RISK AND ADAPTATION BEHAVIOUR TO SEA-LEVEL IN COASTAL RURAL COMMUNITIES IN GHANA

PhD External Defence

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(PhD/SPS/FT/2019/11124)

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Presentation Outline

- Background
- Statement of the problem
- Aim/Objectives
- Study area
- Theoretical framework
- Conceptual framework
- Materials and methods
- Results and Discussion
- Summary of findings
- Conclusion
- Recommendation

Background

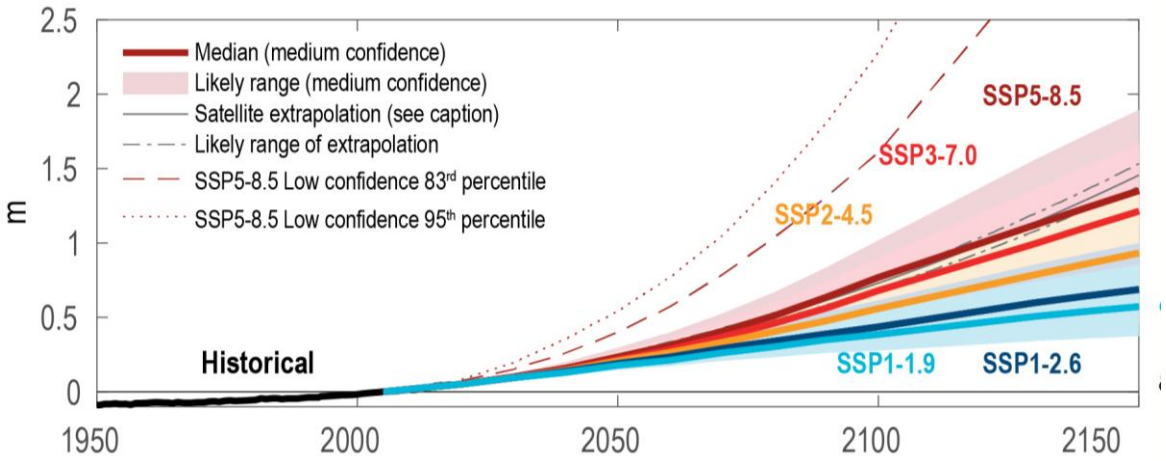

Fig 1: Projected global mean sea level rise under different SSP scenarios. Source: IPCC AR6 report (2021)

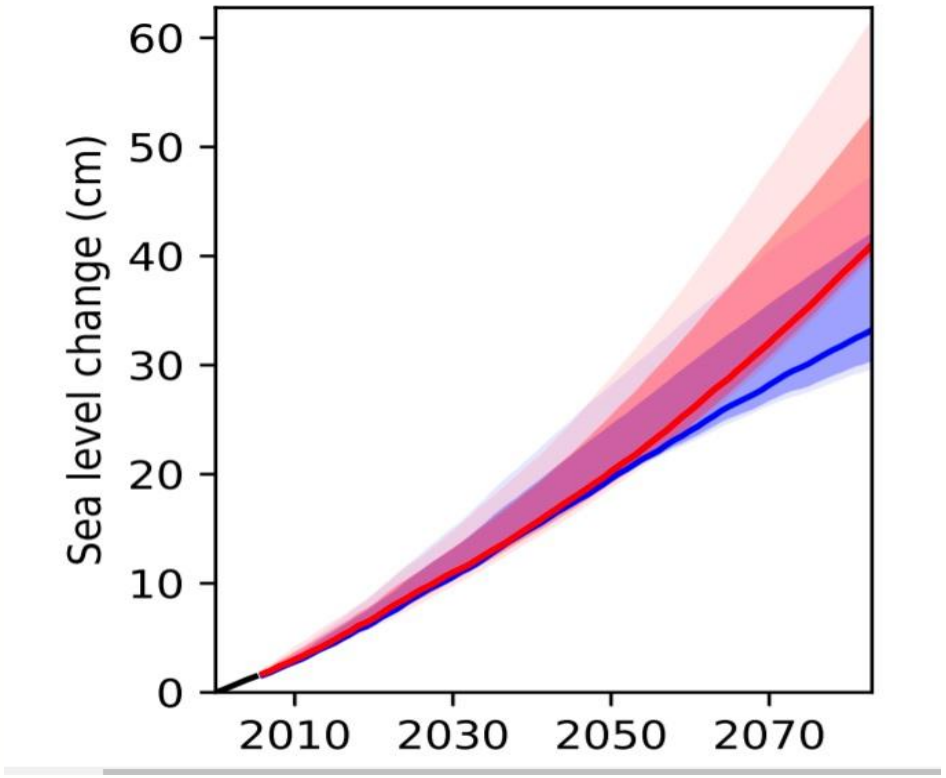

Fig 2: Sea level rise projections for the coast of Ghana for different GHG emissions scenarios, relative to the year 2000. Source: BMZ, (2019)

Background

Sea Level Rise: Why should we care?

- ✓ Decline in extent of salt marshes & mangrove
- ✓ Increased in coral bleaching
- ✓ Increased in coastal erosion and flooding
- ✓ Increased salt intrusion

Coastal rural communities face the double jeopardy of direct risk to human lives and indirect risk to the natural ecosystems they rely on as their primary means of sustenance.
(Osman et al., 2016; Bhattachan et al., 2018)

Statement of Problem

Statement of Problem

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Proper adaptation measures to build coastal rural communities' resilience to the impacts of SLR requires a detailed mapping and understanding of the local sea level dynamics as well as its impacts on socio-ecological systems.

Hence, the study aimed to assess the risk of different sea-level rise scenarios and the adaptation behaviour in study communities.

Aim/Objectives

Assess the sea-level rise risk levels and adaptation behaviour of coastal rural residents in anticipation of sea-level rise.

- Model the impacts of different sea-level rise scenarios on the three rural coastal communities
- Map the elements exposed to impacts of projected sea-level rise within the study communities
- Assess the vulnerability of the rural coastal social-ecological systems to impacts of projected sea-level rise
- Assess the risk levels of the rural coastal communities under study to impacts of projected sea-level rise.
- Examine the factors influencing household's relocation intention in response to anticipation of sea-level rise.

Research Questions

1. How will an increase in sea level rise impact the rural coastal communities?

2. What socio-ecological systems in the communities will be exposed to these impacts?

3. How vulnerable are the rural coastal social-ecological systems to impacts of projected sea-level rise?

4. What are the risk levels of the rural coastal communities under study to impacts of projected sea-level rise?

5. What factors influence the household intention to relocate in anticipation of sea-level rise?

Justification of study

- Few studies have assessed this impact on rural socio-ecological systems globally (Bhattachan et al., 2018; Genua-Olmedo et al., 2016; Smart, 2019).
- In Ghana, the few studies conducted in rural areas mostly considered flood risk to people but without assessment of sea-level rise risk on socio-ecological systems and its associated adaptation (Appeaning Addo et al., 2018; Jayson-Quashigah et al., 2019; Osman et al., 2016).
- The study will provide vital information to the national data which is essential in achieving the Sustainable Development Goals; Sustainable Cities and Communities (Goal 11) and Climate Action (Goal 13).
- This study will also provide the basis for policy and adaptation strategy improvement or formulation for other vulnerable coastal rural communities.

