# DRAFT REPORT

## Coastal Vulnerability Assessment (CVA)
## for UNDP-GEF Project



## SIERRA LEONE


**Submitted by:**

**INTEGEMS Limited**

**Submitted to:**

**UNDP Sierra Leone**

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# TABLE OF CONTENTS

DISCLAIMER ..... I
DOCUMENT CONTROL ..... II
TABLE OF CONTENTS ..... III
LIST OF TABLES ..... VIII
LIST OF FIGURES ..... IX
ACKNOWLEDGEMENT ..... XII
ABBREVIATIONS AND ACRONYMS ..... XIII
GLOSSARY OF TERMS ..... XVII
1 INTRODUCTION ..... 1
1.1 PROJECT BACKGROUND ..... 1
1.2 OBJECTIVES ..... 1
1.3 SCOPE OF WORK ..... 1
1.4 STUDY AREA ..... 2
1.5 REPORT STRUCTURE ..... 4
1.6 STUDY LIMITATIONS ..... 5
2 COUNTRY BACKGROUND ..... 6
2.1 GEOGRAPHICAL CONTEXT ..... 6
2.2 POLITICAL GOVERNANCE AND HISTORICAL CONTEXT ..... 6
2.3 ADMINISTRATIVE DIVISIONS ..... 8
2.4 SOCIO-ECONOMIC CONTEXT ..... 8
2.4.1 Demography ..... 8
2.4.2 Health ..... 10
2.4.3 Education and Literacy ..... 10
2.4.4 Housing Infrastructure ..... 10
2.4.5 Fisheries ..... 11
2.4.6 Agriculture ..... 11
2.4.7 Tourism ..... 11
2.4.8 Energy ..... 12
2.4.9 Mining ..... 12
3 GLOBAL CLIMATE CHANGE ..... 14
3.1 EVIDENCE OF GLOBAL CLIMATE CHANGE ..... 14
3.2 CLIMATE CHANGE DRIVERS ..... 14

DRAFT

**3.3 INTERNATIONAL INSTITUTIONAL FRAMEWORK ..... 15**

3.3.1 United Nations Environment Programme (UNEP) ..... 15

3.3.2 World Meteorological Organisation (WMO) ..... 15

3.3.3 United Nations Framework Convention on Climate Change (UNFCCC) ..... 15

3.3.4 Intergovernmental Panel on Climate Change (IPCC) ..... 15

3.3.5 United Nations Development Programme (UNDP) ..... 16

3.3.6 UN Office for Disaster Risk Reduction (UNDRR) ..... 16

3.3.7 Global Environment Facility (GEF) ..... 16

**3.4 INTERNATIONAL LEGAL FRAMEWORK ..... 16**

3.4.1 Paris Agreement ..... 16

3.4.2 Montreal Protocol ..... 17

3.4.3 Kyoto Protocol ..... 17

3.4.4 Hyogo Framework ..... 17

3.4.5 Sendai Framework ..... 18

3.4.6 United Nations Convention to Combat Desertification (UNCCD) ..... 18

3.4.7 Ramsar Convention on Wetlands ..... 18

3.4.8 Abidjan Convention ..... 18

3.4.9 Sustainable Development Goals ..... 19

**4 CLIMATE CHANGE IN SIERRA LEONE ..... 20**

**4.1 GREENHOUSE GAS EMISSIONS STATUS ..... 20**

**4.2 OBSERVED CLIMATE VARIABILITY AND CHANGE ..... 21**

**4.3 PROJECTED CLIMATE CHANGE ..... 21**

**4.4 CLIMATE CHANGE INFORMATION AVAILABILITY AND ACCESSIBILITY ..... 21**

**4.5 PREVIOUS STUDIES/VULNERABILITY ASSESSMENTS ..... 22**

4.5.1 Climate Change Vulnerability Assessment in Mangrove Regions of Sierra Leone ..... 22

4.5.2 Sierra Leone State of the Marine Environment Report 2015 ..... 22

4.5.3 Diagnostic Analysis of Climate Change and Disaster Management in Relation to the PRSP III in Sierra Leone ..... 22

4.5.4 Sierra Leone Climate Action Report, 2016 ..... 22

**4.6 NATIONAL INSTITUTIONAL FRAMEWORK ..... 23**

4.6.1 Ministry of Environment ..... 23

4.6.2 Environment Protection Agency-Sierra Leone ..... 23

4.6.3 Climate Change Secretariat ..... 23

4.6.4 The Ozone Secretariat ..... 23

4.6.5 Sierra Leone Meteorological Agency ..... 23

4.6.6 Ministry of Fisheries and Marine Resources (MFMR) ..... 24

4.6.7 Ministry of Agriculture, Forestry, and Food Security (MAFFS) ..... 24

4.6.8 Disaster Management Department (DMD) ..... 24

4.6.9 REDD / REDD+ ..... 24


DRAFT

**4.7 LEGISLATION ..... 24**

4.7.1 Environment Protection Agency Act 2008 (amended July 2010) ..... 24

4.7.2 Wildlife Conservation Act (1972) ..... 24

4.7.3 Forestry Act (1988) ..... 25

4.7.4 Draft Forestry Policy and Act ..... 25

4.7.5 Wetland Conservation Act (2015) ..... 25

4.7.6 Environment Protection (Mines and Minerals) Regulations 2013 ..... 25

4.7.7 Sierra Leone Maritime Administration Act (2000) ..... 25

4.7.8 Fisheries Act (2007) ..... 25

4.7.9 Draft Conservation and Wildlife Policy and Act, 2011 ..... 25

4.7.10 National Water Resource Management Act (2016) ..... 26

4.7.11 National Protected Area Authority and Conservation Trust Fund Act, 2012 ..... 26

4.7.12 Merchant Shipping Act (2009) ..... 26

**4.8 POLICIES AND PLANS ..... 26**

4.8.1 National Environmental Policy (1994) ..... 26

4.8.2 National Disaster Management Policy (Draft, 2006) ..... 26

4.8.3 Climate Change Adaptation Plan for the Sierra Leone Coastal Landscape Complex ..... 27

4.8.4 Sierra Leone's Nationally Determined Contribution (NDC) ..... 27

4.8.5 Regional Development Authorities Policy (2007) ..... 27

4.8.6 National Adaptation Programme of Action, 2007 ..... 27

4.8.7 National Land Policy (2015) ..... 28

4.8.8 Sierra Leone's Second National Biodiversity and Strategic Action Plan (2017-2026) ..... 28

4.8.9 Integrated Coastal Zone Management Plan (2015) ..... 28

4.8.10 Coastal Climate Change Adaptation Plan ..... 28

4.8.11 National Climate Change Strategy and Action Plan ..... 28

4.8.12 National Disaster Preparedness and Response Plan (NDPRP, 2006) ..... 29

4.8.13 National Adaptation Programme of Action (2007) ..... 29

4.8.14 The National Disaster Management Policy (Draft, 2006) and National Disaster Preparedness and Response Plan (NDPRP) ..... 29

4.8.15 Mid-Term National Development Plan ..... 30

**4.9 INSTITUTIONAL CHALLENGES ..... 31**

**5 COASTAL SYSTEMS AND HAZARDS ..... 33**

**5.1 COASTAL SYSTEMS ..... 33**

5.1.1 Natural system ..... 33

5.1.2 Human System ..... 33

**5.2 COASTAL HAZARDS ..... 33**

5.2.1 Sea-level Rise ..... 33

5.2.2 Coastal Erosion ..... 34

5.2.3 Coastal flooding ..... 35


DRAFT

5.3 COASTAL LANDSCAPE IN SIERRA LEONE ..... 35
5.3.1 Geography of the Sierra Leone Coastal Landscape Complex ..... 35
5.3.2 Geology and Geomorphology of Sierra Leone Coastal Areas ..... 36
5.3.3 Hydrology of the Sierra Leone Coastal Landscape complex ..... 37
5.3.4 Biological Diversity of the Sierra Leone Coastal Landscape Complex ..... 37
5.3.5 Socio-Cultural and Economic Characteristics of the Sierra Leone Coastal Landscape Complex 37

6 COMMUNITY PROFILES ..... 39
6.1 CONAKRY-DEE ..... 39
6.2 LAKKA ..... 42
6.3 HAMILTON ..... 46
6.4 TOMBO ..... 49
6.5 SHENGE ..... 52
6.6 TURTLE ISLANDS ..... 54

7 COASTAL VULNERABILITY ASSESSMENT ..... 59
7.1 APPROACH ..... 59
7.2 METHODOLOGY ..... 59
7.2.1 Data Collection ..... 60
7.2.2 Selection of Parameters ..... 62
7.2.3 Analytical Hierarchical Process ..... 78
7.3 RESULTS AND ANALYSIS ..... 82
7.3.1 Conakry-Dee ..... 82
7.3.2 Lakka ..... 87
7.3.3 Hamilton ..... 90
7.3.4 Tombo ..... 95
7.3.5 Shenge ..... 100
7.3.6 Turtle Islands ..... 105
7.3.7 Comparative Analysis ..... 111

8 ADAPTATION ACTION PLAN ..... 113
8.1 OBJECTIVES ..... 113
8.2 IDENTIFICATION OF ADAPTATION STRATEGIES ..... 113
8.2.1 Protection Approach ..... 114
8.2.2 Accommodation Approach ..... 121
8.2.3 Retreat Approach ..... 124
8.2.4 Complementary Approach ..... 125
8.3 BENEFITS AND DRAWBACKS OF ADAPTATION OPTIONS ..... 126
8.4 CRITERIA AND PROCESS OF ADAPTATION PRIORITISATION ..... 136
8.5 IDENTIFIED ADAPTATION OPTIONS FOR THE STUDY COMMUNITIES ..... 136

DRAFT

8.6 SYNERGIES, LIMITS AND TRADE-OFFS IN ADAPTATION ..... 138
9 RECOMMENDATIONS ..... 139
9.1 RECOMMENDATION FOR COMPONENT 1: GENERATING SOUND SCIENTIFIC KNOWLEDGE AND ACCESS TO INFORMATION. ..... 139
9.1.1 Update Baseline Data and Information to Understand Climate Impacts and Response. ..... 139
9.1.2 Communicate Climate Data and Information for Public Use ..... 139
9.1.3 Establish Climate Change Observation, Monitoring and Surveillance Network ..... 140
9.1.4 Develop Coastal Information and Early Warning Systems ..... 140
9.1.5 Improve Existing Knowledge and Best Practises and Promote Local Innovations ..... 140
9.1.6 Operationalize the CIDMEWS for Hazard and Risk Communication and Early Warning ..... 140
9.2 RECOMMENDATION FOR COMPONENT 2: CLIMATE INFORMATION INTERNALISED INTO COASTAL DEVELOPMENT POLICY AND PLANS ..... 141
9.2.1 Improve Community Engagements on Climate Adaptation and Resilience Work ..... 141
9.2.2 Develop and Operationalise Coastal Management Plans and Policies ..... 141
9.2.3 Integrate Climate Vulnerability Assessments into Existing Management Tools ..... 141
9.2.4 Policy Mainstreaming and Enforcements of Regulations ..... 141
9.2.5 Strengthen Institutional Capacity to Better Understand the Impacts Of Climate Change ..... 142
9.3 RECOMMENDATION FOR COMPONENT 3: AWARENESS AND ALTERNATIVE, INNOVATIVE ACTIVITIES TO SUPPORT ADAPTATION IN THE COASTAL ZONE ..... 142
9.3.1 Awareness Raising for the Local Communities ..... 142
9.3.2 Land Use Planning and Zoning ..... 142
9.3.3 Utilize Nature-Based Solutions as Part of Long-Term Coastal Resilience Solutions ..... 143
9.3.4 Better Evaluation of Costs and Benefits of Adaptation ..... 143
9.3.5 Develop a Funding Plan ..... 143
9.3.6 Relocation of People and Infrastructure ..... 143
9.3.7 Training ..... 143
10 CONCLUSIONS ..... 144
11 BIBLIOGRAPHY ..... 145
12 APPENDICES ..... 151
APPENDIX I: MAPS ..... 151
APPENDIX II: SUMMARY OF KIIS ..... 152
APPENDIX III: SUMMARY OF FGDS ..... 153
APPENDIX IV: PHOTOS FROM STAKEHOLDER ENGAGEMENT ..... 154
APPENDIX V: SAMPLE OF STAKEHOLDER NOTIFICATION LETTERS ..... 155
APPENDIX VI: STAKEHOLDER ENGAGEMENT ATTENDANCE LIST ..... 156
APPENDIX VII: SURVEY QUESTIONNAIRES ..... 159

DRAFT

# LIST OF TABLES

Table 1-1: Structure of this Report ..... 4
Table 2-1: Sierra Leone Administrative Divisions ..... 8
Table 2-2: Distribution of Population by District and Sex (Open Data Sierra Leone, 2019) ..... 9
Table 7-1: Household Survey Sample ..... 61
Table 7-2: Physical Vulnerability Parameters and Data Sources ..... 62
Table 7-3: Vulnerability Ranking Assigned for Geomorphological Features ..... 63
Table 7-4: Vulnerability Ranking Assigned for Coastal Elevation Ranges ..... 64
Table 7-5: Tidal Ranges (NOAA, 2019) ..... 65
Table 7-6: Vulnerability Ranking Assigned for Tidal Ranges ..... 65
Table 7-7: Significant Wave Heights along the Sierra Leonean Coast (Anthony, 1991) ..... 66
Table 7-8: Vulnerability Ranking Assigned for Significant Wave Height ..... 66
Table 7-9: Present-day Water Levels around the Western Area Peninsula ..... 67
Table 7-10: Vulnerability Ranking Assigned for Geology Features ..... 68
Table 7-11: Vulnerability Ranking Assigned for Coastal Slope ..... 68
Table 7-12: Vulnerability Ranking Assigned for Mean Shoreline Change ..... 69
Table 7-13: Social Vulnerability Parameters and Data Sources ..... 69
Table 7-14: Population Statistics (Stats-SL, 2015) ..... 70
Table 7-15: Vulnerability Ranking Assigned for Population Density ..... 70
Table 7-16: Vulnerability Ranking Assigned for Major Road Distance from Coastline ..... 70
Table 7-17: Vulnerability Ranking Assigned for Land use/land cover ..... 71
Table 7-18: Numbers of Buildings in the Study Area ..... 71
Table 7-19: Vulnerability Ranking Assigned for Number of Buildings ..... 71
Table 7-20: Building Construction Material – Wall Material ..... 72
Table 7-21: Building Construction Material – Floor Material ..... 72
Table 7-22: Building Construction Material – Roof Material ..... 72
Table 7-23: Vulnerability Ranking Assigned for Building Construction Materials ..... 73
Table 7-24: Vulnerability Ranking Assigned for Access to Electricity ..... 73
Table 7-25: Vulnerability Ranking Assigned for Access to Telecommunications Network ..... 74
Table 7-26: Number of Schools and Health Facilities in the Study Area ..... 74
Table 7-27: Vulnerability Ranking Assigned for Access to Schools and Health Facilities ..... 75
Table 7-28: Summary of Vulnerability Ranking Assigned to Parameters ..... 76
Table 7-29: Saaty Rating Scale ..... 78
Table 7-30: Pairwise Comparison Matrix of Physical Variables ..... 79
Table 7-31: Pairwise Comparison Matrix of Socio-economic Variables ..... 79
Table 7-32: Values of RI, with $\boldsymbol{n}$ order of the matrix (Saaty and Vargas, 1980) ..... 80
Table 7-33: Normalised Pairwise Comparison Matrix of Physical Variables ..... 81
Table 7-34: Normalised Pairwise Comparison Matrix of Socio-economic Variables ..... 81
Table 7-35: Length of Coastline under different Vulnerability Categories in Conakry-Dee ..... 83

Table 7-36: Length of Coastline and under different vulnerability categories in Lakka ..... 88
Table 7-37: Length of Coastline under different Vulnerability Categories in Hamilton ..... 91
Table 7-38: Length of Coastline and under Different Vulnerability Categories in Tombo ..... 95
Table 7-39: Length of Coastline and under Different Vulnerability Categories in Shenge ..... 100
Table 7-40: Length of Coastline and under different Vulnerability Categories in Turtle Islands ..... 106
Table 7-41: Summary of Coastline Length under different Vulnerability Categories ..... 111
Table 8-1: Benefits and Drawbacks of Adaptation Options ..... 127
Table 8-2: Identified Adaptation Option ..... 136

## LIST OF FIGURES

Figure 1-1: The Study Area – Communities ..... 3
Figure 2-1: Location of Sierra Leone in West Africa ..... 7
Figure 2-2: Population Pyramid of Sierra Leone (Population and Housing Census 2015) ..... 9
Figure 5-1: Some Coastal Features in the Study Areas ..... 36
Figure 6-1: Aerial Photographs of Study Area – Conakry-Dee – Northern Axis ..... 39
Figure 6-2: Aerial Photographs of Study Area – Conakry-Dee - Southwards ..... 40
Figure 6-3: Aerial Photo of Lakka and Hamilton ..... 42
Figure 6-4: Photos of Climate Change coastal Hazards in Lakka ..... 45
Figure 6-5: Photos of Climate Change Adaptation coastal Hazards in Lakka ..... 46
Figure 6-6: Aerial Photographs of Study Area – Hamilton-Sussex ..... 47
Figure 6-7: Aerial Photographs of Study Area – Tombo (1/2) ..... 49
Figure 6-8: Aerial Photographs of Study Area – Tombo (2/2) ..... 50
Figure 6-9: Aerial Photographs of Study Area – Shenge ..... 52
Figure 6-10: Aerial Photographs of Study Area – Turtle Islands (Yele) ..... 55
Figure 6-11: Aerial Photographs of Study Area – Turtle Islands (Sei) ..... 56
Figure 6-12: Aerial Photographs of Study Area – Turtle Islands (Bumpetoke) ..... 57
Figure 7-1: Assessment Approach Adopted for the Study ..... 60
Figure 7-2: Coastal Geomorphology of Conakry-Dee ..... 84
Figure 7-3: Elevation Profiles for Conakry-Dee (Eastward along the Northern Coast) ..... 85
Figure 7-4: Elevation Profiles for Conakry-Dee (Southward along the Coast) ..... 85
Figure 7-5: Geomorphology Vulnerability Map of Conakry-Dee ..... 86
Figure 7-6: Coastal Elevation Vulnerability Map of Conakry-Dee ..... 86
Figure 7-7: Sea Level Rise Scenario Map of Conakry-Dee ..... 86
Figure 7-8: Geological Vulnerability Map of Conakry-Dee ..... 86
Figure 7-9: Coastal Slope Vulnerability Map of Conakry-Dee ..... 86
Figure 7-10: Shoreline Change Vulnerability Map of Conakry-Dee ..... 86
Figure 7-11: Shoreline Change Scenario Map of Conakry-Dee ..... 86
Figure 7-12: Tidal Range and Mean Significantly Wave Height Vulnerability Map of Conakry-Dee ..... 86
Figure 7-13: Coastal Vulnerability Index Map of Conakry-Dee ..... 86

DRAFT

Figure 7-14: Land Use/Land Cover Vulnerability Map of Conakry-Dee ..... 86
Figure 7-15: Population Vulnerability Map of Conakry-Dee ..... 86
Figure 7-16: Critical Facilities Map of Conakry-Dee ..... 86
Figure 7-17: Coastal Geomorphology of Lakka ..... 89
Figure 7-18: Elevation Profiles for Lakka ..... 90
Figure 7-19: Coastal Geomorphology of Hamilton ..... 92
Figure 7-20: Elevation Profiles for Hamilton ..... 93
Figure 7-21: Geomorphology Vulnerability Map of Hamilton and Lakka ..... 94
Figure 7-22: Coastal Elevation Vulnerability Map of Hamilton and Lakka ..... 94
Figure 7-23: Sea Level Rise Scenarios for Hamilton and Lakka ..... 94
Figure 7-24: Geological Vulnerability Map of Hamilton and Lakka ..... 94
Figure 7-25: Coastal Slope Vulnerability Map of Hamilton and Lakka ..... 94
Figure 7-26: Shoreline Change Vulnerability Map of Hamilton and Lakka ..... 94
Figure 7-27: Shoreline Change Scenarios of Hamilton and Lakka ..... 94
Figure 7-28: Tidal Range and Mean Significantly Wave Height Vulnerability Map of Hamilton and Lakka ..... 94
Figure 7-29: Coastal Vulnerability Map of Hamilton and Lakka ..... 94
Figure 7-30: Land Use/Land Cover Vulnerability Map of Hamilton and Lakka ..... 94
Figure 7-31: Population Vulnerability Map of Hamilton and Lakka ..... 94
Figure 7-32: Critical Facilities Map of Hamilton and Lakka ..... 94
Figure 7-33: Coastal Geomorphology of Tombo ..... 97
Figure 7-34: Elevation Profiles for Tombo ..... 98
Figure 7-35: Geomorphology Vulnerability Map of Tombo ..... 99
Figure 7-36: Coastal Elevation Vulnerability Map of Tombo ..... 99
Figure 7-37: Sea Level Rise Scenario Map of Tombo ..... 99
Figure 7-38: Geological Vulnerability Map of Tombo ..... 99
Figure 7-39: Coastal Slope Vulnerability Map of Tombo ..... 99
Figure 7-40: Shoreline Change Vulnerability Map of Tombo ..... 99
Figure 7-41: Shoreline Change Scenario Map of Tombo ..... 99
Figure 7-42: Tidal Range and Mean Significantly Wave Height Vulnerability Map of Tombo ..... 99
Figure 7-43: Coastal Vulnerability Index Map of Tombo ..... 99
Figure 7-44: Land Use/Land Cover Vulnerability Map of Tombo ..... 99
Figure 7-45: Population Vulnerability Map of Tombo ..... 99
Figure 7-46: Critical Facilities Map of Tombo ..... 99
Figure 7-47: Coastal Geomorphology of Shenge ..... 102
Figure 7-47: Elevation Profiles for Shenge ..... 103
Figure 7-49: Geomorphology Vulnerability Map of Shenge ..... 104
Figure 7-50: Coastal Elevation Vulnerability Map of Shenge ..... 104
Figure 7-51: Sea Level Rise Scenario Map of Shenge ..... 104
Figure 7-52: Geological Vulnerability Map of Shenge ..... 104

DRAFT

Figure 7-53: Coastal Slope Vulnerability Map of Shenge ..... 104
Figure 7-54: Shoreline Change Vulnerability Map of Shenge ..... 104
Figure 7-55: Shoreline Change Scenario Map of Shenge ..... 104
Figure 7-56: Tidal Range and Mean Significantly Wave Height Vulnerability Map of Shenge ..... 104
Figure 7-57: Coastal Vulnerability Index Map of Shenge ..... 104
Figure 7-58: Land Use/Land Cover Vulnerability Map of Shenge ..... 104
Figure 7-59: Population Vulnerability Map of Shenge ..... 104
Figure 7-60: Critical Facilities Map of Shenge ..... 104
Figure 7-61: Coastal Geomorphology of Turtle Islands ..... 107
Figure 7-62: Elevation Profiles for Turtle Islands (1/2) ..... 108
Figure 7-63: Elevation Profiles for Turtle Islands (2/2) ..... 109
Figure 7-64: Screenshot of Satellite Imagery Discrepancy for Turtle Islands ..... 109
Figure 7-65: Geomorphology Vulnerability Map of Turtle Islands ..... 110
Figure 7-66: Coastal Elevation Vulnerability Map of Turtle Islands ..... 110
Figure 7-67: Sea Level Rise Scenario Map of Shenge ..... 110
Figure 7-68: Geological Vulnerability Map of Turtle Islands ..... 110
Figure 7-69: Coastal Slope Vulnerability Map of Turtle Islands ..... 110
Figure 7-70: Shoreline Change Vulnerability Map of Turtle Islands ..... 110
Figure 7-71: Tidal Range and Mean Significantly Wave Height Vulnerability Map of Turtle Islands ..... 110
Figure 7-72: Coastal Vulnerability Index Map of Turtle Islands ..... 110
Figure 7-73: Land Use/Land Cover Vulnerability Map of Turtle Islands ..... 110
Figure 7-74: Population Vulnerability Map of Turtle Islands ..... 110
Figure 7-75: Critical Facilities Map of Turtle Islands ..... 110
Figure 8-1: Examples of Groynes Courtesy Thames-Coromandel District Council – New Zealand ..... 115
Figure 8-2: Example of a 'salient' (left) and a series of 'tombolos' (right) (Courtesy of Google) ..... 116
Figure 8-3: Example of Seawall (L) Courtesy - Google and Bulkhead in Lakka ® Courtesy - INTEGEMS) ..... 117
Figure 8-4: Rock Amour Revetments at Tombo (L) and Conakry Dee ® Courtesy of INTEGEMS) ..... 118
Figure 8-5: Embankments at Shenge (L) and Hamilton (R) ..... 118
Figure 8-6: Examples of Storm Surge in the Netherlands (Courtesy of Google) ..... 119
Figure 8-7: Examples of Rip Rap shown in Tombo, Courtesy- INTEGEMS ..... 120
Figure 8-8: Example floodproofing Google Image (L), Tombo ( R) ..... 121
Figure 8-9: Examples of Floating Agriculture Google Images. ..... 122

DRAFT

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# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| **AHP** | Analytical Hierarchical Process |
| **AOI** | Area of Influence |
| **ASTER** | Advanced Spaceborne Thermal Emission and Reflection Radiometer |
| **CBD** | Convention on Biological Diversity |
| **CCAP** | Climate Change Adaptation Plan |
| **CCS** | Climate Change Secretariat |
| **CDMC** | Community Disaster Management Committee |
| **CHC** | Community Health Centre |
| **CHP** | Community Health Post |
| **CIDMEWS-SL** | Climate Information Deserter Management Ealey Warning Systems |
| **CIESIN** | Centre for International Earth Science Information Network |
| **CMA** | Community Management Associations |
| **CTF** | Conservation Trust Fund |
| **CVA** | Coastal Vulnerability Assessment |
| **CVI** | Coastal Vulnerability Index |
| **CZMS** | Coastal Zone Management Subgroup |
| **DDR** | Disarmament Demobilisation And Disintegration |
| **DEM** | Digital Elevation Model |
| **DMD** | Disaster Management Department |
| **DRM** | Disaster Risk Management |
| **DRR** | Disaster Risk Reduction |
| **DSM** | Digital Surface Model |
| **DTM** | Digital Terrain Model |
| **ECOWAS** | Economic Community of West African States |
| **EDSA** | Electricity Distribution and Supply Authority |
| **EJF** | Environmental Justice Foundation |
| **EPA-SL** | Environment Protection Agency –Sierra Leone |
| **ERSDAC** | Earth Remote Sensing Data Analysis Centre |
| **ESRI** | Environmental System Research Institute |
| **FEMA** | Federal Emergency Management Agency |
| **FGD** | Focus Group Discussion |
| **FIP** | Forest Investment Programme |
| **GDEM** | Global Digital Elevation Model |

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| **GDP** | Gross Domestic Product |
| **GEF** | Global Environment Facility |
| **GEOSS** | Global Earth Observing System of Systems |
| **GFDRR** | Global Facility for Disaster Reduction Recovery |
| **GHG** | Greenhouse Gases |
| **GIS** | Geographic Information System |
| **GSM** | Global System for Mobile Communications |
| **GVWC** | Guma Valley Water Company |
| **HFA** | Hyogo Framework |
| **HHS** | Household Survey |
| **ICVI** | Integrated Coastal Vulnerability Index |
| **ICZM** | Integrated Coastal Zone Management |
| **ICZMP** | Integrated Coastal Zone Management Plan |
| **IEZ** | Inshore Exclusive Zone |
| **IMBO** | Institute of Marine Biology And Oceanography |
| **IMO** | International Meteorological Organization |
| **INTEGEMS** | Integrated Geo-Information And Environmental Management Services |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **ISDR** | International Strategy for Disaster Reduction |
| **ITCZ** | Inter-Tropical Convergence Zone |
| **KII** | Key Informant Interviews |
| **LDC** | Least Developed Country |
| **LDN** | Land Degradation Neutrality |
| **LECZ** | Low-Elevation Coastal Zone |
| **LiDAR** | Light Detection and Ranging |
| **LPDAAC** | Land Processes Distributed Active Archive Centre |
| **LULUCF** | Land Use, Land Use Change and forestry |
| **MAFFS** | Ministry of Agriculture, Forestry and Food Security |
| **MCA** | Multi-Criteria Analysis |
| **MCHP** | Maternal and Child Health Post |
| **MEST** | Ministry of Education, Science and Technology |
| **METI** | Ministry of Economy, Trade, and Industry |
| **MFMR** | Ministry of Fisheries and Marine Resources |
| **MHWN** | Mean High Water Neaps |
| **MHWS** | Mean High Water Springs |

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| **MLWN** | Mean Low Water Neaps |
| **MLWS** | Mean Low Water Springs |
| **MPA** | Marine Protected Area |
| **MSL** | Mean Sea Level |
| **MSWH** | Mean Significant Wave Height |
| **MTA** | Ministry of Transport and Aviation |
| **MTCA** | Ministry of Tourism and Cultural Affairs |
| **MWR** | Ministry of Water Resources |
| **NAPA** | National Adaptation Programmes of Action |
| **NASA** | National Aeronautics and Space Administration |
| **NBSAP** | National Biodiversity Strategies and Action Plans |
| **NDC** | Sierra Leone's Nationally Determined Contribution |
| **ND-GAIN** | Notre Dame Global Adaptation Initiative |
| **NDPBA** | National Disaster Preparedness Baseline Assessment |
| **NDPRP** | National Disaster Preparedness and Response Plan |
| **NDS** | Nationally Designated Agency |
| **NGO's** | Non-Governmental Organisation |
| **NOAA** | National Oceanic and Atmospheric Administration |
| **NPAA** | National Protected Area Authority |
| **NTB** | National Tourist Board |
| **ODS** | Ozone-Depleting Substances |
| **ONS** | Office of National Security |
| **ONS-DMD** | Office of National Security-Disaster Management Department |
| **OSM** | Open Street Map |
| **PHC** | Population and Housing Census |
| **PHU** | Peripheral Health Units |
| **PRA** | Participatory Rural Appraisal |
| **PRSP** | Poverty Reduction Strategy |
| **PVI** | Physical Vulnerability Index |
| **REDD** | Reducing Emissions from Deforestation and forest Degradation |
| **SDG** | Sustainable Development Goals |
| **SLCLC** | Sierra Leone Coastal Landscape Complex |
| **SLR** | Sea Level Rise |
| **SLRE** | Sierra Leone River Estuary |
| **SMCE** | Spatial Multi-Criteria Evaluation |

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| **SRE** | Sherbro River Estuary |
| **SSL/Stats SL** | Statistics Sierra Leone |
| **SVI** | Social Vulnerability Index |
| **TNA** | Technology Needs Assessment |
| **UAV** | Unmanned Aerial Vehicle |
| **UNCBD** | United Nations Convention on Biological Diversity |
| **UNCCD** | United Nations Convention to Combat Desertification |
| **UNDP** | United Nation Development Program |
| **UNDRR** | UN Office for Disaster Risk Reduction |
| **UNEP** | United Nations Environment Programme |
| **UNFCCC** | United Nations Framework Convention on Climate Change |
| **UNOPS** | United Nations Office for Project Services |
| **UNWTO** | United Nations World Tourism Organisation |
| **USGS** | United States Geological Survey |
| **WMO** | World Meteorological Organisation |

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# GLOSSARY OF TERMS

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| **Abatement** | Refers to reducing the degree or intensity of greenhouse-gas emissions |
| **Accretion** | Accretion is the process of coastal sediment returning to the visible portion of a beach or foreshore after a submersion event. |
| **Adaptation** | In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate (IPCC, 2012). |
| **Adaptation Assessment** | The practice of identifying options to adapt to climate change and evaluating them in terms of criteria such as availability, benefits, costs, effectiveness, efficiency, and feasibility (IPCC, 2012). |
| **Adaptation benefits** | The avoided damage costs or the accrued benefits following the adoption and implementation of adaptation measures. |
| **Adaptation Costs** | Costs of planning, preparing for, facilitating, and implementing adaptation measures, including transition costs. |
| **Adaptation Needs** | The circumstances requiring action to ensure the safety of populations and security of assets in response to climate impacts. |
| **Adaptation Opportunity** | Factors that make it easier to plan and implement adaptation actions that expand adaptation options, or that provide ancillary co-benefits. |
| **Adaptation Options** | The array of strategies and measures that are available and appropriate for addressing adaptation needs. They include a wide range of actions that can be categorized as structural, institutional, ecological or behavioural. |
| **Adaptation Technology** | It includes both scientific and traditional technologies. Most adaptation technology focuses on local innovations, knowledge and practices that are effective in adapting to climatic hazards. The application of technology in order to reduce the vulnerability or enhance the resilience of a natural or human system to the impacts of climate change. |
| **Adaptive Capacity** | The combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities. |
| **Afforestation** | Planting of new forests on lands that historically have not contained forests. |
| **Albedo** | The fraction of solar radiation reflected by a surface or object often expressed as a percentage (IPCC AR5WGI, 2014). |
| **Anthropogenic Emissions** | Emissions of greenhouse gases, greenhouse gas precursors, and aerosols associated with human activities. These include the burning of fossil fuels, deforestation, land-use changes, livestock, fertilisation, etc. that result in a net increase in emissions. |

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| **Atmosphere** | The gaseous envelope surrounding the Earth. The dry atmosphere consists almost entirely of nitrogen (78.1% volume mixing ratio) and oxygen (20.9% volume mixing ratio), together with a number of trace gases, such as argon (0.93% volume mixing ratio), helium, and radiatively active greenhouse gases such as carbon dioxide (0.035% volume mixing ratio) and ozone. In addition, the atmosphere contains the greenhouse gas water vapour, whose amounts are highly variable but typically around 1% volume mixing ratio. The atmosphere also contains clouds and aerosols (IPCC, 2012). |
| **Biodiversity** | The variability among living organisms from terrestrial, marine, and other ecosystems. Biodiversity includes variability at the genetic, species, and ecosystem levels. |
| **Capacity** | The combination of all the strengths, attributes, and resources available to an individual, community, society, or organization, which can be used to achieve established goals. |
| **Capacity Building** | The practice of enhancing the strengths and attributes of, and resources available to, an individual, community, society, or organisation to respond to change (UNISDR, 2009). |
| **Capacity Development** | The process by which people, organizations and society systematically stimulate and develop their capacities over time to achieve social and economic goals, including through improvement of knowledge, skills, systems, and institutions is known as capacity development, or capacity development is a concept that extends the term of capacity building to encompass all aspects of creating and sustaining capacity growth over time. It does not involve only learning and various types of training but also continuous efforts to develop institutions, political awareness, financial resources, technology systems and the wider social and cultural enabling environment (UNISDR, 2009). |
| **Carbon Footprint** | The total set of greenhouse gas emissions caused by an organization, event or product is known as carbon footprint. |
| **Carbon Intensity** | The amount of emission of carbon dioxide per unit of Gross Domestic Product is known as carbon intensity. |
| **Carbon Offset** | A mechanism for individuals and businesses to neutralize rather than actually reduce their greenhouse gas emissions by purchasing the right to claim someone else's reductions as their own is known as a carbon offset. |
| **Carbon dioxide** | A naturally occurring gas and a by-product of burning fossil fuels or biomass, of land-use changes and of industrial processes. It is the principal anthropogenic greenhouse gas that affects Earth's radiative balance. It is the reference gas against which other greenhouse gases are measured, and therefore it has a Global Warming Potential of one |
| **Chlorofluorocarbon** | Are non-toxic, non-flammable chemicals containing atoms of carbon, chlorine, and fluorine. They are used in the manufacture of aerosol sprays, blowing agents for foams and packing materials, as solvents, and as refrigerants. CFCs are classified as halocarbons, a class of compounds that contain atoms of carbon and halogen atoms |
| **Climate** | Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and |

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| | variability of relevant quantities over a period of time ranging from months to thousands or millions of years. |
| **Climate Change** | The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods”. |
| **Climate Change Adaptation Strategy** | Refers to a general plan of action for addressing the impacts of climate change, including climate variability and extremes. It may include a mix of policies and measures, selected to meet the overarching objective of reducing the country’s vulnerability |
| **Climate Change Impact Assessment** | Impacts that affect ecosystems or human welfare but that are not directly linked to market transactions, for example, an increased risk of premature death. The analysis of positive and negative consequences of Climate Changes on natural systems and human societies, both with and without adaptation to such changes is known as Climate Change Impact Assessment. |
| **Climate Change Impacts** | The effect of Climate Change on natural and human systems is known as Climate Change Impacts. Depending on the consideration of adaptation, one can distinguish between potential impacts and residual impacts |
| **Climate Change Mitigation** | A human intervention to reduce the sources or enhance the sinks of greenhouse gases |
| **Climate Change Scenario** | A coherent and internally-consistent description of the change in climate by a certain time in the future using specific modelling technique and under specific assumptions about the growth of greenhouse gas and other emissions and about other factors that may influence climate in the future is known as Climate Change Scenario. A “Climate Change Scenario” is the difference between a climate scenario and the current climate. |
| **Climate Change Vulnerability Assessment** | A range of tools that exist to help communities understand the hazards that affect them and take appropriate measures to minimize their potential impact is known as Climate Change Vulnerability Assessment. |
| **Climate Driver** | A changing aspect of the climate system that influences a component of a human or natural system. |
| **Climate Hazard** | The harmful effect of Climate Change on livelihoods and ecosystems is known as climate hazard. They can be caused by gradual climate variability or extreme weather events. Some hazards are continuous phenomena that start slowly, such as the increasing unpredictability of temperatures and rainfall. Others are sudden but relatively discrete events such as heatwaves or floods. |
| **Climate Model** | A numerical representation of the climate system that is based on the physical, chemical, and biological properties of its components, their interactions, and feedback processes, and that accounts for all or some of its known properties. |
| **Climate Prediction** | A climate prediction or climate forecast is the result of an attempt to produce (starting from a particular state of the climate system) an estimate of the |

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| | actual evolution of the climate in the future, for example, at seasonal, interannual, or decadal time scales. Because the future evolution of the climate system may be highly sensitive to initial conditions, such predictions are usually probabilistic in nature |
| **Climate Projection** | A climate projection is the simulated response of the climate system to a scenario of future emission or concentration of greenhouse gases and aerosols, generally derived using climate models. Climate projections are distinguished from climate predictions by their dependence on the emission/concentration/radiative forcing scenario used, which is in turn based on assumptions concerning, for example, future socioeconomic and technological developments that may or may not be realized. |
| **Climate Risk** | The likelihood that the harmful effects will happen is known as climate risk, or it is a measure of the probability of harm to life, property and the environment that would occur if a hazard took place. Risk is estimated by combining the probability of events and the consequences (usually seen as losses) that would arise if the events took place. |
| **Climate Scenario** | A plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change, often serving as input to impact models. Climate projections often serve as the raw material for constructing climate scenarios, but climate scenarios usually require additional information such as the observed current climate (IPCC, 2012). |
| **Climate Sensitivity** | The change in the annual global mean surface temperature (GMST) in response to a change in the atmospheric carbon dioxide ($CO_2$) concentration or other radiative forcings. |
| **Climate System** | The climate system is the highly complex system consisting of five major components: the atmosphere, the hydrosphere, the cryosphere, the lithosphere, and the biosphere, and the interactions among them. The climate system evolves in time under the influence of its own internal dynamics and because of external forcings such as volcanic eruptions, solar variations, and anthropogenic forcings such as the changing composition of the atmosphere and land-use change. (IPCC, 2012) |
| **Climate Variability** | Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability) (IPCC, 2012). |
| **Coast** | The land near the sea. The term ‘coastal’ can refer to that land (e.g., as in ‘coastal communities’), or to that part of the marine environment that is strongly influenced by land-based processes. Thus, coastal seas are generally shallow and near-shore. The landward and seaward limits of the coastal zone are not consistently defined, neither scientifically nor legally. |
| **Coastal Erosion** | Erosion of coastal landforms that results from wave action, exacerbated by storm surge and sea-level rise |
| **Coastal Management** | Are the actions taken to keep residents safe, the economy sound, and natural resources functioning? This is accomplished with federal and state |

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| | partnership programs. Federal legislation provides the overarching mandates; NOAA's Office for Coastal Management oversees implementation and provides technical assistance; federally approved state programs provide day-to-day implementation |
| **Community** | In the context of vulnerability assessment, a community can be defined as people living in one geographical area who are exposed to common hazards due to their location. |
| **Community-Based Adaptation** | Community-based adaptation is one where the explicit objective is to reduce vulnerability to climate change. |
| **Community-Based Adaptation Planning:** | Community-Based Adaptation (CBA) can be viewed simply as an additional layer of community-based development activities, practices, research and policies. |
| **Community-Based Vulnerability Assessment** | Community-based vulnerability assessments are policy and action-oriented assessment done in the community with the help of a range of community-based participatory tools with an overall objective to mitigate the negative impacts of disaster. It is done in full participation of the community. |
| **Community-Based Adaptation** | Local, community-driven adaptation. Community-based adaptation focuses attention on empowering and promoting the adaptive capacity of communities. It is an approach that takes context, culture, knowledge, agency, and preferences of communities as strengths. |
| **Convention** | A formal agreement between countries and/or states on a matter that involves them all. |
| **Coping** | The use of available skills, resources, and opportunities to address, manage and overcome adverse conditions, with the aim of achieving basic functioning of people, institutions, organisations, and systems in short to medium term. |
| **Coping Capacity** | The ability of people, organisations, and systems, using available skills, resources, and opportunities to address, manage, and overcome adverse conditions |
| **Coping Mechanism** | Those means by which societies unassisted from the outside meet relief and recovery needs and adjust to future disaster risk is known as a coping mechanism. |
| **Coping Strategies** | Households develop short-term responses to specific shocks known as coping strategies. These are 'next best' efforts to make do in a difficult situation with the hope that the household can return to normal activities and their normal livelihoods strategy. |
| **Cultural Impacts** | Impacts on material and ecological aspects of culture and the lived experience of culture, including dimensions such as identity, community cohesion and belonging, sense of place, worldview, values, perceptions, and tradition. Cultural impacts are closely related to ecological impacts, especially for iconic and representational dimensions of species and landscapes. |

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| **Deforestation** | Conversion of forest to non-forest. For a discussion of the term forest and related terms such as afforestation, reforestation, and deforestation. |
| **Disaster** | A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources (UNISDR, 2009). |
| **Disaster Management** | Social processes for designing, implementing and evaluating strategies, policies, and measures that promote and improve disaster preparedness, response, and recovery practices at different organizational and societal levels. |
| **Disaster Preparedness** | The knowledge and capacities developed by governments, professional response and recovery organisations, communities and individuals to effectively anticipate, respond to and recover from, the impacts of likely, imminent or current hazard events or conditions. |
| **Disaster Risk** | The likelihood over a specified time period of severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require an immediate emergency response to satisfy critical human needs and that may require external support for recovery. |
| **Disaster Risk Management** | Processes for designing, implementing and evaluating strategies, policies, and measures to improve the understanding of disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster preparedness, response, and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life, and sustainable development. |
| **Disaster Risk Mitigation** | The lessening of the potential adverse impacts of physical hazards (including those that are human-induced) through actions that reduce hazard, exposure, and vulnerability. |
| **Disaster Risk Reduction** | Denotes both a policy goal or objective, and the strategic and instrumental measures employed for anticipating future disaster risk; reducing existing exposure, hazard, or vulnerability; and improving resilience. |
| **Driver** | Any natural or human-induced factor that directly or indirectly causes a change in a system |
| **Early Warning System** | The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities, and organizations threatened by a hazard to prepare to act promptly and appropriately to reduce the possibility of harm or loss. |
| **Ecosystem** | A functional unit consisting of living organisms, their non-living environment and the interactions within and between them. The components included in a given ecosystem and its spatial boundaries depend on the purpose for which the ecosystem is defined: in some cases, they are relatively sharp, while in others they are diffuse. Ecosystem boundaries can change over time. Ecosystems are nested within other ecosystems, and their scale can range from very small to the entire biosphere. |

