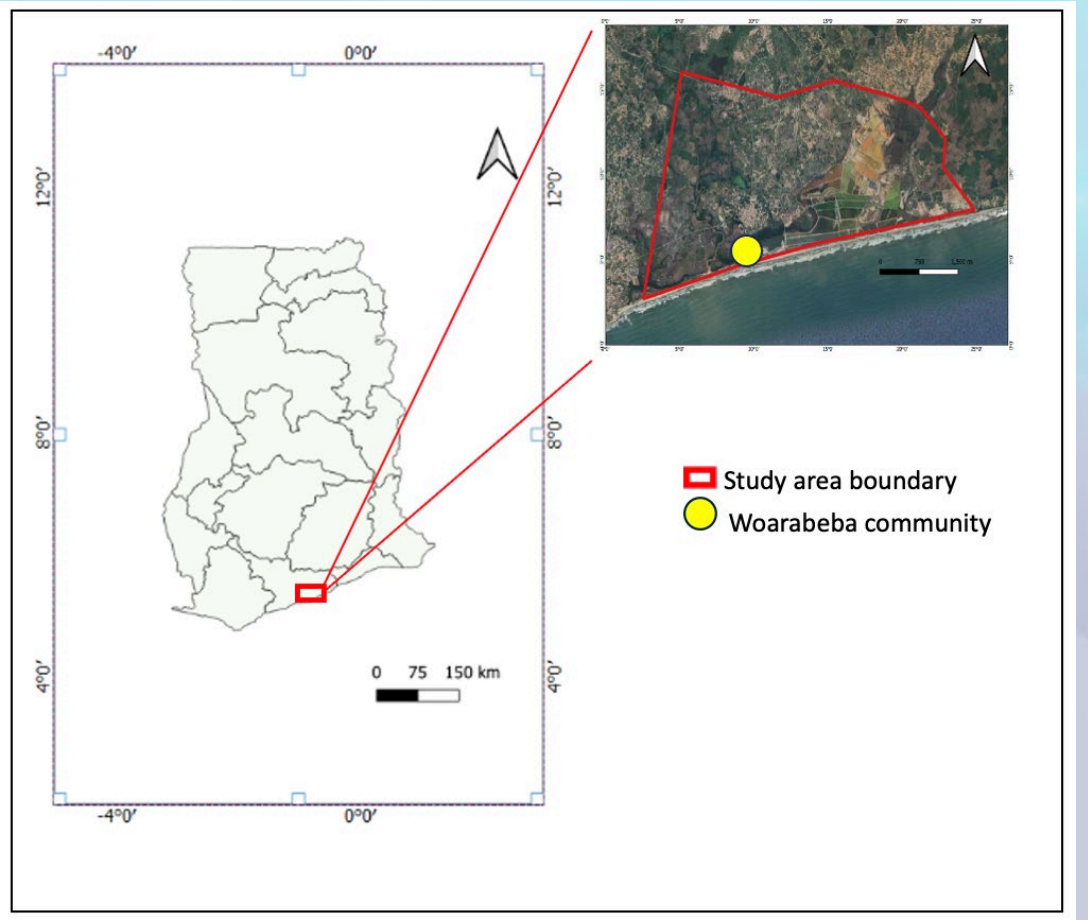


Fig 1.0 Map of study area

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Methodology