Study Area

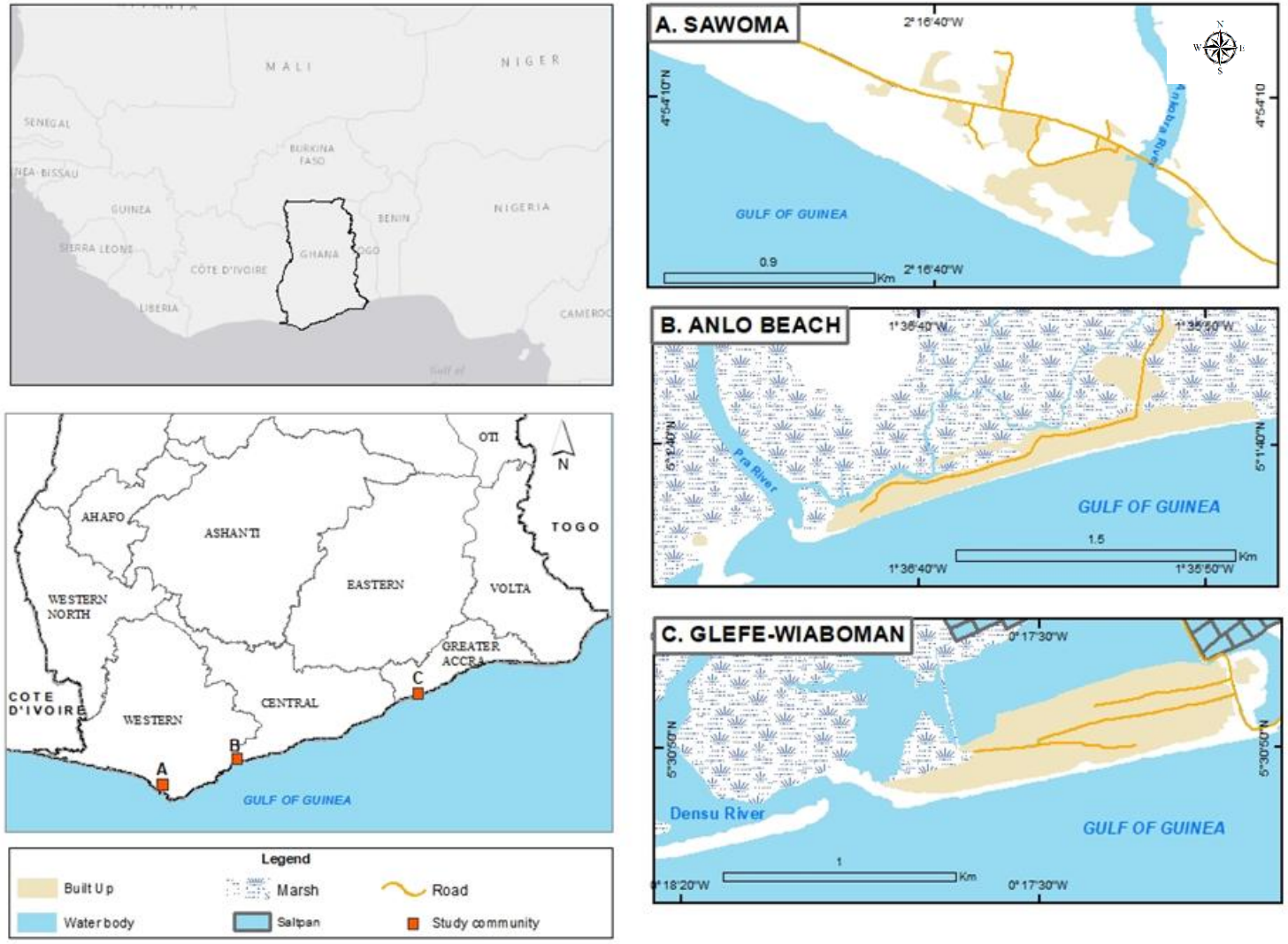


Fig 4: Map showing the location of study communities

Theoretical Framework

- The Concept of Climate Risk Assessment (IPCC,2014)
- Sustainable Livelihood Framework (Department for International Development (2000a)
- The Common International Classification of Ecosystem Services (CICES) Haines-Young & Potschin-Young, (2018).
- Protection Motivation Theory (Rogers, 1975)

Conceptual Framework

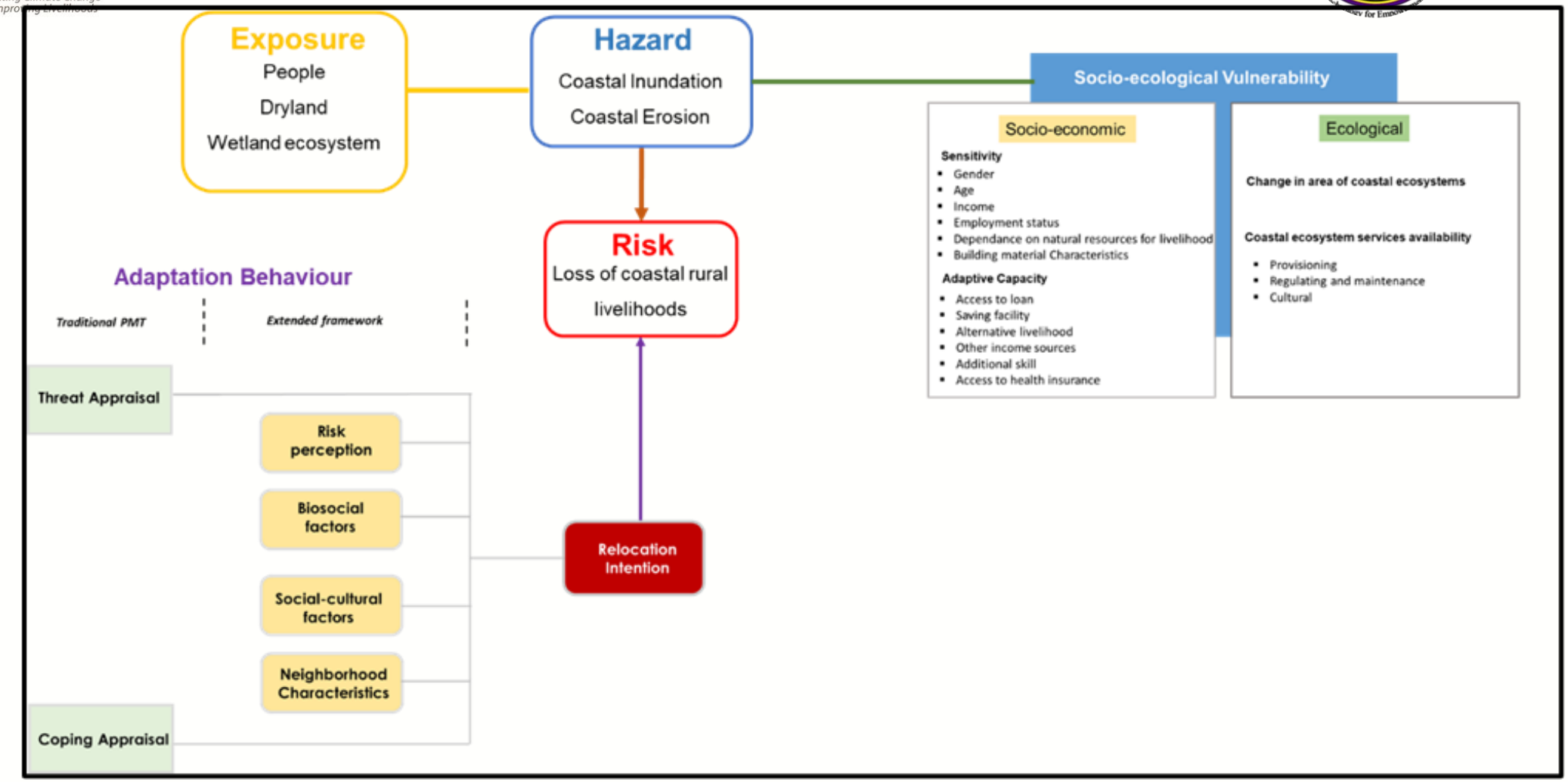


Fig 5: Conceptual framework for the study (Adapted from IPCC (2014a) and Poussin et al. (2014))

Materials and Methods

Field Data Collection

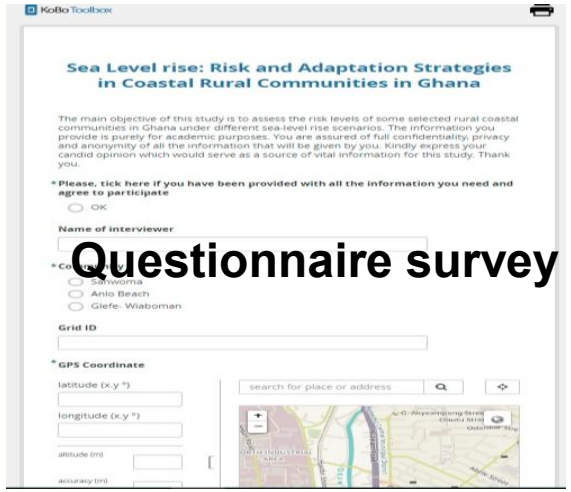
Reconnaissance survey and community entry (Anlo beach)

Focus Group Discussion (Sawoma)

Participatory mapping (Anlo Beach)

UAV survey

GPS survey



Questionnaire survey

Secondary Data Collection

Materials and Methods

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Table 1: Secondary data collected for the study

Data Type	Data source	Use
Aerial orthophoto (1975, 2005 and 2018)	Centre for Coastal Mgt., UCC	Shoreline Analysis
Sentinel satellite images (2021)	Copernicus Scihub	Land use/cover Mapping
Projected average sea level for RCP 8.5	Literature (Church et al., 2013a ;Jevrejeva et al., (2014)	Sea level rise impact modelling

Materials and Methods

Sampling Techniques

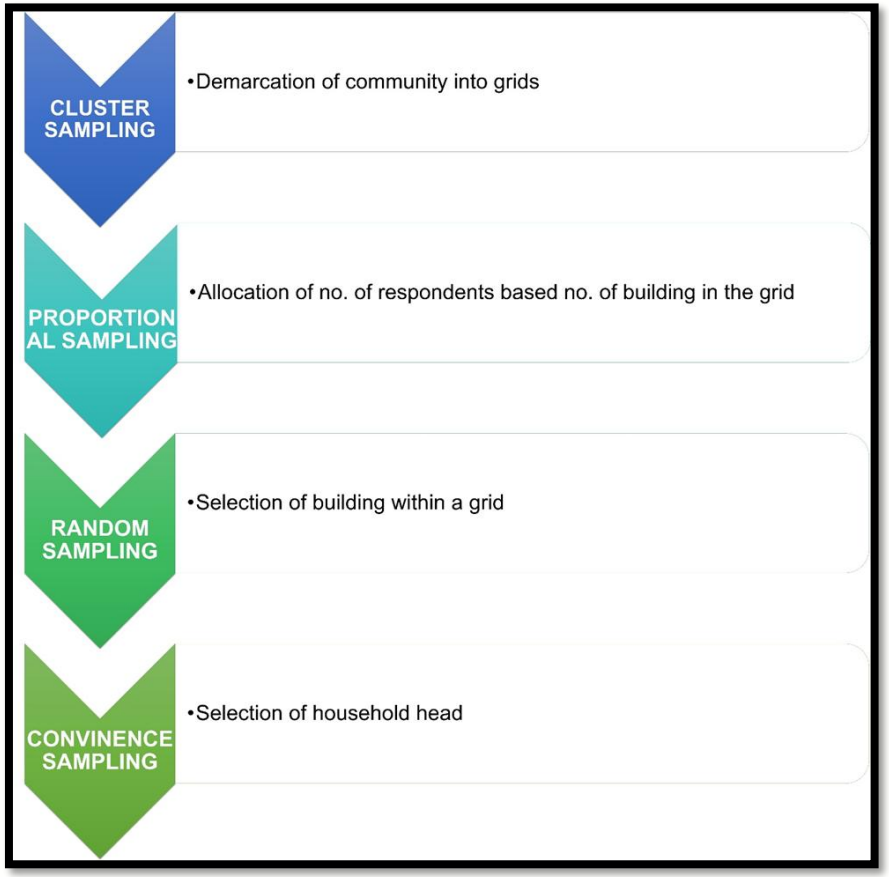

Fig 4: Summary of the sampling procedure for selection of respondents for the study