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| **El Niño-Southern Oscillation (ENSO)** | The term El Niño was initially used to describe a warm-water current that periodically flows along the coast of Ecuador and Peru, disrupting the local fishery. It has since become identified with a basin-wide warming of the tropical Pacific Ocean east of the dateline (IPCC, 2012). |
| **El Niña** | Sometimes referred to as La Niña' is the reverse actions of the El Niño. The cold phase of ENSO is called La Niña. |
| **Environmental Degradation** | The reduction of the capacity of the environment to meet social and ecological objectives and needs is known as environmental degradation. Degradation of the environment can alter the frequency and intensity of natural hazards and increase the vulnerability of communities. |
| **Environmental Degradation** | The reduction of the capacity of the environment to meet social and ecological objectives and needs. |
| **Environmental Impact Assessment** | The process by which the environmental consequences of a proposed project or programme are evaluated, undertaken as an integral part of planning and decision-making processes with a view to limiting or reducing the adverse impacts of the project or programme. |
| **Erosion** | The process of removal and transport of soil and rock by weathering, mass wasting by the action of streams, glaciers, waves, winds and underground water is known as erosion |
| **Exposure** | The presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected. |
| **Extreme Weather Event** | An extreme weather event is an event that is rare at a particular place and time of year. Definitions of rare vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of a probability density function estimated from observations. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g., drought or heavy rainfall over a season). |
| **Flood** | The overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas that are not normally submerged. Floods include river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer floods, coastal floods, and glacial lake outburst floods. |
| **Fossil Fuels** | Carbon-based fuels from fossil hydrocarbon deposits, including coal, peat, oil, and natural gas |
| **Global Warming** | Global warming refers to the gradual increase, observed or projected, in global surface temperature, as one of the consequences of radiative forcing caused by anthropogenic emissions. |
| **Global Warming Potential** | An index measuring the radiative forcing following an emission of a unit mass of a given substance, accumulated over a chosen time horizon, relative to that of the reference substance, carbon dioxide ($CO_2$). |

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| **Greenhouse Gas** | Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, the atmosphere itself, and clouds. This property causes the greenhouse effect. Water vapour ($H_2O$), carbon dioxide ($CO_2$), nitrous oxide ($N_2O$), methane ($CH_4$), and ozone ($O_3$) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances, dealt with under the Montreal Protocol. |
| **Gross domestic product (GDP)** | The sum of gross value added, at purchasers' prices, by all resident and non-resident producers in the economy, plus any taxes and minus any subsidies not included in the value of the products in a country or a geographic region for a given period, normally one year. GDP is calculated without deducting for depreciation of fabricated assets or depletion and degradation of natural resources. |
| **Hazard** | The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. |
| **Hybrid** | It is used here to refer to approaches that apply uniform and site-specific methods in tandem and within an iterative process to develop and assess the range of adaptation strategies. |
| **Impact** | The detrimental and beneficial consequence of climate change on natural and human systems is known as impact. |
| **Impact Assessment** | The practise of identifying and evaluating the detrimental and beneficial consequences of climate change on natural and human systems is known as impact assessment |
| **Impacts** | Effects on natural and human systems. In this report, the term 'impacts' is used to refer to the effects on natural and human systems of physical events, of disasters, and climate change. |
| **Land Use** | Land use refers to the total of arrangements, activities, and inputs undertaken in a certain land cover type (a set of human actions). The term land use is also used in the sense of the social and economic purposes for which land is managed (e.g., grazing, timber extraction, and conservation) |
| **Land Use Change** | Land-use change refers to a change in the use or management of land by humans, which may lead to a change in land cover. Land cover and land-use change may have an impact on the surface albedo, evapotranspiration, sources and sinks of greenhouse gases, or other properties of the climate system and may thus have radiative forcing and/or other impacts on climate, locally or globally |
| **Landfill** | Land waste disposal site in which waste is generally spread in thin layers, compacted, and covered with a fresh layer of soil each day |
| **Landslide** | A mass of material that has moved downhill by gravity, often assisted by water when the material is saturated. The movement of soil, rock, or debris down a slope can occur rapidly or may involve slow, gradual failure. |

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| **Likelihood** | A probabilistic estimate of the occurrence of a single event or of an outcome, for example, a climate parameter, observed trend, or projected change lying in a given range. Likelihood may be based on statistical or modelling analyses, elicitation of expert views, or other quantitative analyses. |
| **Livelihood** | A livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels in the long- and short-term. |
| **Local Adaptive Capacity** | The ability of a local system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities or to cope with the consequences is known as local adaptive capacity |
| **Maladaptation** | Any changes in natural or human systems that inadvertently increase vulnerability to climatic stimuli. An adaptation that does not succeed in reducing vulnerability but increases it instead is known as maladaptation. |
| **Mitigation** | A human intervention to reduce the human impact on the climate system; it includes strategies to reduce greenhouse gas sources and emissions and to enhance greenhouse gas sinks. |
| **Mitigation Measures** | Mitigation measures encompass engineering techniques and hazard-resistant construction as well as improved environmental policies and public awareness. |
| **Mitigation Option** | Options that maintain existing carbon stocks or pool of carbon is known as a mitigation option. |
| **Natural Hazard** | Natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. Natural hazards are a sub-set of all hazards. The term is used to describe actual hazard events as well as the latent hazard conditions that may give rise to future events. Natural hazard events can be characterized by their magnitude or intensity, speed of onset, duration, and area of extent. For example, earthquakes have short durations and usually affect a relatively small region, whereas droughts are slow to develop and fade away and often affect large regions. In some cases, hazards may be coupled, as in flood caused by a hurricane or the tsunami that is created by an earthquake |
| **Ozone** | The triatomic form of oxygen ($O_3$), a gaseous atmospheric constituent. In the troposphere, it is created by photochemical reactions involving gases resulting both from natural sources and from human activities (photochemical smog). In high concentrations, tropospheric ozone can be harmful to a wide range of living organisms. Tropospheric ozone acts as a greenhouse gas. In the stratosphere, ozone is created by the interaction between solar ultraviolet radiation and molecular oxygen ($O_2$). Stratospheric ozone plays a decisive role in the stratospheric radiative balance. |

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| **Ozone-Depleting Substance** | A family of man-made compounds that includes, but are not limited to, chlorofluorocarbons (CFCs), bromo fluorocarbons (halons), methyl chloroform, carbon tetrachloride, methyl bromide, and hydrochlorofluorocarbons (HCFCs). These compounds have been shown to deplete stratospheric ozone, and therefore are typically referred to as ODSs |
| **Ozone depletion** | Depletion of stratospheric ozone, due to chemical reactions that may be enhanced by climate change, results in an increased ground-level flux of ultraviolet (UV) B radiation. |
| **Ozone Layer** | The layer of ozone that begins approximately 15 km above Earth and thins to an almost negligible amount at about 50 km shields the Earth from harmful ultraviolet radiation from the sun. The highest natural concentration of ozone (approximately 10 parts per million by volume) occurs in the stratosphere at approximately 25 km above Earth. The stratospheric ozone concentration changes throughout the year as stratospheric circulation changes with the seasons. |
| **Ozone Layer Depletion** | Ozone depletion describes two distinct but related observations: a slow, steady decline of about four per cent per decade in the total volume of ozone in Earth's stratosphere (the ozone layer) since the late 1970s and a much larger but seasonal decrease in stratospheric ozone over Earth's polar regions during the same period. The latter phenomenon is commonly referred to as the ozone hole. |
| **Preparedness** | Activities and measures are taken in advance to ensure an effective response to the impact of hazards, including the issuance of timely and effective early warnings and the temporary evacuation of people and property from threatened locations |
| **Prevention** | Activities to provide outright avoidance of the adverse impact of hazards and means to minimize related environmental, technological and biological disasters. Depending on social and technical feasibility and cost/benefit considerations, investing in preventive measures is justified in areas frequently affected by disasters. In the context of public awareness and education, related to disaster risk reduction changing attitudes and behaviour contribute to promoting a 'culture of prevention |
| **Projection** | A projection is a potential future evolution of a quantity or set of quantities, often computed with the aid of a model. Unlike predictions, projections are conditional on assumptions concerning, for example, future socioeconomic and technological developments that may or may not be realized. |
| **Recovery** | Decisions and actions taken after a disaster with a view to restoring or improving the pre-disaster living conditions of the stricken community, while encouraging and facilitating necessary adjustments to reduce disaster risk. Recovery (rehabilitation and reconstruction) affords an opportunity to develop and apply disaster risk reduction measures |
| **Resilience** | The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions |

| | |
|---|---|
| **Response** | The provision of assistance or intervention during or immediately after a disaster to meet the life preservation and basic subsistence needs of those people affected. It can be of an immediate, short-term, or protracted duration |
| **Return Period** | An estimate of the average time interval between occurrences of an event (e.g., flood or extreme rainfall) of (or below/above) a defined size or intensity. |
| **Risk** | The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as a probability of occurrence of hazardous events or trends multiplied by the impacts of these events or trends occur—risk results from the interaction of vulnerability, exposure, and hazard. |
| **Risk Assessment** | The qualitative and/or quantitative scientific estimation of risks. |
| **Risk Management** | Plans, actions, strategies or policies to reduce the likelihood and/or magnitude of potential adverse consequences, based on assessed or perceived risks |
| **Salt-water Intrusion** | Displacement of fresh surface water or groundwater by the advance of saltwater due to its greater density. This usually occurs in coastal and estuarine areas due to reducing land-based influence (e.g., either from reduced runoff and associated groundwater recharge or from excessive water withdrawals from aquifers) or increasing marine influence (e.g. sea-level rise) |
| **Sea Level Rise** | Increases in the height of the sea with respect to a specific point on land. Eustatic sea-level rise is an increase in global average sea level brought about by an increase in the volume of the ocean as a result of the melting of land-based glaciers and ice sheets. Steric sea level rise is an increase in the height of the sea induced by changes in water density as a result of the heating of the ocean. Density changes induced by temperature changes only are called thermostatic; density changes induced by salinity changes are called halosteric. |
| **Sea wall** | A human-made wall or embankment along a shore to prevent seawater flooding. |
| **Sendai Framework for Disaster Risk Reduction** | The Sendai Framework for Disaster Risk Reduction 2015-2030 outlines seven clear targets and four priorities for action to prevent new, and to reduce existing disaster risks. The voluntary, non-binding agreement recognizes that the State has the primary role in reducing disaster risk but that responsibility should be shared with other stakeholders including local government, the private sector and other stakeholders, with the aim for the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries. |
| **Sensitivity** | Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise). |
| **Sink** | Any process, activity, or mechanism that removes a greenhouse gas, an aerosol, or a precursor of greenhouse gas or aerosol from the atmosphere. |

| | |
|---|---|
| **Socioeconomic Scenario** | A scenario that describes a possible future in terms of population, gross domestic product, and other socioeconomic factors relevant to understanding the implications of climate change. |
| **Socio-economic Vulnerability Index (SVI)** | Social vulnerability is "the potential negative effects on communities", which is caused by either natural or human-induced factors. The Socio-economic Vulnerability Index (SVI) is an index developed to access coastal vulnerabilities using a combination of socio-economic parameters such as land use/land cover, population density, road network, critical infrastructure, etc. (U.S. Department of Health & Human Services, 2020) |
| **Stakeholder** | A person or an organisation that has a legitimate interest in a project or entity, or would be affected by a particular action or policy. |
| **Storm Surge** | The temporary increase, at a particular locality, in the height of the sea due to extreme meteorological conditions (low atmospheric pressure and/or strong winds). The storm surge is defined as being the excess above the level expected from the tidal variation alone at that time and place. |
| **Strategy** | A broad plan of action that is implemented through policies and measures. A climate change adaptation strategy for a country refers to a general plan of action for addressing the impacts of climate change, including climate variability and extremes. It may include a mix of policies and measures, selected to meet the overarching objective of reducing the country's vulnerability. |
| **Stressor** | Event or trend that has an important effect on the system exposed and can increase vulnerability to climate-related risk |
| **Susceptibility** | Refers to the propensity (i.e. a natural tendency that you have to behave in a particular way.) of a particular receptor to experience harm. It reflects an intrinsic property of an object. |
| **Thermal expansion** | In connection with sea-level rise, this refers to the increase in volume (and decrease in density) that results from warming water. A warming of the ocean leads to an expansion of the ocean volume and hence an increase in sea level. |
| **Vulnerability** | Vulnerability is the degree to which a system is susceptible to and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. |
| **Vulnerability Assessment** | Vulnerability assessment identifies who and what is exposed and sensitive to change. A vulnerability assessment starts by considering the factors that make people or the environment susceptible to harm, i.e. access to natural and financial resources; ability to self-protect; support networks and so on. |
| **Vulnerability Index** | A metric characterising the vulnerability of a system. A climate vulnerability index is typically derived by combining, with or without weighting, several indicators assumed to represent a vulnerability. |
| **Weather** | The atmospheric condition at any given time or place. It is measured in terms of such things as wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation. In most places, weather can change from |

| | |
|---|---|
| | hour-to-hour, day-to-day, and season-to-season. Climate in a narrow sense is usually defined as the “average weather”, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. |

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# 1 INTRODUCTION

## 1.1 Project Background

UNDP is implementing a five-year GEF funded project "Adapting to climate change-induced coastal risk management in Sierra Leone" with the aim to strengthening the ability of coastal communities to systemically manage climate change risks and impacts on physical infrastructures and economic livelihoods.

The coastal zone of Sierra Leone is highly vulnerable to the increased frequency and severity of coastal erosion, flooding and storm surges which severely impact social wellbeing (health), livelihood security (and water resources) and major economic sectors such as fishing, tourism, water resources and agriculture. Coastal communities are already experiencing considerable repercussions of these impacts, notably on their livelihoods with reduced fishing productivity, ecosystem degradation and low farming outputs. The limited accessibility of climate-related data limits the ability of decision-makers to make informed planning and policy decisions for the coast (in particular marine and sea parameter databases such as wave height, wave period, wind speed and direction), and to take any clear strategic actions to remedy these negative effects. This lack of adequate knowledge is contributing to undermining social and economic development, particularly under a changing climate. In addition, weak institutional regulatory capacity coupled with the absence of a national "coastal specific" community-based information system that focuses on supporting the management of climate-related risks continue to hamper long-term coastal planning, management and early warning activities. The GEF-funded project is designed to address these problems. The intended outcome of the project is to help the Government of Sierra Leone (GoSL) to become more climate-resilient while contributing towards achieving Sustainable Development Goals (SDGs).

The project focuses on three thematic components:

- Component 1: Generating sound scientific knowledge and access to information;
- Component 2: Climate information internalized into coastal development policy and plans;
- Component 3: Awareness and alternative, innovative activities to support adaptation in the coastal zone.

Through these components, the project will work towards the update of those policies and any informational barriers that are currently preventing Sierra Leone from systematically managing coastal risks. This will contribute to reducing the vulnerability of both coastal communities and ecosystems and in the process, strengthen institutional capacity and adaptation planning. The Project is to conduct Coastal Vulnerability Assessment (CVA) for six project sites (Lakka, Hamilton, Tombo, Conakry-Dee, Shenge and Turtle Island) along the defined coastal zone of Sierra Leone.

## 1.2 Objectives

The objective of this assignment is to identify, comprehensively analyse and document existing factors that are contributing to the climate vulnerability of coastal communities in Sierra Leone and ensuring the availability of sufficient information that will help determine the type and scale of interventions to enhance coastal resilience into the future. The goal is to inform the design of future project interventions (hard, soft or hybrid) to safeguard both communities and infrastructures at the targeted locations from the impacts of climate change.

## 1.3 Scope of Work

INTEGEMS has undertaken the project under the supervision of the UNDP Team Leader for Sustainable Growth, in close collaboration with the UNDP-GEF National Project Manager and primary stakeholders for the Project – Environment Protection Agency, Sierra Leone (EPA-SL), Ministry of Fisheries and Marine Resources (MFMR) Institute of Marine Biology and Oceanography (IMBO), and National Tourist Board (NTB).

Specifically, the Scope of Work (SoW) includes:

i. Conduct an assessment of the climate change risk of the coastal zones within the six project sites (at least three climate scenarios) and from this to identify features that are required to help develop coastal resilience;

ii. Carry out Oceanography/marine drone-based coastal zone erosion mapping;

iii. Consult key technical partner institutions and experts to identify broader climate change issues, review existing and past climate change interventions at national and sectoral levels;

iv. Conduct field consultation with local coastal community groups regarding existing risks and vulnerabilities as well as documenting their knowledge and experience regarding contemporary challenges that are climate change-related;

v. Identify capacity building needs and develop a training package for key stakeholders in the targeted coastal communities;

vi. Assess and evaluate the occurrence of recorded climate change specific hazards which have occurred over the last ten years at all six project sites;

vii. Identify links between the reported climatic variations and specific livelihood and other income-generating and economic activities that have been carried out on natural resources (ecosystems or specific habitats) within coastal communities;

viii. Identify priority areas (geographic) that are experiencing high climate-related risks or vulnerabilities;

ix. Facilitate a multi-stakeholder discussion and participatory event to communicate the findings and recommendations from the study. The event must include relevant communities, local and regional authorities, the private sector, NGOs and CBOs as appropriate;

x. Identify and prioritize adaptive measures (engineering or non-engineering) based on the findings of the assessment;

xi. Formulate a costed-action plan for the implementation of adaptive measures, including costing and resource requirements.

## 1.4 Study Area

Locations of the coastal communities (Lakka, Hamilton, Tombo, Conakry-Dee, Shenge and Turtle Islands) is shown the Figure 1-1

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**Figure 1-1: The Study Area – Communities**

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660000 680000 700000 720000 740000 760000 780000

970000 940000 910000 880000 850000

Scarcies River Estuary

Karene

Konakridee

Port Loko

Rokel River Estuary

Western Area Urban

Lakka

Hamilton

Tonkolili

Western Area Rural

Tombo

Yawri Bay

Atlantic Ocean

Moyamba

Shenge

Sherbro River Estuary

Turtle Islands

Bonthe

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## Legend

- Project Coastal Communities Visited
- Mangroves
- Sierra Leone Estuaries
- Coastline
- Rivers and Streams
- Major Roads
- District Boundaries

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Coastal Vulnerability Assessment in Six Coastal Communities

**Figure No:** Figure 1-1

**Map Scale:** 0 5 10 20 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

The study area comprises six communities along the coast of Sierra Leone including Lakka, Hamilton, Tombo, Conakry-Dee, Shenge and Turtle Islands. Lakka, Hamilton and Tombo are located along the Freetown Peninsula in Western Area (Urban and Rural), Shenge is located in the Yawri Bay in Moyamba, Conakry-Dee along the coast of Port Loko while the Turtle Islands are located at the entrance of the Sherbro River Estuary in Bonthe.

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Integrated Geo-information and Environmental Management Services

UNDP

National Tourist Board of Sierra Leone

EPA-SL

SLMet
Sierra Leone Meteorological Agency

## 1.5 Report Structure

This Draft Report has been prepared to present the findings of the Coastal Vulnerability Assessment and consists of the sections in Table 1-1.

**Table 1-1: Structure of this Report**

| Sections | Title | Content |
|---|---|---|
| Section 1 | Introduction | Provides an overview and background to the Project; including the study objective, scope of work, and study areas and study limitation of the report. |
| Section 2 | Country Background | Provides a summary and description of the country background, including geographical context; climate and weather; political governance, and historical context. |
| Section 3 | Global Climate Change | Describes the science of climate change, including the evidence of global climate change, climate change drivers and international legal Framework. |
| Section 4 | Climate Change in Sierra Leone | Describes climate change and its adverse effects in Sierra Leone; and highlights previous studies and vulnerability assessments and national institutional and legal framework; legislation and legal framework; policies and plans; and institutional challenges to addressing climate change. |
| Section 5 | Coastal Systems and Hazards | Describes the coastal systems and hazards that are common along the coast of Sierra Leone. |
| Section 6 | Socio-Economic Profile of the Study Area | Provides an overview of the socio-economic make-up of the six communities assessed. |
| Section 7 | Coastal Vulnerability Assessment | Describes the approach and methodology of the coastal vulnerability assessment, including the results and analysis. |
| Section 8 | Adaptation Action Plan | Describes the initial set of measures for future planning, preparedness, risk mitigation and adaptation capacities of the various communities. |
| Section 9 | Recommendations | Outlines prioritisation options, initiatives/opportunities based on the findings of the assessment. |
| Section 10 | Conclusions | Summarises the key findings of the Study. |
| | Bibliography | Provides all references used in the Report. |
| | Appendices | Presents maps; summary of KIIs and FDGs; photos of stakeholder engagement; sample of stakeholder notification letter and stakeholder engagement attendance list. |

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## 1.6 Study Limitations

The limitations to this study include the following:

- One of the biggest limitations for this study was accessing reliable data sources useful to assess the vulnerabilities of these communities. These included meteorological data, environmental and socioeconomic data. Despite a clear need to include these data, some vital data were not available.
- Where data was available, there were challenges with the length of data (historical data) and inconsistencies makes it difficult to interpret and comprehensively analyse the data. This is partly due to method of data collection and dissemination. Institutions collect the same data in different formats and parameters. Furthermore, some information is provided in hard copy format which makes processing a bit tedious and time consuming as data has the be converted into useable electronic format before it can be used.
- A general lack of structured data-limited options on modelling, assessing and visualising quantitative phenomena. In some instances where data was available, they were in coarse spatial resolution (e.g. Community level or 30 m resolution) or lacked adequate temporal coverage; thus limiting the model's ability to extract information at granular spatiotemporal scale.
- Accessibility to some of the communities, especially the Turtle Island community, which require maritime travel, was sometimes constrained by weather conditions posing logistical challenges in navigating through times of frequent high tides.
- Socio-economic research was undertaken during the COVID-19 period. It is assumed that socio-economic information acquired could have been influenced by the conditions imposed by the outbreak and may not be reflective of normal socio-economic conditions.

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# 2 COUNTRY BACKGROUND

## 2.1 Geographical Context

Sierra Leone is located on the West Coast of Africa with an area of about 71,740 km$^2$. The country lies between latitudes 6° N and 10° N and longitude 10° 16' W and 13° 18' W. Bounded on the south-west by the Atlantic Ocean, it stretches along the coastline for approximately 506 km, by Guinea on the north and north-east, and by Liberia on the south-east (see Figure 2-1) (EPA-SL, 2015). Sierra Leone is divided into four main physical regions, namely coastal plains, interior lowland plains, interior plateau, and hills and mountains.

## 2.2 Political Governance and Historical Context

Sierra Leone is a constitutional republic with a directly elected President and a unicameral legislature. In 1961, Sierra Leone gained independence from the British Colonial rule, and in 1971 a Republican Presidential System was established. In 1978, a One-Party Constitution was introduced, and in 1991 Sierra Leone had a multi-party system, which brought into existence the Constitution of Sierra Leone 1991 (Morgan, 2016).

The government system is divided into three arms: The Executive, Legislative and the Judiciary. The seat of power (State House) is housed in the Freetown the capital city. The Government of the Republic of Sierra Leone functions within the legal framework of a presidential representative democratic republic, where His Excellency the President of the Republic of Sierra Leone is the Head of State, the Supreme Executive Authority of the Republic and Commander-in-Chief of the Armed Forces.

An eleven-year civil conflict (1991-2002) led to a total breakdown of state and governance structures. Final stabilisation came with the Lomé Peace Accord in 1999, enforced by the UN Peacekeeping Mission and solidified by the 2002 elections, which initiated the transition period. Now that DDR has been completed, and following the peaceful transition of power after the 2007 presidential elections, Sierra Leone can be characterized as being in the consolidation phase of the peace process, where strengthening governance capacity and achieving development goals are the major objectives.

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**Figure 2-1: Location of Sierra Leone in West Africa**

16°26'40"W 15°25'20"W 14°24'0"W 13°22'40"W 12°21'20"W 11°20'0"W 10°18'40"W 9°17'20"W 8°16'0"W 7°14'40"W

14°16'0"N
13°14'40"N
12°13'20"N
11°12'0"N
10°10'40"N
9°9'20"N
8°8'0"N
7°6'40"N
6°5'20"N
5°4'0"N
4°2'40"N

N W E S

Senegal
Gambia
Mali
Guinea-Bissau
Guinea
Sierra Leone
Côte d'Ivoire
Liberia

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**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Location of Sierra Leone in West Africa

**Figure No:** Figure 2-1

**Map Scale:** 0 62.5 125 250 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

Sierra Leone is located on the West Coast of Africa and it is bounded in the North and Northeastby the Republic of Guinea and the Southeast by the Republic of Liberia. Along the West of Sierra Leone is the stretch of the North Atlantic Ocean.

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## 2.3 Administrative Divisions

Administratively, Sierra Leone is divided into five regions: Eastern, Northern, North-western, Southern Provinces, and the Western Area. Each province is subdivided into districts, and the districts are further divided into Chiefdoms. Overall, there are 16 Districts and 191 Chiefdoms in the country. In addition to this, the 2004 Local Government Act (as amended in 2017) established 19 Local Councils, 7 City Councils and 15 District Councils.

**Table 2-1: Sierra Leone Administrative Divisions**

| Province/Area | Districts | Chiefdoms |
|---|---|---|
| Northern Province | Bombali | 12 |
| | Falaba | 13 |
| | Koinadugu | 11 |
| | Tonkolili | 19 |
| North-western Province | Kambia | 10 |
| | Port Loko | 13 |
| | Karene | 14 |
| Southern Province | Bo | 16 |
| | Bonthe | 11 |
| | Moyamba | 14 |
| | Pujehun | 14 |
| Eastern Province | Kailahun | 14 |
| | Kenema | 16 |
| | Kono | 14 |
| Western Area | Western Area Urban | - |
| | Western Area Urban | - |

## 2.4 Socio-economic Context

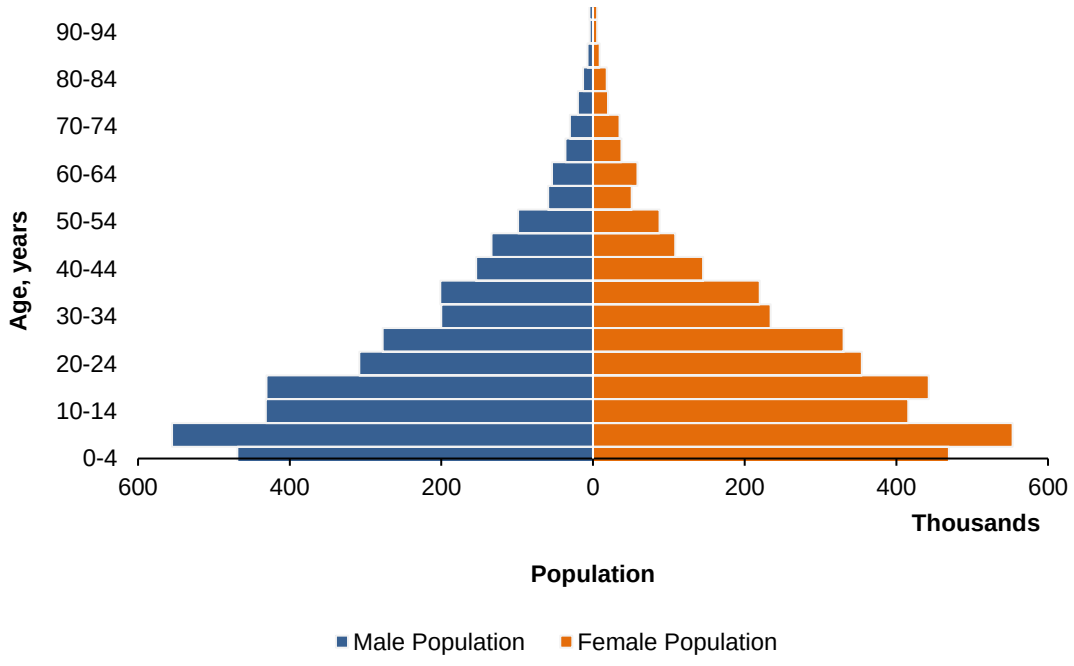
### 2.4.1 Demography

The 2015 Census data indicates that the population grew from 4,976,871 in 2004 to 7,092,113 in 2015, registering an average annual growth rate of 3.2% (Stats-SL, 2015). Males represented 49.1% of the total population and females 50.9%. The 2015 PHC results reflect the demographic profile of a young population, where 40.9% are less than 15 years, and only 3.5% are 65 years and above. The working-age population (15-64 years) represents 55.6%. By type of residence, the 2015 Census reveals that 4,187,016 people live in the rural areas (59.0%), and 2,905,097 people live in the urban areas (41.0%) (Stats-SL, 2015). The age-dependency ratio for Sierra Leone as recorded during the 2015 Population and Housing Census (PHC 2015) range from 55 (Western Area Urban) to 95 (Kambia District) With a national average of 79 (see Figure 2-2).

**Table 2-2: Distribution of Population by District and Sex (Open Data Sierra Leone, 2019)**

| District | Total Population | | |
|---|---|---|---|
| | Male | Female | Total |
| Bo | 280,569 | 294,909 | 575,478 |
| Bombali | 205,914 | 217,046 | 422,960 |
| Bonthe | 99,014 | 101,767 | 200,781 |
| Falaba | 103,691 | 101,662 | 205,353 |
| Kailahun | 260,586 | 265,793 | 526,379 |
| Kambia | 165,541 | 179,933 | 345,474 |
| Karene | 139,244 | 146,302 | 285,546 |
| Kenema | 301,104 | 308,787 | 609,891 |
| Koinadugu | 100,807 | 103,212 | 204,019 |
| Kono | 252,751 | 253,349 | 506,100 |
| Moyamba | 153,699 | 164,889 | 318,588 |
| Port Loko | 255,030 | 275,835 | 530,865 |
| Pujehun | 168,869 | 177,592 | 346,461 |
| Tonkolili | 254,601 | 259,383 | 513,984 |
| Western Area Rural | 221,351 | 222,919 | 444,270 |
| Western Area Urban | 528,207 | 527,757 | 1,055,964 |
| **Total** | **3,490,978** | **3,601,135** | **7,092,113** |

**Figure 2-2: Population Pyramid of Sierra Leone (Population and Housing Census 2015)**



### 2.4.2 Health

The Ministry of Health and Sanitation (MoHS) is the main health care provider in Sierra Leone. The structure of public sector health service delivery involves a multi-level primary, secondary and tertiary care system through which cases of increasing complexity are referred to facilities with increasing capacity. The public health delivery system starts from the peripheral health units (PHU), which are recognised and standardised. At the base, community health workers (CHWs) operate in the community providing a fixed package of health promotion and health care services, as well as conducting surveillance activities.

The primary health care system comprises three levels of progressively larger facilities with increasingly skilled CHWs. From smallest to largest, these include Maternal and Child Health Posts (MCHPs), Community Health Posts (CHPs), and Community Health Centres (CHCs). CHCs also provide basic emergency obstetric and neonatal care (BEmONC) services. Whilst there are staffing, supply chain, and infrastructure challenges at every level (but especially at the primary care level), this structure provides a solid foundation for health service delivery in the country. The secondary care system comprises district hospitals and regional hospitals that provide a comprehensive range of services, including comprehensive obstetric and neonatal care (CEmONC) services. The tertiary care system comprises a number of hospitals that provide the most specialised of services in their area, e.g. paediatric care at Ola During Children Hospital; maternity care at Princess Christian Maternity Hospital; and general medicine and surgery at Connaught Hospital.

Despite efforts to improve service delivery, the country's health system is faced with significant challenges. Over the years, Sierra Leone has suffered from epidemics such as the 2014 Ebola and 2020 COVID-19 outbreaks.

### 2.4.3 Education and Literacy

Sierra Leone inherited the British educational system and had a strong educational base, dating back to the nineteenth-twentieth centuries. The first western-style university in West Africa, Fourah Bay College was founded in Sierra Leone in 1827 and earned the accolade of the "Athens of West Africa". However, decades of gradual negligence after independence led to a decline in the educational standard. Additionally, the 11 years civil war led to further destruction to the educational infrastructures as well as causing thousands of school-going children to be dropouts.

Sierra Leone has the 6-3-3-4 education system, which comprises of 6 years of formal primary education, 3 years of Junior Secondary School (JSS), 3 years of Senior Secondary School (SSS), and 4 years of tertiary level education. The Ministry of Basic and Senior Secondary Education (MBSSE) and Ministry of Tertiary and Higher Education (MTHE) are the government entities in charge of planning, overseeing, and implementing the educational policies of Sierra Leone.

The 2015 Population and Housing Census (PHC) revealed that out of the 6,589,838 people aged 3 years and above, 55.4 % had attended school, and 44.2 % have never attended school. Whereas of those persons 3 years and above who attended school, 37.2 % are currently in school. The percentages of males currently in school (39.1%) and those ever-attended school (60.0%) are more than their female counterparts (35.3% and 50.9% respectively). The percentage of the population that has never attended school in rural areas (32.7%) is almost three times more than those in the urban areas (11.5%) (Stats-SL, 2015).

### 2.4.4 Housing Infrastructure

Housing is one of the basic needs of all human beings that have an impact on the health, welfare, the social and economic productivity of an individual. For many years, the housing environment has been acknowledged as one of the main settings that affect human health (Stats-SL, 2018).

The 2015 PHC revealed that the total stock of houses in the country is 801,417. The proportion of houses in rural areas (60.6%) is higher than that in urban areas (39.4%). The regional distribution shows that eastern province accounts for 21.8 % of the stock of houses, northern province 34.3 %, southern province 22.7 % and western area 21.1%. It should be noted that the housing stock in the northern province has been redistributed between the newly constituted north-western province and the northern province.

On average, Sierra Leone has 1.6 households per house and ranges from a low of 1.4 in the Southern province to a high of 1.9 in the Western Area (Stats-SL, 2015). The common material used for the construction of walls nationally is mud bricks, followed by cement blocks, mud & wattle, clay bricks and zinc. In the rural areas, the data shows that mud bricks account for most of the wall construction followed by mud & wattle, cement blocks, clay bricks and zinc. In the urban areas, the predominant material used for the construction of walls is cement bricks while construction is done with other materials like mud brick zinc and clay. The use of zinc for roofing is highest nationwide with 81.6 %, followed by thatch (13.3%), asbestos (2.0%), concrete (1.6%) and the rest accounting for 1.4% (Stats-SL, 2015).

### 2.4.5 Fisheries

Sierra Leone has an extensive coastline with a sizeable continental shelf (covering an area of over 25,000 square kilometres and a width of up to 140 kilometres in the north) that is fed by substantial rivers and rainfall, providing the basic elements for extremely productive marine fisheries.

The fisheries subsector continues to play a significant role in the national economy and food security of the country. It contributes about 12% of GDP, and it is the most important economic activity along the coastline of Sierra Leone. Fish is the largest source of animal protein for the majority of Sierra Leoneans, supplying about 80% of total animal protein consumption. Over 500,000 people are directly or indirectly employed in the fisheries sector (GoSL, 2019).

The fisheries sector in Sierra Leone constitute three major activities:

- Artisanal Fishing Activity: It operates in estuaries and coastal waters extending from the shoreline to a depth of 15-45m. This activity comprises of a variety of dugout and planked canoes which employ diverse ranges of fisheries gears, which include cast nets, ring nets, driftnets, set net, beach seines and hooks. This fishery contributes significantly (up to 80%) of the total national fish production.
- Industrial Fishing Activity: Industrial fishing activity operates in the deep waters, outside the Inshore Exclusive Zone (IEZ) and it is characterized by multinational fleet which includes trawlers, shrimpers, longliners, canoe support vessels (mother ship) and carriers. It is largely export-oriented.
- Inland Fishing and Aquaculture: Inland fishery operates in rivers, lakes, flood plains and swamps. Aquaculture is mostly practised in inland valley swamps and wetlands and has great potential for development.

### 2.4.6 Agriculture

Sierra Leone's economy is dominated by the agricultural sector, which contributed about 55.1% of GDP. Services contribute 36.6%, while industry makes up 9.3% of GDP. The country also depends on primary commodities for exports. The structure of production is dominated by raw material production from abundant natural resources. (GoSL, 2019)

Agriculture remains the backbone of the economy of Sierra Leone and is comprised of subsectors that have the potential to be key drivers of the country's economic development. The sector directly contributes to the national economy through enhancing food security, income generation, employment, wealth creation, and poverty reduction, and has the potential for industrial development and ensuring equitable distribution of resources. Its share of GDP averages between 40 to 50%, and it provides employment to approximately two-thirds of the population. It further accounts for about 10% of the country's total exports. (GoSL, 2019)

From 2013 to 2018, the sector accounted for 61.1% of rural employment. With support from development partners, contributions were made to food security, as more than 52 agricultural business centres were transformed into functional cooperatives along several crops' value chains. (GoSL, 2019).

### 2.4.7 Tourism

The Ministry of Tourism and Cultural Affairs is the ministry with the mandate of promoting, developing, and preserving tourism and cultural activities in the country.

The tourism sector accounted for $42 million of Government revenue generated in 2012, coming from local hotel accommodation, restaurants, transportation, and souvenirs. Over the last few years,

Government has developed seven-year strategic plans and policies for tourism, a marketing programme, and a tour guide training programme, among other activities. (GoSL, 2013)

The adoption of the National Tourism Policy and the National Ecotourism Policy in 2017 have provided blueprints to guide the orderly and sustainable development of the sector, thereby ameliorating the risk of the haphazard development that had been experienced in the past. The National Ecotourism Policy seeks to attract up to 20,000 international and 30,000 domestic ecotourism visits by 2025. The policy has placed significant emphasis on the protection of the environment, in collaboration with the Environment Protection Agency and the National Protected Area Authority. (GoSL, 2019)

The natural and historical resources of the country are considered its prime tourist attractions, with rich ecosystems and biodiversity harbouring some of the world's most unique flora and fauna (including numerous endemic species), and a coastline of more than 400 kilometres, with excellent beaches, exotic islands, and opportunities for water sports.

There are numerous challenges facing the tourism sector. These include a poor regulatory environment, a weak policy framework, an incomplete and outdated tourism master plan and tourism register, and poor institutional capacity to identify and market tourism products and services. Another critical issue is the inadequate infrastructure. (GoSL, 2019).

### 2.4.8 Energy

Limited access to affordable and reliable electricity supply in Sierra Leone is a challenge for growth and development. Biomass, mostly from wood and charcoal, constitutes the major source of energy (about 80%). The importation of petroleum products (about 13% of the country's energy) uses a significant amount of foreign currency. The large-scale Bumbuna 1 Hydro Project generates around 40% of Freetown's energy. The Government of Sierra Leone unbundled the power sector in 2015 and created new state utilities. The Electricity Generation and Transmission Company (EGTC), together with independent power producers (IPP), is exclusively restricted to electricity generation and transmission. The Electricity Distribution and Supply Authority are charged with the responsibility of bulk power purchase from generators and sale to end-users. (GoSL, 2019)

Sierra Leone has a huge renewable energy potential (solar, hydroelectric and biomass) due to its tropical climate (i.e. continuous sunshine and high levels of rainfall), abundant surface water bodies and large amounts of green vegetation.

In 2018, the energy sector of Sierra Leone had an approximate output of 105 megawatts of installed generation capacity connected to the main grid, with 53% of electricity generated and provided by IPPs. Demand is forecast to exceed 360 megawatts by 2023, due primarily to the Ministry of Energy's desire to restore electricity supply to all the district capitals, in addition to a general increase in domestic demand. (GoSL, 2019)

Challenges exist in energy transmission and distribution. The transmission grid is inadequate for transmission from areas where low-cost renewable electricity can be generated (Bumbuna, Bekongor, Mange) to areas where low-cost fossil fuel (heavy fuel oil, liquefied natural gas, or coal) may be shipped (or produced) and converted to power, and to load centres (towns and mining sites). There is also a need to increase the transmission grid to accommodate the upcoming West African power pool initiative. The distribution network has numerous challenges, with Freetown being the most problem-prone due to outdated infrastructure and capacity (GoSL, 2019).

### 2.4.9 Mining

Mining has been a mainstay of the Sierra Leonean economy since independence. The country is well known for its vast endowment of diamonds and iron ore, but it is also rich in bauxite, rutile, ilmenite, zircon, gold, platinum, tantalite, chromite, and columbite. Diamond productions are concentrated in Kono, Kenema and Bo Districts. Bauxite deposits and production sites include those between Moyamba and Mano, Freetown Peninsular; KrimKpaka, and Port Loko. Rutile production is distributed around Gbangbama, Sembehun, Rotifunk and Kambia. Iron ore has long been mined at Marampa and mining activities have also begun in Tonkolili. Gold is mined artisanally, and presently production comes from alluvial deposits.

Direct and indirect employment in large-scale mines engages over 30,000 people, with an estimated 300,000 people (including dependents and extended families) deriving their livelihoods from these mines. The sector has been contributing about 24% to GDP and over 80% to export earnings (in 2013),

although its contribution has still been well below its potential, providing on average 16% of total revenue (between 2013 and 2017). The mining sector was greatly affected by the dual shock of the drop in commodity prices and the Ebola Virus Disease outbreak in 2014.

DRAFT

# 3 GLOBAL CLIMATE CHANGE

Climate Change could be described as the change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (UNFCCC, 1992). These changes have led to the obstruction of climate systems[1] and by extension have had adverse effects[2] on Earth and its planetary resources. The atmospheric component of the climate system obviously characterises the climate; climate is often defined as 'average weather'. Climate is usually described in terms of the mean and variability of temperature, precipitation and wind over a period of time, ranging from months to millions of years; according to the IPCC, the classical period for climate assessment is 30 years (Le Treut, et al., 2007). The climate system is a complex, interactive system consisting of the atmosphere, land surface, snow and ice, oceans and other bodies of water, and living things (Le Treut, et al., 2007).

## 3.1 Evidence of Global Climate Change

As climate science and the Earth's climate have continued to evolve over recent decades, increasing evidence of anthropogenic influences on climate change has been found (Le Treut, et al., 2007). The current warming trend is of particular significance because most of it is extremely likely (greater than 95% probability) to be the result of human activity since the mid-20$^{th}$ century and proceeding at a rate that is unprecedented over decades to millennia (IPCC, 2014).

Earth-orbiting satellites and other technological advances have enabled scientists to see the big picture, collecting many different types of information about our planet and its climate on a global scale. This body of data, collected over many years, reveals the signals of a changing climate.

The heat-trapping nature of carbon dioxide and other gases was demonstrated in the mid-19$^{th}$ century. Their ability to affect the transfer of infrared energy through the atmosphere is the scientific basis of many instruments flown by NASA; there is no question that increased levels of greenhouse gases must cause Earth to warm in response (NASA, 2020).

Ice cores drawn from Greenland, Antarctica and Tropical Mountain glaciers show that Earth's climate responds to changes in greenhouse gas levels. Ancient evidence can also be found in tree rings, ocean sediments, coral reefs, and layers of sedimentary rocks. This ancient, or paleoclimate, evidence reveals that current warming is occurring roughly ten times faster than the average rate of ice-age-recovery warming. Carbon dioxide from human activity is increasing more than 250 times faster than it did from natural sources after the last Ice Age (NASA, 2020).

Temperature is one indicator of ongoing climate change. Also, sea levels are rising at an increasing pace, through greater warming of the oceans, on the surface and in the depths, and through the enhanced melting of Greenland's ice and of glaciers, exposing coastal areas and islands to a greater risk of flooding and the submersion of low-lying areas (WMO, 2020). The Practical evidence of Global Climate Change is indicative on Climate Systems in the following ways: global temperature rise; warming ocean; shrinking ice sheets; glacial retreat; decreased snow cover; sea-level rise; declining arctic sea ice; ocean acidification; and extreme climatic drivers.

## 3.2 Climate Change Drivers

The climate system evolves in time under the influence of its own internal dynamics and due to changes in external factors that affect climate (called 'forcings'). External forcings include natural phenomena such as volcanic eruptions and solar variations, as well as human-induced changes in atmospheric composition (Le Treut, et al., 2007).

Another way to refer to climate forcings is to call them climate drivers. Natural climate drivers include changes in the sun's energy output, regular changes in Earth's orbital cycle, and large volcanic eruptions that put light-reflecting particles into the upper atmosphere. Human-caused or anthropogenic

[1] Climate system means the totality of the atmosphere, hydrosphere, biosphere and geosphere and their interactions. (UNFCCC, 1992)

2 "Adverse effects of climate change" means changes in the physical environment or biota resulting from climate change which have significant deleterious effects on the composition, resilience or productivity of natural and managed ecosystems or on the operation of socio-economic systems or on human health and welfare. (UNFCCC, 1992)

climate drivers include emissions of heat-trapping gases (also known as greenhouse gases) and changes in land use that make land reflect more or less sunlight energy. Since 1750, human-caused climate drivers have been increasing, and their effect dominates all-natural climate drivers (NOAA, 2020).