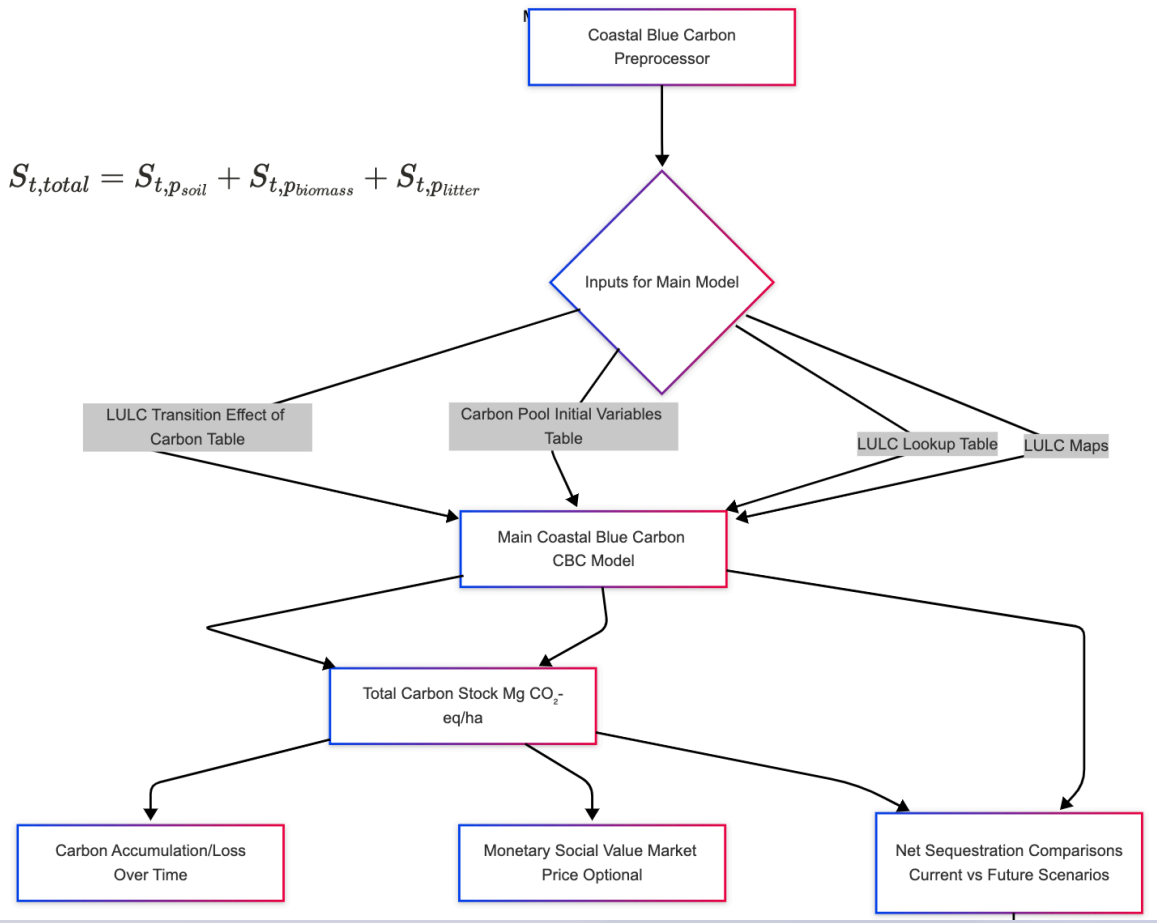


Fig .2.0 InVest Coastal Blue Carbon

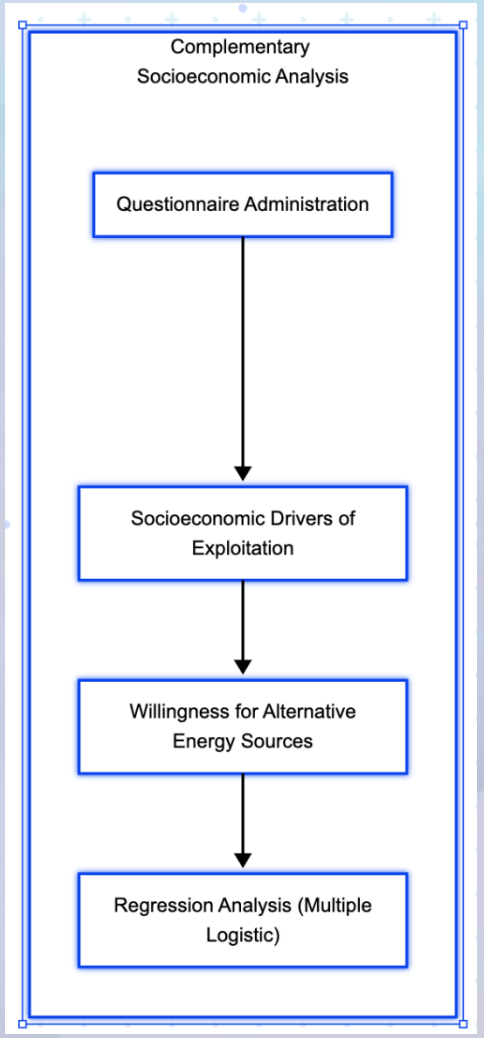
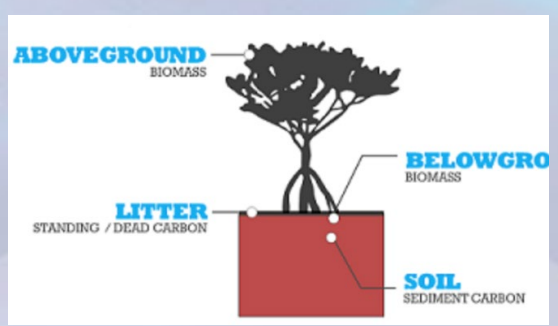