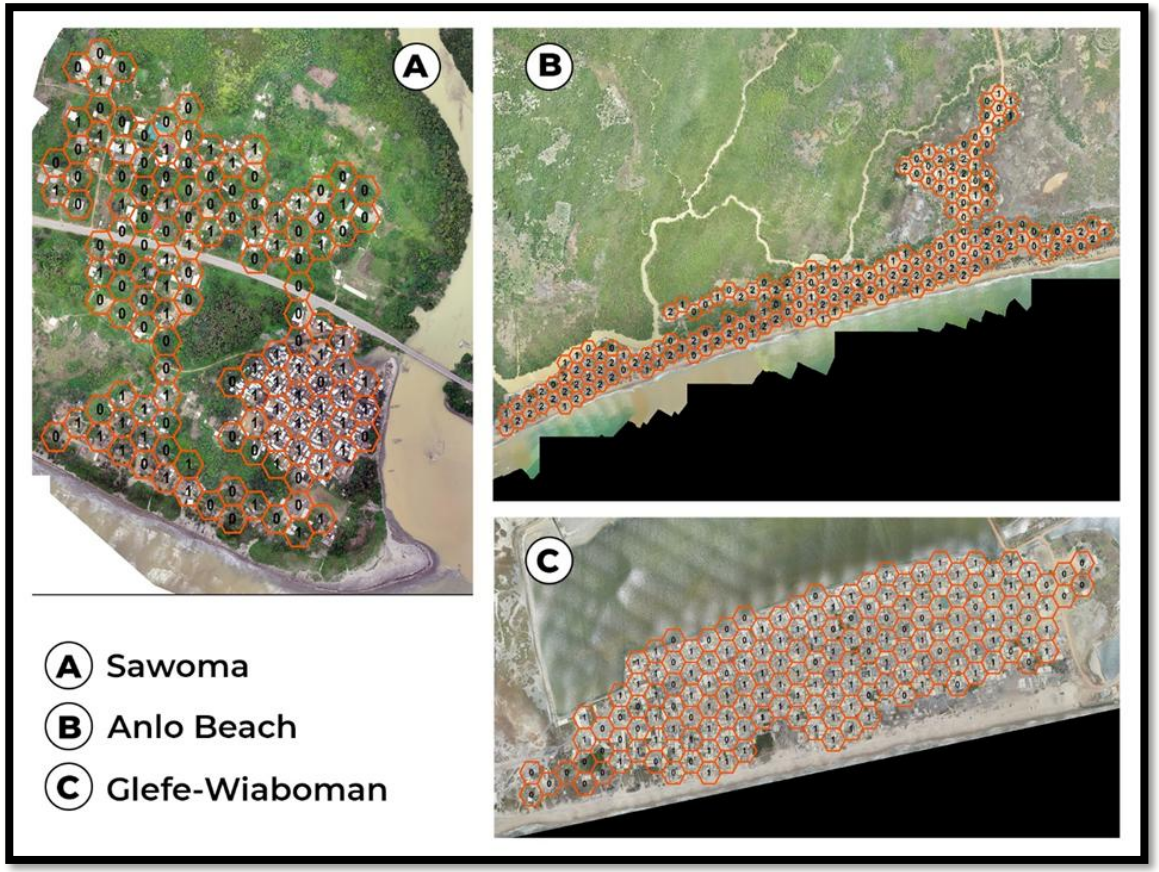

Fig 5: Sample grids for the three study communities

Materials and Methods

Data processing & Analysis

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Table 2: Summary of data types, methods, and outputs

Data type	Processes	Software used	Output
UAV Images	Image processing, orthorectification with GCPs, Point cloud classification, masking, and interpolation	Pix4Dmapper and ArcGIS Pro	Digital Terrain Model (DTM) Orthophoto and Slope
Sentinel Satellite images	Image pre-processing and Classification, Accuracy assessment	ArcGIS Pro	Land use/cover maps
Aerial orthophotos (1975-2021)	Georeferencing, digitization, calculation of shoreline rates	ArcMap, DSAS	Erosion and accretion rates
Social Survey (FGD, household survey, expert survey and Interviews)	Data processing, descriptive analysis, exploratory factor analysis, post-hoc test and multivariate analysis	Microsoft excel, IBM SPSS	Exposure indicator Socio-economic Vulnerability indicators Adaptation behaviour