The Natural Phenomena include climate drivers that have little or no human prints on them; they are mostly characterised by the internal dynamism of climate forcings and their natural dispositions. Anthropogenic Phenomena are human activities that have changed and continue to change the Earth's surface and atmospheric composition. Some of these changes have a direct or indirect impact on the energy balance of the Earth and are thus, drivers of climate change (Stocker, 2013). Human activities include the emission of greenhouse gases (GHG) and their feedback mechanisms.

## 3.3 International Institutional Framework

### 3.3.1 United Nations Environment Programme (UNEP)

The United Nations Environment Programme (UNEP) established in 1972 is the leading global environmental authority that sets the global environmental agenda, promotes the coherent implementation of the environmental dimension of sustainable development within the United Nations system, and serves as an authoritative advocate for the global environment. UNEP acts as a catalyst, advocate, educator and facilitator to promote the wise use and sustainable development of the global environment. To accomplish this, UNEP works with a wide range of partners, including United Nations entities, international organizations, national governments, non-governmental organizations, the private sector and civil society.

### 3.3.2 World Meteorological Organisation (WMO)

The World Meteorological Organisation (WMO) is an intergovernmental organisation with a membership of 193 Member States and Territories (187 Member States and 6 Member Territories). It originated from the International Meteorological Organization (IMO), the roots of which were planted at the 1873 Vienna International Meteorological Congress. Established by the ratification of the WMO Convention on 23 March 1950, WMO became the specialised agency of the United Nations for meteorology (weather and climate), operational hydrology and related geophysical sciences a year later.

On the 30 March 1962, Sierra Leone became a member of the WMO. It coordinates and organizes international research programmes to enhance the ability of its Members to improve weather, climate, water and environmental observations, prediction, service delivery and scientific assessments of regional and global environmental conditions.

### 3.3.3 United Nations Framework Convention on Climate Change (UNFCCC)

The United Nations Framework Convention on Climate Change entered into force on 21 March 1994 with the ultimate aim of preventing dangerous human interference with the climate system. The convention has a near-universal partnership with 197 Countries and is the parent treaty of the 2015 Paris Agreement. The 197 countries that have ratified the Convention are called Parties to the Convention of which Sierra Leone is a party and signed to the convention on the 22nd September 2016 and entered in to force on the 1st December 2016. The main aim of the Paris Agreement is to keep the global average temperature rise this century as close as possible to 1.5 degrees Celsius above pre-industrial levels. The UNFCCC is also the parent treaty of the 1997 Kyoto Protocol.

The ultimate objective of all three agreements under the UNFCCC is to stabilize greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system, in a time frame which allows ecosystems to adapt naturally and enables sustainable development.

### 3.3.4 Intergovernmental Panel on Climate Change (IPCC)

The IPCC was created in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) with the objective to provide governments at all levels with scientific information that can be used to develop climate policies. The IPCC is an organization of governments that are members of the United Nations or WMO and currently has 195 members. Reports

from IPCC are also a key input into international climate change negotiations. For the assessment reports, IPCC scientists volunteer their time to assess the thousands of scientific papers published each year to provide a comprehensive summary of what is known about the drivers of climate change, its impacts and future risks, and how adaptation and mitigation can reduce those risks. An open and transparent review by experts and governments around the world is an essential part of the IPCC process, to ensure an objective and complete assessment and to reflect a diverse range of views and expertise. Through its assessments, the IPCC identifies the strength of scientific agreement in different areas and indicates where further research is needed. The IPCC does not conduct its own research.

### 3.3.5 United Nations Development Programme (UNDP)

The United Nations Development Programme was established in 1965 as the United Nations global development network. It promotes technical and investment cooperation among nations and advocates for change and connects countries to knowledge, experience and other resources to help people build a better life for themselves. The organization operates in 170 countries and territories, where it works with local governments to meet development challenges and develop local capacity. The UNDP help countries to develop policies, leadership skills, partnering abilities, institutional capabilities and build resilience to sustain development results. Since its establishment, the UNDP has been working in partnership with the Government and people of Sierra Leone (SL). Guided by the Medium-Term Development Plan (2018-2023), UNDP Sierra Leone supports Government in the areas of inclusive growth and sustainability; effective and inclusive democratic governance; and environment and energy.

### 3.3.6 UN Office for Disaster Risk Reduction (UNDRR)

The UN Office for Disaster Risk Reduction (UNDRR) was established in 1999 to facilitate the implementation of the International Strategy for Disaster Reduction (ISDR). It was created to be the focal point in the United Nations system for the coordination of disaster risk reduction and ensures synergies among the relevant activities of United Nations agencies and regional organisations, and related activities in socio-economic and humanitarian fields.

UNDRR's current mandate was set down in UN General Assembly Resolution 69/283, adopted in June 2015. It is tasked with supporting the implementation, follow-up and review of the Sendai Framework for Disaster Risk Reduction 2015-2030, including by fostering coherence with other international instruments, such as the 2030 Agenda for Sustainable Development and its Sustainable Development Goals, as well as the Paris Agreement on climate change.

### 3.3.7 Global Environment Facility (GEF)

The Global Environment Facility was established on the eve of the 1992 Rio Earth Summit, to help tackle our planet's most pressing environmental problems. The GEF is a unique partnership of 18 agencies including United Nations agencies, multilateral development banks, national entities and international NGOs working with 183 countries to address the world's most challenging environmental issues. The GEF has a large network of civil society organizations, works closely with the private sector around the world, and receives continuous inputs from an independent evaluation office and a world-class scientific panel. It is a financial mechanism for five major international environmental conventions: the Minamata Convention on Mercury, the Stockholm Convention on Persistent Organic Pollutants (POPs), the United Nations Convention on Biological Diversity (UNCBD), the United Nations Convention to Combat Desertification (UNCCD) and the United Nations Framework Convention on Climate Change (UNFCCC). The GEF Funds are available to developing countries and countries with economies in transition to meet the objectives of the international environmental conventions and agreements.

## 3.4 International Legal Framework

### 3.4.1 Paris Agreement

The Paris Agreement was adopted on 12 December 2015 to respond to the urgent and potentially irreversible threat faced by humans at the community and national level. The agreement builds upon the United Nations Framework Convention on Climate Change (UNFCCC) and brings nations around the world to collectively agree that climate change is driven by human behaviour, that it's a threat to the environment and all of humanity, and that global action is needed to stop it. The Paris Agreement sets

out a global framework to avoid dangerous climate change by limiting global warming to well below 2°C and pursuing efforts to limit it to 1.5°C[3]. It also aims to strengthen countries' ability to deal with the impacts of climate change and support them in their efforts.

The Paris Agreement has made some significant progress by changing the paradigm of climate diplomacy, as 197 countries agreed through the Nationally Determined Contribution (NDC) to transform their development trajectories to slash greenhouse gas emissions. Sierra Leone is, however, contributing to the global scheme by creating a carbon sink which is committed to planting 1 million trees in 2020 and increasing its vegetation cover to 50% by 2022.

### 3.4.2 Montreal Protocol

The Montreal Protocol, finalized in 1987, is a global agreement to protect the stratospheric ozone layer by phasing out the production and consumption of ozone-depleting substances (ODS). The ozone layer filters out harmful ultraviolet radiation, which is associated with an increased prevalence of skin cancer and cataracts, reduced agricultural productivity, and disruption of marine ecosystems.

The Montreal Protocol has proven to be innovative and successful and is the first treaty to achieve universal ratification by all countries in the world. Leveraging this worldwide participation, the Montreal Protocol has spurred global investment in alternative technologies and placed the ozone layer, which was in peril, on a path to repair. Furthermore, On October 15, 2016, Parties to the Montreal Protocol adopted the Kigali Amendment to phase down production and consumption of hydrofluorocarbons (HFCs) worldwide.

### 3.4.3 Kyoto Protocol

The Kyoto Protocol was adopted on 11 December 1997. Owing to a complex ratification process, it entered into force on 16 February 2005. Currently, there are 192 Parties to the Kyoto Protocol. In its Annex B, the Kyoto Protocol sets binding emission reduction targets for 37 industrialized countries and economies in transition and the European Union. Overall, these targets add up to an average 5% emission reduction compared to 1990 levels over the five-year period, 2008–2012 (the first commitment period). In Doha, Qatar, on 8 December 2012, the Doha Amendment to the Kyoto Protocol was adopted for a second commitment period, starting in 2013 and lasting until 2020. However, the Doha Amendment has not yet entered into force; a total of 144 instruments of acceptance are required for entry into force of the amendment.

During the first commitment period, 37 industrialized countries and economies in transition and the European Community committed to reduce GHG emissions to an average of 5% against 1990 levels. During the second commitment period, Parties committed to reduce GHG emissions by at least 18% below 1990 levels in the eight-year period from 2013 to 2020; however, the composition of Parties in the second commitment period is different from the first[4].

### 3.4.4 Hyogo Framework

In 2005, Governments around the world committed to taking action to reduce disaster risk, and adopted a guideline to reduce vulnerabilities to natural hazards, called the Hyogo Framework for Action (HFA). The HFA assisted the efforts of nations and communities to become more resilient to and cope better with the hazards that threaten their development gains. Since the adoption of the HFA, as documented in the National Progress Report on the Implementation of the Hyogo Framework for Action (2009-2011)[5], modest progress has been achieved in reducing disaster risk at local and national levels by the GoSL and other relevant stakeholders, leading to a decrease in mortality in the case of some hazards. Reducing disaster risk is a cost-effective investment in preventing future losses.

Sierra Leone continues to enhance its capacities in disaster risk management, and the HFA was instrumental in the development of policies and strategies and the advancement of knowledge and mutual learning with regards disaster management. Overall, the HFA was an important instrument for

[3] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

[4] https://unfccc.int/kyoto_protocol

[5] http://www.preventionweb.net/files/16241_sle_NationalHFAprogress_2009-11.pdf

raising public and institutional awareness, generating political commitment and focusing and catalysing actions by a wide range of stakeholders at all levels in Sierra Leone.

### 3.4.5 Sendai Framework

The Sendai Framework for Disaster Risk Reduction 2015-2030 is the successor instrument to the HFA, and it is built on elements which ensure continuity with the work done by governments and other stakeholders under the HFA and introduce a number of innovations as called for during the consultations and negotiations. The Sendai Framework focuses on DRR and DRM as opposed to disaster management only; the definition of seven global targets; the reduction of disaster risk as an expected outcome; a goal focused on preventing new risk; reducing existing risk and strengthening resilience, as well as a set of guiding principles, including primary responsibility of states to prevent and reduce disaster risk; and all-of-society and all-of-State institutions engagement. In addition, the scope of disaster risk reduction has been broadened significantly to focus on both natural and man-made hazards and related environmental, technological and biological hazards and risks. Health resilience is also strongly promoted throughout.

### 3.4.6 United Nations Convention to Combat Desertification (UNCCD)

Established in 1994, the United Nations Convention to Combat Desertification (UNCCD) is the sole legally binding international agreement linking environment and development to sustainable land management. The Convention addresses specifically the arid, semi-arid and dry sub-humid areas, known as the drylands, where some of the most vulnerable ecosystems and peoples can be found.

The new UNCCD 2018-2030 Strategic Framework is the most comprehensive global commitment to achieve Land Degradation Neutrality (LDN) in order to restore the productivity of vast expanses of degraded land, improve the livelihoods of more than 1.3 billion people, and reduce the impacts of drought on vulnerable populations to build[6].

### 3.4.7 Ramsar Convention on Wetlands

The Convention on Wetlands is the intergovernmental treaty that provides the framework for the conservation and wise use of wetlands and their resources. The convention “the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world” was adopted in the Iranian city of Ramsar in 1971 and came into force in 1975. Since then, almost 90% of UN member states, from all the world’s geographic regions, have acceded to become “Contracting Parties”.

Under the three pillars of the Convention, the Contracting Parties commit to:

- work towards the wise use of all their wetlands through national plans, policies and legislation, management actions and public education;
- designate suitable wetlands for the list of Wetlands of International Importance (the “Ramsar List”) and ensure their effective management;
- cooperate internationally on transboundary wetlands, shared wetland systems, shared species, and development projects that may affect wetlands.

The Sierra Leone River Estuary (SLRE); an estimated 2,950 km$^2$ is a wetland of international importance under this convention.

### 3.4.8 Abidjan Convention

The Abidjan Convention was signed on 23 March 1981 with 19 countries in Abidjan, Cote d’Ivoire, and went into effect on 5 August 1984. The convention focuses primarily on collaborative partnerships to promote the marine environment and sustainable coastal development in the Convention area.

In 2018, the Contracting Parties agreed to amend the title of the Abidjan Convention and the Protocol to Convention for Cooperation in the Protection, Management and Development of the Marine and Coastal Environment of the Atlantic Coast of the West, Central and Southern Africa Region, which

[6] https://www.unccd.int/convention/about-convention

covers a marine area from Mauritania to South Africa which has a coastline of over 14,000 km[7]. It provides an overarching legal framework for all marine-related programmes in West, Central and Southern Africa.

### 3.4.9 Sustainable Development Goals

The 2030 Agenda for Sustainable Development Goals (SDGs) call for action by all countries to promote prosperity while protecting the planet. The SDGs contain 17 goals with 169 targets covering a broad range of sustainable development issues. The SDGs provide a very timely opportunity to overcome and meaningfully address the remaining and emerging national and global challenges, including vulnerability, coastal risk, hazards and disasters.

The core objectives of the SDGs in Coastal Vulnerability Assessment are to explore the inter-linkages to inform both, risk-informed planning and sustainability achievement for decision-making and resources treatment to navigate effective risk reduction and sustainability, which can provide important information for risk management, and resources treatment to align with risk reduction and sustainability achievement for improving traditional risk assessment frameworks (Sajjad & Chan, March 2019).

The relationship between CVA and SDGs is to serve as a tool for local level risk-informed planning, improving decisions, policy development, and ultimately contributing towards sustainability (Wong, et al., April 2008).

Specifically, the following SDG goals are directly related to the project:

- Goal 1: End poverty in all its forms everywhere
- Goal 11: Make cities and human settlements inclusive, safe, resilient, and sustainable
- Goal 12: Ensure sustainable consumption and production patterns
- Goal 13: Take urgent action to combat climate change and its impacts
- Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development
- Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
- Goal 17: Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development.

[7] https://www.worldbank.org/en/events/2017/03/27/abidjan-convention-cop12

# 4 CLIMATE CHANGE IN SIERRA LEONE

Sierra Leone has been ranked as the third most vulnerable nation after Bangladesh and Guinea Bissau to adverse effects of climate change. The vulnerable population has a low capacity to adapt to climate change, and the rural populations will be the most affected because of their high dependence on rain-fed agriculture and natural resource-based livelihoods. According to the science of climate change, these impacts are likely to continue to affect Sierra Leone in the future, despite the country being least responsible for the problem since Sierra Leone's contribution to global emissions of greenhouse gases is negligible (Global Security, 2017). Also, the Notre Dame Global Adaptation Initiative (ND-GAIN) Index ranks Sierra Leone as the 24th most vulnerable and 46$^{th}$ least ready to adapt to climate change, of the countries it covered for 2015.

Sierra Leone has a predominantly hot and humid tropical climate with two distinct seasons. The Dry Season (November to April) is dominated by winds from the northeast (i.e. the North-east trades), and the rainy season (May to October). Both seasons may have some variations in the commencement and duration. Average temperatures range from 25–27°C, with slightly lower temperatures (22–25°C) during the wet season (Irish Aid, 2017). The average annual temperature has increased by 0.8°C since 1960. Data is limited, but available data show significantly increasing trends in the frequency of 'hot' nights. Average annual rainfall over Sierra Leone has decreased since 1960, but it is difficult to determine whether this is part of a long-term trend because of the variable nature of rainfall in this region. There are insufficient daily rainfall observations available from which to determine changes in extremes (or heavy rainfall events) of daily rainfall (C. McSweeney, 2010).

This rainfall season is largely controlled by the movement of the tropical rain belt (also known as the Inter-Tropical Convergence Zone, ITCZ), which oscillates between the northern and southern tropics over the course of a year, affecting Sierra Leone when it is in its northern position. When the ITCZ is in this northern position, the dominant wind direction in regions south of the ITCZ is south-westerly, blowing moist air from the Atlantic onto the continent. This pattern is referred to as the West African Monsoon and causes exceptionally high rainfalls on the coastline of western Africa in the wet season. Monthly rainfall in coastal Sierra Leone can exceed 1000 mm but decrease rapidly inland to around 300mm per month in the far west. In the winter, the dominant wind direction is reversed, the dry and dusty 'Harmattan' winds blow from the Sahara Desert (C. McSweeney, 2010).

The climate-sensitive agriculture sector provides livelihoods for 75% of the population and contributes more than 50% of GDP. Sierra Leone has extensive natural resources, but these are under pressure from population growth, dependence on biomass for energy needs, water pollution, and environmentally unsound mining activities leading to high rates of deforestation increased rates of soil erosion, and occurrence of landslides. High dependence on agriculture and natural resources, coupled with high rates of poverty, unemployment and environmental degradation, leave Sierra Leone vulnerable to climate change impacts (Irish Aid, 2017).

## 4.1 Greenhouse Gas Emissions Status

According to the Second National Communication of Sierra Leone to the UNFCCC, total carbon dioxide ($CO_2$) emission for the year 2000 was 574.061Gg $CO_2$. The carbon dioxide emissions from energy generation amounted to 529.287Gg of $CO_2$ as Sierra Leone energy generation is based on diesel-powered generators. The Land Use, Land Use Change and Forestry (LULUCF) sector was the least significant source of $CO_2$ emissions by up taking 752.748Gg of $CO_2$, followed by the waste sector emitting 11.8Gg $CO_2$. The industrial processes are, however, marginal amounting to 39.55 Gg of $CO_2$, and these emissions came mostly from cement production. In 2000, the total Methane ($CH_4$) emissions were 32,312.53 Gg $CH_4$. Agriculture was the most significant source of $CH_4$ emissions (86.67%), followed by the LULUCF sector (5.631) and finally the waste sector (11.83). The other sectors were not sources of $CH_4$ emissions. Nitrous oxide ($N_2O$) emissions were estimated at 13.91 Gg $N_2O$ with 8.54Gg $N_2O$ coming almost exclusively from the agricultural sector. The waste sector was also a source of emission and emitted 31.29Gg $N_2O$.

## 4.2 Observed Climate Variability and Change

Studies assessing trends in seasonal (May-September) mean temperature over West Africa for the period 1983-2010, show a clear warming trend is detected over parts of West Africa. Countries in the Gulf of Guinea, including Sierra Leone, have experienced the most significant and warmest signals ranging from 0.2°C to more than 0.5°C per decade (Sylla, 2016). This is consistent with the 5th IPCC report[8]. Also, the whole of West Africa has warmed between 0.3 and 1°C in recent decades (Padgham, 2015)

More localised analysis of recent evolution in rainfall and temperature in coastal areas of Sierra Leone show that rainfall seasonal total average over the period 1951-2014 is around 2,700mm with a standard deviation of approximately 300mm and a coefficient of variation of 11% (Sylla, 2016).

The National Adaptation Programme of Action notes that the characteristics of the seasons have changed. Particularly, the Harmattan period (dry season) in recent times is reported to be warmer than in the past. It is also observed that the pre-monsoon period, which runs from April to June, is now associated with stronger winds and more frequent rain/storms, causing greater damage to lives and properties. Calmer and dryer weather now appears to be associated with the September/November period which was usually characterised by frequent thunder and lightning and short but heavy rainfall. Certain areas of the country have experienced rain delays and/or succession of dry spells and torrential rains leading to flooding. Changes in the characteristics of the seasons have been linked to changing precipitation patterns, intense and frequent storms, rising sea levels and increase water temperature.

## 4.3 Projected Climate Change

According to a study conducted by Greening EU Cooperation in 2020, Climate change projections indicate no or small tendency of rainfall increase and a consistent increase in temperatures. Thus, if managed properly, water resources should not be a threat to Sierra Leone while temperature change may affect ecosystems and agricultural systems in the long term. Further, the study shows Weak changes in rainfall amounts are expected to occur for the 2020- 2049 period, with a potential increase of about 10% on the coast and a 10% decrease inland. In the far future, as much as a 30% increase in rainfall is predicted on the coast and a 20% decrease inland. These precipitation projections, including the increase on the coast, are consistent with the IPCC assessment that the hydrological cycle may increase in intensity, meaning more rainfall, and potentially more frequent extreme events, in regions currently receiving large amounts of rainfall.

The authorising agencies and partners, including international NGO's, have not produced projections of greenhouse gas emissions for the country in recent years. However, historical data shows that the country's contribution is at 0.1% of the total global emissions. As of 2015, Since Sierra Leone gained her independence in 1961, the per capita emissions has not exceeded 0.6 t $CO_2$ e[9].

According to projections done by the US EPA, GHG emissions are projected to increase to about 4.8Mt $CO_2$Eq in 2015 and to about 6.6Mt$CO_2$Eq in 2030. The major greenhouse gas emitted is Methane ($CH_4$) with projected emissions of 3.7Mt$CO_2$Eq in 2015 and about 5.0Mt$CO_2$Eq in 2030. The largest emitting sectors are Agriculture and Waste, and between them, they are projected to emit between 95 to 98% of the projected national emissions from 2015 to 2030. The largest emitting category is Waste Management and will be responsible for about 54% of the total projected emissions in 2015 and 56% in 2030. Waste Management is projected to emit 2.6Mt$CO_2$Eq in 2015 and 3.7Mt$CO_2$Eq in 2030.

## 4.4 Climate Change Information Availability and Accessibility

Climate change science is still a complex one for a country with low literacy and poor communication systems. Climate change knowledge is low, especially for far-out rural communities. Poor transportation and road networks coupled with lack of telecommunications network coverage in some of these communities, make climate change knowledge limited to the cities and urban settlements.

Despite the already provided information in previous sections, much of the available information is sourced from analyses performed at larger regional scales. Climate monitoring with in-situ

[8] Fifth Assessment Report of IPCC, https://www.ipcc.ch/report/ar5/wg1/ , 2013

[9] https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Sierra%20Leone%20First/SIERRA%20LEONE%20INDC.pdf (Accessed on November 15)

instrumentation and analyses of collected data is critical to the identification of natural climate variability and long-term climate changes. This is even more critical in a country like Sierra Leone with strong spatial variability in climate due to the topography, and as values from global networks may stem from observations several hundred kilometres away. There has been recent support from the UK in equipment to rebuild Sierra Leone's capacity to monitor its own climate (which was largely destroyed during the war), yet, this remains insufficient to get accurate data on climate trends, risks and impacts for effective decision-making. Besides, there is a general lack of access to relevant, in-situ information about climate change and related conditions of environmental change because of weak climate research (Greening EU COOPERATION, 2020).

## 4.5 Previous Studies/Vulnerability Assessments

### 4.5.1 Climate Change Vulnerability Assessment in Mangrove Regions of Sierra Leone

The purpose of this coastal climate change vulnerability assessment (VA) is to understand the factors that contribute to the vulnerability and resilience of communities and mangrove ecosystems in coastal Sierra Leone. The goal is to inform the design of project interventions, including climate adaptation activities under the West Africa Biodiversity and Climate Change (WA BiCC) project. The work was led by the Center for International Earth Science Information Network (CIESIN) at Columbia University and included a team of field researchers drawn from WA BiCC staff, Fourah Bay College, Njala University, the National Protected Areas Authority (NPAA), Environmental Protection Agency (EPA), the Ministry of Agriculture, Forestry and Food Security, the Ministry of Lands, Country Planning and Environment, the Ministry of Fisheries and Marine Resources, Conservation Society of Sierra Leone and other stakeholders. This study is the most comprehensive assessment to date of the vulnerability of fishing communities in Sierra Leone – and perhaps for all of coastal West Africa (WA BiCC, 2017)

### 4.5.2 Sierra Leone State of the Marine Environment Report 2015

The Government of Sierra Leone recognizes the threats to the coastal and marine environment from anthropogenic sources as well as from global climate change which is one of the biggest challenges of our generation that threatens the natural resource base of the country. The State of the Marine Environment report highlights the threats to Sierra Leone's marine environment and underscores resources exploitation as one of the primary causes leading to the degradation of the countries marine and coastal environment. Without immediate and concerted efforts, it will be impossible for the present and succeeding generations to achieve sustainable development. Overexploitation of natural resources from the coastal and marine areas is one of the greatest threat to the marine environment (EPA-SL, 2015).

### 4.5.3 Diagnostic Analysis of Climate Change and Disaster Management in Relation to the PRSP III in Sierra Leone

The main objective of the diagnostic analysis is to provide a pathway for the implementation of the integration and mainstreaming of climate change and disaster management in relation to the Poverty Reduction Strategic Paper III (PRSPIII) of Sierra Leone.

Sierra Leone is considered by the UN classification as a Least Developed Country (LDC) with significant inequality in income distribution among its people. While it has substantial mineral, agricultural, and fishery resources, its economic and social infrastructure are not well developed, which hampers its economic development. Furthermore, unsustainable practices of Agriculture, forest exploitation and mining have led to the degradation of the environment causing serious climate change effects and disasters, thereby affecting the development of the country (UNDP, 2012).

### 4.5.4 Sierra Leone Climate Action Report, 2016

In 2016, Ireland provided € 299,876 in 2016 in climate finance to projects in Sierra Leone through its civil society programme. Climate relevant expenditure provided by Irish Aid to civil society organizations in 2016 was Rio marked and accounted for systematically for the first time, in cooperation with the project partners themselves.

Civil Society partners Concern, Goal and World Vision are helping to build resilience to climate change through a range of projects including reducing maternal & child mortality and morbidity in Freetown and poverty alleviation in Tonkolili district; helping community groups to promote locally appropriate and sustainable approaches to improved nutrition; and strengthening programmes through the effective mainstreaming of HIV, Environment, Gender and Child Protection.

This report provides information on Sierra Leone's Climate tracking and reporting for 2017 across Irish Aid programmes, information on the status of climate change in the country, including climate policy context, as well as the country's vulnerability to climate change. Some Case Studies of Irish aid supported programmes ongoing in the country is also provided (Irish Aid, 2017).

## 4.6 National Institutional Framework

The Government of Sierra Leone considers the management of coastal risks and the impacts of climate change to be a high priority, as evident from the development of several national policies and plans. The CVA Project is consistent with the plans and policies described below:

### 4.6.1 Ministry of Environment

A Ministry of Environment was created in 2019, and a Minister of Environment appointed in November 2019. Discussions are still ongoing with other Ministries related to environmental resources (including, Ministry of Agriculture, Forestry, and Food Security and Ministry of Lands, Country Planning) to define the mandate of a Ministry of Environment and relationship with environmental institutions and stakeholders

### 4.6.2 Environment Protection Agency-Sierra Leone

The Environment Protection Agency-Sierra Leone (EPA-SL) was established by an Act of Parliament in September 2008 (Amended in 2010) as a semi-autonomous institution in the Office of the President and is the principal organ of government responsible for coordinating, monitoring, regulating and supervising all matters relating to the environment in Sierra Leone. The Agency also serves as the national focal point for the Global Environment Facility (GEF) and MEAs, including the Convention on Biological Diversity (CBD) in Sierra Leone. It also is the Nationally Designated Agency (NDS) for the Green Climate Fund Its mandate is to implement government's environmental policies, plans, and programs and to coordinate, monitor, regulate, supervise and advise on all issues of the environment in Sierra Leone and serve as a focal point for all international environmental matters.

### 4.6.3 Climate Change Secretariat

The coordination of climate change activities is the responsibility of the Climate Change Secretariat (CCS) under the Office of the President. This secretariat is housed at the EPA-SL. The Secretariat provides guidance and direction for the formulation of a national climate change policy and strategies in line with the National Agenda. It ensures the domestication of the climate change convention and its related instruments through the mainstreaming of climate change into national development planning and budgeting. The Secretariat also ensures that line ministries would be informed of the outcomes of the Conference of the Parties to the UNFCCC.

### 4.6.4 The Ozone Secretariat

It is the administrative office for two very important ozone protection treaties/agreements, the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer. The Ozone Secretariat organises conferences and meetings for the Vienna Convention and the Montreal Protocol, manages the implementation of decisions resulting from these conventions and meetings, provides stakeholders with data and information on the production and consumption of ozone-depleting substances (ODSs) and provides governments, organizations and individuals with information on how they can protect the ozone layer as well.

### 4.6.5 Sierra Leone Meteorological Agency

The Sierra Leone Meteorological Agency (SLMet) is the body responsible for collecting weather data, processing and disseminating information and related services to end-users. Its key policy objective is

to make available and accessible weather, climate and climate-related information and services to various stakeholders and to strengthen the capacity of the Agency to provide good and efficient information and services. The Agency shares relations with local and international partners, notably the EPA-SL, Ministry of Water Resources (MWR), Ministry of Agriculture and Forestry (MAFS) and the DMD of ONS. The major way of collaboration is by providing information and services on weather, climate-related issues and participation in the activities of stakeholders implementing and strengthening climate information and related activities

### 4.6.6 Ministry of Fisheries and Marine Resources (MFMR)

Is responsible for developing and managing fisheries and marine resources across the country. In this regard, MFMR also leads in establishing Community Management Associations (CMA) and getting them to work, undertaking coastal livelihood support interventions, and providing technical advice for the establishment and running of Marine Protected Areas (MPAs) which also involves formulating and enforcing laws and policies as applicable.

### 4.6.7 Ministry of Agriculture, Forestry, and Food Security (MAFFS)

Notably hosts the Forestry Division and the National Protected Areas Authority (NPAA), is responsible for conserving protected areas, and preventing further degradation including in the coast.

### 4.6.8 Disaster Management Department (DMD)

The DMD of the Office of National Security (ONS) led the development of a Disaster Management Policy, Strategy and Action plan, which was approved by the National Security Council in November 2015. DMD has also established a centralised DesInventar database and conducted training to increase staff capacity for efficient collection, processing and dissemination of disaster-related data. As at the time of this report compilation, the DMD was reconstituted as an Agency.

### 4.6.9 REDD / REDD+

Reducing Emission from Deforestation and Forest Degradation (REDD) started in 2008 in Sierra Leone, supported by the UNEP and the Forest Investment Programme (FIP), hosted by the World Bank. In Sierra Leone, a new strategy was launched in July 2013 (with initial capacity building programme piloted earlier on May 2013) to assess compliance and readiness by officials to implement the scheme. This was supported by the EU through the project: “REDD+ capacity building in Sierra Leone (Global Climate Change Alliance). The purpose was to generate basic institutional, technical and social conditions and experience for sound forest governance, benefit from REDD+ initiatives according to a pro-poor approach and for the development of renewable energy. The REDD+ initiative was seen as a compensatory scheme to support the rural poor in reducing their destructive acts of deforesting the environment while enhancing their skills through community initiatives like community-based forestry and agroforestry. In Sierra Leone as a whole, the true impact at the community level, in general, is not well known. Yet, the positive experience of the Gola Rainforest National Park can be underlined: it has achieved REDD+ certification and is now selling carbon credits. Positive impacts on the communities are documented.

## 4.7 Legislation

### 4.7.1 Environment Protection Agency Act 2008 (amended July 2010)

This act established EPA-SL to provide for the effective protection and management of the environment and other related matters. The 2010 amendment gave the Office of the President Oversight responsibility of the Agency. In 2010, an Environmental Impact Assessment License Regulations was prepared as a statutory instrument that outlines the regulations for the application, issuance, fees for license and monitoring of environmental activities of license holders.

### 4.7.2 Wildlife Conservation Act (1972)

It is the primary piece of legislation governing the protection of wildlife in Sierra Leone. The Act established the categories of land to be set aside for wildlife protection. It was supposed to be replaced

by the Draft Conservation and Wildlife Policy and Act, 2011. The draft Conservation and Wildlife Policy sets out five principles for wildlife management (sustainable management, rights-based governance, economic and social benefits, integrated wildlife conservation and culturally-sensitive, knowledge-based conservation) and recommends action in five areas (species management, conservation areas, research and monitoring, education and awareness, and capacity building).

### 4.7.3 Forestry Act (1988)

Forest legislation started in 1912 in Sierra Leone. The principal legislation governing the management and regulation of forestry and Forest Reserves in Sierra Leone remains the 1988 Act, which gave the Ministry of Agriculture Forest and Fisheries, and in particular the Forestry division the power to protect and conserve water, soil, flora and fauna. It also enacted significant provisions promoting more efficient management and rational use of the country's forest resources in order to achieve a combination of benefits through forest production, forest protection and non-forest uses. This act despite been considered as a step forward was poorly applied in practice, more so, due to poor monitoring by officials from the forest division at MAFFS, which then led to one of the highest levels of illegal access, particularly in the protected areas.

### 4.7.4 Draft Forestry Policy and Act

Is under preparation since 2010 to replace the 1988 Act. It set out according to similar guiding principles as the draft Conservation and Wildlife Policy and establishes a set of policy objectives around forestry land management, forest-based industry and practices, ecosystem conservation, education and awareness, research and monitoring, and capacity building. The new Act shall acknowledge the environmental role of forest areas and places emphasis on the preservation of the forest environment.

### 4.7.5 Wetland Conservation Act (2015)

This act was formulated by the NPAA, focuses on improving the sustainable management of priority wetland ecosystems by restoring, maintaining and enhancing the ecosystems and ecological processes essential for their effective functioning.

### 4.7.6 Environment Protection (Mines and Minerals) Regulations 2013

In the exercise of Section 62 of the Environment Protection Act of 2008, the Environment Protection Regulations (Mines and Mineral) was developed to regulate the activities of extractive industries and projects including mining, quarrying, extraction of sand, gravel, silt and peat.

### 4.7.7 Sierra Leone Maritime Administration Act (2000)

This act seeks to improve standards of performance, practice, and safety in the shipping industry, including the coastal and inland water transport system, and the maritime environment.

### 4.7.8 Fisheries Act (2007)

This act seeks to manage, develop and conserve all fisheries and marine resources. It seeks, among other things, to enhance the sustainable use of fisheries resources; increase co-management through committed, informed and involved stakeholders; diversity and increase international trade of fish and fishery; deliver cost-effective and efficient management tools; and promote sustainable aquaculture development.

### 4.7.9 Draft Conservation and Wildlife Policy and Act, 2011

The draft Conservation and Wildlife Policy sets out five principles for wildlife management (sustainable management, rights-based governance, economic and social benefits, integrated wildlife conservation and culturally sensitive, knowledge-based conservation) and recommends action in five areas (species management, conservation areas, research and monitoring, education and awareness, and capacity building).

### 4.7.10 National Water Resource Management Act (2016)

This act aims at providing “equitable, beneficial, efficient, and sustainable” use and management of the country’s water resources. It also establishes a National Water Resource Management Agency and a Water Basin Management Board and Catchment Water Resource Management Committees for the management of the water resources and for other related matters. Part VII of the Act is about water use and permit procedures. The provisions require a permit for water use in all major categories including domestic, commercial, municipal, industrial, agricultural, power generation, water transportation, fisheries, environmental, underwater wood harvesting, and recreational water use.

### 4.7.11 National Protected Area Authority and Conservation Trust Fund Act, 2012

This act provides for the establishment of the National Protected Area Authority (NPAA) and Conservation Trust Fund (CTF). The Act promotes biodiversity conservation, wildlife management, and research and ecosystems services in national protected areas. Part III of the Act states the role of the NPAA, an arm of MAFFS, with the mandate of managing all areas dealing with the improvement of the

- Fisheries Act (2007) seeks to manage, develop and conserve all fisheries and marine resources. It seeks, among other things, to enhance the sustainable use of fisheries resources; increase co-management through committed, informed and involved stakeholders; diversity and increase international trade of fish and fishery; deliver cost-effective and efficient management tools; and promote sustainable aquaculture development.
- Fisheries Development and Management Act (1994) and it's subsidiary regulations of 1995 and 2010, which, together, seek to restrict harmful fishing practices and protect breeding zones.
- Draft Forestry Policy and Act, 2011: The Forestry policy is set out according to similar guiding principles as the draft Conservation and Wildlife Policy and establishes a set of policy objectives around forestry land management, forest-based industry and practices, ecosystem conservation, education and awareness, research and monitoring, and capacity building.

### 4.7.12 Merchant Shipping Act (2009)

This act provides for the registration and licensing of ships, including steps to ensure maritime safety, pollution control, and environmental control.

## 4.8 Policies and Plans

### 4.8.1 National Environmental Policy (1994)

This seeks to ensure sound environmental and natural resources management throughout Sierra Leone. The key objectives are to encourage and facilitate local participation in environmental governance practices; secure an environment that is adequate for the health and wellbeing of communities and ecosystems; and foster learning and knowledge exchange through public education campaigns and programmes.

### 4.8.2 National Disaster Management Policy (Draft, 2006)

The National Disaster Management Policy is a comprehensive approach that enhances increased political commitment to disaster risk management, thereby encouraging government agencies to take the lead and supported by non-governmental organisations. It also promotes public awareness and the incorporation of disaster risk management into development planning. The policy highlights the sources of funding and the reduction of bureaucracies in accessing such funds for effective disaster coordination.

The Policy document emphasizes the following:

- Ensure the integration of disaster risk management into sustainable development programmes and policies to ensure a holistic approach to disaster management.
- Ensure priority and requisite institutional capacities for disaster risk reduction at all levels

- Enhance the use of knowledge, education, training, innovation and information sharing to build safe and resilient societies
- Improve the identification, assessment, monitoring and early warning of risks
- Improve the effectiveness of response through stronger disaster preparedness

### 4.8.3 Climate Change Adaptation Plan for the Sierra Leone Coastal Landscape Complex

This Climate Change Adaptation Plan (CCAP) synthesizes knowledge on known and potential climate change effects on coastal ecosystems within the Sierra Leone Coastal Landscape Complex (SLCLC). It outlines policy and management responses, culled mainly from the extant literature, to foster adaptation to climate change in coastal communities. The CCAP will provide needed tools for adaptation by prioritizing data and decision-support activities based principally on the needs for ecosystem conservation and sustainable livelihoods in the region. More specifically, the CCAP will generate applied science to inform mangrove conservation and livelihood support actions 10 in the SLCLC, which are efforts seeking to address landscape-level vulnerability to climate change and other resource use issues. (Massaquoi, 2020)

### 4.8.4 Sierra Leone's Nationally Determined Contribution (NDC)

Sierra Leone has been ranked as the third most vulnerable nation after Bangladesh and Guinea Bissau to adverse effects of climate change. Our vulnerable population has a low capacity to adapt to climate change, and the rural populations will be the most affected because of their high dependence on rain-fed agriculture and natural resource-based livelihoods. According to the science of climate change, these impacts are likely to continue to affect Sierra Leone in the future, despite the country being least responsible for the problem since Sierra Leone's contribution to global emissions of greenhouse gases is negligible.

The Sierra Leone National Development Plan – the Medium-Term Development Plan 2018 -2023 indicates that Sierra Leone is committed to mainstreaming inclusive green growth in her development process. Thus, the implementation of the NDC will support the transition to low-emission development involving decoupling carbon emissions from economic growth through a series of measures across all economic sectors. This document presents Sierra Leone's Nationally Determined Contribution (NDC) in response to decisions adopted at the 19th and 20th sessions of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), that invite Parties to communicate to the Secretariat their INDCs, towards achieving the objective of the UNFCCC as set out in Article 2 of the Convention.

### 4.8.5 Regional Development Authorities Policy (2007)

This Policy, like the Local Government Act (2004), provides for the use of local-level institutional arrangements to ensure equitable and balanced national sustainable development planning and effective natural resources management. The policy has a direct bearing on streamlining and strengthening the roles and functions of community-based structures in coastal zone development and management.

### 4.8.6 National Adaptation Programme of Action, 2007

The Government of Sierra Leone has recognised that climate change-related disasters such as flooding, drought, coastal erosion, deforestation and biodiversity loss etc. are natural phenomena aggravated by human activities including the emission of greenhouse gases. Damage and losses from such disasters are, however, the consequence of human action.

The National Adaptation Programme of Action (NAPA) for Sierra Leone has been prepared by the Ministry of Transport and Aviation (MTA), as a response to the decision of the Seventh Session of the Conference of the Parties (COP7) of the United Nations Framework Convention on Climate Change (UNFCCC). The preparation process has followed the generic guiding principles outlined in the NAPA annotated Guideline, according to the project coordinator. The whole preparation process was guided by the high-powered Project Steering Committee headed by the Chairman, Director of the Environment, of the Ministry of Lands, Country Planning and the Environment. The basic approach to NAPA

preparation was in consonance with the sustainable development goals and objectives of the country where it has recognized the necessity of addressing environmental issues and natural resource management with the participation of stakeholders (GoSL/UNDP, 2007).

### 4.8.7 National Land Policy (2015)

This Policy is part of efforts to reform land policies in the country to incorporate good practices related to gender equality and land registration.

### 4.8.8 Sierra Leone's Second National Biodiversity and Strategic Action Plan (2017-2026)

This Plan seeks to protect marine and coastal biodiversity by strengthening technical research, developing and applying landscapes, establish Marine Protected Areas (MPAs), foster broad stakeholder participation, facilitate learning and knowledge exchange, and promote positive attitudes through communications and education.
There is a long list of Priority Legislative actions expected during the NBSAP 2017- 2026 implementation, which illustrates the difficulties to progress at this level. This list includes:

- The enactment of the draft reviewed and amended the 1972 Wildlife Conservation Act and its Regulations of 2015.
- The enactment of the draft reviewed and amended the 1988 Forestry Act and its Regulations of 2015.
- Enactment of the draft Wetlands Conservation Act and its Regulations of 2015.
- A review of the Mines and Minerals Acts of 2008 to incorporate biodiversity conservation considerations.
- Introduction of policy, guidelines and regulations that incorporate biodiversity into urban development.
- Review of GoSL's decentralisation policy to include a strong biodiversity component.
- Development of policy and regulations for the utilisation and conservation of inland wetland ecosystems.
- Review of the land tenure and ownership system with the purpose of ensuring a strong element of land preservation for biodiversity

### 4.8.9 Integrated Coastal Zone Management Plan (2015)

The Integrated Coastal Zone Management Plan (ICZMP) seeks to harmonize existing plans for the management of the coastal zone and formalize collaboration between and among concerned sectors. The ICZMP lays out four pathways for improving coastal ecosystems management in Sierra Leone, including increase knowledge generation and conversion into effective management actions; adopt an adaptive collaborative management approach for design and delivery of coastal management institutions and interventions; follow thorough procedures to manage for results, thus improving monitoring, ownership, and accountability.

### 4.8.10 Coastal Climate Change Adaptation Plan

has been developed (latest version: 2020) to contribute towards increasing resiliency and to protect coastal ecosystems across the Sierra Leone Coastal Landscape Complex (the Bonthe-Sherbro River Estuary, the Scarcies Region, the Sierra Leone River Estuary and the Yawri Bay landscapes) and beyond. The plan proposes a fundamental shift in the way practitioners and climate change risk managers work together to protect and restore critical coastal ecosystems and bolster sustainable livelihoods. In addition, the plan advocates for the use of proven best practices, building on previous and ongoing efforts to create fair, equitable and lasting adaptation solutions in coastal West Africa. It is anticipated that this plan will also foster a new culture that prompts practitioners and policy-makers to mainstream consideration of climate change risks, vulnerabilities, and adaptation into decision-making

### 4.8.11 National Climate Change Strategy and Action Plan

This plan entails mechanisms and frameworks for climate adaptation and resilience-building at the national, district and community levels. The plan was supported by UNDP and validated in 2015.

### 4.8.12 National Disaster Preparedness and Response Plan (NDPRP, 2006)

The purpose of the National Disaster Preparedness and Response Plan (NDPRP) is to establish a comprehensive all-hazard approach to national incident management spectrum of activities including preparedness, prevention, mitigation, response and recovery. The plan incorporates best practices, as shown in other regions of the world. The NDPRP, among others, focuses on:

- The National Response Plan provides a framework of interaction between the State, Non-Governmental Organisations, United Nations Agencies, Private sector, Community-Based Organisations and Youth Groups.
- The plan establishes a mechanism to maximise the integration of incident-related prevention, mitigation, preparedness, response and recovery.
- It provides a focus for inter-agency and inter-governmental emergency preparedness, planning, training, exercising, coordination and information sharing.
- It spells out the process and methodology for implementing and managing national recovery and mitigation programmes and support / technical services.
- The plan is meant to maximise efficient utilisation of resources needed for effective incident management and critical infrastructure/key resources' protection and restoration.
- It is intended to improve incident management communication links and increase situation awareness across the public, private and Non-Governmental Organisational structures.
- The plan is geared towards an improvement in coordination and integration of national (and international), provincial, district, private sector and Non-governmental Organisation partners.
- The plan points out the means of central government support in the form of resources to local effort with the view of saving lives and properties and the protection of public health and safety.