Fig 3.0 Social survey



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Methodology

Field work

- 60 questionnaires (random sampling; cochran's formula)
- Five sample plots, each 0.01 ha (10m x 10m), selected from grids on satellite imagery (Kaufmann & Donato, 2011)
- Parameters recorded
    - GPS readings, mangrove heights, mangrove species, canopy length, Diameter at Breast Height (DBH), Root Collar Diameter (RCD), soil core (at 1m depth), leaf litter (0.5m x 0.5m), and the number of trees within each sample plot

LULC Classification

- Sentinel satellite images
- The Normalized Difference Vegetation Index (NDVI)
- Supervised classification was employed, involving the development of training sites by overlaying the NDVI
- Random Forest Classifier (accuracy test) (Amayri, 2016)

Methodology

- **InVest Blue Carbon Model Limitations**
  - all meaningful storage, accumulation and emission in case of impact occurs in the biomass and soil pools.
  - some human activities that may degrade coastal ecosystems do not disturb carbon in the sediments.
  - ignores increases in stock and accumulation with growth and aging of habitats.

Results & Discussion

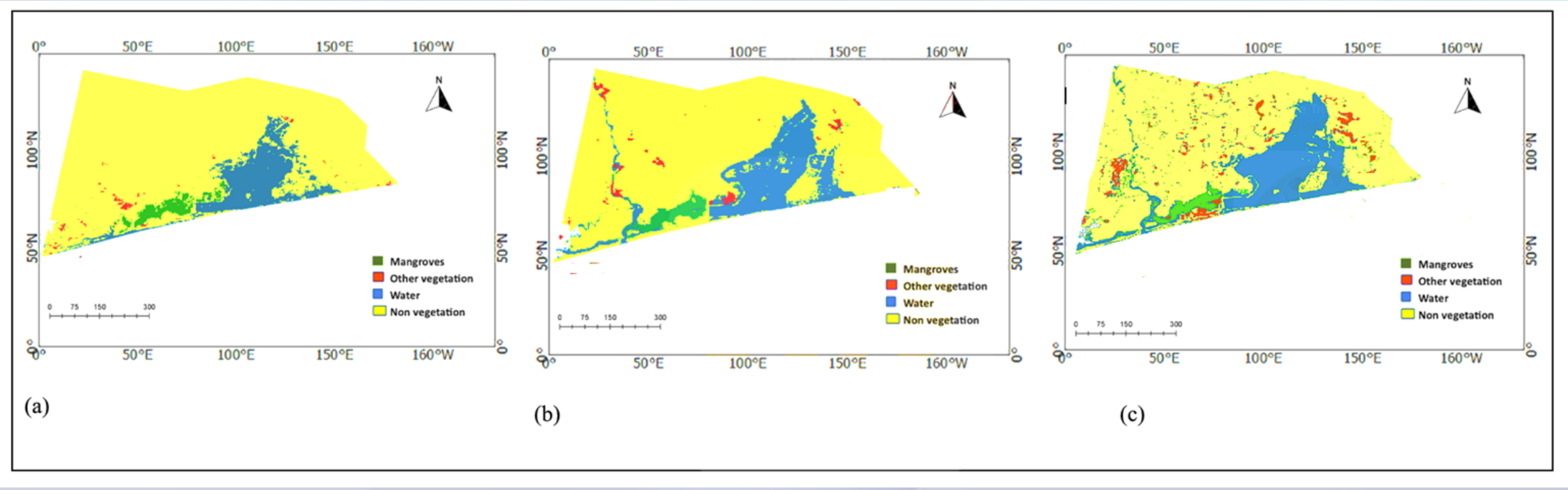

Fig 4.0: Map of land cover features over a decade 2015(a), 2020(b), 2025(c)

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Results & Discussion

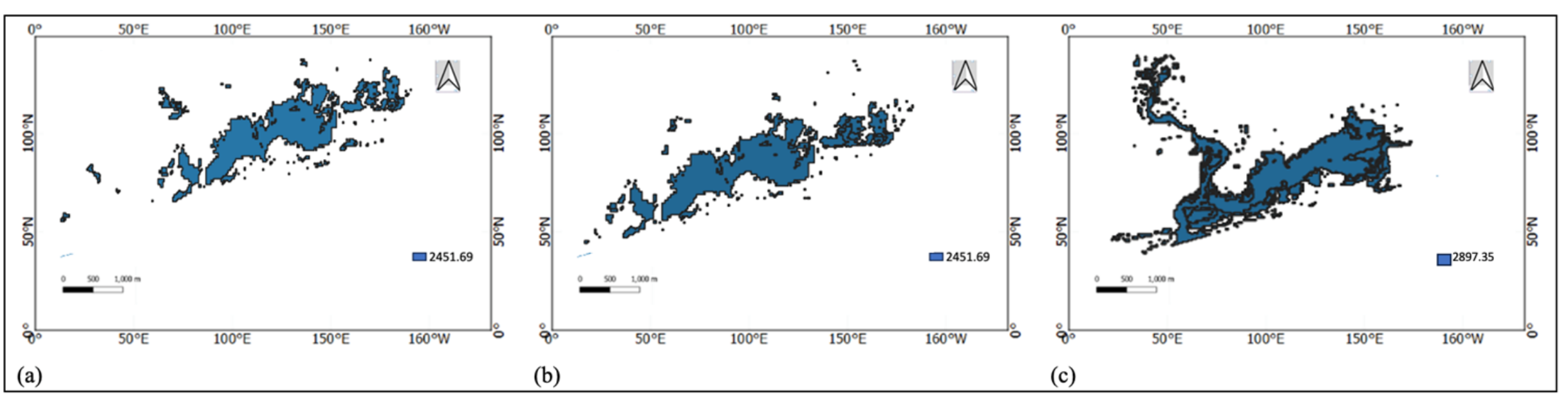

Fig 5.0: Map of total carbon stored over a decade 2015(a), 2020(b), 2025(c)