Materials and Methods

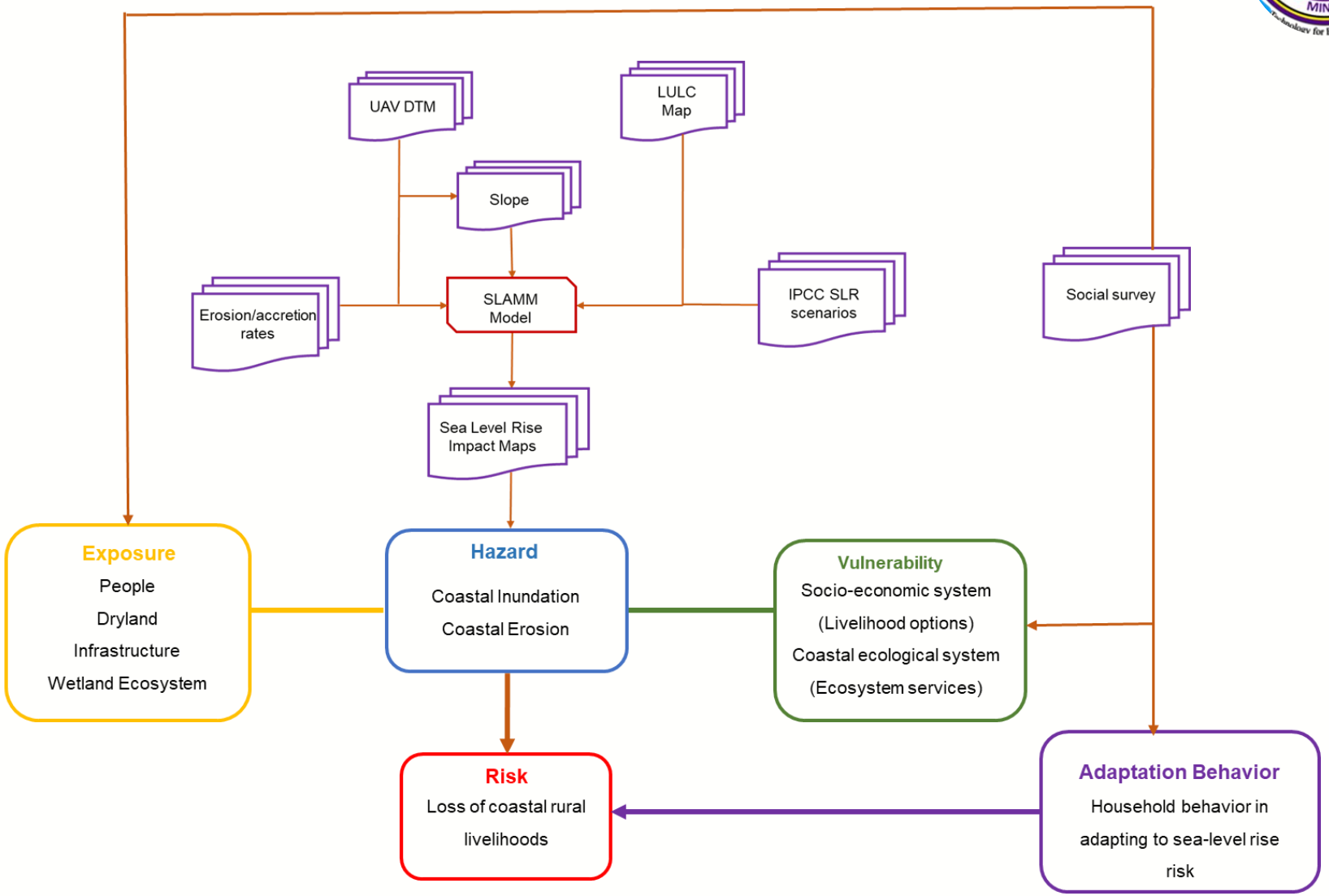

Fig 6: Methodological workflow for the study

OBJECTIVE 1

Results and Discussion

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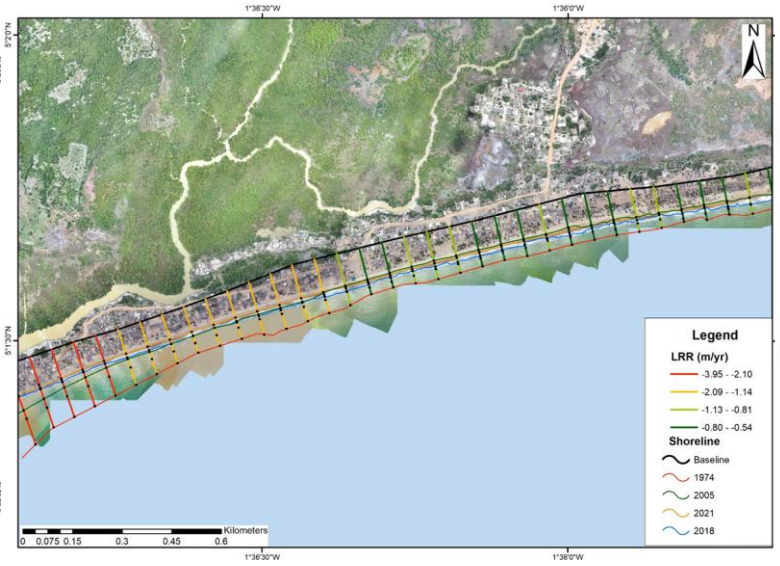
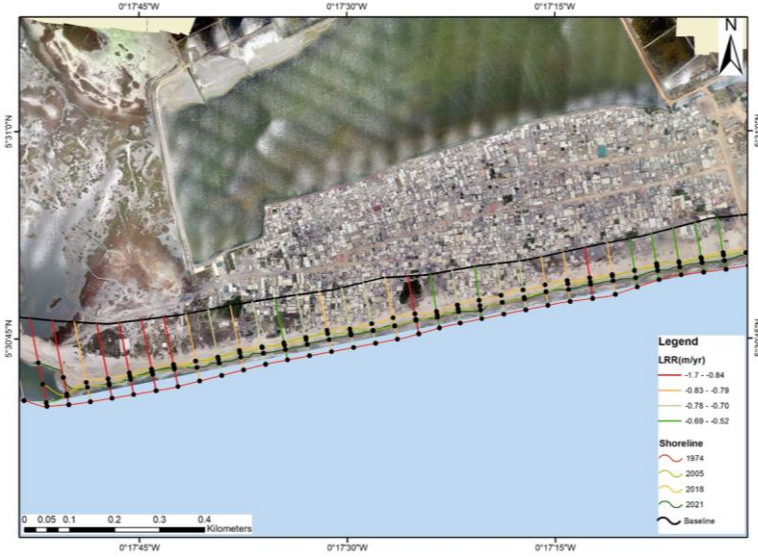
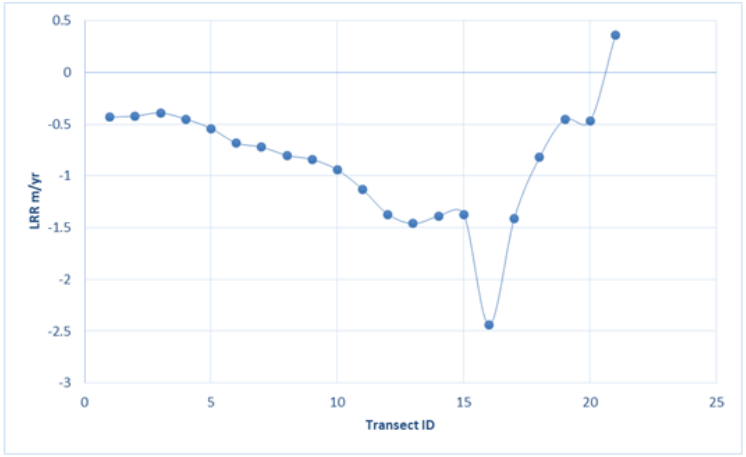
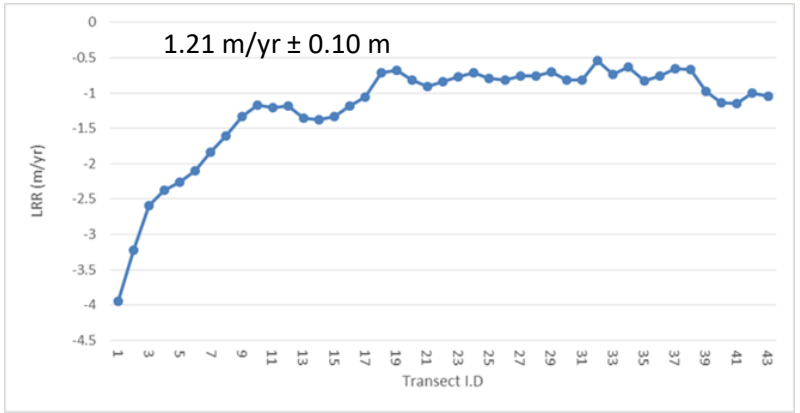
Shoreline change rate (m/yr) for the period 1975-2021