### 4.8.13 National Adaptation Programme of Action (2007)

NAPA documents information and resources used in the identification and prioritization of strategies for climate change adaptation in the country. The Sierra Leone NAPA recommends climate adaptation projects under the following themes: the establishment of early warning systems to facilitate effective climate awareness and education; development of integrated natural resources and environmental management programme; promotion of renewable energy systems; management and protection of forest reserves and catchment areas including wetlands; improvement of energy efficiency and conservation to reduce deforestation for fuelwood and charcoal; development of an integrated coastal zone management plan; development and enactment of appropriate policies and laws; delineation and restoration of degraded vulnerable coastal habitats and ecosystems.

### 4.8.14 The National Disaster Management Policy (Draft, 2006) and National Disaster Preparedness and Response Plan (NDPRP)

Remain the national references for Disaster Risk Reduction. They give strategic directives to the government on steps to be taken before, during and after disasters. The objectives of the Draft Disaster Management Policy are to:

- Ensure the integration of disaster risk management into sustainable development programmes and policies to ensure a holistic approach to disaster management
- Ensure priority and requisite institutional capacities for disaster risk reduction at all levels
- Enhance the use of knowledge, education, training, innovation and information sharing to build safe and resilient societies
- Improve the identification, assessment, monitoring and early warning of risks.
- Analysing the National Disaster Preparedness and Response Plan (draft) and its identified potential disasters, identified key legal issues include: customs duties, delays and restrictions on goods and equipment, facilitation of services for international relief actors (i.e. entry fees and visa for personnel, obtaining legal status for relief providers and their organisations, recognition of professional qualifications, quality of goods and accountability to beneficiaries)

and, last but not least, coordination between relief providers to avert duplication. Also, a National Disaster Preparedness Baseline Assessment (NDPBA) is underway since late 2018.

### 4.8.15 Mid-Term National Development Plan

The mid-term 2019-2023 National Development Plan is the first one to explicitly include climate change as an issue to be considered. Indeed, it makes multiple references to climate-induced risks and impacts and includes in its Theory of Change a full dedicated cluster: “a society that is resilient to climate change and natural disasters” (Cluster 7).

Cluster 7.1 includes environmental resilience and aligns with the NBSAP in terms of policy actions.

Key targets for environmental resilience are:

1. By 2023, put in place an environmental court to prosecute cases related to environmental infractions.
2. By 2023, ensure that a policy is in place for the management of toxic chemicals and hazardous substances.
3. By 2023, review and pursue land degradation neutrality targets.
4. Progressively amend regulations on ozone-depleting substances.

Key policy actions on environmental resilience are:

1. Review the Environmental Protection Agency Act and other legislation to strengthen and enhance the legal framework for enforcement and compliance.
2. Increase the proportion of terrestrial and marine areas protected.
3. Control land degradation and minimise pollution.
4. Increase the coverage of terrestrial sites of biodiversity importance to protect biodiversity and endangered species.
5. Educate and raise awareness about changing traditional and cultural practices that are harmful to the environment.

Forest management and wetland conservation are the focus of sub-cluster 7.2

Key targets are:

1. By 2023, establish a National Timber Agency.
2. By 2023, declare at least two new Ramsar Convention sites for wetlands management.
3. By 2023, ensure that a Wetlands Act is in place.

Key policy actions are:

1. Improve legal and enforcement mechanisms with appropriate laws.
2. Enhance the management and oversight capacity of regulatory agencies.
3. Combat environmental degradation and manage forests and wetlands.
4. Promote the conservation of the environment by educating and mobilizing the population through awareness-raising.
5. Increase marine protection and maintain the number of forest reserves and conservation areas.

The 2019-2023 plan also identifies vulnerabilities and risks and subsequent impacts, in cluster 7.3 dedicated to Disaster management governance. Key targets for Disaster management are:

1. By 2023, achieve 100% completion status for the functioning and operations of a National Disaster Risk Management Agency.
2. By 2023, achieve 100% completion status in the development of Local Disaster Preparedness and Response Plans based on the Vulnerability and Capacity Assessment.

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3. By 2023, achieve 100% completion status in the development of a flexible information system for data on disaster victims, internally displaced persons, missing persons, damaged and lost properties, and the reunion of families.

Key policy actions for Disaster management are:

1. Develop policies and a legal framework on vulnerability and disasters.
2. Improve on disaster response within the country at all levels.
3. Strengthen early warning mechanisms and legal frameworks.
4. Enhance coordination and collaboration among key actors.
5. Increase community involvement in responding to disasters and implement the Climate Information, Disaster Management and Early Warning System developed for climate information dissemination.

While climate is present in policy action 5 of sub-cluster 7.3, there are no specific sub-cluster, targets or Key indicators dedicated to climate change action (even in cluster 7).

Apart from a climate-related target in its sub-cluster 1.4 on Environmental sanitation and hygiene, with the Key target: By 2023, reduce deaths and property loss from natural and human-made disasters and extreme climate events by 30%; there is no other mention of climate-related action (adaptation or mitigation), except to "create systems to track public spending on gender and climate" and "Access support from untapped thematic funds*"* such as the GCF, both presented as possibilities to fund the National Plan.

## 4.9 Institutional Challenges

Institutional challenges presented below are based on findings from the stakeholder engagements and from other previous related studies:

1. **Lack of effective collaboration amongst managing institutions:** there are many institutions that are responsible for the management of coastal areas and climate change. These institutional mandates range from policy formulation, development of strategic action plans and integration of coastal management systems into national development schemes, partnership with international institutions and funding agencies to implement climate change and coastal management projects; however, these institutions tend to duplicate efforts and sometimes misdirect priorities due to little collaboration between them. Reasons for these poor collaborations could not be clearly outlined by any of the agencies.
2. **Lack of definite institutional roles and responsibilities, and sometimes overlapping mandates:** this finding could also be confirmed from a study done in 2020 (Greening EU COOPERATION, 2020); this study also outlined the lack of clearly defined roles and the overlapping mandate of these institutions and how this is causing poor management of natural resources; Many examples of unclear situations could be found, for instance, wetland conservation is placed under the Ministry of Agriculture, Forestry, and Food Security (MAFFS), while the Ministry of Fisheries and Marine Resources (MFMR) is responsible for managing fish and other living resources in the coastal and estuarine habitats. Also, the allocation of large areas of land by MAFFS to private companies can contain part of protected areas managed by NPAA. Another example is related to the management of marine protected areas which may fall under the control of the Ministry of Fisheries and Marine Resources or Conservation and Wildlife division, which is under the Department of Forestry. As the last example, the Conservation Trust Fund (CTF) indicates that MDAs and local governments collect revenues (including in the form of license fees) from ecosystem services and natural resource users, which remain inaccessible to the CTF despite being one of its functions.
3. **Overlapping Leadership and Political jurisdictions:** Central government and its ministries, departments and agencies, and traditional and elected authorities get overlapping jurisdictions, which result in competing mandates and priorities, and poor coordination[10].

[10] http://extwprlegs1.fao.org/docs/pdf/sie143754.pdf

4. **Inadequacy of Financial Support:** these institutions lack the adequate financial capacity to undertake climate change and coastal management researches. This constraint was outlined by almost all key primary stakeholders for this project. Further, despite the presence of international donors, funding for environmental action seems difficult to secure, making it difficult to support continued operations, community-based conservation programs and integrated conservation and development projects (Greening EU COOPERATION, 2020).
5. **Low Staff Capacity:** staff capacity to formulate complex climate change policies and implement their corresponding sustainable projects are assessed to be low. According to NPAA, in their 2017 annual report, they stated that many agencies are understaffed to carry out their delegated tasks, which is partly because the government lacks a sustainable funding strategy for projects designed for and delivered in coastal areas. There are also low capacities for scientific analysis and monitoring; low operating budgets; low political capital; and low capacities for demarcation, patrolling and enforcement.

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# 5 COASTAL SYSTEMS AND HAZARDS

## 5.1 Coastal Systems

According to the IPCC Fifth Assessment Report (AR5), Coastal systems include all areas near mean sea level. Generally, there is no single definition for the coast and the coastal zone/area, where the latter emphasizes the area or extent of the coastal ecosystems. In relation to exposure to potential coastal hazards, the low-elevation coastal zone (LECZ) has been used in recent years with reference to a specific area and population up to 10 m elevation. Coastal systems are conceptualized to consist of both natural and human systems. The human and natural systems form a tightly coupled socio-ecological system.

### 5.1.1 Natural system

The natural systems include distinct coastal features and ecosystems such as rocky coasts, beaches, barriers and sand dunes, estuaries and lagoons, deltas, river mouths, wetlands, and coral reefs. These elements help define the seaward and landward boundaries of the coast.

### 5.1.2 Human System

The human systems include the built environment (e.g., settlements, water, as well as transportation infrastructure and networks), human activities (e.g., tourism, aquaculture, fisheries), as well as formal and informal institutions that organize human activities (e.g., policies, laws, customs, norms, and culture).

## 5.2 Coastal Hazards

According to IPCC, Coastal hazards are physical phenomena that expose a coastal area to the risk of property damage, loss of life and environmental degradation. Rapid-onset hazards last over periods of minutes to several days, and slow-onset hazards develop incrementally over longer time periods.

### 5.2.1 Sea-level Rise

Sea level rise (SLR) is a climatic phenomenon caused by increased rates of thermal expansion, glacier mass loss, groundwater pumping and ice discharge from both ice-sheets. Global warming may cause a sea-level rise, which will have a great impact on the long-term coastal morphology and increased flooding risk.

The Intergovernmental Panel on Climate Change (IPCC) estimate global mean a sea-level rise from 1990 to 2100 to be between nine and eighty-eight centimetres. It is also predicted that with climate change, there will be an increase in the intensity and frequency of storm events. This suggests that coastal flooding from storm surges will become more frequent with sea-level rise. A rise in sea level alone threatens increased levels of flooding, and permanent inundation of low-lying land as sea level simply may exceed the land elevation.

**Causative Factors**

Several phenomena contribute to sea-level rise. On a global scale, sea-level rise is mainly due to an increase in the water mass and water volume of the oceans. This global sea-level rise has three components

- thermal expansion of ocean waters related to decreasing of the density (also referred to as a thermo-steric component of sea-level rise, related to increasing temperature)
- water mass increase, which is mainly due to the melting of mountain glaciers and decrease of the Greenland and Antarctic ice sheets, and
- decreasing storage of surface water and groundwater on land.

Other phenomena can substantially influence sea levels at a regional scale, inducing either sea-level rise or sea-level fall. Most important are:

- vertical earth crust motions - in particular earth crust adjustment to the melting of polar ice caps, the so-called isostatic rebound,
- land surface subsidence, related in particular to the extraction of groundwater and oil/gas mining and compaction of soft deltaic soils
- changes in the earth's gravitational field, related in particular to decrease of the Greenland and Antarctic ice sheets,
- regional atmospheric pressure anomalies and changes in the strength and distribution of ocean currents, related in particular to ocean-atmosphere interaction, and
- regional sea-level change related to changes in seawater salinity.

Due to these phenomena, sea-level rise is not uniform around the globe but differs from place to place. Relative sea-level rise is the locally observed rise of the average sea level with respect to the land level.

### 5.2.2 Coastal Erosion

Coastal erosion is the process by which local sea-level rise, strong wave action, and coastal flooding wear down or carry away rocks, soils, and/or sands along the coast. All coastlines are affected by storms and other natural events that cause erosion; the combination of storm surge at high tide with additional effects from strong waves conditions commonly associated with landfalling tropical storms creates the most damaging conditions[11].

On non-rocky coasts, coastal erosion results in rock formations in areas where the coastline contains rock layers or fracture zones with varying resistance to erosion. Softer areas become eroded much faster than harder ones, which typically result in landforms such as tunnels, bridges, columns, and pillars. Over time the coast generally evens out. The softer areas fill up with sediment eroded from hard areas, and rock formations are eroded away. Also, abrasion commonly happens in areas where there are strong winds, loose sand, and soft rocks. The blowing of millions of sharp sand grains creates a sandblasting effect. This effect helps to erode, smooth and polish rocks. The definition of abrasion is grinding and wearing away of rock surfaces through the mechanical action of other rock or sand particles. According to the IPCC, sea-level rise caused by climate change will increase coastal erosion worldwide, significantly changing the coasts and low-lying coastal areas

**Causative Factors**

**Hydraulic action:** Hydraulic action occurs when waves striking a cliff face compress air in cracks on the cliff face. This exerts pressure on the surrounding rock, and can progressively splinter and remove pieces. Over time, the cracks can grow, sometimes forming a cave. The splinters fall to the sea bed where they are subjected to further wave action.

**Attrition:** Attrition occurs when waves cause loose pieces of rock debris (scree) to collide with each other, grinding and chipping each other, progressively becoming smaller, smoother and rounder. Scree also collides with the base of the cliff face, chipping small pieces of rock from the cliff or have a corrasion (abrasion) effect, similar to sandpapering.

**Solution:** Solution is the process in which acids contained in seawater will dissolve some types of rock such as chalk or limestone

**Abrasion:** Abrasion, also known as corrasion, occurs when waves break on cliff faces and slowly erode it. As the sea pounds cliff faces, it also uses the scree from other wave actions to batter and breaks off pieces of rock from higher up the cliff face which can be used for this same wave action and attrition.

**Corrosion:** Corrosion or solution/chemical weathering occurs when the sea's pH (anything below pH 7.0) corrodes rocks on a cliff face. Limestone cliff faces, which have a moderately high pH, are particularly affected in this way. Wave action also increases the rate of reaction by removing the reacted material.

[11] https://toolkit.climate.gov/topics/coastal-flood-risk/coastal-erosion

### 5.2.3 Coastal flooding

Coastal flooding occurs when normally dry, low-lying land is flooded by seawater. The extent of coastal flooding is a function of the elevation inland floodwaters penetrate which is controlled by the topography of the coastal land exposed to flooding. The seawater can flood the land via several different paths:

Coastal flooding is largely a natural event, however human influence on the coastal environment can exacerbate coastal flooding. Moreover, sea-level rise and extreme weather caused by anthropocentric climate change will increase the intensity and amount of coastal flooding affecting hundreds of millions of people.

## 5.3 Coastal Landscape in Sierra Leone

The coastal zone of Sierra Leone is one of the most densely populated areas of the country and is already vulnerable to a number of natural and man-made hazards including inundations from the major rivers flowing through Sierra Leone to the coast, flash floods which come down from a number of rivers during the monsoon period and also saline intrusions due to decreased low water flows in the dry season. Because of all these characteristics, the coastal zones of Sierra Leone is particularly vulnerable to climate change impact (EPA-SL, 2015).

Sierra Leone's coastal areas are increasingly vulnerable to the impacts of global climate change. The combined effects of sea-level rise and environmentally unsustainable practices such as mangrove deforestation and sand mining are expected to result in accelerated rates of coastal recession and the destruction of infrastructure (UNDP, 2016).

Over 2 million people along coastal areas in Sierra Leone are expected to be at risk from predicted sea-level rise. In addition, to loss of properties and beaches, the consequences of coastal erosion and sea-level rise include population displacements, flooding and saline intrusion, and threats to coastal aquifers, freshwater resources and agricultural water resources, undermining subsistence of local communities (UNDP, 2016).

### 5.3.1 Geography of the Sierra Leone Coastal Landscape Complex

The coastline of Sierra Leone stretches for about 560 km from North East, where it borders with Guinea to the South East by Liberia (EPA-SL, 2015). The Sierra Leone Coastal Landscape Complex (SLCLC), located on the Atlantic edge of Sierra Leone is made up of five distinct administrative regions that stretch from the north to the southern parts of the country. These regions include Scarcies River Estuary (SRE), Sierra Leone River Estuary (SLRE), Yawri Bay, Sherbro-Bonthe River Estuaries (B-SRE), and the Western Area. The SRE is found in Kambia District in the north of Sierra Leone and is formed by the Great and Little Scarcies which merge before emptying into the Atlantic Ocean. The Yawri Bay is in Moyamba District in the southern province along three rivers- Ribi, Bumpe, and Kagboro creek. Bonthe-SRE is also located in the southern province in Bonthe District and primarily stretches along the Sherbro River. The last region, Western Area, is found in the west of the country along the borders of Port Loko and the Western Area (Massaquoi, 2020).

The coastline is characterized by sandy beaches, cliffs, lagoons, estuaries, mudflats, creeks, bays, and mangrove swamps (see Figure 5-1). There are about 105,200 ha of mangrove stands along this coastline, spread across the five regions as follows: Scarcies River Estuary (13,007 ha), Sierra Leone River Estuary (34,234 ha), Yawri Bay (24,505 ha), Bonthe-Sherbro River Estuary (99,854ha) and Western Area (7,189 ha). These mangroves occupy 47% of the coastline. Three of the four regions of the SLCLC are proposed Marine Protected Areas (MPAs), only the SLRE is an MPA and a designated Ramsar site (Massaquoi, 2020).

**Figure 5-1: Some Coastal Features in the Study Areas**

**Cliff at Conakry-Dee**



**Estuary at Conakry-Dee**



**Beach at Lakka**



**Rocky Coast at Lakka**



## 5.3.2 Geology and Geomorphology of Sierra Leone Coastal Areas

Although a limited variety of minerals is found and extracted from the SLCLC, there are reports of the occurrence of diamonds, gold, iron ore, platinum, copper, cobalt, zircon, and manganese. Mining is chiefly in the hands of foreign companies, though exact estimates of the value of these coarse aggregates are not readily available. Fine aggregates like sand are extracted and used for construction purposes, though data on the quantity extracted is not available. Granite rock is also mined along the banks of coastal streams as a source of concrete material for the construction of roads and for export by foreign companies (EPA-SL, 2015).

The coastal swamps where mangroves are typically found consist of alternating banks of silt, sand, gravel and clay. Silt is mostly found in the northwest, while the south has large areas of coarse sand. The Scarcies River Estuary, for example, is characterized by partly compacted, cohesive silts and clays. The clay in this area has a high salt-fixing capacity, providing a base for the development of potentially acid sulphate soils because of the marine influence. This soil type supports swamp rice production, which is mostly cultivated in areas previously forested by mangroves. Furthermore, clay is extracted near beaches by local residents for brick and ceramic making, leading to a significant change in the land cover and increasing coastal erosion. Furthermore, hard rocks are mined along the banks of coastal streams for the construction of homes and roads, and for export by foreign companies (EPA-SL, 2015).

Geomorphologically, the SLCLC is characterized by shelves, water column systems, structural systems and coastal landforms. Weathering of these geomorphologic features is caused mainly by increasing temperature and moisture, producing materials that find their way into rivers and the ocean. Surface waters in the SLCLC demonstrate variant temperatures because of the diluting effect of river discharge and increased precipitation. The western and southern parts of Sherbro Island show this kind of effect, creating a marked distinction in the salinity of shallow water and seawater areas. These features are mostly observable in the dry season when there are less precipitation and river discharge (Massaquoi, 2020). The SLCLC is characterized by canyons and shelf breaks, seamounts, large gulfs, offshore banks, shoals and islands, and upwelling. Canyons mostly serve as sediment traps and are composed largely of rocks. Seamounts are not characteristic of waters in this area and makeup about 0.04% of

seamounts world over. Large gulfs are also atypical of the coastal and marine features in the SLCLC, though offshore banks, shoals and islands can be found (Massaquoi, 2020).

### 5.3.3 Hydrology of the Sierra Leone Coastal Landscape complex

Hydrological features of the SLCLC include lagoons, rivers, estuaries that all end up into the Atlantic Ocean. These water bodies include the bays and estuaries of the Rokel, Great and Little Scarcies, Sherbro, Jong, Moa, Sewa, and Mano. The SLRE comprises major rivers such as Rokel and Bunce, and the Port Loko Creek, while the SRE contains rivers such as the Great (also known as Kobuter River) and Little Scarcies (also known as Kabba River). In Yawri Bay, there are rivers such as Ribi, Kukuli, and Kagboro. The B-SRE shelters abroad waterway that is about 60km long, into which the Bagru, Jong, and Kittam rivers discharge. Together, these estuaries support diverse biodiversity which supports local livelihoods. These water bodies contain large amounts of nutrients because of their nearness to terrestrial sources of sediments and surface run-offs from rains. In these waters, diverse florae and faunae also thrive because of the shallowness of the water and nutrients. Additional benefits of water bodies in this area include providing a means of transportation, a source of recreation and food, and a receptacle for waste disposal (Massaquoi, 2020).

### 5.3.4 Biological Diversity of the Sierra Leone Coastal Landscape Complex

The SLCLC is a large ecological complex of great environmental and biological importance. Common in this coastal scape are mangroves, fish and other marine species, with occasional spotting of terrestrial and marine mammals. There are six mangrove species in the SLCLC, including *Avicennia germinans, Rhizophora harissonii, Rhizophora mangle, Rhizophora racemosa, Laguncularia racemosa*, and *Anisophylia laurina*, but three are commonly reported by the local communities, including black, white, and red mangroves. In addition, different forms and sizes of biodiversity such as crabs, oysters, and abnormally-sized shrimp and lobsters are also found in the coastal waters of the SLCLC. Critically endangered species of wintering birds, such as Ringed and Kentish Plover, Sanderlings, and Curlew Sandpipers have also been reported to occur in this landscape. About twenty-three species of these threatened bird species have been identified and recorded along the Sierra Leonean coastline. The 350km stretch of beaches is dominated by mangroves and fine-grained sand, and provide a feeding and nesting ground for turtles and birds. The mangrove ecosystem also provides feeding grounds for terrestrial mammals such as monkeys and the West African Manatee, and a nesting and feeding ground for various species of turtles, fish and shrimps. Molluscs (bernacles, mussels, oysters, periwinkles, limpets, and gastropods), algae, and coralline sponges can also be found on rocky shores in this area (Massaquoi, 2020).

### 5.3.5 Socio-Cultural and Economic Characteristics of the Sierra Leone Coastal Landscape Complex

**Demography:** The SLCLC is home to approximately 2.2 million people. The average age of inhabitants across the SLCLC is 22, while the sex ratio measured as a number of males per 100 females are as follows: 90.27 for the Scarcies, 87.35 for Sherbro, 70.86 for the SLRE, and 94.84 for the Yawri Bay (USAID, 2017). The statistics compare with the 2004 national census data, which places the sex ratio at 94 and the 2015 census that places the same at 96 for males. Most regions of the SLCLC have slightly lower numbers of female-headed households and a slightly higher number of male-headed households than the national average of 74.6%. The four regions are characterized by very low levels of literacy, with female residents being the most education-deprived. Movements between and across the different regions are associated with inter-marriages and the search for jobs and trade. The majority of residents speak more than one language; the most common being Themne and Krio. Other languages spoken in the SLCLC include Limba, Loko, Sherbro, Mende, and Maninka (Massaquoi, 2020).

**Social groupings and economic activities:** Social groups found in the SLCLC include religious groups, cultural groups, and fishermen associations. Some groups are labour-related, like groups made up of fishermen, miners, farmers etc. Social groupings generally provide a means to making a living or gaining socio-cultural and political identity in the communities. Fishing is the major livelihood activity in all SLCLC regions, though smallholder rice cultivation can also be found. Tombo, Shenge, and Yeliboya supply most of the fish consumed in Freetown, which has increased in intensity due to the development of small artisanal fishing projects by UNDP, Africare, and other agencies. Other economic activities include salt production, which uses large quantities of mangrove wood. Fish processing, especially

smoking using traditional methods, also uses large quantities of mangrove wood brought into the communities by boats. Whereas fishing is the mainstay of the coastal economy, providing a source of income and livelihoods for both fishers, fish processors, and fish traders, it has also given rise to a booming secondary economy of boat building, woodcutting, fish transportation, basket weaving, selling fishing gears, and petty trading. It is believed that around 40,000 artisanal fishers and their families operate more than 12000 fishing boats that create up to 50,000 jobs in the fisheries sector (EJF, 2009).

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# 6 COMMUNITY PROFILES

The information presented in this section are mainly sourced from the Household survey, Focused Group Discussions, Key Informant Interviews and transect walk observations during the study. Where there were constraints and as needed, data were sourced from the 2015 Sierra Leone Population and Housing Census and referenced accordingly.

## 6.1 Conakry-Dee

Conakry Dee is located in Mayaia section, Kaffu Bullom Chiefdom in Port Loko District. It lies 10 km North-West off Lungi International Airport, on one of the most climate-induced vulnerable coastal regions of Sierra Leone.

**Figure 6-1: Aerial Photographs of Study Area – Conakry-Dee – Northern Axis**



**Figure 6-2: Aerial Photographs of Study Area – Conakry-Dee - Southwards**



### Population and Demography

For this study, 103 households were surveyed with a total population of 1,345, which averages 13.1 persons per household. The community is dominated by extended families (96.1%) and has an almost balanced male-female population with 50.1% male and 49.9% female. The age distribution constitutes of 34.4% children under age 15; 17.9% aged 15-17; 27.2% aged 18-35; 18.0% aged 36-64; and a 2.5% were 65 years and older. Working-class population (age 15-64 years) accounted for about 63.5% of the total population sampled, while 36.5% are within the non-working class. Temne is the largest ethnic group in Conakry-Dee, accounting for 70.9% of households. The second-largest ethnic group is Susu, with 20.4% of the respondents. Others include the Fullah, Kono, Limba, Mandingo and Mende. Islam is the most practised religion by 99.0% of the respondents in Conakry Dee.

### Education Levels

The community has two primary schools and one secondary school, which were reported to be constrained with a shortage of trained and qualified teachers, classrooms and furniture and inadequate teaching and learning materials. This has led to many school dropouts who end up with fishing or other livelihood activities such as sand mining. 69.2% of the sampled population are literate while 30.8% have no formal education.

### Health and Sanitation

There is one community health centre in Conakry-Dee, which is located in the centre of the community and accessible via road from all around the community. Also, the community can access the hospital in Lungi, which is about 30 mins drive away. 18.4% of households seek traditional health services whenever they are sick, while 81.6% seek formal medical health services. Most of the households do not have proper toilet facilities; only 51.5% of households have access to a toilet facility, whereas the remainder (49.5%) use either bush, beach areas or river banks. Open defecation on the beach area is common, and this affects the community with the risks of contamination of food with pathogens resulting to illness. Consequently, there is a prevalence of water-borne diseases such as typhoid, cholera, diarrhoea, as depicted in the survey.

### Livelihood

Fishing, fish mongering and boat making are the main livelihood activities in the community; alternative economic activities include rice farming and vegetable gardening as well as formal employment. From the survey, 22.3% are engaged in fishing and boat making. Women are mostly engaged in fish mongering which constitutes 15.5% of livelihood activities. About 21.6% are engaged in skilled jobs, 5.8% are formally employed, while 10.7% are gardeners. Only 12.6% are engaged in other income-generating activities such as petty trading, while about 15.5% are unemployed.

### Energy and Communication

Many households in Conakry-Dee are now connected to the Community Health Centre (CHC) solar electrification grid implemented by UNOPS. Other sources of energy include rechargeable/battery-powered lights. Some of the community members (mostly the affluent) also use mini-solar panels or generators for lighting. Majority of households rely on the community solar grid (51.5%) as their main source of electricity, 24.3% rely on rechargeable lights, while 24.2% use other means. Additionally, 81.6% of households rely on firewood for cooking, while 18.4% use charcoal for cooking.

Conakry-Dee is served by mobile telecommunications network operators (Orange SL and Africell), though coverage in certain areas is a challenge.

### Water Supply and Access

The main source of water is piped borne water which is sourced from a solar-powered borehole submersible pump through a communal overhead tank. However, public tap, hand-pumps and wells are also other water sources available in the community; some of these are either not functional or malfunctioning requiring some maintenance. Nonetheless, during the dry season, many of these water sources dry up.

From the survey, 29.1% use public tap, 22.3% use a hand pump, 19.4% gets their water from protected wells and 5.8% from unprotected wells. About 1.9 % of households source their domestic water from a stream and 4.9 % from a communal water tank.

### Housing and Infrastructure

Housing consists of a mixture of traditional and modern buildings. The houses on the higher ground are mostly rectangular structures, made of mud or cement brick walls and corrugated zinc roofs. Houses on the coastal frontiers are mostly constructed with raffia palm, grass, mud and bamboo with plastered. The majority of households live in single-unit buildings (67.0%). About 13.6% lived in apartment buildings while 11.7% live in semi-detached houses. An equal proportion of about 2.9% each lives in huts and uncompleted buildings respectively.

### Climate Change Knowledge and Attitude

Within the community, there have been several climate change sensitisation programmes undertaken; 73.5% of respondents claimed to have heard about climate change via various media including radio/television broadcasts, social media, public sensitisation, academic institutions, and places of work. The remaining 26.5% haven't heard about climate change but expressed willingness to learn about climate change. From community knowledge; causes of climate were mostly attributed to deforestation and mangrove exploitation and sand mining; effects of climate change include; rise in temperature, strong winds, coastal erosion, heavy rainfall, flooding and sea-level rise in which has been seriously affected by these disastrous effects.

### Climate Change-Induced Disasters and Adaptation Actions

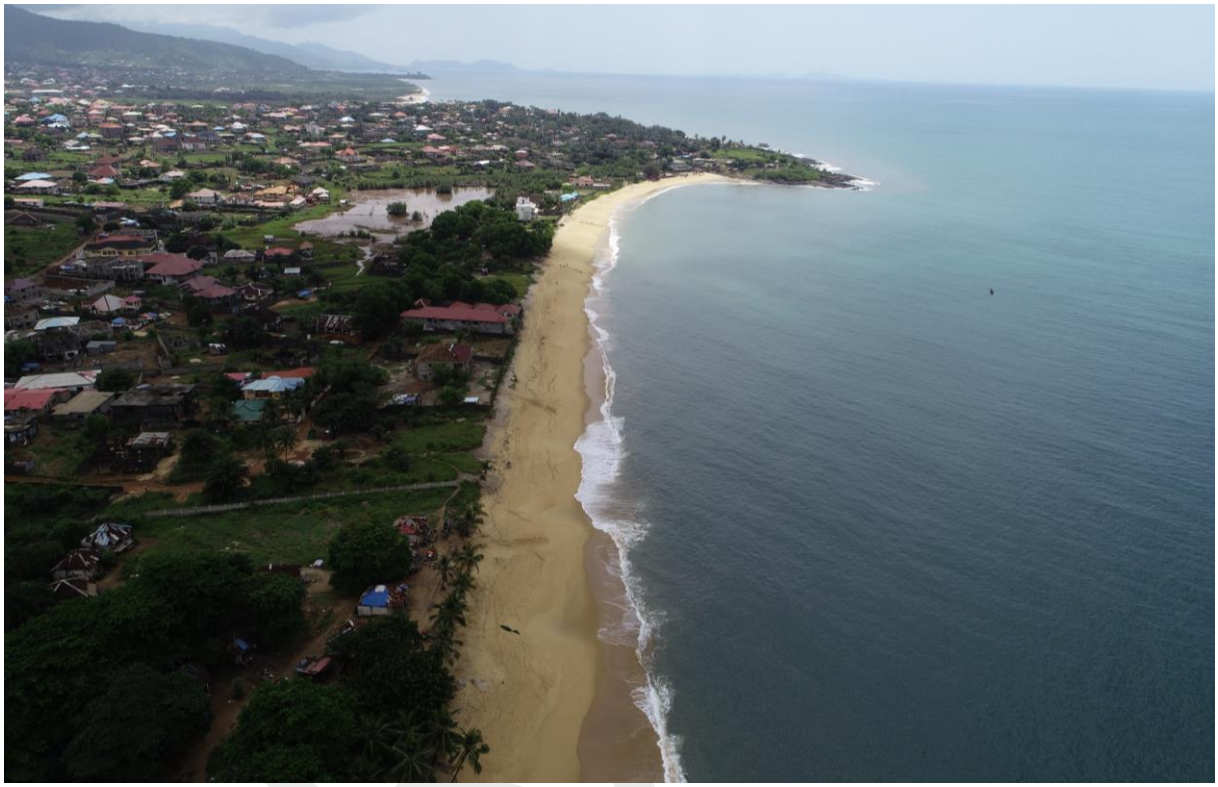
The community is mostly affected by fluvial floods, heavy winds, fire and coastal erosion; 68% of respondents highlighted these as major disasters over the last decade. Some of the effects caused by these disaster events include damage/loss of property and infrastructure. Some of the environmental changes in the community, as mentioned, are poor waste management, loss of landmass and poor road conditions.

Local adaptation measures that have been undertaken by the community are tree planting, protection of mangroves and public sensitisation.

## 6.2 Lakka

Lakka is a small settlement along the Freetown Peninsular Road, about 10km South-West of Freetown. It is known as a popular tourist and recreational community along the Western Area Peninsular due to its location and the nature of the coastline (sandy beach). Southward, the community shares boundary with another coastal community, Hamilton and North of Lakka is the Ogu Farm community.

**Figure 6-3: Aerial Photo of Lakka and Hamilton**



### Population and Demography

Lakka Community is within Hamilton Section, which hosts a combined population of 15,888 people, with 8,336 male (52.5%) and 7,552 female (47.5%) (Statistics Sierra Leone, 2015).

The survey recorded a total of 801 people (49.4% male and 50.6% female) from 122 households, with an average household size of 6.5 persons per household. Out of the sampled population, children under age 15 comprised 30%; 15-17 years accounted for 11.7%; youth (age 18-35 years) constituted 39.7%; aged 36-64 years accounted for 17.4% and 1.1% for aged 65 and older. Lakka has a working-class population of about 68.8%.

Lakka is an ethnically diverse community. However, while Krio is widely spoken, the Temne ethnic group accounts for 23.0% of the sampled population, followed by Mende with 22.1%. Also, Muslims and Christians constitute an equal proportion of the sampled population (50% each).

### Education

There are five primary schools, six secondary schools and one vocational training institute in the community. The community boasts of 93.6% literacy as against 7.4 % that did not attain any formal education.

### Health and Sanitation

Lakka hosts two public hospitals (Tuberculosis and Leprosy Government Hospitals) and one Community Health Centre (Lakka-Ogu Health Centre). The survey revealed that malaria, diarrhoea, common cold, body pain, yellow fever and typhoid are the illnesses prevalent in the community. 24.6%

of the respondents stated that they seek traditional health services whenever they fall ill, while 75.4% seek modern health services.

Lakka is seriously challenged with proper waste management. Majority of its inhabitants dispose of their wastes in drainages, open places and by the seaside. This is contributing to the seasonal flooding in the area as drainages get blocked which disrupt the flow of water whenever it rains. The survey also revealed that 34.4% of the respondents use shared pit latrine, 32.0% use flush toilet (Private), 10.7% utilise flush toilet (Shared), 8.2% use VIP latrine (Private). 4.1% utilise VIP latrine (Shared), 7.4% use pit latrine (Private), 2.5% utilise river or seaside, and 0.8% reported to not have any toilet facility. . However, MASADA has been engaged for the collection and dumping of wastes for those that can afford or willing to pay for the service.

**Livelihoods**

The major livelihood activities in Lakka are tourism and recreation. Other income-generating activities are sand mining, fishing, commercial bike riding and motor driving (*Poda-poda* and taxi), carpentry, tailoring, masonry, stone mining and petty trading. The community has a long history of sand mining which has contributed to serious land degradation and massive coastal erosion posing serious threats to lives and properties, especially those living very close to the shore. The impact of environmental degradation is clearly threatening the livelihood and other economic activities within the community, particularly in the area of tourism.

From the survey, 45.9% of the respondents are engaged in skilled jobs; 8.2% are in the fishing industry (fishing, fish mongering and boat making); 4.1% are formally employed; 1.6% are engaged in gardening; 2.5% are sand miners; 17.2% are engaged in other income-generating activities such as commercial bike riding and tourism and 20.5% are of the respondents reported being unemployed. The main sources of income are from parents and remittances from relatives and other business ventures.

**Energy and Communication**

Lakka community is connected to the main Energy Distribution and Supply Authority (EDSA) grid where the majority of the population reported (72.9%) to source their energy from. Alternative sources of electricity/lighting are private generator, solar energy and rechargeable light. This constitutes 23.8% using rechargeable lights as their main source of lighting, 2.4% utilise solar energy and 0.8% use candle. Charcoal is widely used in the community for cooking. Alternative options are firewood (8.2% and gas (4%).

Mobile telecommunication networks, Orange SL, Africell, Qcell and Sierratel, are present in the community. However, coverage and connectivity are limited in some areas.

**Water Supply and Access**

The community is connected to Guma Valley Water Company (GVWC) which supply piped-borne water used for drinking and domestic purposes. The major challenge is the access which necessitates alternatives such as water wells, streams, communal water tank and springs.

41.8% of the respondents source their water from a public tap, 14.8% from plumbing outside, 18.8% from either protected spring or wells, 12.3% from a hand pump, 7.4% from plumbing inside, 1.6% from communal water tank and 3.2% source theirs from either unprotected wells, rainwater or village streams. However, water for drinking purposes is mainly sourced from vendors selling sachets water. The demand for water resources is increasing due to rapid population growth and pressures from climate change and environmental degradation. Access to both domestic and drinking water supply is most challenged in the dry season due to the shortage of water from either GVWC dam, drying up of water wells and/or streams.

**Housing and Infrastructure**

Housing infrastructure in Lakka consists of makeshift zinc structures and modern (concrete) buildings with mostly corrugated zinc roof sheets. Majority of the houses surveyed are separate houses (35.2%); flat/apartment (30.3%); semi-detached (13.1%) and improvised home also accounting for 13.1%; others include huts and uncompleted buildings. On average, most of the houses are cement/concrete buildings, though a considerable amount is zinc structures (Pan-body). 62.3% used cement wall material, whilst 37.7% had either zinc, timber or mudbrick wall material. 62.3% of the floor are cemented/concrete, while 37.7% had tile, mud, stone or other floor materials.

The types of a roof range from thatch roofs, tarpaulin plastic to congregated zinc sheets; 97.5% of houses had zinc roof material, whilst 2.5% had either concrete, tarpaulin or thatch roof material.

**Climate Change Knowledge and Attitude**

Majority of the HHS respondents (71.3%) in Lakka are aware of climate change and receive information from friends and families, radio/television broadcasts, social media, public sensitisation, academic institutions, and/or places of work. The remaining 28.7% are unaware of climate change but expressed a willingness to learn.

Their understanding of climate change is limited; the majority of the participants revealed that climate change is caused by deforestation, charcoal burning, sand mining and industrialisation. This further revealed that the effects of climate change include the rise in temperature, heavy wind, coastal erosion, heavy rainfall, flooding and sea-level rise in which the community has been seriously affected. In other to control these effects, the community people have engaged in tree planting exercise, provide security at the beach to stop those involved in illegal sand mining, cleaning of drainages and discourage the act of deforestation.

**Climate Change-Induced Disasters and Adaptation Strategies**

The study revealed that 34.4% of the households had been affected by climate change-induced disasters such as flash floods, heavy thunderstorm, wind storm and coastal erosion. There is an unusual occurrence of boulders rolling from hilltops mostly on the aftermath of a heavy rainfall and stone mining.

Additionally, an abnormal change in seasonality and heavy wind are some of the environmental changes observed in the community. Lakka is faced with key environmental concerns such as poor drainage systems, poor waste management, deforestation, illegal sand mining and loss of landmass.

Some of the adaptation measures that have been undertaken by the community are replanting of trees, the embankment of flooded areas, bracing of rooftops and temporal relocation. The community have established the Community Disaster Management Committee (CDMC) in an effort to respond to disasters.

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**Figure 6-4: Photos of Climate Change coastal Hazards in Lakka**

**Destruction of infrastructure at the beach in Lakka**




**Roots of a Tree (Coconut) now Exposed due to Coastal Erosion**




**Seaweed surfacing at the Beach Frontiers**



**Figure 6-5: Photos of Climate Change Adaptation coastal Hazards in Lakka**

**Raised Foundations along the Lakka beach**







**Buildings Designed to withstand Coastal Inundation at Lakka Beach**




## 6.3 Hamilton

Hamilton is located on the southern coast of the Western Area Rural District of Sierra Leone, 7 mile (or 12 km) south of Freetown. Also shares boundary (north) with the Lakka community. Like Lakka, Hamilton is known for its beaches as it attracts tourist from within and outside the country.

**Population and Demography:**

Out of 81 households that were interviewed with a population of 558 persons, 52% were female persons per household. The survey also revealed that children under age 15 comprise 34.4% of the total population recorded, 15-17 years constituted 11.8%, youth (age 18-35 years) accounted for 27.2%, aged 36-64 years accounted for 22.4% and 4.1% were those aged 65 and older.

Various ethnic groups are residents of the Hamilton community. The dominant ethnic groups are Temnes (27%), Mende (23.5%), Limba (14.8%), Fullahs 8.6%, Konos & Sherbros (6.2%), Madingos (3.7%), Loko and Krios and Other minority groups sum up respectively. The study also revealed that about 63% of participants in the study area are Muslims, while 37% are Christians.

### Education

There are seven pre/primary schools and three secondary schools within the community; with only two government schools (one primary and one secondary), the rest been privately owned schools. The study reveals a literacy rate of 84.9% literacy rate as against 15.1% of the illiterate group.

### Health and Sanitation:

The community has one health centre, which is a clinic but facing challenges with the number of nurses, as the available nurses cannot meet the demand of the community's population. Therefore, 29.6% of the respondents revealed that they seek traditional health services whenever they fall ill, while 70.4% seek medical health services.

Hamilton community has no functional central sewage system. The community has no official dumpsite for waste disposal. Most of the community dwellers practice open dumping at sea, coupled with the high reliance on pit latrines has increased the incidence of water-borne diseases. Further, the most practised method of disposing of waste is burning, community trash, open pits; bush and drainages.

For the type of toilet facility used in the community, pit latrine (private) is extremely used with an average of 33.3%, 19.8% uses for other types of toilet 14.8% uses river/stream or flush toilet (private), 6.2% uses pit latrine (shared), 3.7% uses VIP latrine or flush toilet shared, and 1.2% have no toilet facility.

**Figure 6-6: Aerial Photographs of Study Area – Hamilton-Sussex**



### Livelihood

The main source of livelihood activity in Hamilton is petty trading. Other sources include; fishing, gardening, stone mining, skilled job, formal employment and sand mining. The survey revealed that 29.6% are engaged in petty trading activities, 28.4% are either students or unemployed, 17.3% are engaged in skilled trading and 8.6% are formally employed, 7.4% for sand mining and 2.5% for gardening. Most household income is highly driven by parents and remittances from relatives and other business ventures. Also, majority of the households spend their income on food, house rent and education.

### Energy and Communication

EDSA is the main source of electricity in the community. Alternative sources are private generators and rechargeable lights. The study was recorded that 50.5% of the respondents rely on EDSA as their main source of lighting, 42% utilise rechargeable light, 2.5% uses private generators or solar grid and others means of lighting.

Charcoal is a traditional form of energy for cooking and is used by about 66.6% of respondents from 23.5% rely on firewood as their main source, while 9.9% uses gas.

The community has access to all communication service providers, such as Orange Sierra Leone, Africell Sierra Leone, GCELL, and Sierratel.

### Water Supply and Access

Guma Valley Water Company is the main source of water supply. Alternative water sources are private wells, nearby streams and rivers. From the survey, 49.4% uses public tap, 18.5% uses hand pump, 12.3% gets their water from plumbing outside, 4.9% from unprotected wells, 3.7% from protected wells, 2.6% from village stream and 1.2% from a communal water tank or protected springs.

However, water constraints are experienced due to the expensive cost of Guma valley connection and; during the dry season, due to the drying up of Guma Valley dams and the drying up of wells and streams.