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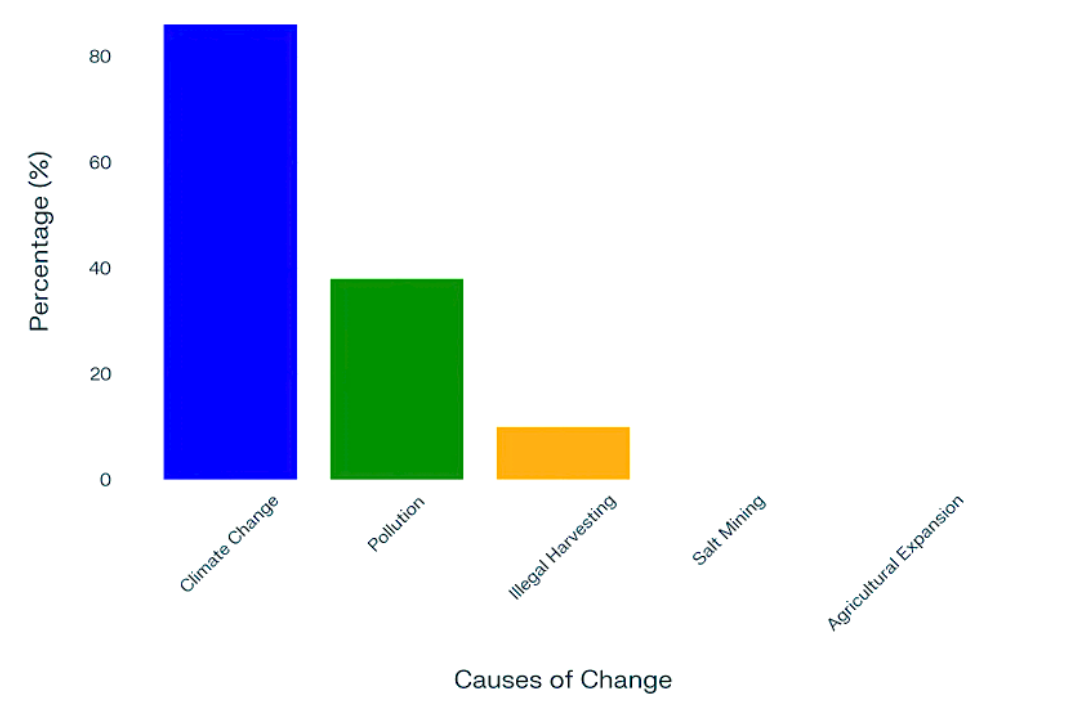
Results & Discussion



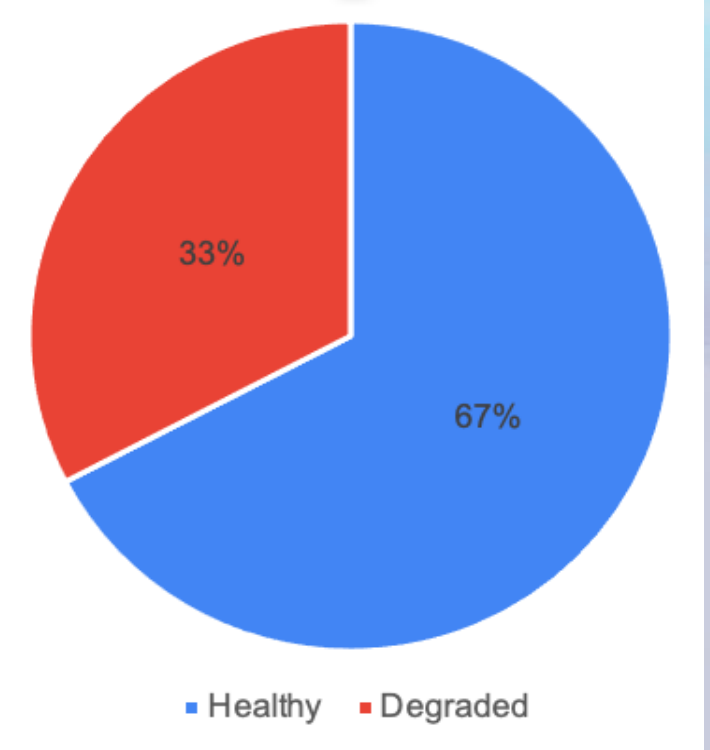


Fig 6.0: Perception of change in mangrove ecosystem

Results & Discussion

Table 1.0: Socio-economic factors influencing mangrove exploitation

Variable	Coefficient	Standard Error	P-value
Wood for Construction	0.60	0.20	0.003
Medicinal Purpose	0.30	0.25	0.231
Supply of Wood Fuel for Domestic Use	1.20	0.30	<0.001
Food (Fish/Shellfish)	0.50	0.25	0.046

Table 2.0: Willingness to use LPG as alternative energy sources

Variable	Coefficient	Standard Error	P-value
Subsidized Cost	1.50	0.30	<0.001
Improved Availability	1.20	0.25	<0.001
Training/Community Awareness	0.80	0.35	0.022

Conclusion

- Slight increase in mangrove cover (0.3,km^2, 0.31km^2, 0.4km^2)
- InVEST Coastal Blue Carbon model revealed similar carbon stock estimates of 2,451 Mg CO_2-eq for the 2015-2020 period, followed by a notable increase to 2,897.35 Mg CO_2-eq by 2025
- Local community perception generally viewed the mangroves as healthy, but a significant portion recognized degradation, primarily attributing changes to climate change.
- Socio-economic driver of mangrove exploitation in Woarabeba is the demand for wood fuel for domestic use, despite a community-attested ban.
- Willingness to adopt alternative energy sources, such as LPG, is strongly influenced by subsidized costs, highlighting as a crucial factor for reducing pressure on mangrove resources.