A. Sanwoma



B. Anlo Beach

C. Glefe-wiaboman

Results and Discussion

OBJECTIVE 1

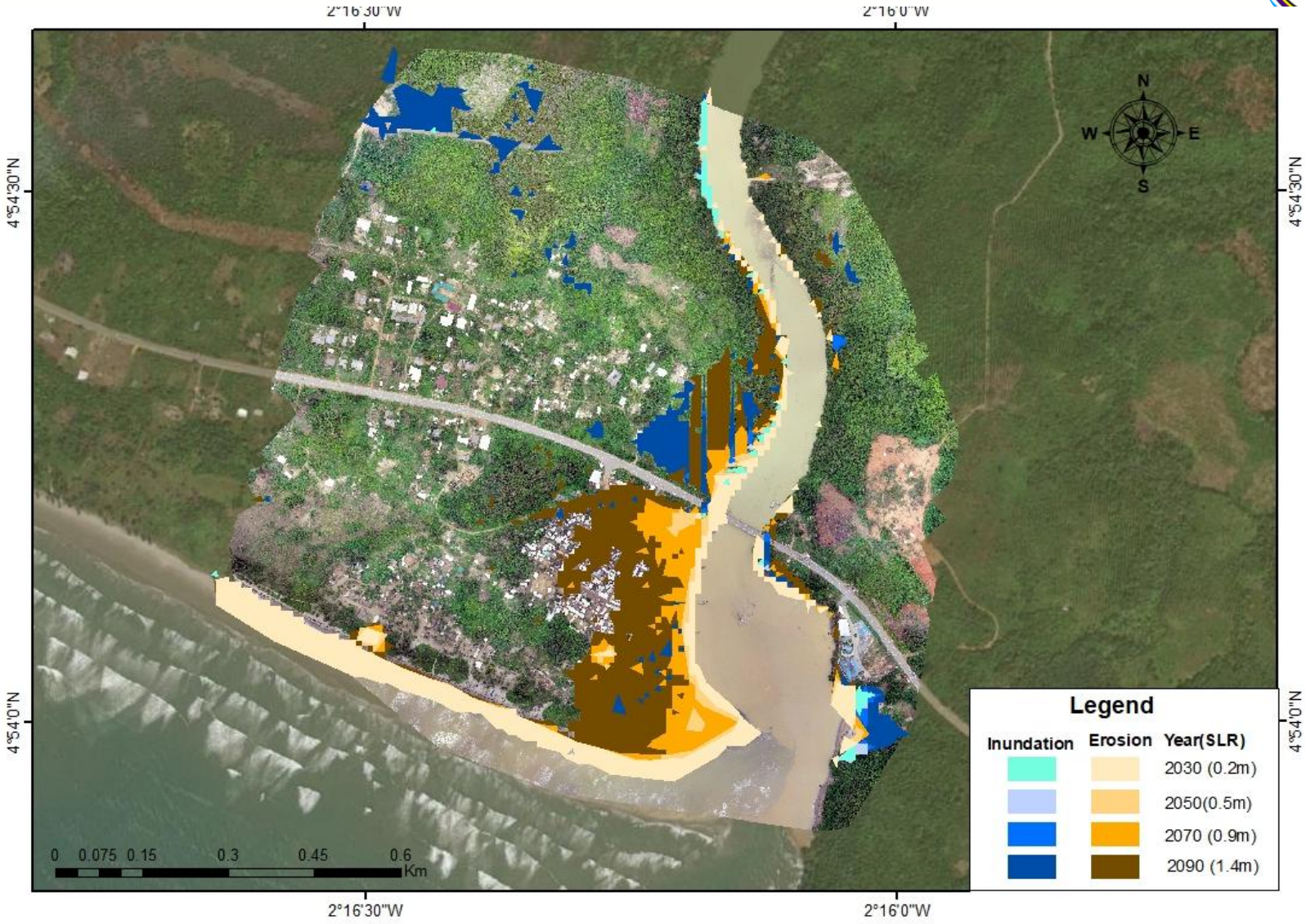


Fig 7: Sea level rise impacts map for Sanwoma community

Results and Discussion

OBJECTIVE 1

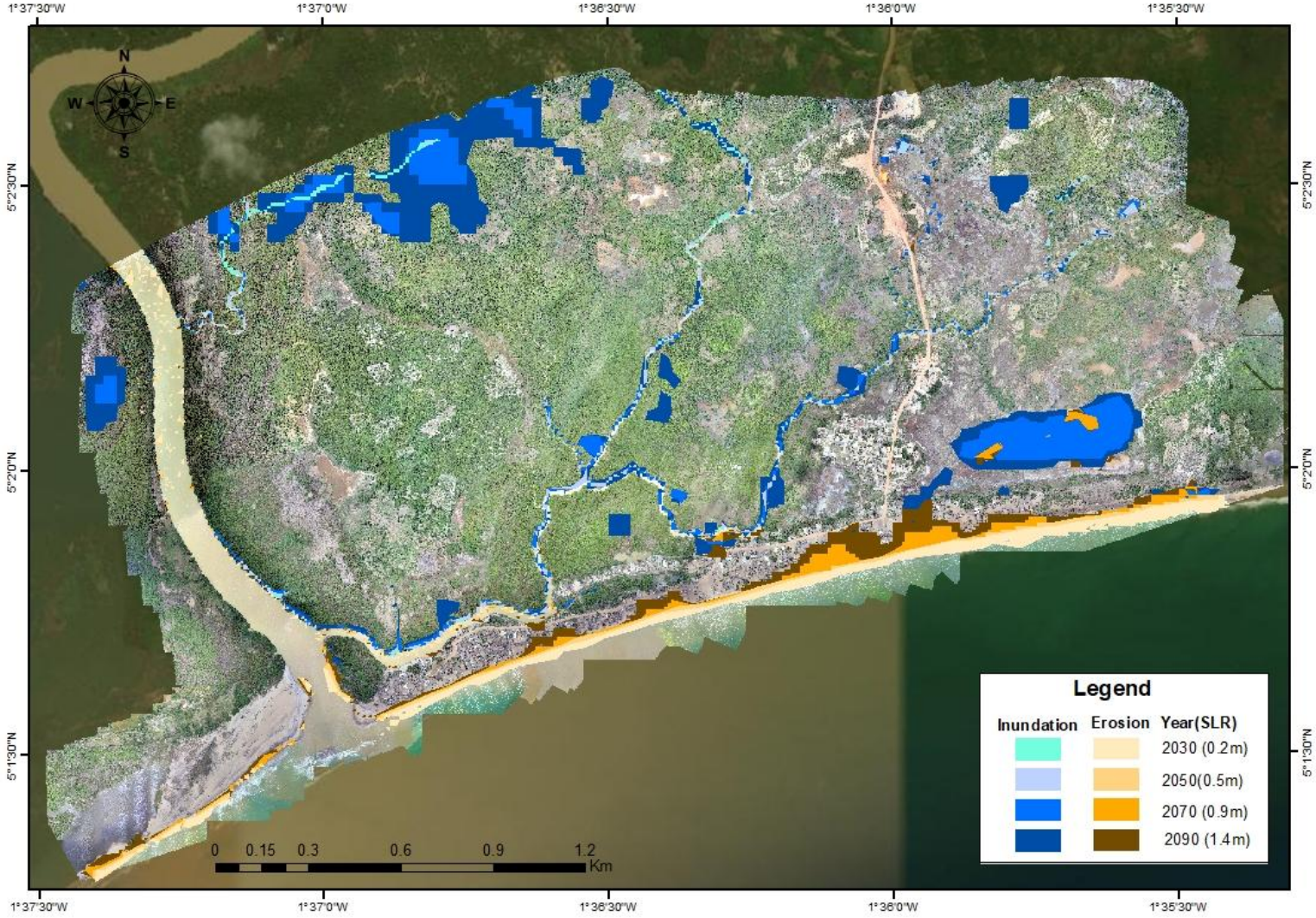


Fig 8: Sea level rise impacts map for Anlo beach community

Results and Discussion

OBJECTIVE 1

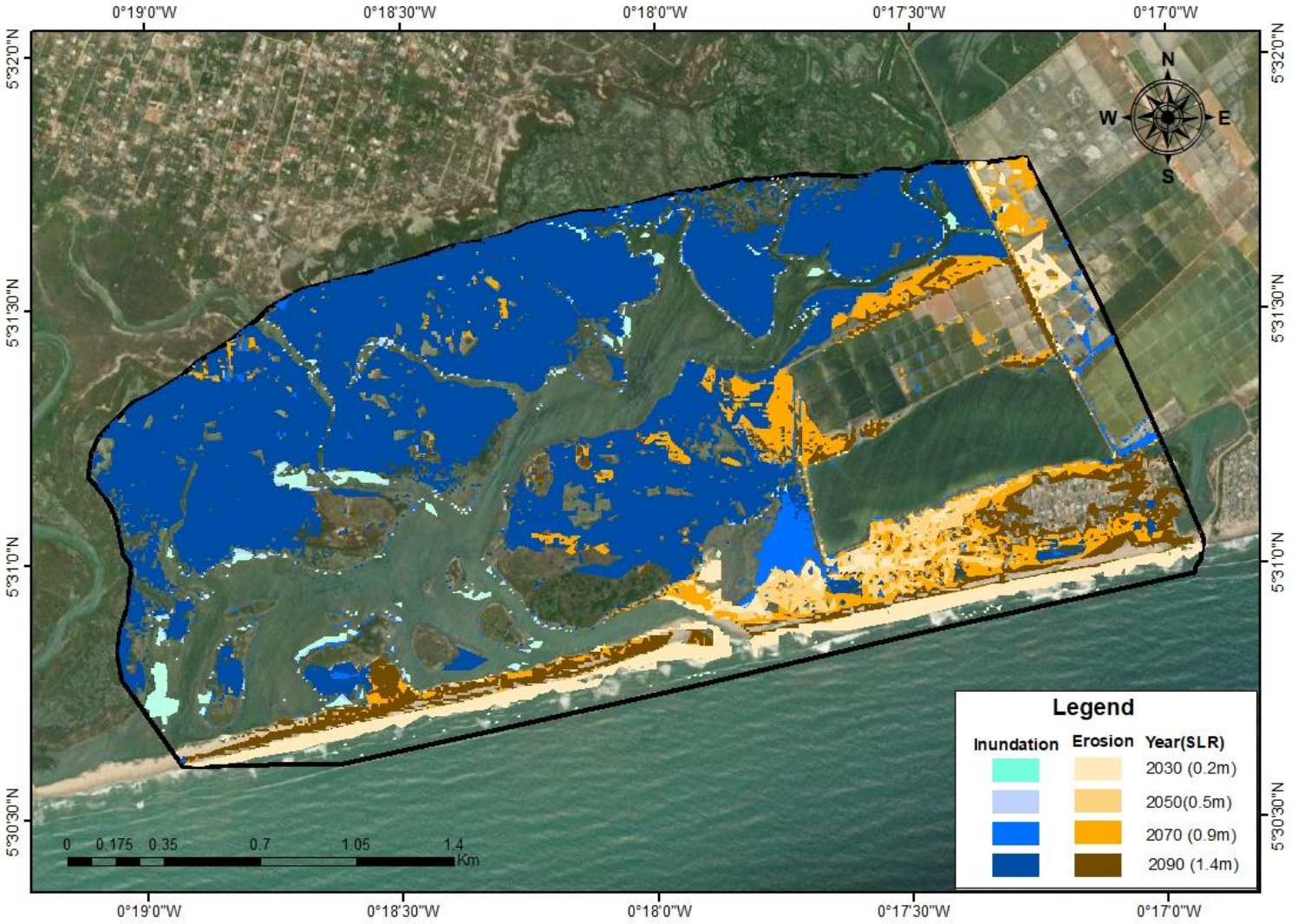
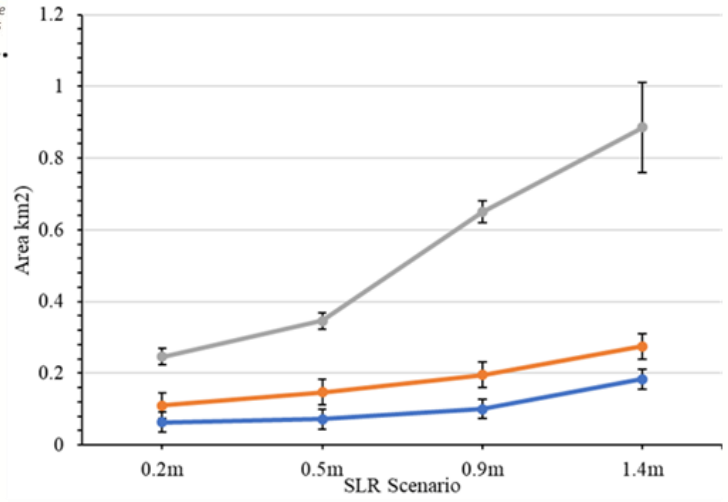


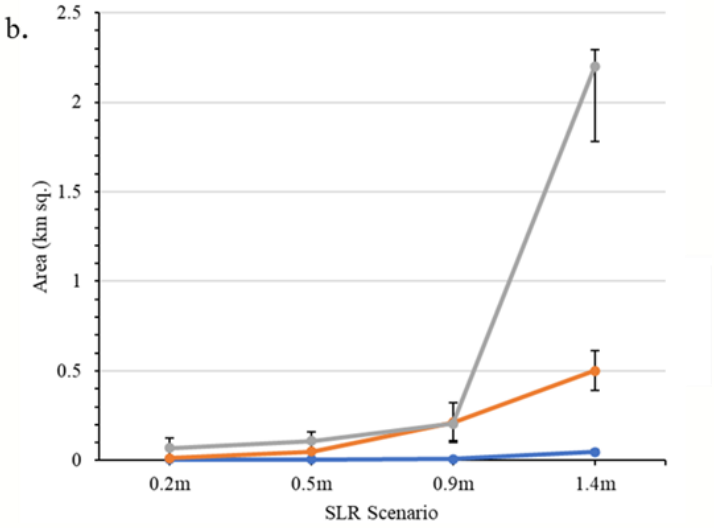
Fig 9: Sea level rise impacts map Glefe-wiaboman community