### Housing and Infrastructure

The degree of housing infrastructural development in Hamilton varies with different housing standards and conditions. Housing in the community consists of traditional structures and modern buildings. The survey shows, 44.4% households lived in a single-unit house; 16% lived in flat Apartment; 12.3% lived in semidetached houses; 9.9% resides in Improvised Home Kiosk, and 8.6% lived in uncompleted buildings and Hut. Most of the houses in Hamilton community are covered with zinc for roofing, cement Blocks mostly for the wall material and generally concrete for floor material, the survey confirmed that 97.5% of houses had zinc roof material, 1.2% for concreate and others roofing materials 61.7% used cement wall material, 34.6% uses zinc and 1.2% for thatch, timber or other types of wall materials whilst 58% of the floors are cemented/concrete, 33.3% are tile floors, 7.4% are mud and 1.2% for other types of floor material.

### Climate Change Knowledge and Attitude

From the study, 55.6% of respondents are aware of climate change mostly via radio/television broadcasts, social media, public sensitisation, academic institutions, and places of work. The remaining 44.4% haven't heard about climate change but expressed willingness to learn about climate change.

The community knowledge believes that climate change is mostly caused by deforestation, charcoal burning, stone mining and industrialisation; the effects of climate change are rise in temperature, strong winds, coastal erosion, heavy rainfall, flooding and sea-level rise in which Hamilton has been seriously affected by these disastrous effects.

### Climate Change-Induced Disasters and Adaptation Actions

From the survey, (50.6%) reported that their households had been affected by either flash floods, heavy wind, and/or coastal erosion. It was revealed that deforestation, sand mining, the poor drainage system and stone mining could have exacerbated the frequent occurrence of these disasters. Some of the effects of these disasters on the community are property damage and loss and also contribute to poor road conditions.

Some of the adaptation measures that have been undertaken by the community are replanting of trees, the embankment of flooded areas, bracing of rooftops and temporal relocation of most affected households and infrastructure.

Hamilton is faced with key environmental concerns such as poor waste management, deforestation, illegal sand mining, poor drainage network and loss of beach area.

## 6.4 Tombo

The coastal community of Tombo is located on the southern coast of the Western Area Rural District of Sierra Leone (about 49km east of Freetown).Tombo is a very popular community as it's one of the main fishing communities that supply Freetown (Greening EU COOPERATION, 2020)

**Figure 6-7: Aerial Photographs of Study Area – Tombo (1/2)**



### Population and Demography

According to the 2015 population and housing census, Tombo has an estimated population of 33,750 inhabitants. It has a female population of 17,003 (50.1%) and a male population of 16,747 (49.9%).

For the study, 463 households were surveyed with a population of 4,905 persons; 55.2% female and 44.8% male. The survey recorded an average household size of 10.5 persons per household. The survey also revealed that children under age 15 comprise 33.7%, 15-17 years constitute 16.2%, youth (age 18-35 years) account for 29.3%, aged 36-64 years accounted for 16.9% and 3.9% were those aged 65 and older.

Tombo is an ethnically diverse community with Krio as the widely spoken language, the Temne ethnic group accounts for 64.4% of the population, followed by Sherbro with 8.0%. The Tombo is a Muslim dominated community, with about 95.7% of the respondents as Muslims and 4.3% Christians.

### Education

The community has thirty pre/primary schools, four junior and one senior secondary schools and one vocational training institute in the community. The survey also revealed that 20.0% had had no formal education and an 80% literacy rate.

**Figure 6-8: Aerial Photographs of Study Area – Tombo (2/2)**



### Health and Sanitation

There is only one public health centre (Tombo Community Health Centre) and about five private clinics in Tombo. The survey revealed that malaria, cholera, diarrhoea, Common cold and Typhoid are the illnesses prevalent in Tombo. Also, 36.5% seek traditional health services whenever they fall ill, while 63.5% seek medical health services.

There is no proper sewage and refuse disposal facilities in the community; thus, this may have contributed to the incidence of water-borne diseases. Of the sample households, 67.4% use shared pit latrine, 11.2% use private pit latrine, 5.2% use bush and 4.8% has no toilet facility. Admittedly, Solid wastes generated by households and businesses within the community are not properly managed; household wastes are mostly dumped in drainages, open places and seaside.

### Livelihoods

The major livelihood activity is fishing. Other income-generating activities include petty trading, commercial bike riding and moto driving (*Poda-poda* and taxi), boat making carpentry, tailoring and masonry. There are also formal institutions and other small businesses that are providing employment opportunities for locals in the community.

47.5% of the respondents are engaged in the fishing industry, 15.8% are engaged in skilled jobs, 1.7% are formally employed, 1.5% are gardeners, 0.4% are sand miners, 22.5% are engaged in other income-generating activities such as petty trading, while about 10.6% are unemployed. Most household's income is highly driven by parents and remittances from relatives and other business ventures.

### Energy and Communication

Tombo relies mainly on rechargeable light as their main source of lighting (70.8%) of the households, 8.9% utilise private solar, 4.9% utilise local electricity, and 6.9% utilise solar grid, 2.2% utilise private generator, and 6.2 utilise other means of lighting.

Charcoal is the main source of energy for cooking which accounts for about 68.3%; 30.5% rely on firewood as their main source, while 1.2% use gas and other sources.

Three mobile telecommunication company operators (Orange SL, Africell, and Qcell) are present in Tombo.

**Water Supply and Access**

There is a community dam that serves as the main source of water supply in Tombo. Alternatives sources include water wells, nearby streams, communal water tank and springs. 80.8% of the respondents source their water from the public tap which is supplied by the dam, 5.6% from a hand pump, 4.3% from plumbing outside, 6.3% from either protected spring or wells and 3.0% sourced theirs from either communal water tank, nearby streams or unprotected wells. However, water for drinking purposes is mainly sourced from vendors selling sachets water. The demand for water resources is increasing due to rapid population growth. Access to both domestic and drinking water supply is most challenged in the dry season due to the shortage of water from the dam, water wells, and nearby streams.

**Housing and Infrastructure**

The Survey shows that 58.5% dwell in separate houses, 22.0% dwell in semidetached houses, 11.2% resides in flat/apartment, 3.0% dwell in uncompleted buildings and 5.2% dwell in either hut or improvised houses. Additionally, 88.6% of houses had zinc roof material, 58.8% used cement wall material, and 80.1% of the floors are cemented/concrete.

**Climate Change Knowledge and Attitude**

Climate change knowledge is low within the community with just 31.2% of the respondents that have some knowledge about climate change either via radio/television broadcasts, social media, religious houses, public sensitisation, academic institutions, or places of work. The greater portion (68.8%) admitted to having no idea about climate change but expressed willingness to learn about it.

According to the community knowledge, climate change is caused by deforestation, charcoal burning, stone mining and industrialisation. Also, the effects of climate change are rise in temperature, strong winds, coastal erosion, heavy rainfall, flooding and sea-level rise.

**Climate Change-Induced Disasters, and Adaptation Strategy**

Households have been affected by climate change-induced hazards, with 61.1% of the respondents been affected either flash floods, heavy wind, and/or coastal erosion. An incident of a fire outbreak in 2020 was reported to have resulted to the loss of lives and properties. The community people believe that deforestation, sand mining, a poor drainage system and stone mining may have exacerbated the frequent occurrence of these disasters. Some of the effects of these disasters in the community include property damage and loss of lives and properties. Adaptation measures that have been implemented by the community are tree planting, the embankment of flooded areas including construction of retaining wall, bracing of rooftops and temporal relocation.

About 63.9% of the respondents and majority of the participants from the claimed abnormal change in seasonality, rise in temperature and heavy winds are some of the environmental changes observed in the community. Tombo is also faced with key environmental concerns such as poor waste management, deforestation and illegal sand mining.

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## 6.5 Shenge

Shenge is a coastal fishing town along the Atlantic Ocean in Moyamba Tassor Section, Kagboro Chiefdom, Moyamba District and the host community of the Kagboro Chiefdom local administration. The community is marred with accessibility challenge of poor road network from Moyamba Town and is still most easily reached by small local fishing and passenger boats commonly called *'pampas'*.

**Figure 6-9: Aerial Photographs of Study Area – Shenge**



**Population and Demography**

The surveys recorded a total of 473 people from 52 households, with an average household size of 9.1 persons per household. 48.3% male and 51.7% females from the sampled population. Households surveyed where of extended families (28.7%), and 71.2% are nuclear families.

The dominant ethnic groups in Shenge are the Sherbro (73.1%) and Temne (13.5%). Other notable ethnic groups comprise Mendes (5.8%), Fullah, Limba, Mandingo, Susu, each less than 2% of the household population sampled. Majority of the population in the community are Christians, constituting a fair share of 55.8% of the households.

The age structure for the community has children under age 15, comprising 34.7% of the total population recorded. Ages 15-17 accounted for 15.7%, ages 18-35 years accounted for 29.4%, aged 36-64 accounted for 16.4% and 3.8% were those at aged 65 and older. Working-class population (age 15-64 years) accounted for about 61.5% of the total population sampled, while 38.5% are within the non-working class.

**Education Levels**

Shenge has only two pre/primary and one junior and one senior secondary school located in the community. These institutions are challenged with concerns of untrained and unqualified teachers, overcrowding of pupils and shortage of school materials. However, the literacy level of the community is at 81.9% as against 12.1% who have no formal education.

### Health and Sanitation

There is only one community health centre (CHC) located in Shenge serving about 12 catchment communities. The majority (82.7%) of the respondents revealed that they seek formal medical services. The survey also revealed that malaria, cholera, diarrhoea, common cold and typhoid are the prevalent illnesses in the community.

Solid wastes generated by households and businesses within the community are not properly managed; household wastes are mostly dumped into drainages, open places and seaside. Also, there's no structured community sewage system, with 53.8% of households use private pit latrine, 21.2% use shared pit latrine, 7.7% use bush and 5.7% use VIP latrines.

### Livelihoods

The major socio-economic activities of Shenge are fishing and fish mongering. Other sources of livelihood which include agriculture (rice cultivation), boat construction, woodcutting, transportation, weaving baskets, selling fishing gears, and petty trading

The fishing industry (Fishing, Fish mongering) represents the major livelihood and economic sector of Shenge, which constitutes 26.9% of livelihood source for the respondents. Petty trading makes up 25% of livelihood source, 23.1% are engaged in skilled jobs, 9.6% formally employed, and 7.4% engaged in agriculture. However, 7.6% are either students or unemployed.

### Energy and Communication

The majority of the households depend on battery-powered or rechargeable lamps or flashlights (90.4%) for lighting; while very few use private solar lamps constituting only 3.8% of households surveyed. Community members recharge their mobile phones and other appliances, including rechargeable lights at the telecentre which operates on portable generators.

The traditional source of energy used almost exclusively by households within Shenge for cooking and smoking of fish is firewood; this accounts for about 88.5% of households, while 11.5% of households use charcoal for cooking.

Mobile telecommunications network operators within Shenge include Orang and Africell; with a good network for calls and internet access.

### Water Supply and Access

The community mainly depend on hand pumps and wells as their main sources. However, some of these are either not functional or frequently subjected to breakages. Households also obtain water for domestic use from nearby streams. During the dry season, most of these water sources dry up, resulting in a limited water supply and access for the community.

The survey shows that 65.4% of households use hand pump as their main source of water, 21.2% gets their water from protected wells and 13.5% from public taps.

### Housing and Infrastructure

The quality of houses is, therefore, an indication of the socio-economic status of the people. The degree of housing infrastructural development in Shenge is almost homogenous across the community and shows very little contrast. On the average, most of the houses are built out of mud bricks, though some are plastered with cement for a better finishing and structural integrity—the types of roof range from few thatch roofs to congregated zinc sheets.

From the survey, 88.5% dwell in single-unit structures, 9.6% dwell in flat-apartments and 1.9% in semi-detached houses; these structures are composed of 84.6% corrugated zinc sheets and 15.4% thatch; the walls comprise of 57.7% mudbrick, 26.9% mud and wattle and 15% concrete bricks; And the floor of the houses are mostly concrete floors (59.6%), 36.5% mud and 3.8% tiles.

Poor feeder roads condition is a development problem that is faced by the Shenge community. The main road linking Moyamba and Shenge is a very poor condition. This road is likely to open many economic corridors in Shenge if well-constructed or repaired. A fish landing site was constructed in Shenge among three other sites in 2010 by the African Development Fund (ADF) to promote the fishing industry in Sierra Leone. Despite good intentions, they have been left idle, mainly due to a lack of technical know-how in the community on how to run and maintain the facilities. A new jetty is also under construction, and it is said to be funded by UNDP.

**Climate change Knowledge and Attitude**

The survey respondent's knowledge on climate change was captured, and responses showed that 69.2% of respondents claimed to have heard about climate change via various media including radio broadcasts and public sensitisation and workshops which were often held at Chepo. Climate change is generally understood by participants as unfavourable weather condition, often leading to disaster events.

Additionally, causes of climate change were mostly linked to human activities such as deforestation, charcoal burning, stone mining and bad fishing methods. Although the remaining 30.8% haven't heard about climate change, they, however, expressed willingness to learn about climate change. The effects of climate change as expressed by respondents are; rise in temperature, strong winds, coastal erosion, heavy rainfall, flooding and sea-level rise, all of which have seriously affected the community. Poverty and lack of social infrastructures such as education, healthcare access, and lack of government support were highlighted during community engagement. Lack of toilets and problems with fishing materials and lack of food are all issues that mentioned by the participants.

When asked to name changes in the local climate, responses reveal that a large number had observed more frequent abnormal climatic conditions as strong winds, more intense storms, more extreme heat, more intense and frequent flooding, and coastal erosion.

**Disasters, Vulnerability and Adaptation Actions**

Only about 8.0% mentioned that they had been affected by climate change disaster events such as strong winds, coastal erosion, increased sea level and coastal recession, increased temperature, changes in rainfall patterns. Strong winds have often led to fires mostly in fish smokehouses (*bandas*) and destruction properties and other valuable assets. Winds also cause destruction of roofs and even houses as well as capsizing of the boats at sea. Generally, heavy winds cause more damage and need to be addressed quickly. Strong winds seemed less predictable while floods are a frequent seasonal event that can be better anticipated and managed and may cause less destruction.

Construction of homes which includes making them sturdier and/or using local materials, as well as the construction of drainage systems, were identified as adaptation measures. Livelihood diversification and promotion were also mentioned, referring to increased farming activities and access to loan schemes.

## 6.6 Turtle Islands

Turtle Islands is an archipelago of eight tiny islands – Bakie, Bumpetuk, Chepo, Hoong, Mut, Nyangei, Sei and Yele – located in the Atlantic just off the western shore of Sherbro Island in Sierra Leone. The Islands is mostly accessed via sea transportation. The islands are tethered to a traditional way of life and swing to their own cultural rhythms. While Chepo is home to the paramount chief, Hoong is strictly a male-only island reserved for rites of passage. The turtle islands are located at the western edge of the Sherbro estuary which is located far from administrative and economic centres and has poor infrastructure and services as they are outside the main municipal area. Three locations were sampled in Turtle Islands; Yele, Bumpetoke and Sei communities.

**Population and Demography**

The surveys recorded a total of 295 people from 33 households in the three communities, with an average household size of 8.9 persons per household. The survey recorded 55.6% male and 44.4% females from the sampled population. Majority of the households surveyed are extended families (72.7%), while 27.3% are nuclear families; Children under age 15 comprise 32.5% of the total population recorded. Age 15-17 accounted for 7.8.%, aged 18-35 years accounted for 40.0%, aged 36-64 accounted for 17.6%, and only 2% were those at aged 65 and older. Working-class population (age 15-64 years) accounted for about 65.4% of the total population sampled, while 34.6% are within the non-working class.

There has been an increase in population within the archipelago in the last five years. In-migration and high birth rates are the main factors that have contributed to population growth in the islands. Turtle Islands is ethnically diverse due to the high movement of people for businesses. The Sherbro's are the indigenes of the Islands, but Temne and Mende also have a higher population, with Sherbro being the widely spoken language. Also, Sherbro is the main ethnic group with 72.7%, followed by Mende with

9.1%. Turtle Island is a Muslim dominated area with about 87.9% of the sampled population being Muslims, while 12.1% are Christians.

**Figure 6-10: Aerial Photographs of Study Area – Turtle Islands (Yele)**



### Education Levels

The archipelago has four pre/primary schools but no secondary school. Like in many other parts of Bonthe District, schools in Turtle Islands also have a problem with the lack of adequate infrastructure and overcrowding. 51.6% of the respondents have no formal education, while 34.9% had attained primary school education only. The survey also recorded that 12.4% had attained either junior and/or senior secondary level. Additionally, technical and vocational education accounted for only 1.1% of the sampled population.

The major educational challenge highlighted during the community consultations is the lack of government/government-assisted schools within the communities.

### Health and Sanitation

Primary healthcare which is the initial point of health contact for communities in Sierra Leone, is lacking in all the communities in Turtle Islands and available only at the chiefdom headquarter town, Chepo. For this reason, home treatment of diseases is common, including the pervasive use of native herbs. Malaria, cough, diarrhoea, typhoid and were among the common health problems reported in the communities. Sanitary conditions are very poor; the communities use the bush (63.6), Beach area (24.2%), shared pits (3%), and Rivers (3%).

Waste management is also poor as there is no proper waste dumpsite within these communities. Wastes are dumped along the beach, the bushes and some open pits.

**Figure 6-11: Aerial Photographs of Study Area – Turtle Islands (Sei)**



### Livelihoods

Fishing is the main occupation of inhabitants of Turtle islands. Households also engage in agricultural activities including livestock rearing, petty trading and hand-woven textiles. The fishing sector (Fishing, processing and mongering) accounts for about 75.7% of their economic and livelihood activities; 15.2% are engaged in other income-generating activities such as petty trading, while about 6.1% are unemployed. Much of the household's income is highly driven by parents and remittances from relatives and other business ventures.

### Energy and Communication

The majority of the households in Turtle Island depend on battery-powered or rechargeable lamps or flashlights (93.9%) for lighting at night, while very few use private solar lamps constituting only 6.1% of households surveyed. The traditional source of energy used in the Turtle Islands for cooking and fish smoking is firewood and accounts for about 90.9% of households, while 9.1% of households use charcoal for cooking.

Network coverage and connection within the Turtle Islands is very poor. In communities such as Yele, mobile communication is totally absent. In Bumpetoke and Sei, coverage is only restricted to certain areas in the community that are in proximity to the nearest signal towers.

### Water Supply and Access

Access to safe drinking water is important to help prevent waterborne diseases such as cholera, typhoid and schistosomiasis, and to reduce the adverse health consequences associated with other contaminants. The survey reveals that that 66.7% of households interviewed sourced their domestic water from unprotected wells, 15.2% from protected wells, 15.2% from hand pumps and 3.0% source theirs from unprotected springs.

**Figure 6-12: Aerial Photographs of Study Area – Turtle Islands (Bumpetoke)**



### Housing and Infrastructure

Turtle Islands is mostly accessed by water, and this is the only means of travelling within the Islands. Most of the housing units are substandard, built up of mud and thatch with no concrete floors.

Majority of the houses surveyed are a single-unit (75.8%). Other housing types are semi-detached (18.2%) and huts 6.1%. The walls are mostly made of mud and wattle (84.8%), mud-brick (15.2%).

Floor covering with mud accounted for 69.7% and cement (30%); also, about 60.6% of the houses are covered with thatch roof and 39.4% with zinc.

### Climate change Knowledge and Attitude

Community and individual's perceptions about climate change vary within the archipelago, about 69.7% of respondents claimed to have heard about climate change via various media including radio broadcasts and public sensitisation and workshops which were often held at Chepo. From community knowledge, climate change is generally understood as unfavourable weather condition often leading to accidents, flooding and unpredictable strong winds; causes of climate were mostly attributed to human activities such as cutting of mangroves; effects of climate change include; rise in temperature, strong winds, coastal erosion, heavy rainfall, flooding and sea-level rise, all of which have seriously affected the community. About 30.3% haven't heard about climate change but expressed a willingness to learn about climate change.

Observed changes in the local climate are more frequent abnormal climatic conditions such as strong winds, more intense storms, more extreme heat, more intense and frequent flooding, and coastal erosion.

Poverty and lack of social infrastructures such as education, healthcare access, lack of government support, lack of toilets, unavailability of fishing materials and lack of food were highlighted as key social concerns.

### Climate Change-Induced Disasters and Adaptation Actions

About 57.6% of respondents in the Turtle Islands indicated that they had been affected by disaster events, including strong winds, flooding, increased sea level and coastal inundation. Additionally, heavy winds cause fires mostly in smokehouses *(bandas)* which often move quickly through the densely build areas destroy houses and properties. Winds also cause destruction of roofs and even houses as well capsizing of the boats at sea.

For climate adaptation, range of adaptation measures was mentioned and broadly categorized into livelihood diversity and financial strategies; construction and infrastructure maintenance, and water, sanitation, and health. Planting of mangroves along the coast to prevent windstorms, climate and disaster early warning systems, and avoidance of sand mining and protection of mangroves were the key among adaptation measures proposed by the community.

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# 7 COASTAL VULNERABILITY ASSESSMENT

## 7.1 Approach

According to IPCC (2007), the term vulnerability can be defined as the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability assessment is used to estimate the amount of damage to the community resulting due to any hazardous event of about certain severity. This may include harm to the structures that are intact, injuries to people and interruption to normal human life. Consequently, the detection and mapping of coastal areas particularly vulnerable to the impacts of climate change-induced hazards are a powerful decision-making tool that serves to promote the sustainable use of coastal resources and guarantee their conservation. Currently, there are numerous methodologies and tools used to assess the vulnerability of the coast. The most commonly used methods to assess coastal vulnerability to climate change-induced hazards are index- or indicator-based methods, GIS-based Decision Support Systems (DSS) and methods based on dynamic computer models (CCA, 2011).

The Coastal Vulnerability Index (CVI) is one of the most commonly used and simple methods to assess coastal vulnerability to sea-level rise, in particular, due to erosion and/or inundation (Gornitz, 1991). The CVI provides a discretisation of the coastline in various segments, assigning ranking values for each of them, based on different parameter evaluation. However, the principal limitations of the index- and indicator-based approaches is the incapacity to address socio-economic aspects. Accordingly, they need to be extended/modified by adjusting not only the number but also the typology of the key variables (CCA, 2011). Thus, for this assessment, INTEGEMS has used an Integrated Coastal Vulnerability Index (ICVI) that incorporates Physical Vulnerability Index (PVI) generated by seven physical parameters and a Socio-economic Vulnerability Index (SVI) generated by eight socio-economic parameters. This ICVI indicates the degree of exposure of coastal areas to the impacts of physical and socio-economic factors.

This approach is based on a new formulation, different from the classical one by Gornitz (1991) and Gornitz et al. (1991), which has been developed by De Serio, et al. (2018) and the GIS implementation has been based on data collection and processing, by means of superposition, graphical visualisation of the parameters and mapping of the results (see Figure 7-1).

## 7.2 Methodology

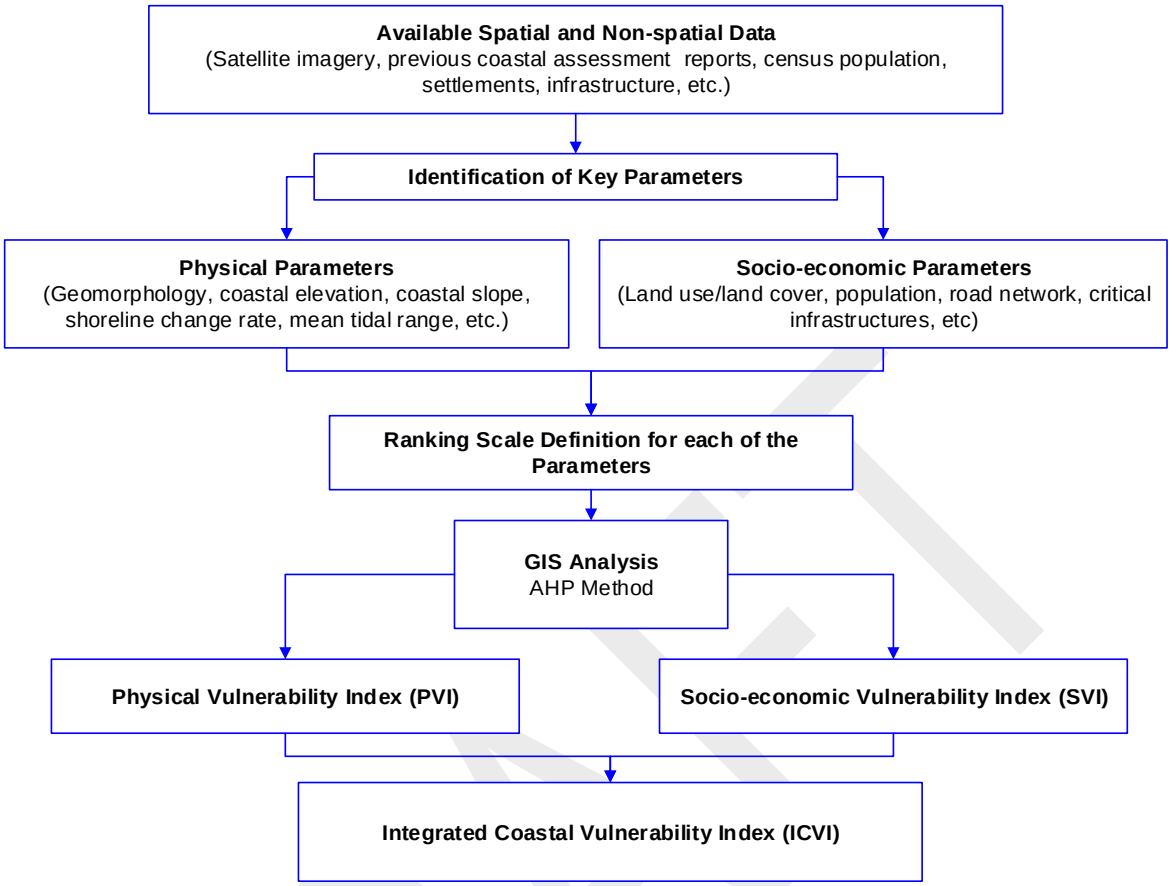
The ICVI method firstly consists of identifying and classifying qualitative and quantitative physical and socio-economic factors as vulnerability variables. Each variable is assigned values ranging from 1 to 5 to illustrate its degree of vulnerability from very low, low, moderate, high and very high, respectively.

A semi-quantitative approach has been adopted using the Spatial Multi-Criteria Evaluation (SMCE) method, which assists and guides users in spatially doing multi-criteria evaluation. The theoretical background for the SMCE is based on the Analytical Hierarchical Process (AHP) developed by Saaty (Saaty & Vargas, 1991), which has been extensively applied to coastal vulnerability assessments.

A range of scores and settings for each factor is used to assess the extent to which that factor is favourable or unfavourable to the occurrence of coastal hazards (i.e. erosion and sea-level rise induced inundation). Criteria of standardisation and weighting methods for each of the variables were determined following the examples by Gornitz (1991) and Gornitz et al. (1994); Thieler & Hammar-Klose, (1999); Barbanti et al., (2011); Murali et al., (2013); and De Serio et al. (2018).

Following the selection of the ICVI variables, different physical and socio-economic data were acquired from various sources through literature reviews, consultations, internet downloads, household surveys, drone mapping and data extrapolations. The AHP followed for the ICVI is detailed in Section 7.2.3 with results and analysis presented in Section 7.3.

**Figure 7-1: Assessment Approach Adopted for the Study**




## 7.2.1 Data Collection

### 7.2.1.1 Secondary Data Collection

Secondary data acquisition provided background knowledge and understanding of the study areas and the coastal processes and entailed the collection and preparation of spatially and non-spatially referenced data for the study areas. Based on the approach described above, the study identified data requirements and information sources for the individual variables. Secondary data/information for the assessment was acquired through literature reviews and information requests as well as via web searches from online data repositories.

In some cases, older geospatial data such as building footprints were updated using standard digitising techniques from the most recent available satellite imagery and drone aerial photograph. All data were checked for topological fidelity (spatial relationship), spatial accuracy, and accuracy of tabular data (attributes) in ArcGIS Desktop 10.5.

### 7.2.1.2 Primary Data

Following the acquisition of secondary data, a data gap analysis was undertaken to develop a protocol for the collection of primary data required for the CVA. Primary data was acquired using field research methods such as observations, focus group discussions (FGDs), household surveys, and key informant interviews (KIIs).

#### 7.2.1.2.1 Household Surveys

The aim of the surveys was to acquire household-level information from the communities. Information acquired from the surveys includes household demographics, housing and infrastructure, livelihood and income, land ownership and use, health and education, vulnerability, climate change knowledge and perception, disaster risk management and environmental degradation (see Appendix VII for Survey

Questionnaire). The surveys involved selecting a representative and unbiased sample of households drawn from the six (6) communities. Households were selected randomly using a skip logic that ensures that they are evenly spread within the community. The surveys were conducted face to face using a questionnaire, with an adult household member (preferably the household head/spouse) who had knowledge of the local communities.

The enumerators were trained on the study subject matter, socio-economic research ethics (as applied to surveys) and the techniques involved in undertaking surveys using GIS-enabled mobile data collection applications. The surveys were coordinated and supervised by INTEGEMS consultants and provided insights into the characteristics of the communities and served to support some of the data collected through the desk review, KII and FGD. A total of 854 households were surveyed with the proportions per community presented in Table 7-1.

**Table 7-1: Household Survey Sample**

| Community | Number of Households | Sample Size | |
|---|---|---|---|
| | | No. of Surveys | Percentage (%) |
| Hamilton | 818 | 81 | 10 |
| Lakka | 1218 | 122 | 10 |
| Tombo | 4277 | 463 | 10 |
| Conakry-Dee | 933 | 103 | 11 |
| Shenge | 305 | 52 | 17 |
| Turtle Islands (Sei, Bumpetoke and Yele) | 300 | 33 | 11 |
| **Total** | **7851** | **854** | **11** |

#### 7.2.1.2.2 Key Informant Interviews (KIIs)

KIIs are qualitative in-depth interviews with people who are well-informed about the communities and/or have a mandate in environmental and coastal management, climate change and disaster risk management sectors. The KIIs were undertaken to collect information from a wide range of people who have first-hand knowledge about the community and the sectors under considerations. These informants, with their particular knowledge and understanding, provided insight into the nature of problems and recommendations for solutions that could enhance resilience within the study area. KIIs during the CVA included officials from GoSL MDAs, Professors from the University of Sierra Leone, NGOs, community headmen, harbour masters, youth leaders, women's leaders, town chiefs, etc.

#### 7.2.1.2.3 Focus Group Discussions (FGDs)

Focus Group Discussions (FGDs), which are generally a type of interactive group interview, was used to collect in-depth information on a particular theme or topic. Groups engaged for the FGD included fishermen, 'sand-miners', women (traders and fishmongers), local authorities (i.e. headmen, women's leaders, chiefs, religious leaders, tribal heads, youth leaders and elders). These groups were considered to have particular experience or knowledge about the communities, including the demographic and economic makeup as well as the community history and environmental changes. Summaries of FGDs, attendance registers and photographs are presented in Appendix III.

#### 7.2.1.2.4 Field Observations

The observations undertaken as part of the field studies were used to ground-truth secondary data retrieved from third parties and to primarily acquire additional data/information on the bio-physical, geological, geomorphological and oceanographic conditions as well as the socio-economic and cultural environment within the communities.

Reconnaissance transect walks were undertaken through the communities to observe the surroundings and its resources to note the sites and topography of the area and to understand inter-relationships in

their natural surroundings. The field observations were useful in the assessment stage to get an understanding of the issues and capacities that exist in a community.

#### 7.2.1.2.5 Drone Surveys and Photogrammetry

Aerial photography and photogrammetry were undertaken along the coast of the communities to ensure that the physical and socio-economic aspects of the vulnerability assessments are covered and that secondary data (satellite imagery, information from reports) collected are verified. The drone mapping activities included mapping out the coastline and some parts of the coastal communities, approximately 250 m from the shoreline, using high resolution unmanned aerial vehicle (drone). The coastal communities were mapped to also keep track of future changes. Pix4D Mapper, a photogrammetric software, was used to produce high-resolution Digital Terrain Models (DTM), Digital Surface Models (DSM) and orthomosaic. The outputs from the drone survey were used in ArcMap, a GIS tool, to assess the level of coastal vulnerabilities in the study area.

## 7.2.2 Selection of Parameters

### 7.2.2.1 Physical Vulnerability Parameters

Parameters for the PVI have been selected based on expert-judgement and previous applications of the CVI method by Gornitz (1991) and Gornitz et al. (1994); Thieler & Hammar-Klose, (1999); Barbanti et al., (2011); Murali et al., (2013); and De Serio et al. (2018) who applied the index-based method to evaluate the potential vulnerability of the US coastline at a national scale. The analysed physical parameters contributing to the PVI are presented in Table 7-2, together with the data sources and time period covered.

To ensure that the findings are reflective of the local context in which the study was undertaken, INTEGEMS has adapted the parameter selection to the specific target sites, taking into account their geographical and morphological peculiarities. The variables have been assembled using criteria such as suitability, availability of data, usefulness and ease of recollection. It is worthy to note that some of these parameters are dependent and exert reciprocal feedbacks. For example, if the shoreline rate change is negative, that is, the shore is eroding, it becomes wider and gentler. Consequently, the impact of waves is lower for the same given energy. It is difficult to quantitatively consider these interactions; thus, the adoption of the AHP approach is very useful. The reciprocal influence of the variables is estimated in the procedure, by means of proper matrices of comparison.

In the adopted technique, the targeted coastline has been segmented into strips of equal lengths (about 500 m). For each strip and for each considered physical parameter, a vulnerability ranking from 1 to 5 has been assigned, representing very low, low, moderate, high and very high vulnerability, respectively. The thresholds chosen for the classes are already used in previous classical studies previously highlighted.

**Table 7-2: Physical Vulnerability Parameters and Data Sources**

| Variable | Data Source |
|---|---|
| Geomorphology | Drone Imagery (2020), Landsat 8, Google Earth Imagery, ESRI Imagery, Field Observations |
| Elevation | Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM)[12] (Version 3, 2019) |
| Geology | Geological Map of Sierra Leone (National Minerals Agency, 2014); Field Observations (2020) |
| Slope | Derived from ASTER GDEM Version 3 |

[12]EarthData EOISDIS (Accessed via https://earthdata.nasa.gov/learn/articles/new-aster-gdem, 17 November 2020)

| Variable | Data Source |
|---|---|
| Tidal Range | Tide Tables 2019 – Europe And West Coast of Africa including the Mediterranean Sea from NOAA[13] |
| Mean Significant Wave Height | From a study undertaken by (Anthony, 1991) |
| Sea Level Rise | (IPCC, 2013; Tarawalli, 2012; Arup, et al., 2019) |
| Shoreline Change Rate | Derived from Landsat and Google Earth Imagery |

#### 7.2.2.1.1 Coastal Geomorphology

Coastal landforms/features deal with the coastal morphology due to marine processes and landscape evolution. They represent the response of the coast to both erosion and sea-level rise and offer a certain degree of resistance to erosion. For instance, rocky cliffs and wave-cut benches offer maximum resistance and therefore are much less vulnerable than sandy and muddy forms such as dunes and mudflats, offering the least resistance and so being extremely vulnerable to sea-level rise (Thieler & Hammar-Klose, 2000). Therefore, coastal geomorphology is one of the key factors considered in developing the ICVI for the study areas. Geomorphological characteristics express the relative erodibility of different landform types and require information on the spatial distribution and their stability (Gaki-Papanastassiou, et al., 2010).

The geomorphological features of the study area were defined using 30-m-resolution satellite imagery (2020) from Maxar and Landsat 8, combined with DEM and geological maps of Sierra Leone. The accuracy and reliability of the geomorphological profiles of the study areas were verified from field observations as well as through the use of a drone to capture high-resolution (2-3cm) aerial imagery and photographs along the coastline of the communities.

Generally, the geomorphology of Sierra Leone's coast shows variations alongshore that reflect locations of open estuary alternating with muddy intertidal, largely-mangrove-colonised plains sometimes comprising cheniers, with bedrock or soft-rock headlands. The development of this muddy coast reflects a primary geological heritage involving a wide shallow, low-gradient shelf favourable to the dissipation of waves and to tidal amplification. Because of the poor development of fluvial floodplains, much of the fluvial sediment load has been delivered directly to the coast. Remobilisation of this sediment in the near-shore zone by wind waves contributes to the formation of highly turbid suspensions that migrate alongshore under the influence of tidal and wind-induced currents (Anthony, 2006).

The geomorphological features have been considered to classify the vulnerability ranking for this physical parameter, as presented in Table 7-3. To a large extent, the study area is characterised by similar geomorphological features consisting of sand beaches; low to medium cliffs (3 -20m above mean sea level) of poorly consolidated clays, sands, and gravels; marshy swamps and mudflats associated with estuaries; and pocket beaches alternating with rocky headlands. Some parts of the coast present natural wave breakers such as rocks, and in other areas man-made breakers, such as concrete retaining walls, rip-raps and sandbags.

**Table 7-3: Vulnerability Ranking Assigned for Geomorphological Features**

| Parameter | Coastal Vulnerability Ranking | | | | |
|---|---|---|---|---|---|
| | Very Low (1) | Low (2) | Moderate (3) | High (4) | Very High (5) |
| Geomorphology | Natural breakers (high rocky cliffs, rocky headlands) | Man-made breakers - retaining walls, rip-raps, sandbags | Low cliffs of poorly consolidated clays, sands, and gravels<br>Mangrove swamps | Estuary, Lagoon, Alluvial Plains | Sand beaches, Mudflats, marshland |

[13]National Oceanic and Atmospheric Administrative (NOAA) (Accessed via: https://oceanservice.noaa.gov/news/nov18/tide-tables-2019.html, 30 October 2020)

| Parameter | Coastal Vulnerability Ranking | | | | |
|---|---|---|---|---|---|
| | Very Low (1) | Low (2) | Moderate (3) | High (4) | Very High (5) |
| | | Natural breakers (low rocky coastlines)<br>Medium Cliffs, Indented coasts | | | |

#### 7.2.2.1.2 Coastal Elevation

Coastal elevation is defined as the average height of a particular area above the mean sea level (amsl). Elevations play an important role in identifying and estimating the extent of land threatened by future climate change scenarios. Coastal area having low elevations are considered highly vulnerable, whereas those having higher elevations are considered less susceptible. This is mainly because areas at higher elevations provide more resistance to inundation due to rising sea levels and storm surges. Coastal elevation data for this study has been derived from a 30-m resolution ASTER GDEM.

The ASTER GDEM is being distributed by METI and NASA through the Earth Remote Sensing Data Analysis Center (ERSDAC), and the NASA Land Processes Distributed Active Archive Center (LP DAAC) at no charge to users worldwide as a contribution to the Global Earth Observing System of Systems (GEOSS). It is packaged in 1°-by-1° tiles and covers land surfaces between 83°N and 83°S with estimated accuracies of 20 meters at 95 % confidence for vertical data and 30 meters at 95 % confidence for horizontal data[14].

The aim of using DEM in this analysis is to evaluate and separate the low-lying areas from other higher areas along the coasts. Coastal elevation profiles have also been created using ESRI ArcGIS Earth for multiple cross-sections of the communities. The elevations of the study areas are relatively low, ranging from 0 – 250m amsl. Five coastal elevation vulnerability classes have been established for the study as recommended by (Gornitz, et al., 1994). The coastline along the six communities cover all the five vulnerability classes of coastal elevation. However, the majority of the coast comes under the moderate to very high vulnerability zones.

**Table 7-4: Vulnerability Ranking Assigned for Coastal Elevation Ranges**

| Parameter | Coastal Vulnerability Ranking | | | | |
|---|---|---|---|---|---|
| | Very Low (1) | Low (2) | Moderate (3) | High (4) | Very High (5) |
| Coastal Elevation, m | ≥ 30.0 | 20.1 – 30.0 | 10.1 – 20.0 | 5.1 – 10.0 | 0 – 5.0 |

#### 7.2.2.1.3 Tidal Range

Tidal range is defined as the vertical difference (in meters) between the high tide and the consecutive low tide. Tides are the rise and fall of sea levels caused by the combined effects of the gravitational forces exerted by the moon and the sun and the rotation of the Earth. The tidal range could trigger both permanent and episodic inundation hazards (Murali, et al., 2013). Gornitz (1991) suggests that high tidal range is associated with stronger tidal currents, which have the capacity to cause erosion and transport of sediment. Therefore, macro-tidal coasts (≥ 6.1 m) are highly vulnerable, while coastal areas characterised by low tidal ranges (<2.0 m) are designated to be of low vulnerability (Barbanti, et al., 2011; Gornitz, 1991).

For this study, data on mean tidal ranges along the Sierra Leonean coastline have been acquired from US National Oceanic and Atmospheric Administrative (NOAA) Tide Tables for Europe and West Coast of Africa including the Mediterranean Sea (see Table 7-5) for tide gauges located at Shenge Point (for Shenge), York Island (for Turtle Islands), Freetown (for Lakka, Hamilton and Tombo) and Pepel (for Conakry-Dee). Five classes of vulnerability ranking have been defined, as shown in Table 7-6.

[14] US Geological Surveys (Accessed via: https://lpdaac.usgs.gov/news/meti-and-nasa-release-version-2-aster-global-dem/, 18 November 2020)

With the exception of Tombo, all the coastal communities' mean tidal ranges fall into the moderate vulnerability category (see Table 7-6).

**Table 7-5: Tidal Ranges (NOAA, 2019)**

| Location | Study Area | Position | | Tidal Ranges | | | | Mean Tidal Level | |
|---|---|---|---|---|---|---|---|---|---|
| | | Lat. | Long. | Mean | | Spring | | | |
| | | N | W | ft | m | ft | m | ft | m |
| Shenge Point, Sherbro River | Shenge | 7° 55' | 12° 58' | 7.1 | 2.16 | 9.2 | 2.80 | 5.2 | 1.59 |
| Buoy Point, Sherbro River | Turtle Islands | 7° 42' | 12° 42' | 6.8 | 2.07 | 8.8 | 2.68 | 5.3 | 1.62 |
| Banana Islands | Tombo | 8° 08' | 13° 11' | 6.0 | 1.83 | 8.0 | 2.44 | 5.6 | 1.71 |
| Freetown | Lakka & Hamilton | 8° 30' | 13° 14' | 6.8 | 2.07 | 8.8 | 2.68 | 5.6 | 1.71 |
| Maroon River | Conakry-Dee | 8° 25' | 13° 07' | 7.1 | 2.16 | 9.2 | 2.80 | 6.1 | 1.86 |

**Table 7-6: Vulnerability Ranking Assigned for Tidal Ranges**

| Parameter | Coastal Vulnerability Ranking | | | | |
|---|---|---|---|---|---|
| | Very Low (1) | Low (2) | Moderate (3) | High (4) | Very High (5) |
| Tidal Range, m | ≤ 0.99 Microtidal | 1.0 – 1.9 Microtidal | 2.0 – 4.0 Mesotidal | 4.1 – 6.0 Mesotidal | ≥ 6.1 Macrotidal |

#### 7.2.2.1.4 Mean Significant Wave Height

The mean significant wave height (MSWH) is a pivotal parameter in many aspects of coastal evolution, especially considering that wave energy is directly related to the wave height, as $E = 1/8\ \rho g H^2$, where $E$ the energy density, $H$ the wave height, $\rho$ the water density and $g$ the gravity acceleration (De-Serio, et al., 2018). Increasing wave energy results in an increased intensity of coastal processes (more often erosion than accretion), wave set-up and inundation along the coast, finally causing loss of land. Coastlines experiencing high wave heights are thus considered more vulnerable than those exposed to low wave heights (Thieler & Hammar-Klose, 2000; Pendleton, et al., 2005), assuming that higher waves breaking has a stronger impact on the beach and mobilises and transports coastal sediments. Furthermore, the wave action may endanger the cultural heritage and the infrastructures in low-lying areas (Valdmann, et al., 2008).

The variations in marine processes along the coast are hinged on the relative contributions of wave energy and tidal currents. Sierra Leone's wave climate consists of two components – North of Sherbro Island, the coast is exposed year-round to a mixture of long-period swells (T = 7-16 s) and seas (T < 5 s) from the north-west (Anthony, 1991). Wave energy is low to moderate with deep-water heights less than 1.2 m occurring 72 % of the time. Between June and October, moderate to high energy (1.5-4 m) waves from the south are superimposed on the north-westerly waves and may even become dominant for short periods of time (Anthony, 1991).