Recommendation

- Address any human-induced alterations to local hydrology (e.g., blocked tidal creeks) that might exacerbate climate impacts like sea-level rise
- Community-led planting activities aiming to increase the overall carbon sequestration capacity to surpass current levels.
- Develop targeted community awareness programs to align local perceptions with observed ecological changes, emphasizing the gradual nature of degradation.
- Enforce the existing ban on mangrove exploitation more effectively while providing viable alternatives to meet community needs.
- Implement programs that offer subsidized costs for alternative energy sources, especially LPG, to make them more affordable for coastal communities.

References

- Adotey, J., Acheampong, E., Aheto, D. W., & Blay, J. (2022). Carbon stocks assessment in a disturbed and undisturbed mangrove forest in Ghana. Sustainability, 14(19), 12782.
- Awuku-Sowah, E. M., Graham, N. A., & Watson, N. M. (2023). The contributions of mangroves to physiological health in Ghana: Insights from a qualitative study of key informants. Wellbeing, Space and Society, 4, 100137.
- Cummings, D., Boone Kauffman, J., Perry, D.A. & Flint Hughes, R. (2002). Aboveground biomass and structure of rainforests in the southwestern Brazilian Amazon. Forest Ecology and Management, 163, 293–307
- Ghana Statistical Service. (2010). 2010 Population and Housing Census: Summary Report of Final Results.
- Hoogsteen, M. J., Lantinga, E. A., Bakker, E. J., Groot, J. C., & Tittonell, P. A. (2015). Estimating soil organic carbon through loss on ignition: effects of ignition conditions and structural water loss. European Journal of soil science, 66(2), 320-328.
- Jaramillo, V. J., Kauffman, J. B., Rentería-Rodríguez, L., Cummings, D. L., & Ellingson, L. J. (2003). Biomass, carbon, and nitrogen pools in Mexican tropical dry forest landscapes. Ecosystems, 6, 609-629.
- Kauffman JB, Sanford RL, Cummings DL, Salcedo IH, Sampaio EVSB (1993) Biomass and nutrient dynamics associated with slash fires in neotropical dry forests. Ecology 74: 140–151
- Kauffman, J.B., & Donato, D. (2011). Protocols for the measurement, monitoring and reporting of structure, biomass and carbon stocks in mangrove forests. Bogor, Indonesia: Center for International Forestry Research (CIFOR).
- Komiyama, A., Ong, J.E., & Poungparn, S. (2008). Allometry, biomass, and productivity of mangrove forests: A review. Aquatic Botany, 89, 128–137.Lee, C. K., Duncan, C., Nicholson, E., Fatoyinbo, T. E., Lagomasino, D., Thomas, N., ... & Murray, N. J. (2021). Mapping the extent of mangrove ecosystem degradation by integrating an ecological conceptual model with satellite data. Remote Sensing, 13(11), 2047.
- Mcleod, E., Chmura, G.L., Bouillon, S., Salm, R., Björk, M., Duarte, C.M. et al. (2011). A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO2 . Frontiers in Ecology and the Environment, 9, 552–560.
- Nunoo, F. K., & Agyekumhene, A. (2022). Mangrove degradation and management practices along the coast of Ghana. Agricultural Sciences, 13(10), 1057-1079.
- Sagoe-Addy, K., & Appeaning Addo, K. (2013). Effect of predicted sea level rise on tourism facilities along Ghana's Accra coast. Journal Of Coastal Conservation, 17(1), 155-166.
- Spalding, M., Kainuma, M., & Collins, L. (2010). World Atlas of Mangroves (London: Earthscan and James & James)

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