Results and Discussion

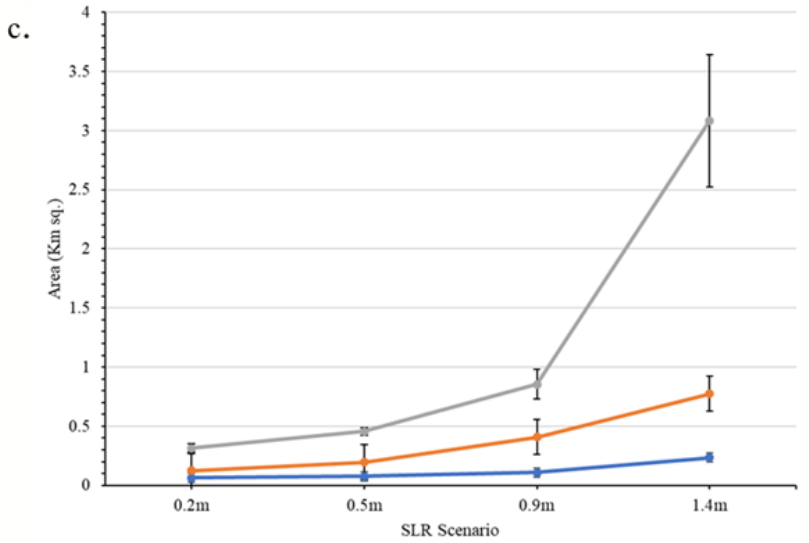
OBJECTIVE 1



a. Erosion/accretion



b. Inundation



C. Erosion and Inundation

Fig 10: Area of land impacted by coastal hazards under different SLR scenarios

OBJECTIVE 2

Results and Discussion

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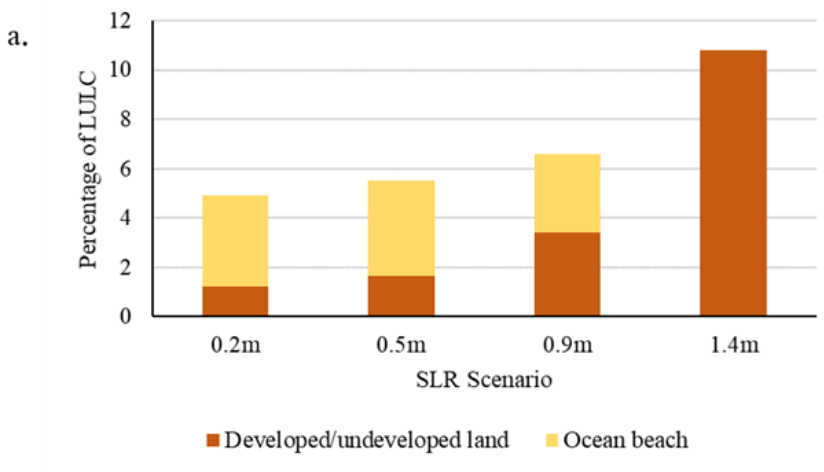
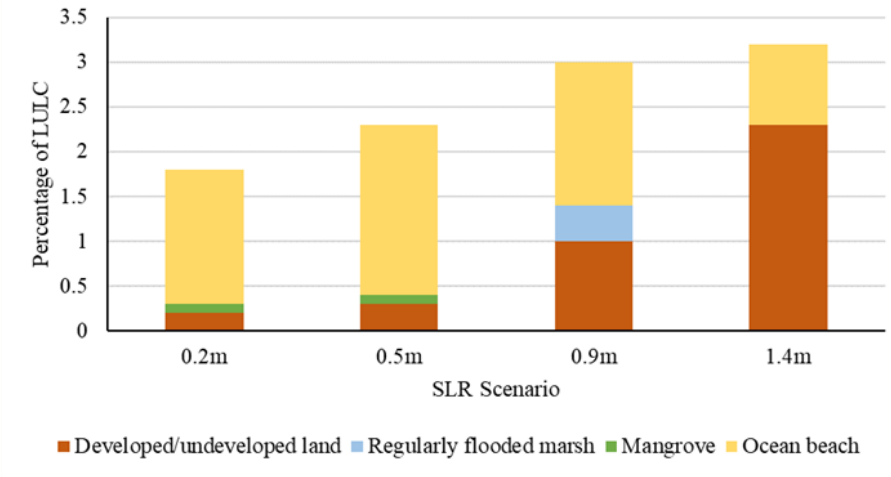
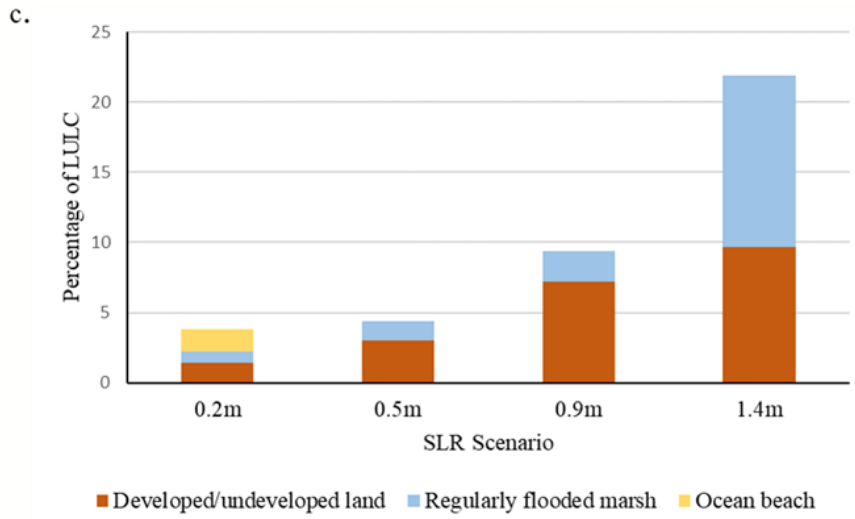
A. Sanwoma



B. Anlo Beach





C. Glefe-wiaboman

Fig 11: Percentage of Land use/cover likely to be exposed to SLR impacts

Results and Discussion

OBJECTIVE 2

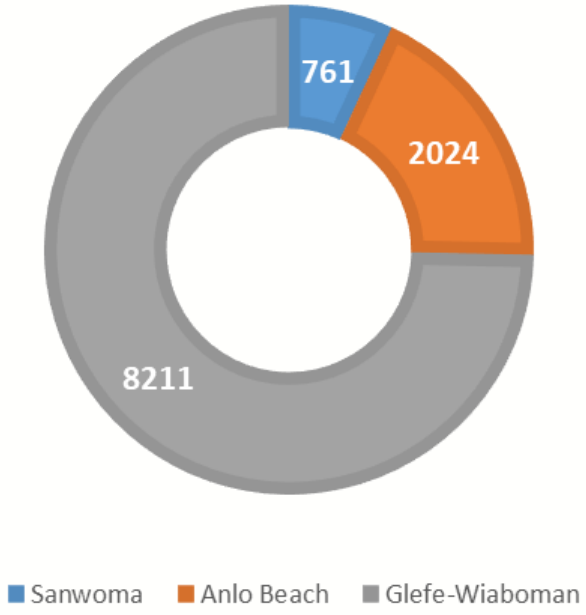


Fig 12: Number of people likely to be exposed to SLR impacts

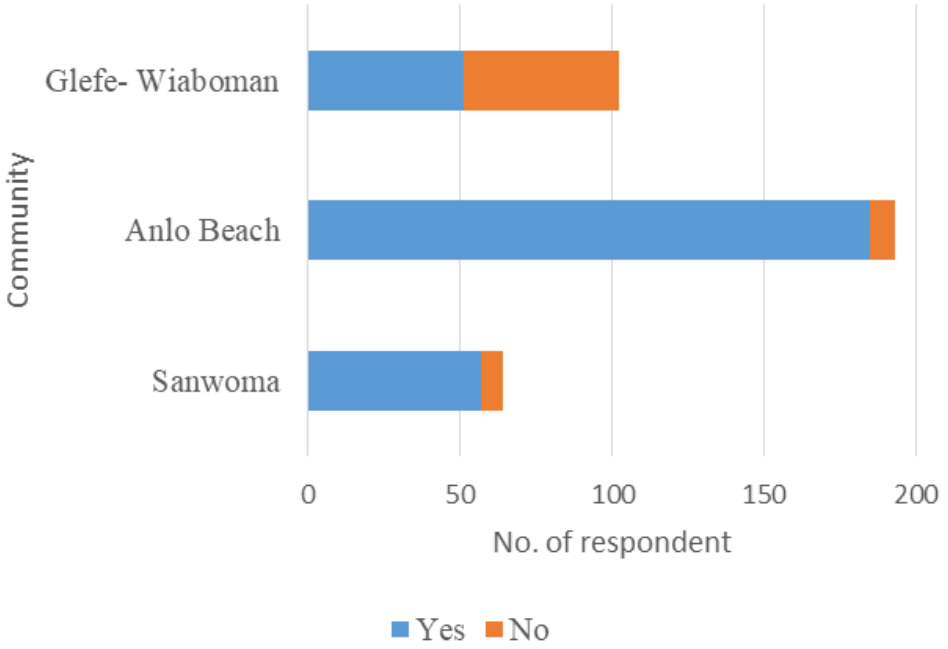


Fig 13: Respondents' experience of sea-level impacts (Coastal erosion/flooding)

Results and Discussion

OBJECTIVE 3

WASCAL
Combating Climate Change and Improving Livelihoods

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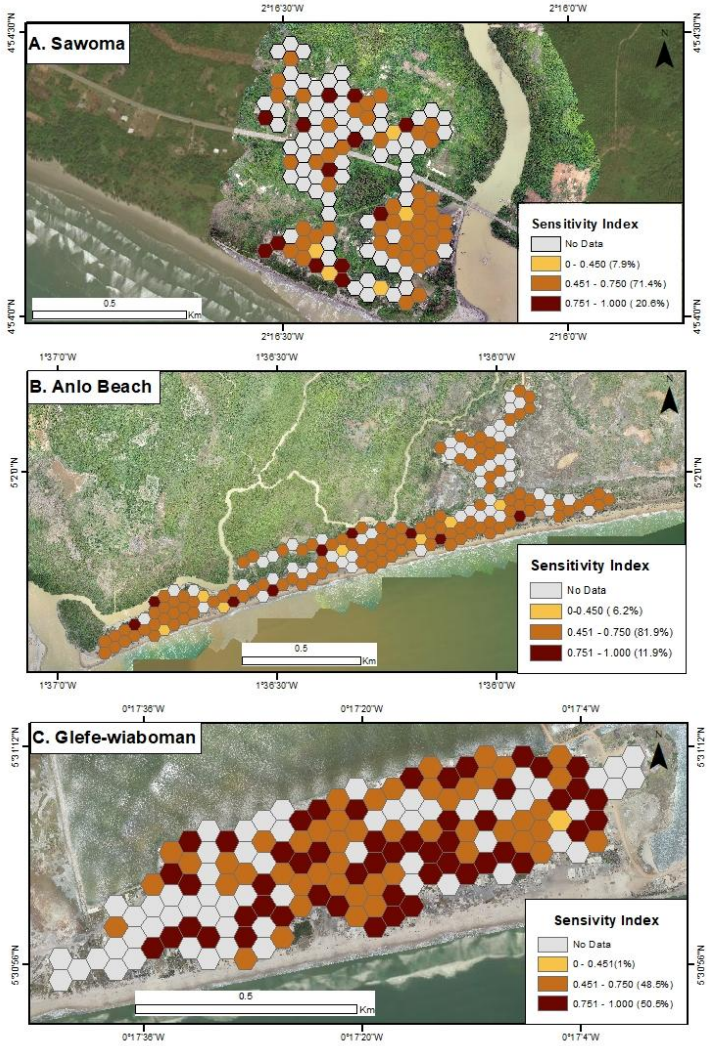
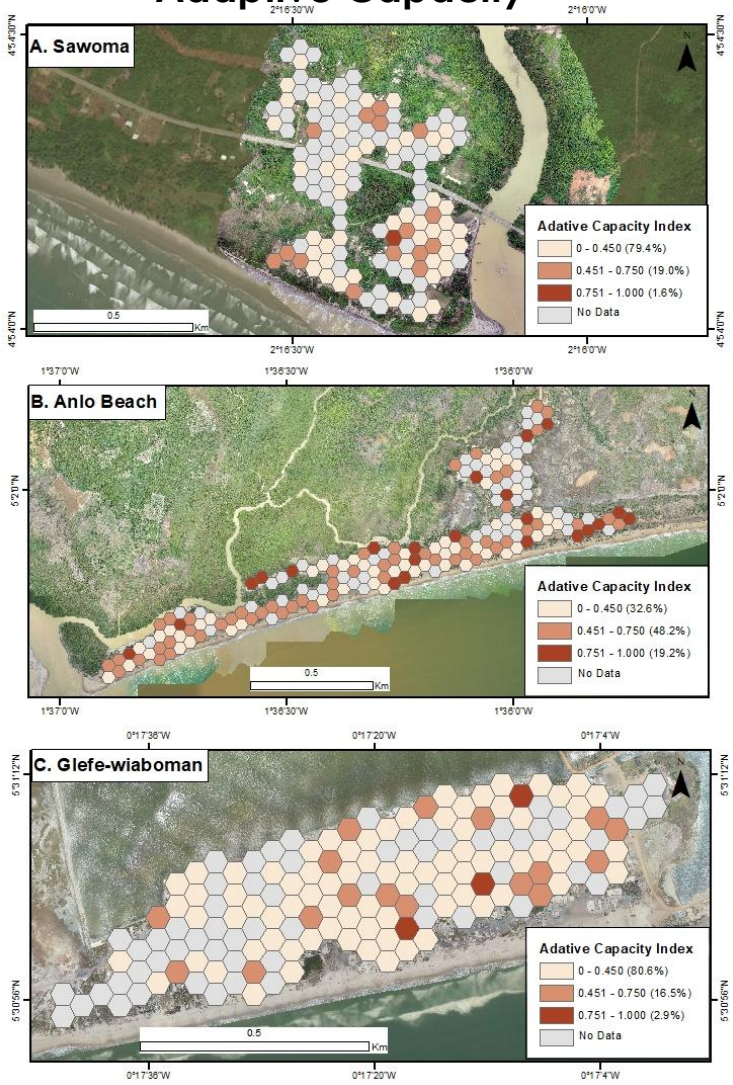
Sensitivity