Throughout the year, the coast south of the Freetown Peninsula is exposed to low to moderate energy (H = 0.5-1.5 m), long-period (T = 8-16 s) swells from the southwest. Swell energy increases from June to October (Anthony, 1991). In spite of the fairly identical nature of the deep-water wave regime, characterised essentially by low to moderate energy swell, near-shore wave energy levels vary spatially as a function of near-shelf geometry. This variation illustrates the important control exerted by inner shelf characteristics, including antecedent geomorphology, on wave parameters.

MSWH data used in this study come from previous work by Anthony (1991). Five vulnerability categories based on MSWH have been established (see Table 7-8). The study area falls within low to moderate vulnerability categories based on significant wave heights.

**Table 7-7: Significant Wave Heights along the Sierra Leonean Coast (Anthony, 1991)**

| Location/Section | Corresponding Study Area | Significant Wave Heights, m |
|---|---|---|
| Sallatouk Point | - | <0.25 |
| Bullom Peninsula | Conakry-Dee | 0.25-0.5 |
| Freetown Peninsula | Lakka, Hamilton Tombo | 0.5-1 |
| Yawri Bay | - | <0.25 |
| Shenge Peninsula | Shenge | 0.25-0.5 |
| Shebro Bay | - | <0.25 |
| St Ann's Peninsula | Turtle Islands | 0.5-1 |
| Turner's Peninsula | - | 0.5-1 |

**Table 7-8: Vulnerability Ranking Assigned for Significant Wave Height**

| Parameter | Coastal Vulnerability Ranking | | | | |
|---|---|---|---|---|---|
| | Very Low (1) | Low (2) | Moderate (3) | High (4) | Very High (5) |
| Significant Wave Height, m | < 0.25 | 0.25-0.5 | 0.5-1.0 | 1.0-1.25 | > 1.25 |

#### 7.2.2.1.5 Sea Level Rise

Sea Level Rise (SLR) is one of the most important consequences of climate change. Mean sea level is usually described as a tidal datum that is the arithmetic mean of hourly water elevations observed over a specific 19-yr cycle. "Global sea-level rise" refers to the increase currently observed in the average global sea level trend, which is primarily attributed to changes in ocean volume due to two factors: ice melt and thermal expansion (Murali, et al., 2013).

Over the past century, the mean global sea level has risen approximately 1.7 mm per year accelerating to a rate of 3.2 mm per year since 1993 (IPCC, 2013). From the IPCC data, a global rise in the sea level is expected, ranging from a minimum of 53 cm to a maximum of 97 cm within 2100 (IPCC, 2014). The variation in sea level is based on global and local environmental and physical factors, with a strong temporal variation. Its effects, depending on the coastal site morphology, lithological composition, hydrodynamic regime and extension of anthropogenic pressure can be mainly: accelerated erosion at sedimentary coasts; intrusion of saline water into groundwater, thus impacting ecosystems; and changes in tides, affecting coastal flooding.

Using the RCP8.5[15], SLR to 2050 in Freetown is estimated to be +0.26 m, a value slightly higher than the global mean sea-level rise of +0.25 m calculated using RCP8.5. This means that for a calm sea state at the highest astronomical tide, including an allowance for SLR to 2050, the sea level would be approximately 2 m above the current global mean sea level. This projection does not include an allowance for storm surge or wave run-up, which could increase the level (although this allowance would usually be added to the mean high-water spring level, rather than the highest astronomical tide). For this reason, and considering that the use of global elevation models typically underestimates the effects of sea-level rise, particularly in urban settings, the 2050 scenario sea-level is estimated to be 3 – 4 m above the current global mean sea level (Arup, et al., 2019). This estimate includes an allowance for SLR, highest astronomical tidal conditions and a nominal allowance for wave-action[16]. A conservative

[15] The high-emissions 'RCP8.5' global warming scenario https://www.carbonbrief.org/explainer-the-high-emissions-rcp8-5-global-warming-scenario

[16] Based on a high-level review of the tail ends of historical hurricane tracks off the coast of West Africa, we can conservatively assume a storm surge that relates to a category 1 on the Saffir-Simpson Hurricane Intensity Scale. Using this scale, this relates to a storm surge of 1.0m – 1.7m.

range of 1–2 m can therefore be assumed for potential storm surge as a high-level estimate (Arup, et al., 2019). Diagnostics Analysis of Climate Change and Disaster Management in Sierra Leone projects sea level increase due to climate change between 0.2–0.5 m by the year 2100 and could change to 1–2 m under the same emission scenario (Tarawalli, 2012).

The potential for sea-level inundation events is assessed in the above SLR scenarios by comparing the elevation of low-lying areas around the coastline with the potential effects of an increase in sea level. It is assumed that the SLR within coastal communities outside the Freetown Peninsula will be similar to the above estimates by Arup (2019). SLR has, therefore, been eliminated from the PVI variables since its influence in the study areas is uniform. Notwithstanding, analysis has been undertaken using different SLR scenarios (+ 1 m, +2 m, +3 m, +4 m & +5 m) using a 30-m resolution DEM to estimate the potential areas at risk of inundation.

**Table 7-9: Present-day Water Levels around the Western Area Peninsula**

| Level Elevation relative to Chart Datum | Metres asl |
|---|---|
| HAT (Highest Astronomical Tide) | +3.50 |
| MHWS (Mean High Water Springs) | +3.00 |
| MHWN (Mean High Water Neaps) | +2.30 |
| MSL (Mean Sea Level) | +1.77 |
| MLWN (Mean Low Water Neaps) | +1.00 |
| MLWS (Mean Low Water Springs) | +0.40 |
| LAT (Lowest Astronomical Tide) | +0.00 |

#### 7.2.2.1.6 Geology

Geology allows for the evaluation of the rocks and sediments that form the coastal regions, as well as its classification based on the behaviour of those materials when subjected to coastal forcing. For example, plutonic, volcanic and high-grade metamorphic rocks are of high hardness and therefore of low vulnerability to erosion, unlike small non-consolidated sediments.

Sierra Leone forms the central part of the West African Craton (Archean craton) whose counterpart forms the Guyana Shield of northern America (Morel, 1979). The eastern cratonic fragment extends from Western Sahara and Anti-Atlas Mountains eastward to the Hoggar and southward to Mauritania, Senegal, Guinea, Sierra Leone, Liberia, Cote D'Ivoire, and Ghana. The western portion of the craton forms the Guyana Shield, which extends from north-western South America. The geology is divided into two major tectonostratigraphic units. The eastern unit is part of the stable Precambrian West African and consists of high-grade metamorphic rocks and granitic gneisses. The western unit contains elements of an orogenic belt named the *'Rokelides'* or *'Rokel River Group'* that was deformed during the Pan-African tectonothermal event, about 550 million years ago. A minor, 20-40 km wide coastal strip is made up of Pleistocene to recent marine sediments.

Most of Sierra Leone is underlain by a series of ancient, folded, crystalline rocks of varying lithology, of Precambrian age (Fileccia, 2017). These rocks are over 2.1 billion years old and are overlain unconformably by the Rokel River and Saionya Scarp Groups of late Precambrian to late Ordovician age, and the much younger Bullom Group sediments of Tertiary to Recent age. Prior to the deposition of the Bullom group, a period of intensive igneous activity in the Mesozoic period which gave rise to the Freetown gabbroic complex and associated minor sills and dykes. The youngest lithostratigraphic group is the Bullom Group which comprises onshore Cenozoic sediments deposited along the coastal margin

The coastal area of Sierra Leone comprises two rock groups which are the Bullom Group and Freetown Igneous Complex. The Bullom Group sediments occupy the low-lying coastal plain of Sierra Leone with a deposit that stretches approximately 50 km inland with an elevation of about 40 m above sea level. The Bullom Group consists of a laterally variable sequence of poorly consolidated, near horizontal, often iron-stained gravels, sands and clays with occasional intraformational laterites and lenticular

seams of lignite. The Bullom Group also has a coastal cliff that is about 20-25 m high and 5-10 m exposure at the base, overlain by a deep laterite weathering profile (Warnsloh, 2011).

The Freetown Igneous Complex (FIC) is a moderately well-exposed mafic layered igneous complex that consists of a 6 km thick series of cumulate rocks of Gabbroic composition, containing layers of Dunite, Troctolite, Olivine-gabbro, Gabbro, Leucogabbro and Anorthosite. The mineral composition is Olivine, Plagioclase, Orthopyroxene, etc., that were formed under high temperature and pressure during the Triassic period (i.e. 202 million years). These rock formations intruded into the gneisses of the Kasila Group and overlain by sediments of the Bullom Group whose lower beds are of Eocene age (56 – 34 million years) (Warnsloh, 2011).

Part of the FIC along the Western Area coastline has gone through geological processes (weathering, transportation and deposition) and coastal ecosystem services and activities to form sedimentary rocks and loosely consolidated sediments (Sandstone etc.). Areas along the coastline with sedimentary rocks are less vulnerable to coastal hazards (for example coastal erosion) than areas with unconsolidated sediments.

Erosional susceptibility (not erosion rates) is classified in the PVI context by rankings (1-5), assigned according to the rock hardness. Therefore, unconsolidated sediments (class 5), such as beaches and dunes, are more susceptible to erosion than hard rocks (class 1) or even sandstones and consolidated sediments (class 3) based on Gornitz et al. (1994).

**Table 7-10: Vulnerability Ranking Assigned for Geology Features**

| Parameter | Coastal Vulnerability Ranking | | | | |
|---|---|---|---|---|---|
| | Very Low (1) | Low (2) | Moderate (3) | High (4) | Very High (5) |
| Geological Features | Plutonic<br>Volcanic<br>High-medium grade metamorphics | Low-grade metamorphics<br>Sandstones and Conglomerates | Most sedimentary rocks | Coarse, poorly sorted unconsolidated sediments | Fine unconsolidated sediments |

#### 7.2.2.1.7 Coastal Slope

Coastal slope is obtained as the ratio of the altitude change to the horizontal distance between any two points on the coast perpendicular to the shoreline. Coastal slope is an indicator of not only the relative risk of inundation but also the potential speed of shoreline retreat. Coastal areas with gentle land slope are considered highly vulnerable, since they allow abundant penetration of seawater, whereas location with steeper slopes is assumed as areas of low vulnerability, providing greater resistance to inundation due to rising sea levels and storm surges. Coastal Slope rankings are based on Thierler & Hammar – Klose (2000) Rankings.

**Table 7-11: Vulnerability Ranking Assigned for Coastal Slope**

| Parameter | Coastal Vulnerability Ranking | | | | |
|---|---|---|---|---|---|
| | Very Low (1) | Low (2) | Moderate (3) | High (4) | Very High (5) |
| Coastal Slope, ° | >11.5 | 11.5 - 5.5 | 5.5 – 3.5 | 3.5 – 2.2 | <2.2 |

#### 7.2.2.1.8 Shoreline Change Rate

Shoreline changes are the result of coastal processes which mainly depend on wave characteristics, near-shore circulation, littoral transport and beach forms. Accreting coastlines are considered less vulnerable because they benefit from the accumulation of land areas. Eroded coastlines are considered highly vulnerable due to the loss of natural and man-made resources. The historical shoreline positions have been detected from geo-referenced Drone Imagery orthophotos and satellite imagery (Table 7-2). Specifically, shoreline data referring to the years 2006, 2010, 2015, and 2020 have been digitised and superimposed for comparison. The shoreline rate of change has been computed using the ArcGIS Generate Rubbersheet Links to calculate the distance between the baseline shoreline 2006 and the current shoreline 2020. Distances were then used to calculate the rate of shoreline change. The vulnerability ranking leverages Gornitz et al. (1994) ranking for mean shoreline displacement.

**Table 7-12: Vulnerability Ranking Assigned for Mean Shoreline Change**

| Parameter | Coastal Vulnerability Ranking | | | | |
|---|---|---|---|---|---|
| | Very Low (1) | Low (2) | Moderate (3) | High (4) | Very High (5) |
| Mean Shoreline Change, m/year | >2.0 | 1.1 to 2.0 | -1.0 to 1.0 | -1.1 to -2.0 | <-2.0 |

### 7.2.2.2 Socio-economic Vulnerability Parameters

The socio-economic vulnerability assessment has been undertaken as a composite socio-economic vulnerability index (SVI) constructed as a function of exposure, sensitivity, and adaptative capacity. While the PVI is intended to assess the likelihood of climate change-induced hazards (particularly erosion and flood/sea-level rise induced inundation) affecting the communities and the level of exposure of the coastal zone, the SVI assesses the level of exposure, sensitivity and adaptive capacity of the coastal communities. The study has assessed socio-economic vulnerability in the communities using their site-specific peculiarities and social dimensions, including demographics, social, economic, and infrastructural components. Eight parameters have been utilised to compute the SVI for the coastal zones in the study area. These include population density, the proximity of major roads to the coastline, land use, building footprints, type of building materials, access to electricity, access to health and education facilities and access to a telecommunications network (see Table 7-13).

**Table 7-13: Social Vulnerability Parameters and Data Sources**

| Sub-component | Variable | Data Source |
|---|---|---|
| Exposure | Population density | Statistics Sierra Leone (Stats-SL) |
| | Proximity of Major Roads to the coastline | OpenStreetMap (OSM) |
| | Building Numbers/Footprints | OpenStreetMap (OSM), Satellite Imagery (Google Earth Pro, ESRI) |
| Adaptive Capacity | Type of Building Materials | OpenStreetMap (OSM), Satellite Imagery (Google Earth Pro, ESRI), Household Surveys |
| | Access to health and education facilities | Ministry of Basic and Secondary Education<br>Ministry of Health and Sanitation; |
| | Access to Electricity | Field observations and stakeholder consultations |
| | Access to a telecommunications Network | Field observations and stakeholder consultations |
| Sensitivity | Land use/land cover | Drone Imagery, Satellite Imagery (Google Earth Pro, USGS, ESRI), Field Observations, Stakeholder consultations |

#### 7.2.2.2.1 Population Density

Population data is essential in order to understand the effect and the dimension of coastal hazards. Human beings' vulnerability is considered a social condition, or a measure of the resilience of society to a disaster. By using census data, household surveys, and the mapping capabilities of GIS, the level of the communities' population vulnerability has been assessed. The 2015 Sierra Leone Population and Housing Census data has been utilised to estimate the population and population densities of the communities at the enumeration area level. A five-scale population density vulnerability rating has been developed, as presented in Table 7-15.

**Table 7-14: Population Statistics (Stats-SL, 2015)**

| Communities | Number of Households | Population | | | Approximate Area, sq. km | Population Density, persons/sq. km |
|---|---|---|---|---|---|---|
| | | Male | Female | Total | | |
| Lakka | 1,112 | 5,059 | 4,875 | 9,934 | 18 | 559 |
| Hamilton | 818 | 4,812 | 4,182 | 8,994 | 40 | 223 |
| Tombo | 4,277 | 15,258 | 15,568 | 30,826 | 15 | 2,041 |
| Shenge | 305 | 1,050 | 1,103 | 2,153 | 20 | 106 |
| Conakry-Dee | 933 | 3,839 | 4,127 | 7,966 | 10 | 839 |
| Turtle Island | 507 | 1,473 | 1,283 | 2,756 | 14 | 193 |

**Table 7-15: Vulnerability Ranking Assigned for Population Density**

| Parameter | Coastal Vulnerability Ranking | | | | |
|---|---|---|---|---|---|
| | Very Low (1) | Low (2) | Moderate (3) | High (4) | Very High (5) |
| Population Density, persons/sq. km | ≤ 100 | 100-500 | 500-2,000 | 2,000-10,000 | > 10,000 |

#### 7.2.2.2.2 Proximity of Major Roads to Coastline

Road networks are essential during a disaster, especially with reference to providing relief and emergency services. A disruption in road networks due to a disaster can lead to a cut-off and increase the impact of the disaster as a result of scarcity of resources. Therefore, the assessment of road exposure has been undertaken by classifying major roads within the community based on the proximity of a particular section of the road to the shoreline. The road network data was created in the GIS environment using OSM road networks data and complemented by digitising unmapped roads using ArcMap. The five vulnerability classes based on road exposure are presented in Table 7-16.

**Table 7-16: Vulnerability Ranking Assigned for Major Road Distance from Coastline**

| Parameter | Coastal Vulnerability Ranking | | | | |
|---|---|---|---|---|---|
| | Very Low (1) | Low (2) | Moderate (3) | High (4) | Very High (5) |
| Major Road distance from Coastline, m | > 800 | 601-800 | 401-600 | 201-400 | < 200 |

#### 7.2.2.2.3 Land Use/Land Cover

Land use refers to purposes served by land (i.e., recreation, tourism, agriculture, residence) whereas Land cover refers to surface cover on the ground (i.e., vegetation, urban infrastructure, water, bare soil or other). A land use/land cover (LU/LC) map is essential to understanding the land use/land cover classes in a particular region. LU/LC of a community is attributed to the anthropogenic activities in addition to the climate changes (Murali, et al., 2006). The LU/LC categories within a community give an indication of the livelihood practices and ecosystems services from an area as well an understanding of the social, economic and cultural value attached to the area. Therefore, the type of LU/LC within the community has been used as an indicator of the sensitivity of the area and as such, the level of vulnerability of an area.

Data for land use/land cover was acquired by digitising LU/LC type from Google Earth Imagery, drone orthomosaic and OSM in ArcMap. LU/LC types for this study are broadly classified into settlement, industrial (i.e., wharf, fish landing and processing point, boat making yard), institutions (health facilities, schools), recreational (beach, resorts), cultural sites (cemetery, shrines, society bushes), farmland,

vegetation cover, barren area (bare ground, bare rock), march, and water body. From these categories, five vulnerability classes have been identified, as shown in Table 7-17 below.

**Table 7-17: Vulnerability Ranking Assigned for Land use/land cover**

| Parameter | Coastal Vulnerability Ranking | | | | |
|---|---|---|---|---|---|
| | Very Low (1) | Low (2) | Moderate (3) | High (4) | Very High (5) |
| Land Use/ Land Cover | Bare Ground, Marsh, waterbody, Bare Rock | Vegetation Cover | Beach | Farm Land | Settlement, School, Hospital, Warf, Cultural Sites, Resort, Fish Landing Point |

#### 7.2.2.2.4 Building Footprint

Housing is a key sector, which may be affected by coastal hazards. Building infrastructure within the communities is a critical resource for the socio-economic wellbeing of the residents. Therefore, the number of buildings exposed to coastal hazards within a community is crucial in understanding its vulnerability. The housing characteristics data captured during the 2015 Population and Housing Census presents the number of households in each of the districts living in buildings of different wall, floor, and roof material without specifically geotagging the buildings at the community level.

Therefore, to assess the community vulnerability based on the number of buildings exposed, building footprints data was sourced from OSM and complemented by digitisation from satellite and drone imagery. A total of about 6,171 buildings were mapped in the study area to extract the number of buildings exposed to multiple coastal hazards. Five categories of building exposure have been determined based on the number of buildings within the communities (see Table 7-19).

**Table 7-18: Numbers of Buildings in the Study Area**

| Communities | Buildings |
|---|---|
| Lakka | 1,282 |
| Hamilton | 1,141 |
| Tombo | 2,245 |
| Shenge | 127 |
| Conakry-Dee | 838 |
| Turtle Island | 538 |
| **Total** | **6,171** |

**Table 7-19: Vulnerability Ranking Assigned for Number of Buildings**

| Parameter | Coastal Vulnerability Ranking | | | | |
|---|---|---|---|---|---|
| | Very Low (1) | Low (2) | Moderate (3) | High (4) | Very High (5) |
| Number of Buildings | <500 | 500-1,500 | 1,501-2,000 | 2,001-2,500 | >2,500 |

#### 7.2.2.2.5 Building Construction Material Type

The built environment plays an important role in every community, and recent disasters have highlighted the vulnerability of the built assets to natural disasters. Therefore, it is very important that buildings are designed with sufficient consideration of coastal risks and constructed to be disaster-resistant. In general, the type of construction material is important in determining the resilience of a building and a community to the potential impacts of climate change-induced hazards.

Therefore, to assess the adaptive capacity of the communities, the vulnerability assessment has taken into consideration the type of construction materials of the buildings within the areas of interest. The buildings in the study area vary significantly depending on whether the area is urban or rural. Most of the houses' walls in the rural communities (Shenge and Turtles Islands) are made of weak and non-resistant materials such as sundried mud brick, and wattle and mud. With the exception of the Turtle Islands, the roofing material for buildings in the communities is predominantly made from zinc sheets.

Three vulnerability categories have been determined based on the construction materials of the wall, floor and roof. The categories are based on existing information and correspond with very low, moderate, and very high (see Table 7-23).

**Table 7-20: Building Construction Material – Wall Material**

| Material | Hamilton | | Conakry Dee | | Lakka | | Shenge | | Tombo | | Turtle Islands | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Freq | % | Freq | % | Freq | % | Freq | % | Freq | % | Freq | % |
| Cement Brick | 50 | 61.7 | 5 | 4.9 | 76 | 62.3 | 8 | 15.4 | 277 | 59.8 | 0 | 0.0 |
| Mud Brick | 0 | 0.0 | 62 | 60.2 | 11 | 9.0 | 30 | 57.7 | 133 | 28.7 | 5 | 15.2 |
| Mud and Wattle | 0 | 0.0 | 35 | 34.0 | 1 | 0.8 | 14 | 26.9 | 14 | 3.0 | 28 | 84.8 |
| Stone | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 3 | 0.6 | 0 | 0.0 |
| Tarpaulin/ Plastic | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 9 | 1.9 | 0 | 0.0 |
| Thatch | 1 | 1.2 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 0.2 | 0 | 0.0 |
| Timber | 1 | 1.2 | 1 | 1.0 | 1 | 0.8 | 0 | 0.0 | 19 | 4.1 | 0 | 0.0 |
| Zinc | 28 | 34.6 | 0 | 0.0 | 33 | 27.0 | 0 | 0.0 | 6 | 1.3 | 0 | 0.0 |
| Other | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |

**Table 7-21: Building Construction Material – Floor Material**

| Material | Hamilton | | Conakry-Dee | | Lakka | | Shenge | | Tombo | | Turtle Islands | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Freq | % | Freq | % | Freq | % | Freq | % | Freq | % | Freq | % |
| Concrete | 47 | 58.0 | 48 | 46.6 | 76 | 62.3 | 31 | 59.6 | 371 | 80.1 | 6 | 18.2 |
| Mud | 6 | 7.4 | 43 | 41.7 | 5 | 4.1 | 19 | 36.5 | 33 | 7.1 | 23 | 69.7 |
| Stone | 0 | 0.0 | 9 | 8.7 | 1 | 0.8 | 0 | 0.0 | 23 | 5.0 | 0 | 0.0 |
| Tile | 27 | 33.3 | 0 | 0.0 | 39 | 32.0 | 2 | 3.8 | 36 | 7.8 | 0 | 0.0 |
| Other | 1 | 1.2 | 3 | 2.9 | 1 | 0.8 | 0 | 0.0 | | 0.0 | 4 | 12.1 |

**Table 7-22: Building Construction Material – Roof Material**

| Material | Hamilton | | Conakry Dee | | Lakka | | Shenge | | Tombo | | Turtle Islands | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Freq | % | Freq | % | Freq | % | Freq | % | Freq | % | Freq | % |
| Concrete | 1 | 1.2 | 0 | 0.0 | 1 | 0.8 | 0 | 0.0 | 3 | 0.6 | 0 | 0.0 |
| Tarpaulin/ Plastic | 0 | 0.0 | 17 | 16.5 | 1 | 0.8 | 0 | 0.0 | 42 | 9.1 | 0 | 0.0 |
| Thatch | 0 | 0.0 | 1 | 1.0 | 1 | 0.8 | 8 | 15.4 | 7 | 1.5 | 20 | 60.6 |

| Material | Hamilton | | Conakry Dee | | Lakka | | Shenge | | Tombo | | Turtle Islands | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Freq | % | Freq | % | Freq | % | Freq | % | Freq | % | Freq | % |
| Zinc | 79 | 97.5 | 85 | 82.5 | 119 | 97.5 | 44 | 84.6 | 410 | 88.6 | 13 | 39.4 |
| Other | 1 | 1.2 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 0.2 | 0 | 0.0 |

**Table 7-23: Vulnerability Ranking Assigned for Building Construction Materials**

| Parameter | Coastal Vulnerability Ranking | | | | |
|---|---|---|---|---|---|
| | Very Low (1) | Low (2) | Moderate (3) | High (4) | Very High (5) |
| Building Construction Materials | Cement block > 80 %<br>Concrete & Tile Floor > 80 %<br>Zinc Roof > 80 % | - | Mudbrick 30-60%<br>Zinc Roof ≥ 30% | - | Mud and Wattle wall > 80%<br>Thatch Roof > 80 % |

#### 7.2.2.2.6 Access to Electricity

Access to electricity is at the heart of development and the lifeblood of all modern societies. Poor access to electricity is a fundamental barrier to progress and has impacts on a wide range of development indicators, including health, education, food security, gender equality, livelihoods, and poverty reduction (World Bank, 2018). Furthermore, Energy plays a crucial role in all stages of the disaster risk management cycle, as all societal service systems rely on the energy sector for everyday activities, as well as for emergency response and recovery (e.g., telecommunications, health, and infrastructure) (Kinna & Abbotta, 2014).

Communities with good access to electricity are considered to have higher adaptive capacities and less vulnerable to hazards than those with little or no access. Therefore, as critical infrastructure, the communities' vulnerability has been assessed based on the level of access its residents have to electricity using the five categories presented in Table 7-24.

**Table 7-24: Vulnerability Ranking Assigned for Access to Electricity**

| Parameter | Coastal Vulnerability Ranking | | | | |
|---|---|---|---|---|---|
| | Very Low (1) | Low (2) | Moderate (3) | High (4) | Very High (5) |
| Access to Electricity | Access to national grid | Access to communal grid | Access to private power generation | - | No Access |

#### 7.2.2.2.7 Access to Telecommunications Network

The world is interconnected and fast-changing, largely due to the rapid development of information and communication technologies (ICT). ICT represents our "collective nerve system", impacting and connecting every fabric of our lives through intelligent, adaptive and innovative solutions. Particularly, a telecommunications network is a tool that can help solve some of our economic, social and environmental challenges, and promote more inclusive and sustainable development.

The Sendai Framework for Disaster Risk Reduction (2015 – 2030) recognises, as one of its targets, the need to substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people. Reliable telecommunications infrastructure provides more efficient, transparent and reliable means and platforms for communication and cooperation for disaster risk management as well as serves as a bridge that connects people from different localities and sectors. As such, access to information and knowledge through a robust telecommunications infrastructure has the potential to significantly improve the livelihoods of the poor

and marginalised, promote gender equality and disaster resilience (Asian Disaster Preparedness Center, 2012). Furthermore, the lack of or failure of telecommunications infrastructure leads to preventable loss of life and damage to property, by causing delays and errors in emergency response and disaster relief efforts (Townsend & Moss, 2005).

Therefore, the vulnerability of the six coastal communities has been assessed based on access to Global System for Mobile Communications (GSM) and internet connectivity. Communities with good access to a combination of the two components are considered to have a higher adaptive capacity (i.e. very low vulnerability) and vice versa. As such, four vulnerability categories have been determined, as presented in Table 7-25.

**Table 7-25: Vulnerability Ranking Assigned for Access to Telecommunications Network**

| Parameter | Coastal Vulnerability Ranking | | | | |
|---|---|---|---|---|---|
| | Very Low (1) | Low (2) | Moderate (3) | High (4) | Very High (5) |
| Access to Telecommunications Network | Access 2G (call) and 4G/LTE (internet) | Access 2G (call) and 3G (internet) | Access to 2G only | - | Inaccessible |

#### 7.2.2.2.8 Access to Schools and Health Facilities

Health and education facilities are considered as critical infrastructures and are generally understood to be vital to the basic operations of a society. Knowledge production and implementation processes are critical for disaster risk reduction. Schools can serve as pioneers for disaster education, which aims to provide knowledge among individuals and groups to take actions to reduce their vulnerability to disasters. Furthermore, school buildings may not only provide children with protection and access to education, but they may also serve as a social safety net for communities and can provide shelter to displaced people during disaster response.

Preserving life and health is both the objective and the measure of success in disaster reduction. In an emergency, health sector professionals will always be called upon to collaborate in response operations and recovery actions.

Therefore, access to schools and health facilities is crucial in building community resilience and improving preparedness. Communities with access to improved healthcare services and adequate schools are less vulnerable to the impacts of disasters compared to those without. Five vulnerability rankings have been assigned based on access to schools and health facilities, as presented in Table 7-27.

**Table 7-26: Number of Schools and Health Facilities in the Study Area**

| Communities | Pre/Primary Schools | Secondary School | | Health Facility |
|---|---|---|---|---|
| | | Junior | Senior | |
| Lakka | 5 | 3 | 3 | 3 |
| Hamilton | 7 | 2 | 1 | 1 |
| Tombo | 30 | 4 | 1 | 4 |
| Shenge | 2 | 1 | 1 | 1 |
| Conakry-Dee | 2 | 1 | 1 | 1 |
| Turtle Island | 4 | 0 | 0 | 0 |

**Table 7-27: Vulnerability Ranking Assigned for Access to Schools and Health Facilities**

| Parameter | Coastal Vulnerability Ranking | | | | |
|---|---|---|---|---|---|
| | Very Low (1) | Low (2) | Moderate (3) | High (4) | Very High (5) |
| Access to Schools and Health Facilities | At least one health facility<br>Two Primary Schools<br>Two Junior and two Senior Secondary Schools | At least one health facility<br>Two Primary Schools<br>Two Junior & one Secondary School | At least<br>One Primary School<br>One Junior Secondary School | Just<br>One Primary School | No access |

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**Table 7-28: Summary of Vulnerability Ranking Assigned to Parameters**

| Variable | | Coastal Vulnerability Ranking | | | | |
|---|---|---|---|---|---|---|
| | | Very Low (1) | Low (2) | Moderate (3) | High (4) | Very High (5) |
| Physical | Geomorphology | Natural breakers (high rocky cliffs, rocky headlands) | Man-made breakers - retaining walls, rip-raps, sandbags<br>Natural breakers (low rocky coastlines)<br>Medium Cliffs, Indented coasts | Low cliffs of poorly consolidated clays, sands, and gravels<br>Mangrove | Estuary, Lagoon, Alluvial Plains | Sand beaches, Mudflats, marshy swamps |
| | Coastal elevation, m | ≥ 30.0 | 20.1 – 30.0 | 10.1 – 20.0 | 5.1 – 10.0 | 0 – 5.0 |
| | Tidal range, m | ≤ 0.99 Microtidal | 1.0 – 1.9<br>Microtidal | 2.0 – 4.0<br>Mesotidal | 4.1 – 6.0<br>Mesotidal | ≥ 6.1<br>Macrotidal |
| | Significant wave height, m | < 0.25 | 0.25-0.5 | 0.5-1.0 | 1.0-1.25 | > 1.25 |
| | Geology features | Plutonic<br>Volcanic<br>High-medium grade metamorphics | Low-grade metamorphics<br>Sandstones and Conglomerates | Most sedimentary rocks | Coarse, poorly sorted unconsolidated sediments | Fine unconsolidated sediments<br>Volcanic ash |
| | Coastal Slope, ° | >11.5 | 11.5 - 5.5 | 5.5 – 3.5 | 3.5 – 2.2 | <2.2 |
| | Mean shoreline change, m/year | >2.0 | 1.1 to 2.0 | -1.0 to 1.0 | -1.1 to -2.0 | <-2.0 |
| Socio-economic | Population density, persons/sq. km | ≤ 100 | 100-500 | 500-2,000 | 2,000-10,000 | > 10,000 |
| | Major road distance from coastline, m | > 800 | 601-800 | 401-600 | 201-400 | < 200 |
| | Number of buildings | <500 | 500-1,500 | 1,501-2,000 | 2,001-2,500 | >2,500 |
| | Building construction materials | Cement block > 80 %<br>Concrete & Tile Floor > 80 %<br>Zinc Roof > 80 % | - | Mudbrick 30- 60%<br>Zinc Roof ≥ 30% | - | Mud and Wattle wall > 80%<br>Thatch Roof > 80 % |

| Variable | Coastal Vulnerability Ranking | | | | |
|---|---|---|---|---|---|
| | Very Low (1) | Low (2) | Moderate (3) | High (4) | Very High (5) |
| Access to electricity | Access to National Grid | Access to communal Grid | Access Private Power Generation | | No Access |
| Access to schools and health facilities | At least one health facility<br>Two Primary School<br>Two Junior and Senior Secondary School | At least one health facility<br>Two Primary School<br>Two Junior & one Secondary School | At least<br>One Primary School<br>One Junior Secondary School | Just<br>One Primary School | No access |
| Access to a telecommunications network | Access 2G (call) and 4G/LTE (internet) | Access 2G (call) and 3G (internet) | Access to 2G only | | Inaccessible |

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### 7.2.3 Analytical Hierarchical Process

The Analytical Hierarchical Process (AHP) is a multi-criteria decision analysis method that solves decision-making problems by ranking possible alternatives according to several criteria (Saaty, 1977; Saaty & Vargas, 1991). The AHP evaluates the needed weighting factors by means of a preference matrix, where all the selected parameters, considered relevant for the study, are compared against each other. Firstly, pairwise comparisons are carried out for all the parameters involved in the definition of both PVI and SVI, and the matrix is completed using scores based on their relative importance. In the construction of the pairwise comparison matrix, each parameter is rated against every other one by assigning a relative dominant value between 1 and 9, according to Saaty rating scale as shown in Table 7-29. In this way, qualitative evaluations are transformed into a quantitative assessment.

**Table 7-29: Saaty Rating Scale**

| Intensity of Importance | Definition | Explanation |
|---|---|---|
| 1 | Equal importance | Two factors contribute equally to the objective |
| 3 | Somewhat more important (Moderate importance) | Experience and judgment slightly favour one over the other |
| 5 | Much more important (Strong importance) | Experience and judgment strongly favour one over the other |
| 7 | Very much more important (Very strong importance | Experience and judgment very strongly favour one over the other. Its importance is demonstrated in practice |
| 9 | Absolutely more Important (Extreme importance) | The evidence favouring one over the other is of the highest possible validity |
| 2, 4, 6, 8 | Intermediate values (values in-between) | Compromise is needed |

A score has been assigned to each couple of compared parameters, following the Saaty scale and two different pairwise comparison matrixes have been derived (Table 7-30 and Table 7-31). This operation greatly relies on expert judgement and in any case involves a certain arbitrariness, even if deductions on the relative importance of the parameters have previously been made. Based on the pairwise comparison computed using the Saaty matrix, significance ratings have been calculated for each of the physical and socio-economic variables of the ICVI as presented in Table 7-33 and Table 7-34[17].

The Saaty method explains that the matrix must be consistent in order to overcome the subjectiveness of the evaluation. Thus, an index of consistency, known as consistency ratio (CR), must be computed with the following formula:

$$CR = \frac{CI}{RI} \quad (1)$$

Where $CI$ - Consistency Index (expressed as in equation 2), and $RI$ – Radom index - The random index (RI) is defined as the average of the resulting consistency index that depends on the order of the matrix. The RI values for different values of the n can be obtained by Saaty and Vargas, as shown in Table 7-32.

$$CI = \frac{(\lambda_{max} - n)}{(n-1)} \quad (2)$$

$\lambda_{max} = 7.636$ – the largest principal eigenvalue of the matrix and *n* is the order of the matrix (*n* = 7).

$$CI_{pvi} = \frac{(7.636 - 7)}{(7-1)} = \frac{0.636}{6} = 0.106$$

[17] The pairwise comparisons and relative significance matrix was computed with the aid of a web-based AHP tool (accessed via https://bpmsg.com/ahp/ahp-calc1.php?t=AHP+priorities&n=1&new=Go, 19 November 2020)

$$CR_{pvi} = \frac{0.106}{1.32} = 0.08$$

$$CI_{svi} = \frac{(8.819 - 8)}{(8 - 1)} = \frac{0.819}{7} = 0.117$$

$$CR_{svi} = \frac{0.117}{1.41} = 0.08$$

**Table 7-30: Pairwise Comparison Matrix of Physical Variables**

| Variable | Geomorphology | Elevation | Geology | Slope | Tidal Level | Significant Wave Height | Shoreline Change Rate |
|---|---|---|---|---|---|---|---|
| Geomorphology | 1 | 5 | 3 | 3 | 9 | 8 | 9 |
| Elevation | 1/5 | 1 | 5 | 2 | 9 | 6 | 5 |
| Geology | 1/3 | 1/5 | 1 | 1 | 5 | 5 | 5 |
| Slope | 1/3 | 1/2 | 1 | 1 | 5 | 4 | 6 |
| Tidal Level | 1/9 | 1/9 | 1/5 | 1/5 | 1 | 2 | 2 |
| Significant Wave Height | 1/8 | 1/6 | 1/5 | 1/4 | 1/2 | 1 | 2 |
| Shoreline Change Rate | 1/9 | 1/5 | 1/5 | 1/6 | 1/2 | 1/2 | 1 |
| **Column Total** | **2.21** | **7.18** | **10.6** | **7.62** | **30** | **26.5** | **30** |

**Table 7-31: Pairwise Comparison Matrix of Socio-economic Variables**

| Variable | Population Density | Road Network | Land Use | Buildings Numbers | Building Construction Material | Access to Schools and Health Facilities | Access to Electricity | Access to Telecommunication |
|---|---|---|---|---|---|---|---|---|
| Population Density | 1 | 7 | 3 | 3 | 5 | 3 | 4 | 3 |
| Road Network | 1/7 | 1 | 1/5 | 1/5 | 1/2 | 1/2 | 2 | 1/2 |
| Land Use | 1/3 | 5 | 1 | 2 | 4 | 1/2 | 2 | 3 |
| Buildings Numbers | 1/3 | 5 | 1/2 | 1 | 1 | 1 | 3 | 3 |
| Building Construction Material | 1/5 | 2 | 1/4 | 1 | 1 | 1/4 | 3 | 1/3 |
| Access to schools and health facilities | 1/3 | 2 | 2 | 1 | 4 | 1 | 4 | 3 |
| Access to electricity | 1/4 | 1/2 | 1/2 | 1/3 | 1/3 | 1/4 | 1 | 1/ |
| Access to telecommunication | 1/3 | 2 | 1/3 | 1/3 | 3 | 1/3 | 3 | 1 |
| **Column Total** | **2.91** | **24.5** | **7.78** | **8.86** | **18.83** | **6.83** | **22** | **14.16** |

**Table 7-32: Values of RI, with $n$ order of the matrix (Saaty and Vargas, 1980)**

| n | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| RI | 0.00 | 0.00 | 0.58 | 0.90 | 1.12 | 1.24 | 1.32 | 1.41 |

The matrix is considered consistent since *CR* < 0.1. Therefore, we have summed the values in each column of the pairwise matrix and have normalised each value by its column total, thus generating a normalised pairwise matrix as shown in Table 7-33 and Table 7-34 for physical and socio-economic parameters, respectively. The mean value of each row of this normalised matrix is the weight to be used for the row entry parameter. Using the AHP-derived weightings, the PVI, SVI and the resulting ICVI are calculated using equations (3), (4) and (5), respectively.

$$PVI = \sum_{i=1}^{n=7} P_i \cdot W_{Pi} \quad (3)$$

$$SVI = \sum_{i=1}^{n=x} S_i \cdot W_{Si} \quad (4)$$

$$ICVI = \frac{PVI + SVI}{2} \quad (5)$$

Where $W_{Pi}$ and $W_{Si}$ are the weight values of the $i-th$ variable and the $P_i$ and $S_i$ – its vulnerability score.

The entire coast is considered a linear feature in which every 500 m segment along the coast is analysed for its vulnerability. The PVI, SVI and ICVI values for the different segments of the coastline are further classified into vulnerability scales described for the variables above.

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**Table 7-33: Normalised Pairwise Comparison Matrix of Physical Variables**

| Variable | Slope | Elevation | Geomorphology | Geology | shoreline Change Rate | Significant Wave Height | Tidal Range | Weight | Percentage |
|---|---|---|---|---|---|---|---|---|---|
| Slope | 0.413 | 0.592 | 0.351 | 0.346 | 0.254 | 0.197 | 0.214 | 0.338 | 33.8 |
| Elevation | 0.136 | 0.197 | 0.351 | 0.346 | 0.254 | 0.225 | 0.214 | 0.246 | 24.6 |
| Geomorphology | 0.207 | 0.099 | 0.176 | 0.207 | 0.254 | 0.254 | 0.214 | 0.201 | 20.1 |
| Geology | 0.083 | 0.039 | 0.058 | 0.069 | 0.181 | 0.197 | 0.190 | 0.117 | 11.7 |
| shoreline Change Rate | 0.058 | 0.028 | 0.025 | 0.014 | 0.036 | 0.085 | 0.095 | 0.049 | 4.9 |
| Significant Wave Height | 0.058 | 0.024 | 0.019 | 0.010 | 0.012 | 0.028 | 0.048 | 0.028 | 2.8 |
| Tidal Range | 0.045 | 0.022 | 0.019 | 0.008 | 0.009 | 0.014 | 0.024 | 0.020 | 2.0 |

**Table 7-34: Normalised Pairwise Comparison Matrix of Socio-economic Variables**

| Variable | Population Density | Road Network | Land Use | Buildings Numbers | Building Construction Material | Access to Schools and Health Facilities | Access to Electricity | Access to Telecommunication | Mean | Percentage |
|---|---|---|---|---|---|---|---|---|---|---|
| Population Density | 0.344 | 0.286 | 0.386 | 0.339 | 0.266 | 0.439 | 0.182 | 0.212 | 0.307 | 31 |
| Road Network | 0.048 | 0.041 | 0.026 | 0.023 | 0.027 | 0.073 | 0.091 | 0.035 | 0.045 | 5 |
| Land Use | 0.113 | 0.204 | 0.129 | 0.226 | 0.212 | 0.073 | 0.091 | 0.212 | 0.158 | 16 |
| Buildings Numbers | 0.113 | 0.204 | 0.064 | 0.113 | 0.053 | 0.146 | 0.136 | 0.212 | 0.130 | 13 |
| Building Construction Material | 0.069 | 0.082 | 0.032 | 0.113 | 0.053 | 0.037 | 0.136 | 0.023 | 0.068 | 7 |
| Access to schools and health facilities | 0.113 | 0.082 | 0.257 | 0.113 | 0.212 | 0.146 | 0.182 | 0.212 | 0.165 | 16 |
| Access to electricity | 0.086 | 0.020 | 0.064 | 0.037 | 0.018 | 0.037 | 0.045 | 0.023 | 0.041 | 4 |
| Access to telecommunication | 0.113 | 0.082 | 0.042 | 0.037 | 0.159 | 0.048 | 0.136 | 0.071 | 0.086 | 9 |

## 7.3 Results and Analysis

### 7.3.1 Conakry-Dee

**Coastal Geomorphology:** Conakry-Dee is characterised by sand beaches; low to medium cliffs of poorly consolidated clays, and gravels; marshy swamps and mudflats associated with estuaries and mangrove-colonised plains. The northern part of the community settles in a low-lying area of alluvium sandy beach and is ranked with very high vulnerability to erosion (S95-97). The south of the community is situated on a raised cliff, which is rapidly being degraded by coastal wave actions, especially in areas that are not naturally protected by boulders or rock elements and vegetation cover. The mid and southern coastline is predisposed to erosion with a vulnerability ranking of high (S 91-94 & S104) (see Figure 7-2 and Figure 7-5).

**Coastal Geology:** Conakry-Dee is characterised by recent sedimentary deposits. The northern part of the community is primarily alluvium and beach sand and thus has a high erodibility vulnerability (S95-97). This part is also situated next to an estuary located to the east. Towards the south, the prevalence of clay and sand-clay is responsible for the moderate vulnerability ranking (S91-94 & S104) (see Figure 7-8).

**Coastal Slope:** Conakry-Dee coastal slope vulnerability varies from very low to very high. The very low and low ranking is attributed to cliffs along the southern part of Conakry Dee's coastline with slopes along certain segments exceeding 17° (Chainage S92). The northern portion of the coastline (i.e. S95, S96, S97), is characterised by slopes varying between 1.9° - 6° (see Figure 7-9).