Adaptive Capacity



Socio-economic Vulnerability

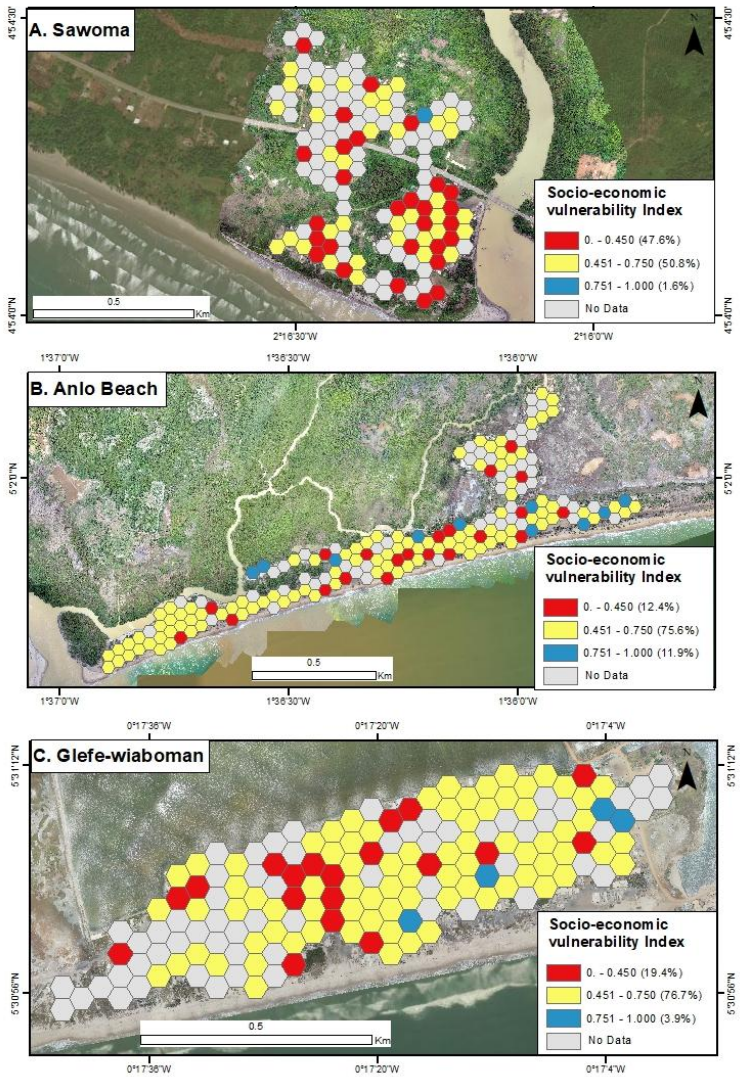


Fig. 14: Socio-economic Vulnerability Assessment

Results and Discussion

OBJECTIVE 3

Table 3: Change in area (Km^2) coastal ecosystems induced by different SLR scenarios

	0.2m	0.5m	0.9m	1.4m
Coastal ecosystems	**Sawoma**			
Regularly flooded marsh	+0.277	+0.350	+0.562	+2.197
Open beach	-3.715	-3.883	-3.197	+1.919
	Anlo Beach			
Regularly flooded marsh	+0.138	+0.173	-0.370	+0.115
Mangrove	-0.101	-0.115	+0.586	+0.439
Open beach	-1.495	-1.854	-1.632	-0.907
	Glefe-wiaboman			
Regularly flooded marsh	-0.737	-1.369	-2.212	-12.186
Mangrove	+0.750	+1.384	+2.451	+12.974
Open beach	-1.601	-0.174	+2.599	+2.683

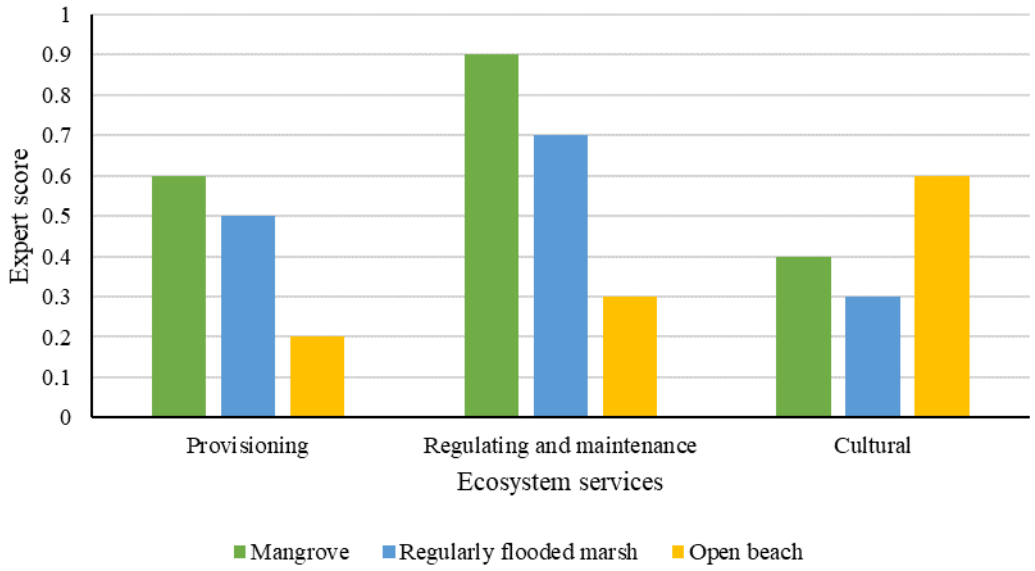


Fig. 15: Expert scores on coastal ecosystem services

Table 4: Cumulative ecological vulnerability index for the study communities

Community	Ecological vulnerability
Sawoma	0.5
Anlo beach	0.6
Glefe-wiaboman	0.3

OBJECTIVE 3

Results and Discussion

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Table 5: Socio-ecological Vulnerability Index for Study Communities

Community	Socio-economic Vulnerability	Ecological Vulnerability	Socio-Ecological Vulnerability
Sawoma	0.484	0.5	0.49
Anlo beach	0.599	0.6	0.60
Glefe-wiaboman	0.551	0.3	0.43

Results and Discussion

OBJECTIVE 4

Table 6: Indices for hazard, exposure, vulnerability, and risk for the study communities

Community	Hazard	Exposure	Vulnerability	Risk
Sawoma	0.01	0.31	0.49	0.27
Anlo Beach	0.25	0.48	0.60	0.44
Glefe-wiaboman	1	0.7	0.43	0.71

Results and Discussion

OBJECTIVE 5

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Table 7: Ordered logistic regression model showing the relation between relocation intention and household characteristics.

Variables	Odds ratio	Robust SE	P-value	Conf. Interval	
Model 1: Cognitive Factors					
Risk perception	1.495	0.179	0.001	1.182	1.890
Threat Appraisal	1.334	0.160	0.017	1.054	1.688
Coping Appraisal	1.304	0.190	0.068	0.980	1.734
Model 2: Model 1 + Biosocial factors					
Risk perception	1.572	0.200	0.000	1.225	2.018
Threat Appraisal	1.327	0.165	0.023	1.040	1.692
Coping Appraisal	1.290	0.182	0.071	0.979	1.700
Sex (ref: Female)					
Male	1.202	0.350	0.527	0.679	2.128
Age (ref: Young adult)					
Middle-aged adult	0.440	0.155	0.020	0.221	0.876
Older adult	0.919	0.490	0.875	0.323	2.614
Model 3: Model 2 + Socio-cultural factors					
Risk perception	1.633	0.215	0.000	1.261	2.115
Threat Appraisal	1.359	0.177	0.019	1.052	1.754
Coping Appraisal	1.208	0.178	0.198	0.906	1.611
Sex (ref: Female)					
Male	1.141	0.346	0.664	0.629	2.068
Age (ref: Young adult)					
Middle-aged adult	0.397	0.154	0.017	0.185	0.850
Older adult	0.725	0.402	0.562	0.245	2.148
Education (ref: No formal education)					
Primary	1.370	0.608	0.478	0.574	3.270
Middle School/JHS	1.383	0.615	0.467	0.578	3.308
Secondary School and above	1.290	0.717	0.646	0.434	3.832
Household monthly income (GHC) (ref: below 100)					
101-500	0.394	0.218	0.093	0.133	1.167
501-999	1.014	0.692	0.984	0.266	3.862
1000 and above	0.303	0.189	0.056	0.089	1.030
Model 4: Model 3+ Contextual factors					
Risk perception	1.421	0.223	0.025	1.045	1.933
Threat Appraisal	1.316	0.175	0.039	1.014	1.707
Coping Appraisal	1.178	0.171	0.260	0.886	1.565
Sex (ref: Female)					
Male	1.141	0.352	0.668	0.623	2.090
Age (ref: Young adult)					
Middle-aged adult	0.403	0.155	0.018	0.190	0.857
Older adult	0.693	0.380	0.504	0.237	2.030
Education (ref: No formal education)					
Primary	1.473	0.676	0.398	0.599	3.620
Middle School/JHS	1.547	0.702	0.336	0.636	3.765
Secondary School and above	1.519	0.908	0.485	0.471	4.900
Household monthly income (GHC) (ref: below 100)					
101-500	0.375	0.200	0.067	0.132	1.069
501-999	0.995	0.661	0.994	0.271	3.657
1000 and above	0.302	0.184	0.049	0.092	0.995
Hazard Experience (ref: No)					
Yes	1.704	0.683	0.184	0.777	3.739
Elevation	1.010	0.100	0.918	0.832	1.226
Distance of house from Shoreline (ref: below 100m)					
100-300m	0.655	0.238	0.244	0.321	1.335
Above 300m	0.862	0.469	0.785	0.297	2.502

Summary of Findings

1. Some coastal rural communities with open sandy beaches experienced higher coastal erosion rates.

2. SLR impacts influence settlement growth and patterns in the rural coastal communities in Ghana.

3. High exposure of the socio-ecological systems to SLR impacts is due to contextual factors such as topography and proximity hazard-prone areas.

4. Most of the coastal rural communities have high sensitivity levels but low adaptive capacity. These are critical to building resilience to SLR risk

5. Glefe-wiaboman community was identified as a high-risk community despite its high socioeconomic structure and population density.

6. The study reveals that cognitive and social-economic variables appear to be significant factors in explaining relocation intention.

Conclusion

1. A rise in sea levels by up to 1.4 meters could impact roughly 3.8 square kilometres of land through erosion and flooding.

1. With a sea level rise of 0.5-1.4 meters above the current Mean Sea Level (MSL), a significant number of people and coastal ecosystems will be exposed to SLR impacts especially in Glefe-wiaboman community.

2. Socio-ecological vulnerability levels varied between 0.43 and 0.60, with Anlo Beach recording the highest score of 0.60, as anticipated due to its highest ecological vulnerability score.

3. Glefe-wiaboman community is a high-risk community despite its high socioeconomic structure and population density.

4. The study reveals that apart from the cognitive factors, compositional factors such as household age and income are more important for predicting the relocation intention of coastal rural communities in Ghana.

Recommendations

Policy Improvement

- The study calls on stakeholders such as the Land Use and Spatial Planning Authority (LUSPA) and National Disaster Management Organization (NADMO) to prepare a disaster risk management plan that involves strict zoning regulations that prohibit or restrict construction within a certain distance from the coastline.
- Assessing the level of risk due to SLR is an important study for policy design and national sustainable development, especially Sustainable Cities and Communities (Goal 11) and Climate Action (Goal 13).
- Strategies to relocate these rural communities should target cognitive characteristics as well as compositional characteristics and, in particular, promote household-level adaptation as a viable and cost-effective approach to responding to sea-level rise impacts.

Recommendations

- It is expected that risk/vulnerability maps as well as the inundation maps will be useful for the district assemblies to develop a sustainable land use planning and zoning for the communities.
- the communities should be encouraged to adopt nature-based solution to the SLR impacts which involve educating the communities on protect and restore natural barriers, such as mangrove forests, salt marshes, and dune systems.

Recommendations

Further Research

- This study only considered other impacts of SLR. Additional studies on the other impacts such as salt intrusion and storm surges should be carried out to gain a deeper understanding of SLR risk and adaptation measures for the entire coast of Ghana. studies

Publications and Presentations

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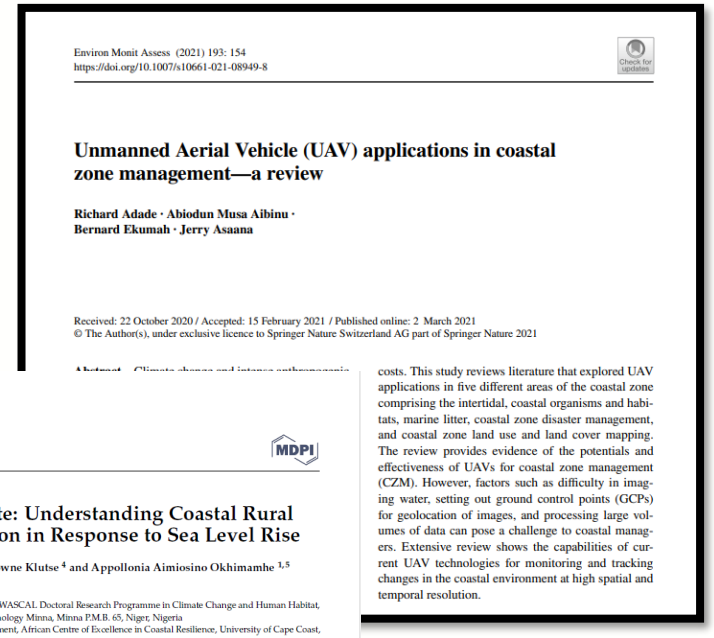
Oral Presentation

- World Climate Change Student Summit (2022)
- Ghana Geographers Annual Conference (2023)
- 3rd Conference on Fisheries and Coastal Environment (Blue Economy Conference) (2023)

Poster Presentation

- 5th WASCAL Ministerial Council meeting (2023)

Publications



Environ Monit Assess (2021) 193: 154
https://doi.org/10.1007/s10661-021-08949-8

Unmanned Aerial Vehicle (UAV) applications in coastal zone management—a review

Richard Adade · Abiodun Musa Aibinu · Bernard Ekumah · Jerry Asaana

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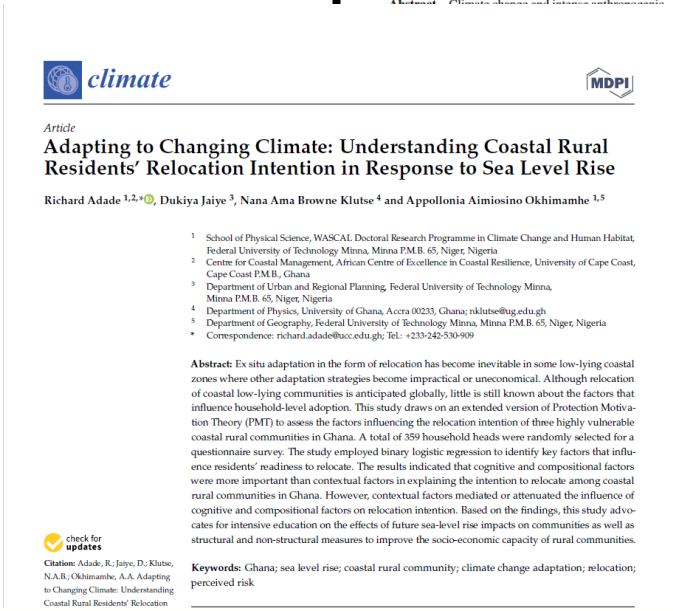
costs. This study reviews literature that explored UAV applications in five different areas of the coastal zone comprising the intertidal, coastal organisms and habitats, marine litter, coastal zone disaster management, and coastal zone land use and land cover mapping. The review provides evidence of the potentials and effectiveness of UAVs for coastal zone management (CZM). However, factors such as difficulty in imaging water, setting out ground control points (GCPs) for geolocation of images, and processing large volumes of data can pose a challenge to coastal managers. Extensive review shows the capabilities of current UAV technologies for monitoring and tracking changes in the coastal environment at high spatial and temporal resolution.



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Article

Adapting to Changing Climate: Understanding Coastal Rural Residents' Relocation Intention in Response to Sea Level Rise

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Abstract: Ex situ adaptation in the form of relocation has become inevitable in some low-lying coastal zones where other adaptation strategies become impractical or uneconomical. Although relocation of coastal low-lying communities is anticipated globally, little is still known about the factors that influence household-level adoption. This study draws on an extended version of Protection Motivation Theory (PMT) to assess the factors influencing the relocation intention of three highly vulnerable coastal rural communities in Ghana. A total of 359 household heads were randomly selected for a questionnaire survey. The study employed binary logistic regression to identify key factors that influence residents' readiness to relocate. The results indicated that cognitive and compositional factors were more important than contextual factors in explaining the intention to relocate among coastal rural communities in Ghana. However, contextual factors mediated or attenuated the influence of cognitive and compositional factors on relocation intention. Based on the findings, this study advocates for intensive education on the effects of future sea-level rise impacts on communities as well as structural and non-structural measures to improve the socio-economic capacity of rural communities.

Keywords: Ghana; sea level rise; coastal rural community; climate change adaptation; relocation; perceived risk

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