**Coastal Elevation:** The coastline along Conakry-Dee varies North to South with the northernmost part of the community situated in a low-lying area and increases in elevation southwards reaching heights of approximately 16.5 m amsl. The entire stretch of the community's northern coast is at risk of inundation from SLR of 1-2 m amsl, while over half of its landmass could be exposed to an SLR scenario of +4 m amsl (see Figure 7-6).

**Shoreline Change Rate:** The average rate of shoreline change along Conakry-Dee's coastline has been 2.69 m/year. At such a rate, it is expected that the coastline would be 26.9 m inshore by 2030, 80.7 m by 2050, and 215.2 m by 2100. The coastline S95 has seen a shoreline change rate of approximately 4.14 m/year. The slowest rate of shoreline change has been along S93 with a rate of 1.4 m/year (see Figure 7-10). Chainage S95, which is shown to have receded the fastest geomorphologically comprises of sandy beach. This segment of the coastline is of high economic value to the community as it is home to its wharf and hosts a dense stretch of residential and recreational buildings as well as commercial entities such as boat making and net mending yards. Holding all factors constant, the coastline in this area could recede inshore by 41.4 m by 2030, 124.2 m by 2050 and 331.2 m by 2100 (see Figure 7-10).

**Physical Vulnerability Index:** The calculated PVI scores for Conakry-Dee ranges from 2.59 (S92) to 4.87 (S95, S97) with a mean value of 3.81. Approximately, 1.4 km of the 3.5 km coastline (about 40%) is extremely vulnerable in physical terms (i.e. chainages S95, S96 and S97 - areas found along the low-lying and highly erodible sandy beach along the northern coastline). About 0.7 km (20%) of the coastline falls under high physical vulnerability. This area coincides with the midsection of the coastline which comprises of high cliffs and recent sedimentary deposits that are currently under active erosion. The remaining 40% of the coastline is of moderate physical vulnerability as these areas consist of relatively low cliffs with a significant portion of vegetation cover serving as a shield (see Figure 7-13). The high to very high physical vulnerability along more than half of the community's coastline can be attributed to the high vulnerability ranking of geology, elevation, geomorphology, slope and shoreline change.

**Social Vulnerability Index:** The calculated SVI scores for Conakry-Dee ranges from 2.48 (S91, S92, S104) to 3.34 (S94) with a mean value of 2.80. Approximately 1.5 km of the 3.5 km coastline (43 %) is highly vulnerable in social terms (i.e., chainages S93, S94 and S95). The remaining 57% of the coastline is of moderate social vulnerability.

The high social vulnerability along chainages S93, S94 and S95, can be attributed to the high ranking of population density falling between 2,000-10,000 persons/sq. Km and the distances from the coastline to the road being less than or equal to 400m (see Figure 7-13).

Access to critical infrastructure such as schools, health facilities, electricity, mobile GSM and internet connectivity is relatively good in Conakry-Dee. The community is easily accessible via road and is in

close proximity to Lungi, an urban community that is home to the country's international airport. Conakry-Dee has access to electricity via a communal solar grid as well as mobile GSM and 3G internet connectivity from Orange and Africell. Although the community has only one health centre within its boundaries, it is located within close proximity to Lungi, which has a government hospital that provides advanced healthcare services.

**Integrated Coastal Vulnerability Index:** The calculated ICVI scores for Conakry Dee ranges from 2.53 (S92) to 4.03 (S95) with a mean value of 3.30. Approximately 2.5 km (71.4 %) of the 3.5 km coastline is highly vulnerable, 0.5 km (14.3%) being extremely vulnerable, with the remaining 0.5 being moderately vulnerable (see Figure 7-13).

**Table 7-35: Length of Coastline under different Vulnerability Categories in Conakry-Dee**

| Variable | Length of Coastline, km | | | | | |
|---|---|---|---|---|---|---|
| | Very Low | Low | Moderate | High | Very High | Total |
| Coastal Geomorphology | 0 | 0 | 0 | 2.2 | 1.3 | 3.5 |
| Coastal Geology | 0 | 0 | 0 | 2.2 | 1.3 | 3.5 |
| Coastal Slope | 0.5 | 1 | 0.7 | 0.5 | 0.8 | 3.5 |
| Coastal Elevation | 0 | 0 | 1 | 0.5 | 2 | 3.5 |
| Shoreline Change Rate | 0 | 0 | 0 | 0.5 | 3 | 3.5 |
| Tidal Range | 0 | 0 | 3.5 | 0 | 0 | 3.5 |
| Mean Significant Wave Height | 0 | 3.5 | 0 | 0 | 0 | 3.5 |
| **Physical Vulnerability (PVI)** | **0** | **0** | **1.5** | **0.7** | **1.4** | **3.5** |
| Population density | 0 | 1.2 | 1.3 | 1 | 0 | 3.5 |
| Road network | 0 | 3.5 | 1.2 | 0 | 2.3 | 3.5 |
| Land use/land cover | 0.5 | 0.3 | 1.7 | 0.5 | 0.5 | 3.5 |
| Buildings numbers | 0 | 3.5 | 0 | 0 | 0 | 3.5 |
| Building construction material | 0 | 3.5 | 0 | 0 | 0 | 3.5 |
| Access to schools and health facilities | 0 | 3.5 | 0 | 0 | 0 | 3.5 |
| Access to electricity | 0 | 0 | 3.5 | 0 | 0 | 3.5 |
| Access to telecommunication | 0 | 0 | 3.5 | 0 | 0 | 3.5 |
| **Social Vulnerability (SVI)** | **0** | **0** | **2** | **1.5** | **0** | **3.5** |
| **Integrated Coastal Vulnerability (ICVI)** | **0** | **0** | **0.5** | **2.5** | **0.5** | **3.5** |

**Figure 7-2: Coastal Geomorphology of Conakry-Dee**

**Sandy beach along the northern flank of the coast**




**Vegetationg Cover along the Central Axis of the Coast**




**Degraded low-moderate cliff along the central axis**




**Degraded high cliff along the southern coast**



**Figure 7-3: Elevation Profiles for Conakry-Dee (Eastward along the Northern Coast)**

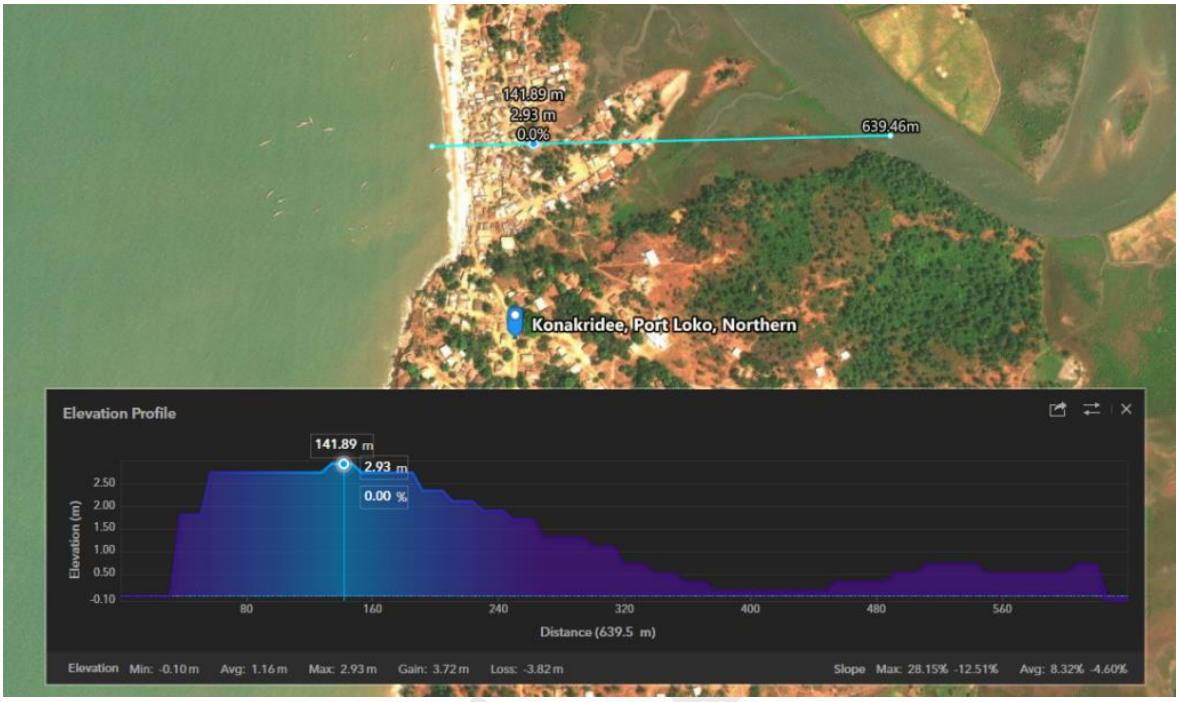


**Figure 7-4: Elevation Profiles for Conakry-Dee (Southward along the Coast)**



**Figure 7-5: Geomorphology Vulnerability Map of Conakry-Dee**

**Figure 7-6: Coastal Elevation Vulnerability Map of Conakry-Dee**

**Figure 7-7: Sea Level Rise Scenario Map of Conakry-Dee**

**Figure 7-8: Geological Vulnerability Map of Conakry-Dee**

**Figure 7-9: Coastal Slope Vulnerability Map of Conakry-Dee**

**Figure 7-10: Shoreline Change Vulnerability Map of Conakry-Dee**

**Figure 7-11: Shoreline Change Scenario Map of Conakry-Dee**

**Figure 7-12: Tidal Range and Mean Significantly Wave Height Vulnerability Map of Conakry-Dee**

**Figure 7-13: Coastal Vulnerability Index Map of Conakry-Dee**

**Figure 7-14: Land Use/Land Cover Vulnerability Map of Conakry-Dee**

**Figure 7-15: Population Vulnerability Map of Conakry-Dee**

**Figure 7-16: Critical Facilities Map of Conakry-Dee**

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N W E S

S97 S96 S95 S94 S93 S92 S91 S104

Conakry-Dee

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Rivers and Streams

### Geomorphology

**Geomorphology Vulnerability Ranking**

- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Coastal Geomorphology Vulnerability for Conakry-Dee

**Figure No:** Figure 7-5

**Map Scale:** 0 0.275 0.55 1.1 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

Conakry-Dee is characterised by sand beaches; low to medium cliffs of poorly consolidated clays, and gravels; marshy swamps and mudflats associated with estuaries and mangrove-colonised plains.

The northern part of the community is low-lying while the south of the community is situated on raised cliffs, which are rapidly being degraded by coastal wave actions.

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Conakry-Dee

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## Legend

- Study Area
- Major Roads
- Coastline
- Rivers and Streams

**Coastal Elevation**

- 0 - 5m
- 6 - 10m
- 11 - 20m
- 21 - 30m
- > 30m

**Vulnerability Ranking**

- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Coastal Elevation Vulnerability for Conakry-Dee

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.175 0.35 0.7 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

The elevations of the study areas are relatively low, ranging from 0 – 250m amsl. Five coastal elevation vulnerability classes have been established for the study.

All the five vulnerability levels relative to coastal elevation are found within the communities at varying degrees.

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## Legend

- Study Area
- Major Roads
- Coastline
- Rivers and Streams

**Sea-Level Rise Scenarios**

**Elevation, m amsl**

- 0-1 m
- 1-2 m
- 2-3 m
- 3-4 m
- > 4 m

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Sea Level Rise Scenario for Conakry-Dee

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.175 0.35 0.7 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

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**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

Using the RCP8.5, SLR to 2050 in Sierra Leone is estimated to be +0.26m meaning that for a calm sea state at the highest astronomical tide, the sea level would be approximately 2m above the current global mean sea level. Therefore, the 2050 scenario sea-level is estimated to be 3 – 4m above the current global mean sea level. A conservative range of 1m – 2m can therefore be assumed for potential storm surge as a high-level estimate.

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963600 962900 962200 961500 960800 960100

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Sand, clay, clay sand, Lignite

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Conakry-Dee

Sand, clay, clay sand, Lignite

Alluvium & beach sand

Sand, clay, clay sand, Lignite

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## Legend

- Study Area
- Major Roads
- Coastline

### Coastal Geology

- Alluvium & beach sand
- Freetown Complex
- Sand, clay, clay sand, Lignite

### Geological Vulnerabiliy Ranking

- Very Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Geological Vulnerability Ranking of Conakry-Dee

**Figure No:** Figure 7-8

**Map Scale:** 0 0.175 0.35 0.7 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

Conakry-Dee is characterised by recent sedimentary deposits. The northern part of the community and area of interest is primarily alluvium and beach sand and thus has a high erodibility vulnerability this part of the AOI is also situated next to an estuary located on it East. Towards the south, the prevalence of clay and sand-clay is responsible for the moderate vulnerability rankin.

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Conakry-Dee

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Rivers and Streams

**Coastal Slope Vulnerability**

- Very Low
- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Coastal Slope Vulnerability for Conakry-Dee

**Figure No:** Figure 7-9

**Map Scale:** 0 0.175 0.35 0.7 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

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**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI, NOAA

Coastal slope is an indicator of the relative risk of inundation and the potential speed of shoreline retreat. Coastal areas with gentle land slope are considered highly vulnerable, since they allow abundant penetration of seawater, whereas location with steeper slopes is assumed as areas of low vulnerability, providing greater resistance to inundation due to rising sea levels and storm surges.

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Conakry-Dee

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Rivers and Streams

**Shoreline Change Rate Vulnerability**

- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Shoreline Change Rate Vulnerability for Conakry-Dee

**Figure No:** Figure 7-10

**Map Scale:** 0 0.175 0.35 0.7 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

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The historical shoreline positions have been for the years 2006, 2010, 2015, and 2020 have been digitised and superimposed for comparison.

The shoreline rate of change has been computed using the ArcGIS Generate Rubbersheet Links to calculate the distance between the baseline shoreline 2006 and the current shoreline 2020.

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## Legend

- Study Area
- Major Roads
- Rivers and Streams

### Shoreline Change Scenarios

- 2020 (Current)
- 2030
- 2050
- 2100

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Shoreline Change Scenarios for Conakry-Dee

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.175 0.35 0.7 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

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**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI, NOAA

The average rate of shoreline change along Conakry-Dee's coastline has been 2.69 m/year. At such a rate, it is expected that the coastline would be 26.9 m inshore by 2030, 80.7 m by 2050, and 215.2 m by 2100.

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Conakry-Dee

Tidal Range

MSWH

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Rivers and Streams

**Mean Significant Wave Height and Tidal Range**

- Low
- Moderate

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** MSWH and Tidal Range Vulnerability for Conakry-Dee

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.175 0.35 0.7 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

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**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI, NOAA

Using the available data, five vulnerability categories based on mean significant wave height (MSWH) and tidal range have been established. The study area falls within low to moderate vulnerability categories based on significant wave heights.

With the exception of Tombo, all the coastal communities' mean tidal ranges fall into the moderate vulnerability category

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Conakry-Dee

ICVI

SVI

PVI

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## Legend

- Study Area
- Major Roads
- Coastline
- Rivers and Streams

### Vulnerability Index

- Very Low
- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Coastal Vulnerability Index of Conakry-Dee

**Figure No:** Figure 7-4

**Map Scale:** 0 0.175 0.35 0.7 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

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**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

The coastal vulnerability idex has been computed as a Integrated Coastal Vulnerability Index from physical and socio-economic variables that define likelihood of coastal hazard occurrence and impact as well as community sensitivity and adaptive capacity.

The ICVI has be computed as the arithmentic mean of the Physical and Social Vulnerability Indices computed using the Spatial Multi-Criteria Evaluation method.

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Conakry-Dee

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## Legend

- Study Area
- Major Roads
- Coastline
- Rivers and Streams

**Land use/ Land cover**

- Settlement
- Industrial (Shenge Fish Landing Point; Wharf)
- Institutional (Hospital; School)
- Recreational (Beach; Resort)
- Cultural Site
- Farm Land
- Vegetation Cover
- Barren Area (Bare Ground; Bare Rock)
- Marsh
- Water Body

**Land use/ Land cover Vulnerability**

- Very Low
- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Land use/ Land cover Vulnerability for Conakry-Dee

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.175 0.35 0.7 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

Data for land use/land cover was acquired by digitising LU/LC type from Google Earth Imagery,drone orthomosaic and OSM in ArcMap 10.5. Land cover/land use types for this study are broadly classified into bare ground, marsh, water body, bare rock, vegetation cover, beach, farm land, settlement, wharf, cultural sites and resort. Using the LU/LC data acquired five vulnerability classes have been identified

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Conakry-Dee

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**Population Density Vulnerability Ranking**

- Very low
- Low
- Moderate
- High
- Very High

**Population Density**

- 1 - 100
- 100 - 500
- 500 - 2000
- 2001 - 10000
- >10000
- Major Roads
- Rivers and Streams

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Population Density for Conakridee

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.175 0.35 0.7 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

The Population densityt data used in this study come from a Stats SL 2015 Population housing Census. Using the available data, five vulnerability categories based on population densityt have been established.

The study area falls within low to moderate vulnerability categories based on Population density.

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Conakry-Dee

Rowal

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**Building Footprints Vulnerability Ranking**

- Very Low
- Very High
- Major Roads
- Rivers and Streams

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Building Footprints of Conakridee

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.175 0.35 0.7 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

The Building footprint data used in this study come from OSM and Drone Aerial photos. U ta, five vulnerability categories based onBuilding footprintst have been established.

The study area falls within very low to very high vulnerability categories based on proximity to the shoreline.

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### 7.3.2 Lakka

**Coastal Geomorphology:** Lakka is predominantly characterised by sandy beaches. The destructive effect of a wave attack/coastal zone retreat is visible in this area. The Lakka coastline is faced with serious degradation and massive coastal erosion. The absence of natural and man-made defence mechanisms against coastal erosion and sea-level rise, the geomorphological features of the area have been characterised to be extremely vulnerable in segments S86, 87 and 89, while S88 and 90 are ranked low and high due to the presence of rocky headlands and small patches of vegetation cover, respectively (see Figure 7-17 and Figure 7-21).

**Coastal Geology:** Lakka's geological vulnerability is very low due to the prevalence of FIC gabbro (see Figure 7-24).

**Coastal Slope:** Lakka's coastal slope vulnerability varies very high to high. Coastal section S88, S89 and S90 are classified as high due to the slope of the beaches ranging between 5.1° – 9.98° and the range from 0.3° – 2.3°. Coastal sections S86 and S87 are of very high vulnerability as a result of moderately slope beaches 3.6°- 5.4° adjoining land along these stretches are low lying 0.3° – 2.3° (see Figure 7-25).

**Coastal Elevation:** The immediate southern coast of Lakka is dominated by moderately vulnerable elevations (10.1–20.0 m) while its northern fringe ranges from very low in the highlands across the peninsula highway to high along the coastline (Figure 7-22). The average elevation of the community is about 10 m amsl for the first 600 m from the coastline (see Figure 7-18). The SLR scenarios using the 30-m resolution DEM indicates that Lakka is largely unexposed to SLR-induced inundation for scenarios less than 5 m. However, a small segment of the community along a stream from the eastern highlands into the ocean could be exposed to a +5m SLR scenario (Figure 7-23).

**Shoreline Change Rate:** The average rate of shoreline change along Lakka's coastline has been 2.2 m/year. At such a rate, it is expected that on average Lakka's coastline would have receded by 22 m, 66 m, and 176 m by 2030, 2050 and 2100, respectively. The most significant rate of coastline change has occurred along S90 with a shoreline change rate of 3.37 m/year. The shoreline along S90 could recede by 33.7 m by 2030, 101 m and 235.9 m by 2050 and 2100, respectively (see Figure 7-26 and Figure 7-27). The area along this segment of the coastline currently comprises of sandy beaches residential roads and bare ground with sparse vegetation. Within the immediate vicinity of this segment is S89 along which lies the iconic building destroyed by the gradual erosion of the coast (see the top left image of Figure 7-17). The slowest change is found along S86, with an average shoreline change rate of 0.5 m/year.

**Physical Vulnerability Index:** The calculated PVI scores for Lakka ranges from 2.998 (S88) to 3.94 (S87) with a mean value of 3.65. Approximately, 0.3 km of the 2.3 km Lakka coastline (13%) is highly vulnerable in physical terms (i.e., chainage S90), while 1.5 km (65 %) is extremely vulnerable (see Figure 7-24). The high to very high physical vulnerability could be attributed to very high shoreline change rate, geomorphology and slope scoring along the southern segment of the coastline. This level of vulnerability is particularly evident in chainages S89 and 90, where sea walls and buildings have been toppled by wave action-induced erosion (see top images of Figure 7-17). The central segment, which comprises of rocky headlands is moderately vulnerable in physical terms.

**Social Vulnerability Index:** The calculated SVI scores for Lakka ranges from 2.37 (S90) to 2.72 (S86, S87) with a mean value of 2.64. Accordingly, the entire 2.3 km stretch of Lakka's coastline (100%) is moderately vulnerable in social terms (see Figure 7-24).

As an urban community, Lakka has a moderate average populated density of about 559 persons/sq. Km. However, the community's population is concentrated within highly populated EAs (with greater than 2,000 persons/sq.km) along the central segment of its coastline, making that area densely populated and significantly contributing to its vulnerability. Thus, Lakka's population density ranked high in the central segments of its coast, where residents are concentrated. The community's SVI is greatly influenced by the relatively high exposure of critical land-use categories, such as settlements and recreational areas along the beaches. Lakka has a comparatively high adaptive capacity owing mainly to its good access to critical infrastructure and services such as schools, health care, electricity, mobile communication, internet, and easy accessibility.

**Integrated Coastal Vulnerability Index:** The calculated ICVI scores for Lakka ranges from 2.84 (S88) to 3.33 (S87) with a mean value of 3.14. Approximately 1.5 km (65 %) of the 2.3 km coastline is highly vulnerable. The ICVI ratings along Lakka's coastline are greatly influenced by its physical susceptibility to coastal hazards (particularly to coastal erosion) (see Figure 7-24).

**Table 7-36: Length of Coastline and under different vulnerability categories in Lakka**

| Variable | Length, km | | | | | |
|---|---|---|---|---|---|---|
| | Very Low | Low | Moderate | High | Very High | Total |
| Coastal Geomorphology | 0 | 0.5 | 0 | 0.3 | 1.5 | 2.3 |
| Coastal Geology | 2.3 | 0 | 0 | 0 | 0 | 2.3 |
| Coastal Slope | 0 | 0 | 0 | 1.3 | 1 | 2.3 |
| Coastal Elevation | 0 | 0 | 1.5 | 0.8 | 0 | 2.3 |
| Shoreline Change Rate | 0 | 0 | 0.5 | 0 | 1.8 | 2.3 |
| Tidal Range | 0 | 0 | 2.3 | 0 | 0 | 2.3 |
| Mean Significant Wave Height | 0 | 0 | 2.3 | 0 | 0 | 2.3 |
| **Physical Vulnerability (PVI)** | **0** | **0** | **0.5** | **0.3** | **1.5** | **2.3** |
| Population density | 0 | 0 | 0.3 | 2 | 0 | 2.3 |
| Road network | 1.8 | 1 | 0 | 0 | 0 | 2.3 |
| Land use/land cover | 0 | 0 | 0 | 0 | 2.3 | 2.3 |
| Buildings numbers | 0 | 2.3 | 0 | 0 | 0 | 2.3 |
| Building construction material | 2.3 | 0 | 0 | 0 | 0 | 2.3 |
| Access to schools and health facilities | 2.3 | 0 | 0 | 0 | 0 | 2.3 |
| Access to electricity | 2.3 | 0 | 0 | 0 | 0 | 2.3 |
| Access to telecommunication | 2.3 | 0 | 0 | 0 | 0 | 2.3 |
| **Social Vulnerability (SVI)** | **0** | **0** | **2.3** | **0** | **0** | **2.3** |
| **Integrated Coastal Vulnerability (ICVI)** | **0** | **0** | **0.8** | **1.5** | **0** | **2.3** |

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**Figure 7-17: Coastal Geomorphology of Lakka**

**Damaged buildings from eroded areas along the northern axis of Lakka coastline**




**Raised medium cliff under active erosion along the northern end of Lakka coastline**



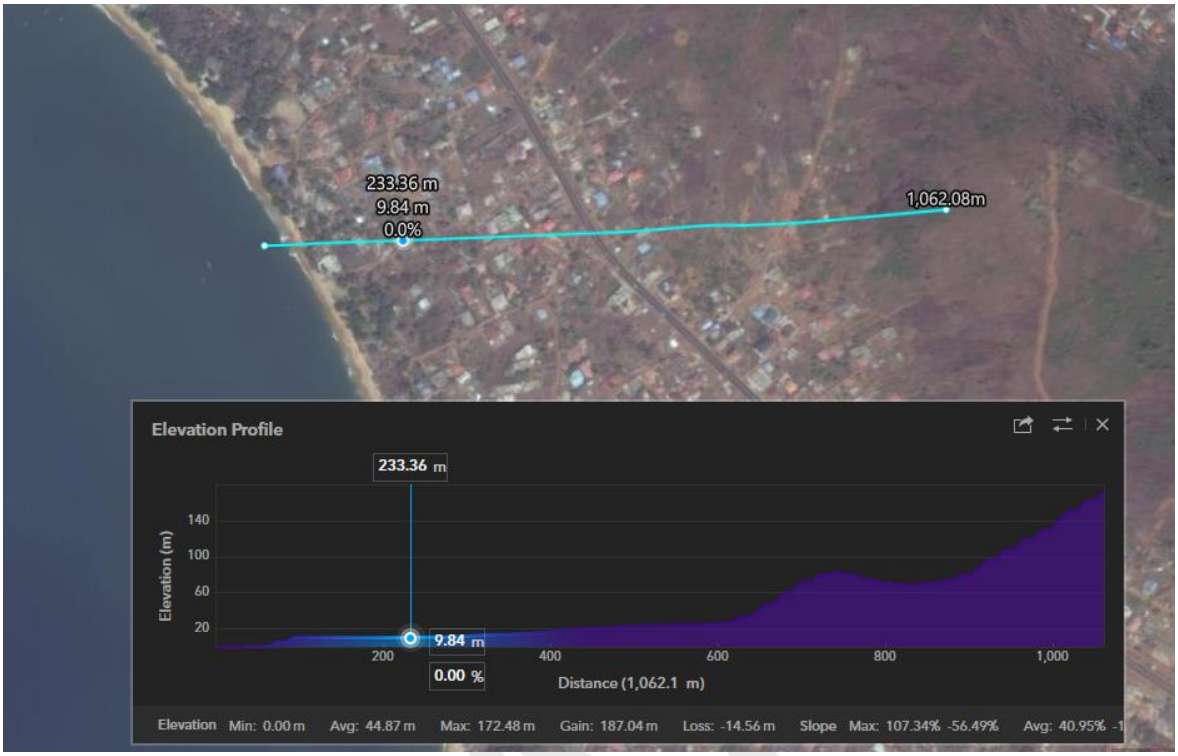

**Rocky headlines in the section of Lakka coastline cliff along the central axis**




**Low-lying sandy beach viewed towards south of Lakka**



**Figure 7-18: Elevation Profiles for Lakka**




### 7.3.3 Hamilton

**Coastal Geomorphology:** The mid-section of the Hamilton coastline (S81-83) is generally stable and resistant to wave attacks, and its vulnerability to coastal processes can be categorised as low. However, geomorphological processes (sediment transport) from inland are possible by torrential flow, and the processes of erosion and/or accumulation are visible in the beach area due to the wave influence and active sand mining activities. Behind the beach is characterised by marshy swamps and mudflats. The vulnerability level in these zones is high due to the geomorphological and anthropogenic activities (see Figure 7-19 and Figure 7-21).

**Coastal Geology:** Approximately half Hamilton's coastline exhibits very low and the other half very high geological vulnerability. The very low ranking can be attributed to visible FIC gabbro outcrops be visible in parts of the coastline (S82&81), while S78-81 are of very high vulnerability due to the predominance of unconsolidated sediments particularly alluvium and beach sand which can be attributed to the two rivers one running throughout the AOI in an N-S orientation and another located in Sussex running ENE-SWS direction (see Figure 7-24).

**Coastal Slope:** The slope within Hamilton ranges from very high to very low. The community appears concentrated in regions of varying slope – low – high. The southernmost part of AOI is predominated by low relief and indicates very high vulnerability. The coastline, however, ranges in vulnerability from very high to moderate the ranking takes into consideration the slope of the beaches (4.6° - 8.2°) and the slopes immediately after the beaches 0.2° - 6.04°.

**Coastal Elevation:** Hamilton is mostly covered by high vulnerability elevation ranges (6 – 10 m) with small patches of very high vulnerability (0 -5 m amsl) along its northern coastline (see Figure 7-22). The SLR scenarios using the 30-m resolution DEM indicates that Hamilton is largely unexposed to SLR-induced inundation for scenarios less than 5 m. Only a small patch of the community's landmass is exposed to an SLR scenario of 5 m amsl (Figure 7-23).

**Shoreline Change Rate:** The average rate of shoreline change along Hamilton's coastline has been 2.2 m/year. Accordingly, the coastline could recede by 22 m, 66 m, and 176 m by 2030, 2050 and 2100 respectively. The coastline segment S80 has seen a shoreline change rate of approximately 10 m/year. At such a rate, it is estimated that the coastline would have receded inshore by 100 m by 2030, 300 m

in 2050, and 700 m by 2100. The slowest rate of shoreline change has been the accretion in S85 with a rate of 0.79 m/year (see Figure 7-26 and Figure 7-27).

**Physical Vulnerability Index:** The calculated PVI scores for Hamilton range from 2.61 to 4.65 with a mean value of 3.69. Approximately, 1.5 km of the 4 km Hamilton coastline (37.5%) is ranked as extremely (very high) vulnerable (i.e. S78–S80). About 0.5 km (12.5%) of the coastline is ranked with high physical vulnerability, while the remaining half of the coastline is moderately vulnerable. These PVI values appear to have been influenced by high vulnerability geomorphology, geology, shoreline change rate and coastal slope rankings. Areas of very high physical vulnerability coincide with a vast stretch of sandy beach that is flanked to the east by marshlands (see Figure 7-19). The high and moderately vulnerable areas coincide with the built environment that is immediately adjacent to the rocky headline.

**Social Vulnerability Index:** The calculated SVI scores for Hamilton ranges from 1.45 (S78, S79) to 2.89 (S81) with a mean value of 2.29. Approximately 3 km of the 4 km Hamilton coastline (74.43%) is ranked as moderately vulnerable in social terms (i.e. S80 – S85). These SVI values appear to have been influenced by low vulnerability rankings of building materials - 1, critical infrastructure – 2, Road Network - 1, building footprints - 2. Only chainages S82 and S81 had a population density of rank of 4 (i.e., 2,000-10,000 persons/sq. km).

Like Lakka, Hamilton's vulnerability is greatly influenced by the sensitivity of its exposed land area and the population density. However, the community's easy accessibility, the resilience of building infrastructure and access to critical infrastructure contributes to reducing its vulnerability.

**Integrated Coastal Vulnerability:** The calculated ICVI scores for Hamilton ranges from 2.67 (S83) to 3.22 (S85) with a mean value of 3.30. Approximately 2.5 km (62.5%) of the 4 km coastline is highly vulnerable, while the rest is moderately vulnerable to impacts of coastal erosion and SLR.

**Table 7-37: Length of Coastline under different Vulnerability Categories in Hamilton**

| Variable | Length of Coastline, km | | | | | |
|---|---|---|---|---|---|---|
| | Very Low | Low | Moderate | High | Very High | Total |
| Coastal Geomorphology | 0 | 1.5 | 0.5 | 0.5 | 1.5 | 4 |
| Coastal Geology | 2 | 0 | 0.5 | 0 | 1.5 | 4 |
| Coastal Slope | 0 | 0 | 1 | 1.5 | 1.5 | 4 |
| Coastal Elevation | 0 | 0 | 1 | 3 | 0 | 4 |
| Shoreline Change Rate | 0 | 0 | 1 | 1.5 | 1.5 | 4 |
| Tidal Range | 0 | 0 | 4 | 0 | 0 | 4 |
| Mean Significant Wave Height | 0 | 0 | 4 | 0 | 0 | 4 |
| **Physical Vulnerability (PVI)** | **0** | **0** | **1.5** | **0.5** | **2** | 4 |
| Population density | 1 | 0.5 | 1.5 | 1 | 0 | 4 |
| Road network | 3.5 | 0.5 | 0 | 0 | 0 | 4 |
| Land use/land cover | 0 | 1 | 0 | 0.5 | 2.5 | 4 |
| Buildings numbers | 0 | 4 | 0 | 0 | 0 | 4 |
| Building construction material | 4 | 0 | 0 | 0 | 0 | 4 |
| Access to schools and health facilities | 0 | 4 | 0 | 0 | 0 | 4 |
| Access to electricity | 4 | 0 | 0 | 0 | 0 | 4 |

| Variable | Length of Coastline, km | | | | | |
|---|---|---|---|---|---|---|
| | Very Low | Low | Moderate | High | Very High | Total |
| Access to telecommunication | 4 | 0 | 0 | 0 | 0 | 4 |
| **Social Vulnerability (SVI)** | **0** | **1.5** | **2.5** | **0** | **0** | 4 |
| **Integrated Coastal Vulnerability ICVI** | **0** | **0** | **1.5** | **2.5** | **0** | 4 |

**Figure 7-19: Coastal Geomorphology of Hamilton**

**Low-lying Sandy Beach flanked by Estuarine Marshland with Mangrove like Vegetation Cover**



**Figure 7-20: Elevation Profiles for Hamilton**

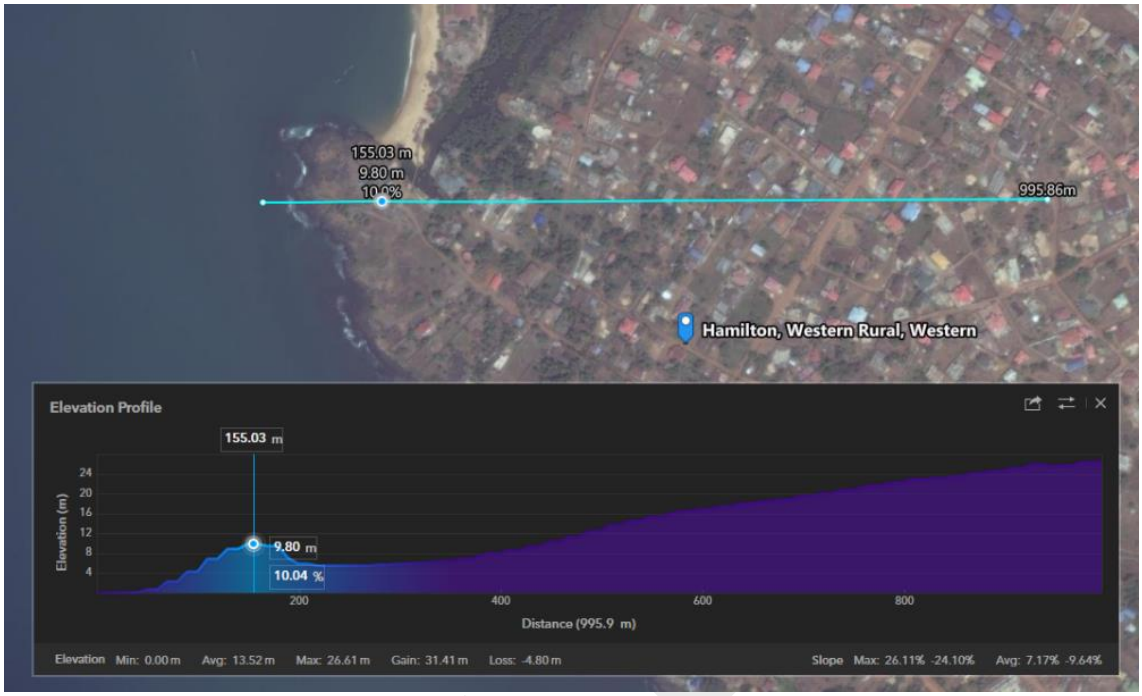



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**Figure 7-21: Geomorphology Vulnerability Map of Hamilton and Lakka**

**Figure 7-22: Coastal Elevation Vulnerability Map of Hamilton and Lakka**

**Figure 7-23: Sea Level Rise Scenarios for Hamilton and Lakka**

**Figure 7-24: Geological Vulnerability Map of Hamilton and Lakka**

**Figure 7-25: Coastal Slope Vulnerability Map of Hamilton and Lakka**

**Figure 7-26: Shoreline Change Vulnerability Map of Hamilton and Lakka**

**Figure 7-27: Shoreline Change Scenarios of Hamilton and Lakka**

**Figure 7-28: Tidal Range and Mean Significantly Wave Height Vulnerability Map of Hamilton and Lakka**

**Figure 7-29: Coastal Vulnerability Map of Hamilton and Lakka**

**Figure 7-30: Land Use/Land Cover Vulnerability Map of Hamilton and Lakka**

**Figure 7-31: Population Vulnerability Map of Hamilton and Lakka**

**Figure 7-32: Critical Facilities Map of Hamilton and Lakka**

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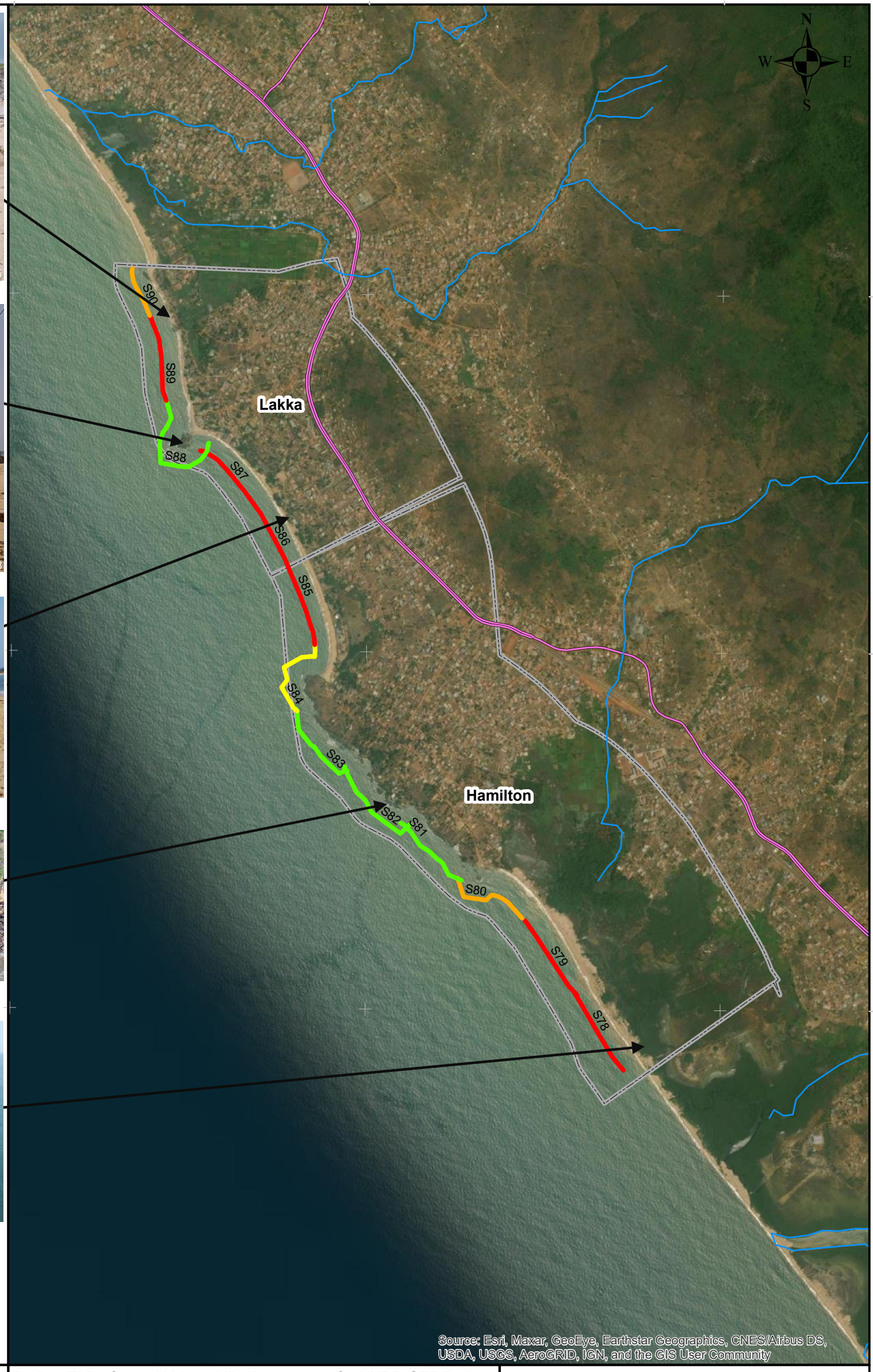


## Legend

- Study Area
- Major Roads
- Rivers and Streams

### Geomorphology

**Geomorphology Vulnerability Ranking**

- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Coastal Geomorphology Vulnerability for Lakka & Hamilton

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.375 0.75 1.5 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

The mid-section of the Hamilton coastline is generally stable and resistant to wave attacks. However, erosion and/or accumulation are visible in the beach area. Behind the beach is characterised by marshy swamps and mudflats.

Lakka is predominantly characterised by sandy beaches.
The coastal zone retreat is visible in this area. The is faced with serious degradation and massive coastal erosion.

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Lakka

Hamilton

S90 S89 S88 S87 S86 S85 S84 S83 S82 S81 S80 S79 S76

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## Legend

- Study Area
- Major Roads
- Coastline
- Rivers and Streams

**Coastal Elevation**

- 0 - 5m
- 6 - 10m
- 11 - 20m
- 21 - 30m
- > 30m

**Vulnerability Ranking**

- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Coastal Elevation Vulnerability for Lakka & Hamilton

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.275 0.55 1.1 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

The elevations of the study areas are relatively low, ranging from 0 – 250m amsl. Five coastal elevation vulnerability classes have been established for the study.

All the five vulnerability levels relative to coastal elevation are found within the communities at varying degrees.

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E

S

Lakka

Hamilton

Desmond Lane

Ogoo Farm

Saidu Lane

Upper Lakka Village

Lakka

Fakia Drive

St Michael

Hamilton Beach Road

Mensurah Lane

Sirca Drive

Beach Cemetery Road

Baneh Road

Dillet Street

Meheux Drive

Mambo

Upper Mambo

Peninsular Road

Western Area Urban

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## Legend

- Study Area
- Major Roads
- Coastline
- Rivers and Streams

**Sea-Level Rise Scenarios**

**Elevation, m amsl**

- < 1
- 1-2
- 2-3
- 3-4
- 4-5

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Sea Level Rise Scenario for Lakka & Hamilton

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.275 0.55 1.1 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

Using the RCP8.5, SLR to 2050 in Sierra Leone is estimated to be +0.26m meaning that for a calm sea state at the highest astronomical tide, the sea level would be approximately 2m above the current global mean sea level. Therefore, the 2050 scenario sea-level is estimated to be 3 – 4m above the current global mean sea level. A conservative range of 1m – 2m can therefore be assumed for potential storm surge as a high-level estimate.

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Lakka

Freetown Complex

Hamilton

Alluvium & beach sand

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## Legend

- Major Roads
- Coastline
- Study Area

### Coastal Geology

- Alluvium & beach sand
- Freetown Complex
- Sand, clay, clay sand, Lignite

### Geological Vulnerabiliy Ranking

- Very Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Geological Vulnerability of Lakka and Hamilton

**Figure No:** Figure 7-XX

**Map Scale:** 0 0.275 0.55 1.1 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

Lakka's geological vulnerability is very low due to the prevalence of FIC gabbro.
Approximately half Hamilton AOI exhibits very low and the other half very high geological vulnerability. The very low ranking can be attributed to visible FIC gabbro outcrops be visible along parts of the coastline are of very high vulnerability due to the predominance of unconsolidated sediments particularly alluvium and beach sand.

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S90 S89 S88 S87 S86 S85 S84 S83 S82 S81 S80 S79 S78

Lakka

Hamilton

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Rivers and Streams

**Coastal Slope Vulnerability**

- Very Low
- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Coastal Slope Vulnerability for Lakka and Hamilton

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.275 0.55 1.1 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI, NOAA

Coastal slope is an indicator of the relative risk of inundation and the potential speed of shoreline retreat. Coastal areas with gentle land slope are considered highly vulnerable, since they allow abundant penetration of seawater, whereas location with steeper slopes is assumed as areas of low vulnerability, providing greater resistance to inundation due to rising sea levels and storm surges.

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S90 S89 S88 S87 S86 S85 S84 S83 S82 S81 S80 S79 S78

Lakka

Hamilton

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Rivers and Streams

**Shoreline Change Rate Vulnerability**

- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Shoreline Change Rate Vulnerability for Hamilton and Lakka

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.25 0.5 1 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI, NOAA

The historical shoreline positions have been for the years 2006, 2010, 2015, and 2020 have been digitised and superimposed for comparison.

The shoreline rate of change has been computed using the ArcGIS Generate Rubbersheet Links to calculate the distance between the baseline shoreline 2006 and the current shoreline 2020.

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N W E S

Lakka

Hamilton

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Rivers and Streams

### Shoreline Change Scenarios

- 2020 (Current)
- 2030
- 2050
- 2100

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Shoreline Change Scenarios for Lakka and Hamilton

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.275 0.55 1.1 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

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**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI, NOAA

The average rate of shoreline change along the coastline of Hamilton and Lakka has been 2.2 m/year. Accordingly, the coastline could recede by 22 m, 66 m, and 176 m by 2030, 2050 and 2100, respectively.

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N W E S

Lakka

Hamilton

Tidal Range

MSWH

S90 S89 S88 S87 S86 S85 S84 S83 S82 S81 S80 S79 S78

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Rivers and Streams

**Mean Significant Wave Height and Tidal Range**

- Low
- Moderate

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** MSWH and Tidal Range Vulnerability for Conakry-Dee

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.25 0.5 1 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI, NOAA

Using the available data, five vulnerability categories based on mean significant wave height (MSWH) and tidal range have been established. The study area falls within low to moderate vulnerability categories based on significant wave heights.

With the exception of Tombo, all the coastal communities' mean tidal ranges fall into the moderate vulnerability category

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689210 690610 692010 693410

928763 927363 925963 924563

N W E S

Lakka

Hamilton

PVI

SVI

ICVI

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Coastline
- Rivers and Streams

### Vulnerability Index

- Very Low
- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Coastal Vulnerability Index of Lakka and Hamilton

**Figure No:** Figure 7-7

**Map Scale:** 0 0.275 0.55 1.1 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

The coastal vulnerability idex has been computed as a Integrated Coastal Vulnerability Index from physical and socio-economic variables that define likelihood of coastal hazard occurrence and impact as well as community sensitivity and adaptive capacity.

The ICVI has be computed as the arithmentic mean of the Physical and Social Vulnerability Indices computed using the Spatial Multi-Criteria Evaluation method.

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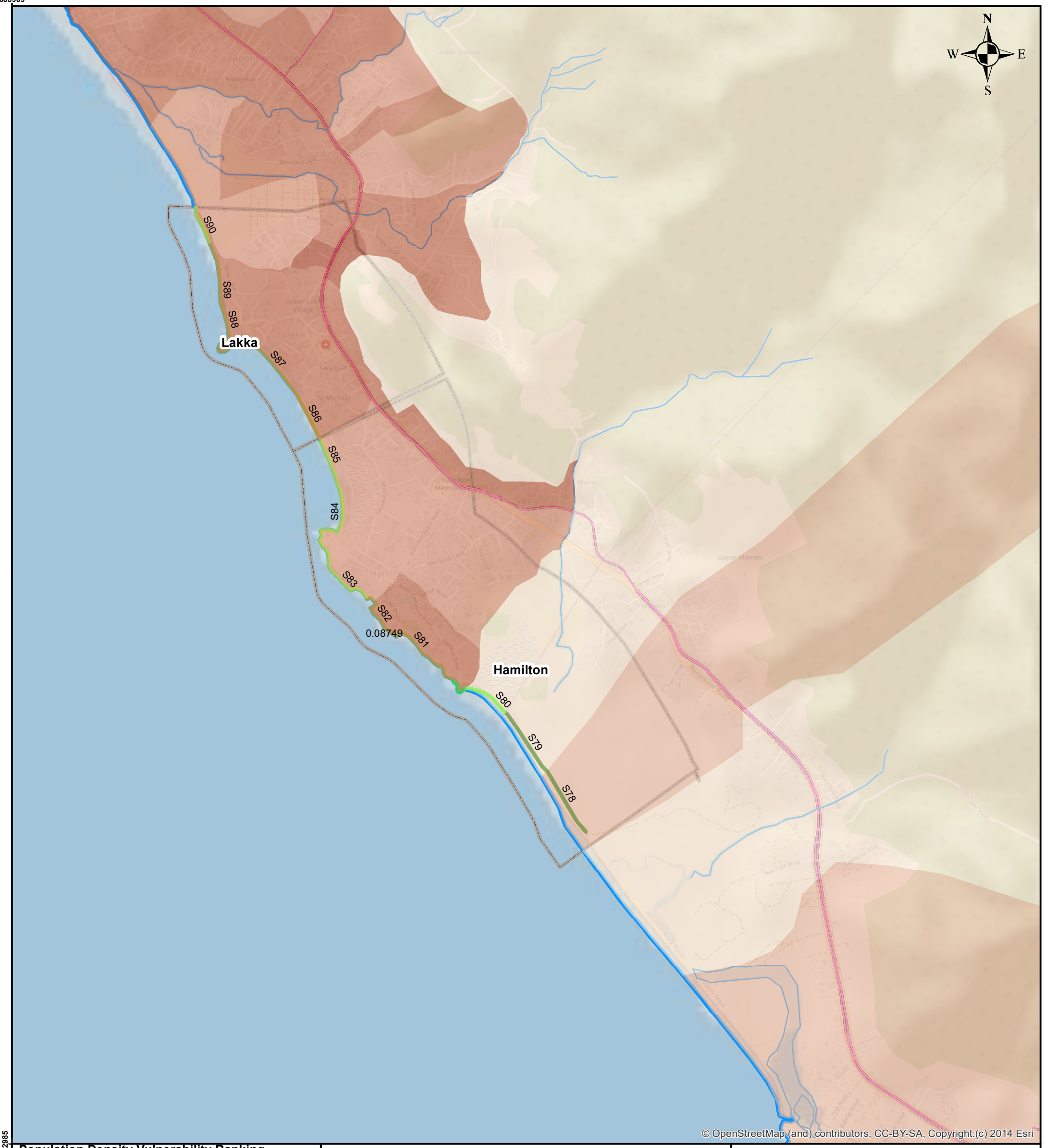


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**Population Density Vulnerability Ranking**

- Very low
- Low
- Moderate
- High
- Very High

**Population Density**

- 1 - 100
- 100 - 500
- 500 - 2000
- 2001 - 10000
- >10000
- Major Roads
- Rivers and Streams

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Population Density for Lakka and Hamilton

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.4 0.8 1.6 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

The Population densityt data used in this study come from a Stats SL 2015 Population housing Census. Using the available data, five vulnerability categories based on population densityt have been established.

The study area falls within low to moderate vulnerability categories based on Population density.

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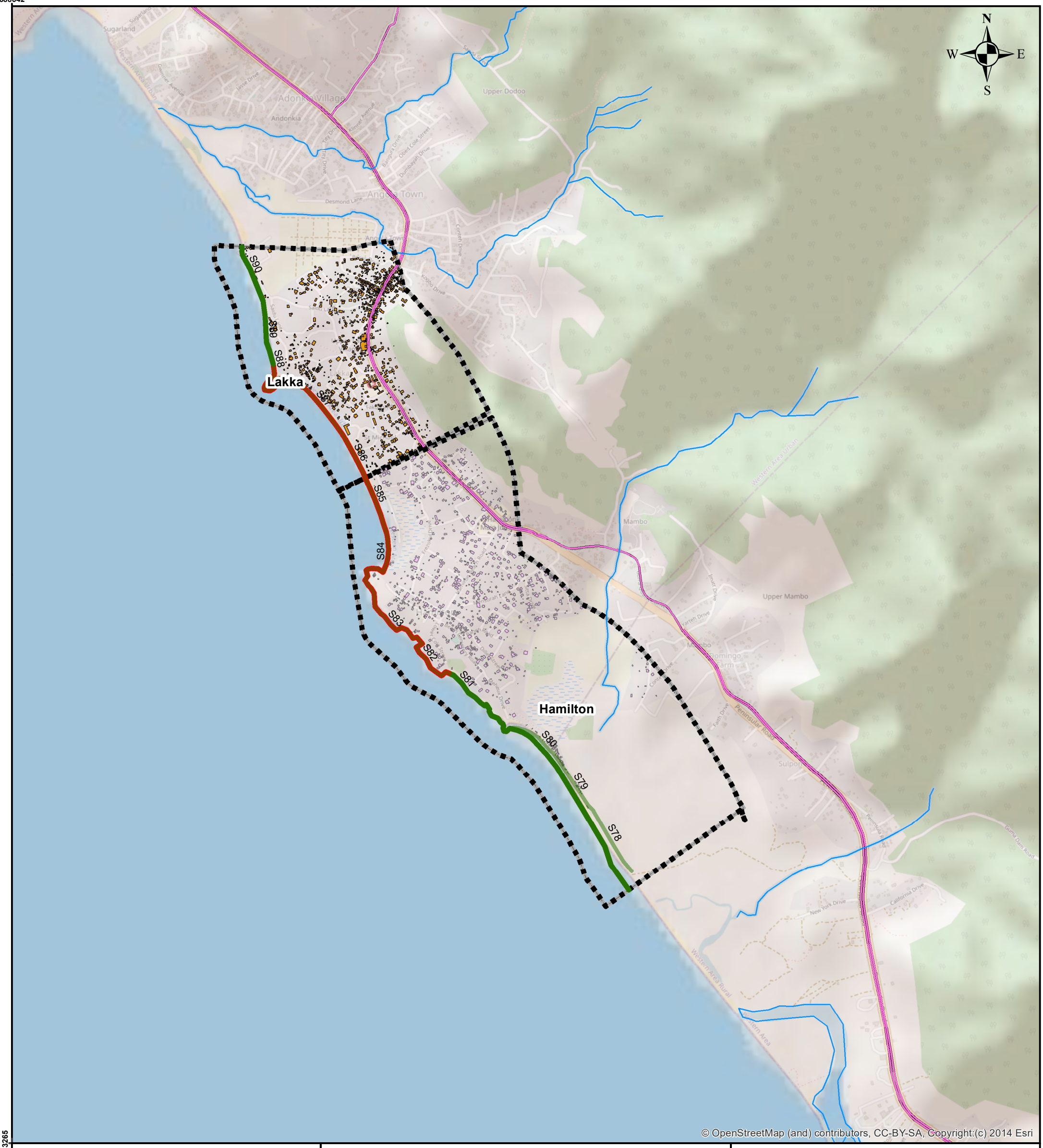


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**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Building Footprints of Lakka and Hamilton

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.4 0.8 1.6 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

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**Building Footprints Vulnerability Ranking**

- Very Low
- Very High
- Major Roads
- Rivers and Streams

The Building footprint data used in this study come from OSM and Drone Aerial photos. U ta, five vulnerability categories based onBuilding footprintst have been established.

The study area falls within very low to very high vulnerability categories based on proximity to the shoreline.

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### 7.3.4 Tombo

**Coastal Geomorphology:** Tombo is a low-lying community, and its coastline is faced with degradation primarily as a result of active fishing activities. Tombo is characterised by sandy beaches, marshy swamps and mudflats associated with estuaries. In some areas on the coast in Tombo are seen rip-raps created by community members, using large stones, gravels and sandbags to reduce coastal wave actions; thus, reducing the rate of coastal erosion (see Figure 7-35 and Figure 7-36).

**Coastal Geology:** The western part of the Tombo exhibits very low geological vulnerability with a prevalence of FIC outcrops. However, approximately half of the south-facing coastline is of moderate vulnerability (S69-72) due to a high presence of sand clay and clay and to the north-west (S73&74) (see Figure 7-38).

**Coastal Slope:** The coastal sections of Tombo range in vulnerability from very low to high the very low and low area vulnerability areas are characterised of slope varying between 7.8° – 19.3°. The rest of the coastal sections S69, S70, S71 and S72 ranges from moderate to high vulnerability. Coastal section is S70 and S71 of high vulnerability with slopes ranging from 1.7°–4.8° (see Figure 7-39).

**Coastal Elevation:** The north-eastern coast of Tombo mostly falls within moderate to very high vulnerability relative to elevation whilst the southwestern segment of the community's coast is almost evenly split between very low vulnerability in the elevated areas and small segments of moderate to high vulnerability (see Figure 7-34, Figure 7-36 and Figure 7-37). The western axis of Tombo's coast is unexposed to inundation from SLR scenarios that are less than 5 m amsl. However, the eastern flank with elevations of less than 5 m amsl up to distances between 100-400 m inshore from the coastline is exposed to the different scenarios (+1, +2, +3, +4 and +5 m amsl) at varying degrees.

**Shoreline Change Rate:** The average rate of shoreline change along Tombo's coastline has been 1.5 m/year. The chainage S71 has seen a shoreline change at a rate of approximately 3.42 m/year. The slowest rate of shoreline change has along S72 with a rate of 0.34 m/year (see Figure 7-40). Assuming that the factors leading to shoreline recession in Tombo are held constant, the coastline is expected to recede on average by 15 m, 45 m, and 120 m by 2030, 2050 and 2100, respectively. Specifically, S71 could potentially recede by 34.2 m, 102.6 m, and 273.6 m by 2030, 2050 and 2100, respectively.

**Physical Vulnerability Index:** The calculated PVI scores for Tombo range from 1.92 (S74) to 3.81 (S71), with a mean value of 3.22. Approximately 1.5 km of the 3.15 km Tombo coastline (47.6%) is highly or extremely vulnerable in physical terms (S70-72), while the adjacent segments S69 and S73 are moderately vulnerable (see Figure 7-43). Tombo's physical vulnerability is greatly influenced by its relatively high shoreline and low elevation.

**Social Vulnerability Index:** The calculated SVI scores for Tombo ranges from 2.32 (S69) to 3.49 (S71, S72) with a mean value of 2.99. Approximately 1.5 km of the 3.15 km of Tombo coastline (47.6%) is highly vulnerable in social terms. Chainages S71, S72 and S73 which had individual high rankings for building footprints (2,001 – 2,500 buildings), land-use (sensitive land-use types with a high concentration of settlement, school, hospital, wharf, cultural sites, resort, fish landing point) and population density ranging of exceeding 10,000 persons/sq. km (see Figure 7-43).

**Integrated Coastal Vulnerability Index:** The calculated ICVI scores for Tombo ranges from 2.42 (S74) to 3.65 (S71) with a mean value of 3.12. Approximately 2 km of the 3.15 km Tombo coastline (63.4%) is highly vulnerable (see Figure 7-43).

**Table 7-38: Length of Coastline and under Different Vulnerability Categories in Tombo**

| Variable | Length, km | | | | | |
|---|---|---|---|---|---|---|
| | Very Low | Low | Moderate | High | Very High | Total |
| Coastal Geomorphology | 0 | 0.65 | 1 | 0.5 | 1 | 3.15 |
| Coastal Geology | 1 | 0 | 2.14 | 0 | 0 | 3.15 |
| Coastal Slope | 0.5 | 0.5 | 1.15 | 1 | 0 | 3.15 |
| Coastal Elevation | 0 | 0.5 | 0 | 2.65 | 0 | 3.15 |

| Variable | Length, km | | | | | |
|---|---|---|---|---|---|---|
| | Very Low | Low | Moderate | High | Very High | Total |
| Shoreline Change Rate | 0 | 0 | 0 | 1 | 2.15 | 3.15 |
| Tidal Range | 0 | 3.15 | 0 | 0 | 0 | 3.15 |
| Mean Significant Wave Height | 0 | 0 | 3.15 | 0 | 0 | 3.15 |
| **Physical Vulnerability (PVI)** | **0** | **0.5** | **1.15** | **1** | **0.5** | **3.15** |
| Population density | 0 | 1.14 | 0 | 1 | 1 | 3.15 |
| Road network | 1.15 | 0 | 1 | 0.5 | 0.5 | 3.15 |
| Land use/land cover | 0 | 0 | 0.5 | 0.65 | 2 | 3.15 |
| Buildings numbers | 0 | 0 | 0 | 3.14 | 0 | 3.15 |
| Building construction material | 0 | 3.14 | 0 | 0 | 0 | 3.15 |
| Access to schools and health facilities | 3.14 | 0 | 0 | 0 | 0 | 3.15 |
| Access to electricity | 0 | 0 | 3.14 | 0 | 0 | 3.15 |
| Access to telecommunication | 3.14 | 0 | 0 | 0 | 0 | 3.15 |
| **Social Vulnerability (SVI)** | **0** | **0** | **1.65** | **1.5** | **0** | **3.15** |
| **Integrated Coastal Vulnerability (ICVI)** | **0** | **0** | **1.15** | **2** | **0** | **3.15** |

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**Figure 7-33: Coastal Geomorphology of Tombo**

**Rocky low-lying inter-tidal zone at Low Tide along the Central Segment of Tombo**



**Weathered Gabbroic Rock along the eastern coast of Tombo**



**Actively eroded area adjacent the Jetty in Tombo**



**Low-lying sandy beach west of the Tombo Jetty**



**Figure 7-34: Elevation Profiles for Tombo**

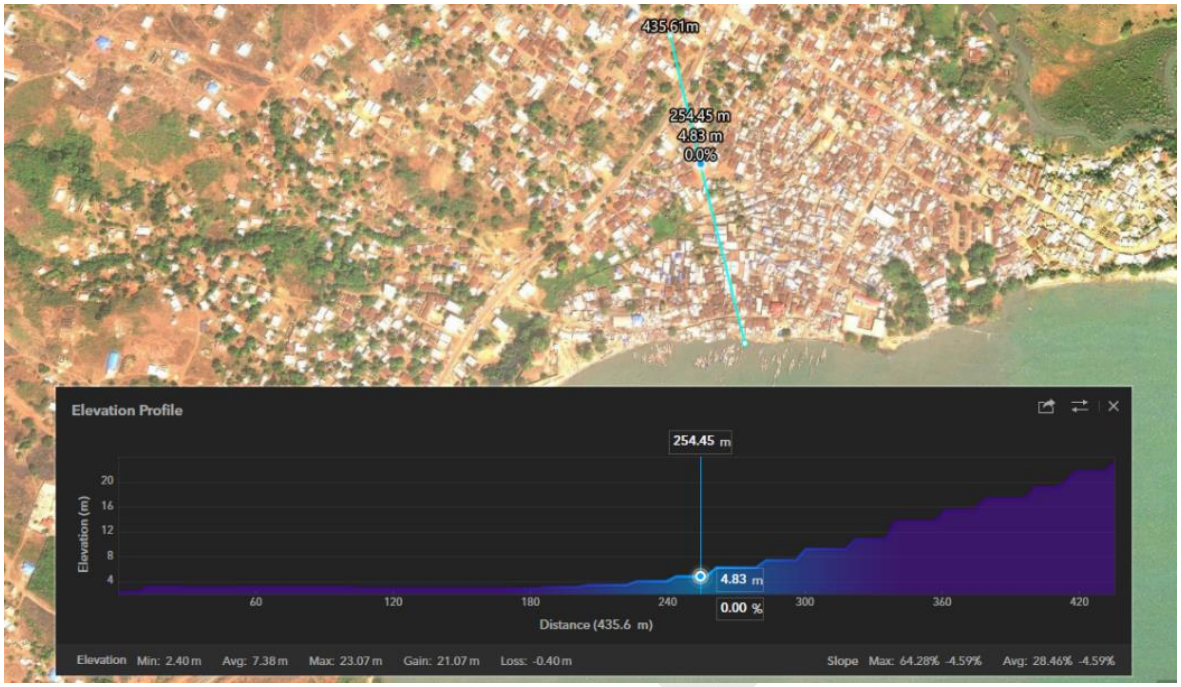


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**Figure 7-35: Geomorphology Vulnerability Map of Tombo**

**Figure 7-36: Coastal Elevation Vulnerability Map of Tombo**

**Figure 7-37: Sea Level Rise Scenario Map of Tombo**

**Figure 7-38: Geological Vulnerability Map of Tombo**

**Figure 7-39: Coastal Slope Vulnerability Map of Tombo**

**Figure 7-40: Shoreline Change Vulnerability Map of Tombo**

**Figure 7-41: Shoreline Change Scenario Map of Tombo**

**Figure 7-42: Tidal Range and Mean Significantly Wave Height Vulnerability Map of Tombo**

**Figure 7-43: Coastal Vulnerability Index Map of Tombo**

**Figure 7-44: Land Use/Land Cover Vulnerability Map of Tombo**

**Figure 7-45: Population Vulnerability Map of Tombo**

**Figure 7-46: Critical Facilities Map of Tombo**

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708043 709043 710043 711043

910849 909849 908849 907849 906849 905849

N W E S

Tombo

S69 S70 S71 S72 S73 S74

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Rivers and Streams

### Geomorphology

**Geomorphology Vulnerability Ranking**

- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Coastal Geomorphology Vulnerability for Tombo

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.275 0.55 1.1 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

Tombo is a low-lying community, and its coastline is faced with degradation primarily as a result of active fishing activities. Tombo is characterised by sandy beaches, marshy swamps and mudflats associated with estuaries.

In some areas on the coast in Tombo are seen rip-raps using large stones, gravels and sandbags to reduce coastal wave actions; thus, reducing the rate of coastal erosion.

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N W E S

Tombo

S69 S70 S71 S72 S73 S74

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## Legend

- Study Area
- Major Roads
- Coastline
- Rivers and Streams

**Coastal Elevation**

- 0 - 5m
- 6 - 10m
- 11 - 20m
- 21 - 30m
- > 30m

**Vulnerability Ranking**

- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Coastal Elevation Vulnerability for Tombo

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.175 0.35 0.7 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

The elevations of the study areas are relatively low, ranging from 0 – 250m amsl. Five coastal elevation vulnerability classes have been established for the study.

All the five vulnerability levels relative to coastal elevation are found within the communities at varying degrees.

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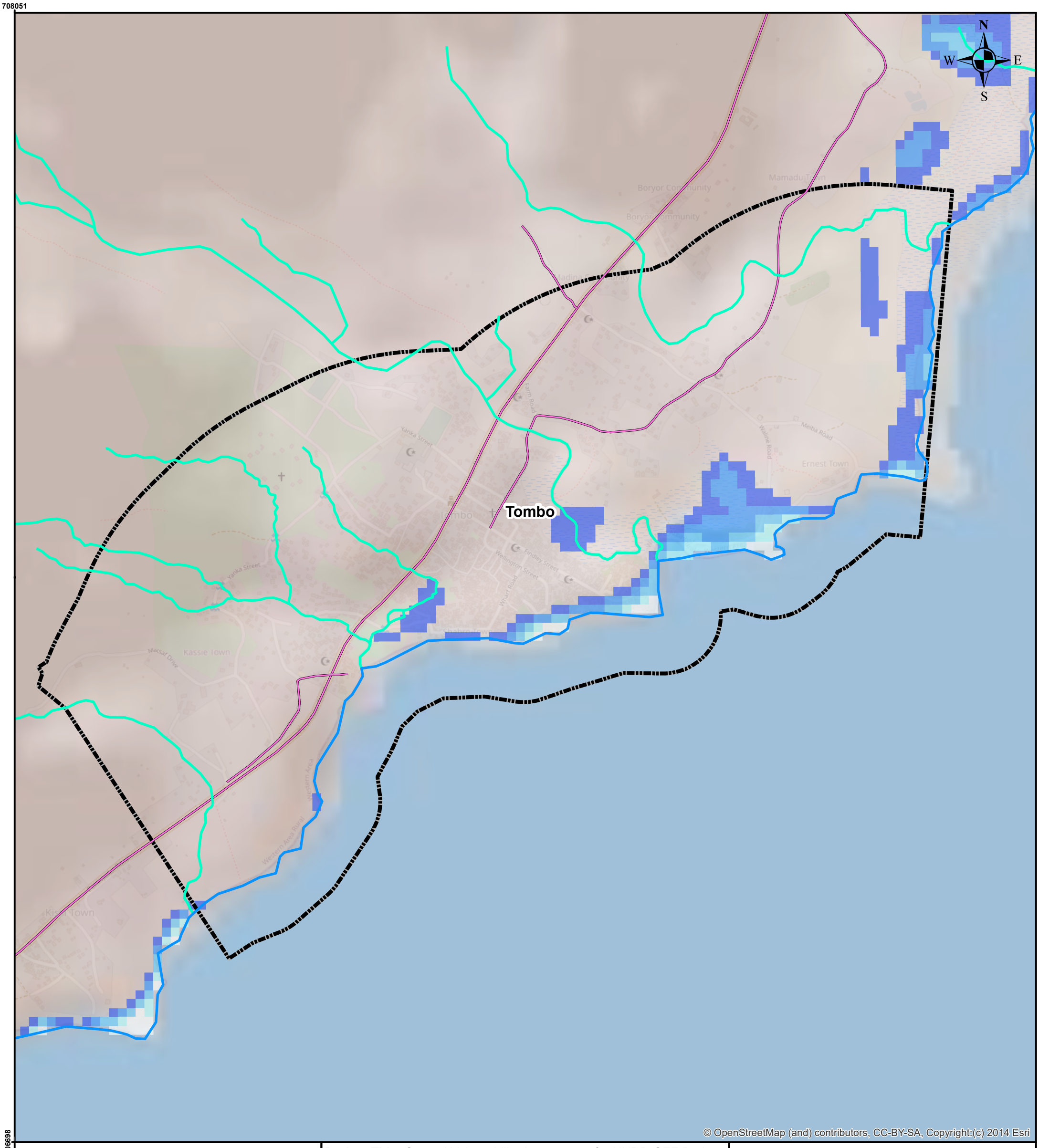


906698

## Legend

- Study Area
- Major Roads
- Coastline
- Rivers and Streams

**Sea-Level Rise Scenarios**

**Elevation, m amsl**

- < 1
- 1-2
- 2-3
- 3-4
- 4-5

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Sea Level Rise Scenario for Tombo

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.175 0.35 0.7 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

Using the RCP8.5, SLR to 2050 in Sierra Leone is estimated to be +0.26m meaning that for a calm sea state at the highest astronomical tide, the sea level would be approximately 2m above the current global mean sea level. Therefore, the 2050 scenario sea-level is estimated to be 3 – 4m above the current global mean sea level. A conservative range of 1m – 2m can therefore be assumed for potential storm surge as a high-level estimate.

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708100 708800 709500 710200 710900

910400 909700 909000 908300 907600 906900

N W E S

Alluvium & beach sand

Sand, clay, clay sand, Lignite

Freetown Complex

Tombo

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## Legend

- Study Area
- Major Roads
- Coastline

### Coastal Geology

- Alluvium & beach sand
- Freetown Complex
- Sand, clay, clay sand, Lignite

### Geological Vulnerability Ranking

- Very Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Geological Vulnerability of Tombo

**Figure No:** Figure 7-XX

**Map Scale:** 0 0.175 0.35 0.7 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

Tombo is a low-lying community, and its coastline is faced with degradation primarily as a result of active fishing activities. Tombo is characterised by sandy beaches, marshy swamps and mudflats associated with estuaries. In some areas on the coast in Tombo are seen rip-raps created by community members, using large stones, gravels and sandbags to reduce coastal wave actions; thus, reducing the rate of coastal erosion

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909698 908698 907698 906698

N W E S

Tombo

S69 S70 S71 S72 S73 S74

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Rivers and Streams

**Coastal Slope Vulnerability**

- Very Low
- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Coastal Slope Vulnerability for Tombo

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.175 0.35 0.7 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI, NOAA

Coastal slope is an indicator of the relative risk of inundation and the potential speed of shoreline retreat. Coastal areas with gentle land slope are considered highly vulnerable, since they allow abundant penetration of seawater, whereas location with steeper slopes is assumed as areas of low vulnerability, providing greater resistance to inundation due to rising sea levels and storm surges.

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N W E S

Tombo

S69 S70 S71 S72 S73 S74

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Rivers and Streams

**Shoreline Change Rate Vulnerability**

- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Shoreline Change Rate Vulnerability for Tombo

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.175 0.35 0.7 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI, NOAA

The historical shoreline positions have been for the years 2006, 2010, 2015, and 2020 have been digitised and superimposed for comparison.

The shoreline rate of change has been computed using the ArcGIS Generate Rubbersheet Links to calculate the distance between the baseline shoreline 2006 and the current shoreline 2020.

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N W E S

Tombo

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Rivers and Streams

### Shoreline Change Scenarios

- 2020 (Current)
- 2030
- 2050
- 2100

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Shoreline Change Scenarios for Tombo

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.175 0.35 0.7 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI, NOAA

The average rate of shoreline change along Tombo's coastline has been 1.5 m/year. Assuming that the factors leading to shoreline recession in Tombo are held constant, the coastline is expected to recede on average by 15 m, 45 m, and 120 m by 2030, 2050 and 2100, respectively.

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N W E S

Tombo

MSWH

S69 S70 S71 S72 S73 S74

Tidal Range

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Rivers and Streams

**Mean Significant Wave Height and Tidal Range**

- Low
- Moderate

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** MSWH and Tidal Range Vulnerability for Tombo

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.175 0.35 0.7 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI, NOAA

Using the available data, five vulnerability categories based on mean significant wave height (MSWH) and tidal range have been established. The study area falls within low to moderate vulnerability categories based on significant wave heights.

With the exception of Tombo, all the coastal communities' mean tidal ranges fall into the moderate vulnerability category

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909499 908099 906699

N W E S

Tombo

PVI

SVI

ICVI

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Coastline
- Rivers and Streams

### Vulnerability Index

- Very Low
- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Coastal Vulnerability Index of Tombo

**Figure No:** Figure 7-9

**Map Scale:** 0 0.175 0.35 0.7 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

The coastal vulnerability idex has been computed as a Integrated Coastal Vulnerability Index from physical and socio-economic variables that define likelihood of coastal hazard occurrence and impact as well as community sensitivity and adaptive capacity.

The ICVI has be computed as the arithmentic mean of the Physical and Social Vulnerability Indices computed using the Spatial Multi-Criteria Evaluation method.

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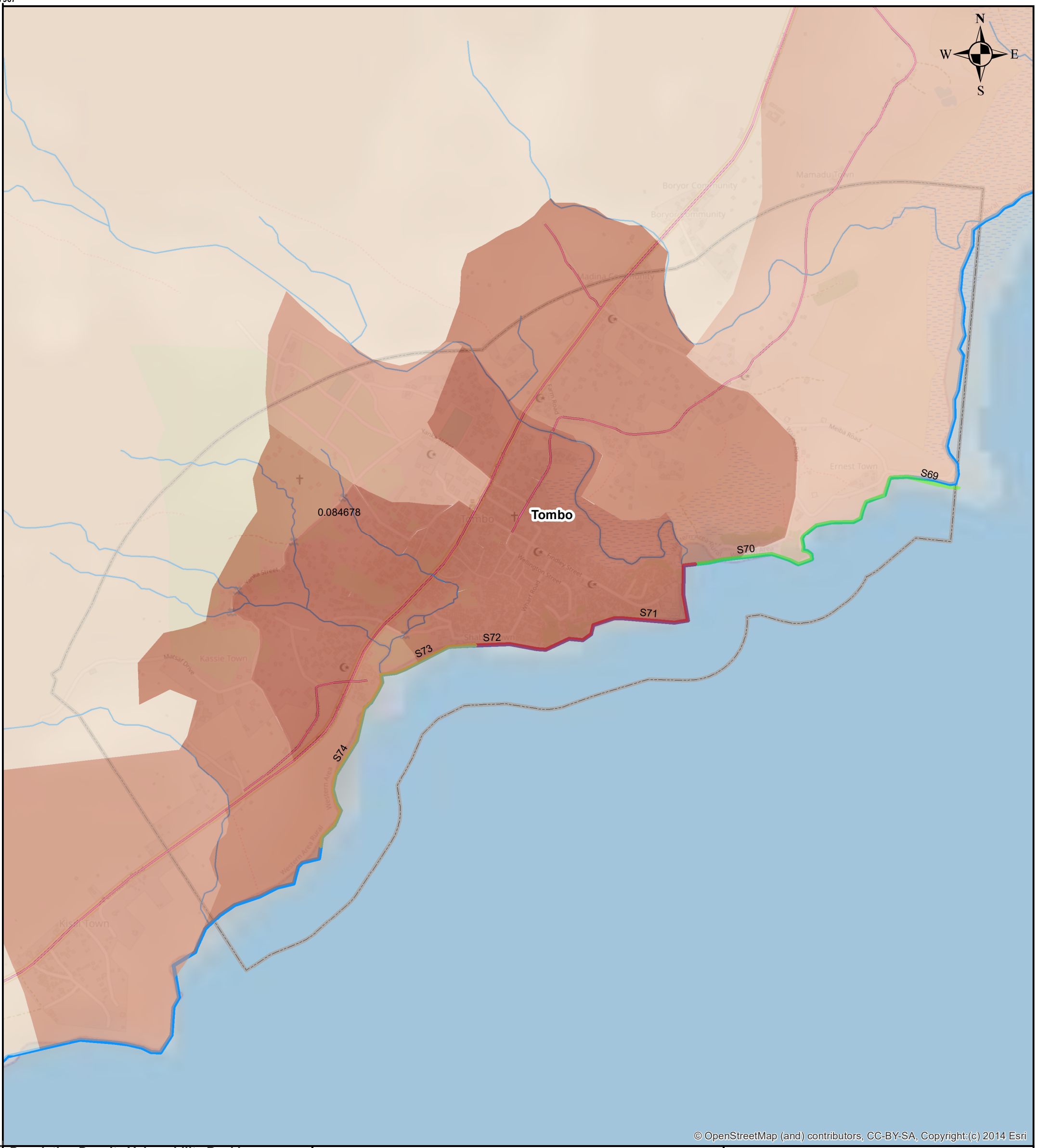


906737

**Population Density Vulnerability Ranking**

- Very low
- Low
- Moderate
- High
- Very High

**Population Density**

- 1 - 100
- 100 - 500
- 500 - 2000
- 2001 - 10000
- >10000
- Major Roads
- Rivers and Streams

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Population Density for Tombo

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.175 0.35 0.7 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

The Population densityt data used in this study come from a Stats SL 2015 Population housing Census. Using the available data, five vulnerability categories based on population densityt have been established.

The study area falls within low to moderate vulnerability categories based on Population density.

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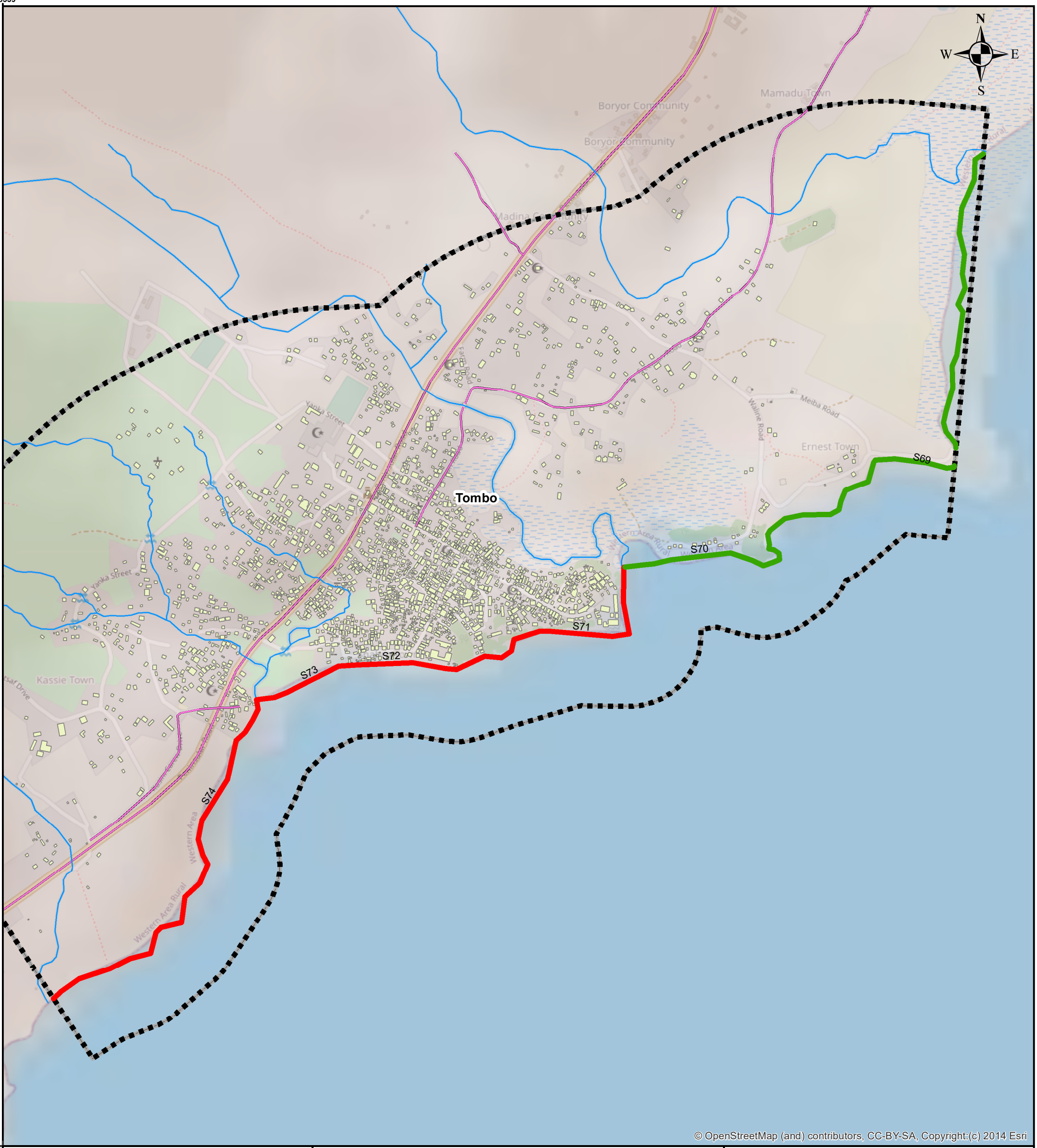


**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Building Footprints of Tombo

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.15 0.3 0.6 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

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**Building Footprints Vulnerability Ranking**

- Very Low
- Very High
- Major Roads
- Rivers and Streams

The Building footprint data used in this study come from OSM and Drone Aerial photos. U ta, five vulnerability categories based onBuilding footprintst have been established.

The study area falls within very low to very high vulnerability categories based on proximity to the shoreline.

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### 7.3.5 Shenge

**Coastal Geomorphology:** Similar to the other coastal communities, Shenge is characterised by pockets of sand beaches and low to high coastal cliffs of poorly consolidated clays and gravels. The community is also a low-lying coastal plain, with elevations less than 20m amsl, which extends inland from the coastline (see Figure 7-47 and Figure 7-49).

**Coastal Geology:** Shenge's geology is predominantly characterised by the prevalence of clay and sand-clay. Accordingly, the coastline of the community is ranked with moderate vulnerability alongside pockets of alluvium and sand beaches (S59-67) (see Figure 7-52).

**Coastal Slope:** Slope vulnerability in Shenge varies between low and high. Coastal section S14 is high due to moderate beach slope and very high slope vulnerability of adjoining land <2.2°. At the same time, sections S63-S68 are of moderate vulnerability characterised by low vulnerability beaches and high vulnerability 11.5° – 2.2° (see Figure 7-53).

**Coastal Elevation:** The coastlines along Shenge are mostly under moderate to high vulnerability areas 6 – 20m. Risk of SLR of inundation is mostly concentrated along the beach at the foot of the cliffs that make up the community's coastline (see Figure 7-50).

**Shoreline Change Rate:** The average rate of shoreline change along Shenge coastline has been 1.32 m/year. At this rate, Shenge's coastline could recede to 13.2 m by 2030, 39.6 m and 105.6 m in 2050 and 2021, respectively. The coastline along S63 has seen a shoreline change rate of approximately 2.3 m/year. Without mitigation or exacerbation by extreme events, the coastline along this segment would have receded by 23 m in 2030, 69 m and 184 m in 2050 and 2100, respectively.

**Physical Vulnerability Index:** The calculated PVI scores for Shenge ranges from 2.43 (S66) to 3.88 (S57) with a mean value of 3.32. Approximately 1 km (15.2%) of the 6.5 km Shenge coastline is extremely vulnerable in physical terms; about 1.36 km (20.9%) is highly vulnerable, while the remaining 4.14 km is moderately vulnerable. Shenge's vulnerability is mostly influenced by its coastal area being geomorphologically and geologically susceptible to erosion. Furthermore, the rate of shoreline changes significantly contributed to the PVI as over half of the coastline is ranked with high to very high shoreline recession rates.

**Social Vulnerability Index:** The calculated PVI scores for Shenge ranges from 2.18 (S67 & S68) to 2.84 (Multiple) with a mean value of 2.59. Accordingly, the entire 6.5 km Shenge coastline moderately vulnerable in social terms.

Shenge's SVI is rated at moderate, which is mostly reflective of the community's low population exposure (2,153 residents and population density of 106 persons/sq. km). Although the peninsula occupied by the community is dominated by very sensitive land use types (settlements, wharves, cultural sites), the effect of their exposure to coastal hazards is dampened by the relatively low building exposure and moderate building material quality.

The community has appreciable access to critical infrastructure including schools for primary, junior and senior secondary levels, 2G mobile and 3G internet coverage, and a community health centre. However, the community does not have access to the national or communal electricity grid, posing significant challenges to the full realisation of it its fishing industry's potential. The internal road network is relatively good within a community. However, due to their proximity to the coastline in areas of potentially high physical vulnerability makes them very vulnerable.

**Integrated Coastal Vulnerability Index:** The calculated ICVI scores for Shenge ranges from 2.55 (S67) to 3.36 (S57) with a mean value of 2.96. Approximately 2 km (30.45%) of the 6.5 km Shenge coastline is highly vulnerable.

**Table 7-39: Length of Coastline and under Different Vulnerability Categories in Shenge**

| Variable | Length of Coastline, km | | | | | |
|---|---|---|---|---|---|---|
| | Very Low | Low | Moderate | High | Very High | Total |
| Coastal Geomorphology | 0 | 0 | 1 | 0.5 | 5 | 6.5 |
| Coastal Geology | 0 | 0 | 4.65 | 0.85 | 1 | 6.5 |

| Variable | Length of Coastline, km | | | | | |
|---|---|---|---|---|---|---|
| | Very Low | Low | Moderate | High | Very High | Total |
| Coastal Slope | 0 | 1.5 | 4.5 | 0.5 | 0 | 6.5 |
| Coastal Elevation | 0 | 0 | 5 | 1.5 | 0 | 6.5 |
| Shoreline Change Rate | 0 | 0 | 2.5 | 3 | 1 | 6.5 |
| Tidal Range | 0 | 0 | 6.5 | 0 | 0 | 6.5 |
| Mean Significant Wave Height | 0 | 0 | 6.5 | 0 | 0 | 6.5 |
| **Physical Vulnerability (PVI)** | **0** | **0** | **4.14** | **1.36** | **1** | **6.5** |
| Population density | 0 | 6.5 | 0 | 0 | 0 | 6.5 |
| Road network | 2 | 0 | 0 | 0 | 4.5 | 6.5 |
| Land use/land cover | 0 | 1.36 | 1 | 1 | 3.14 | 6.5 |
| Buildings numbers | 6.5 | 0 | 0 | 0 | 0 | 6.5 |
| Building construction material | 0 | 0 | 6.5 | 0 | 0 | 6.5 |
| Access to schools and health facilities | 0 | 0 | 6.5 | 0 | 0 | 6.5 |
| Access to electricity | 0 | 0 | 0 | 0 | 6.5 | 6.5 |
| Access to telecommunication | 0 | 6.5 | 0 | 0 | 0 | 6.5 |
| **Social Vulnerability (SVI)** | **0** | **0.86** | **5.64** | **0** | **0** | **6.5** |
| **Integrated Coastal Vulnerability (ICVI)** | **0** | **0** | **4.5** | **2** | **0** | **6.5** |

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**Figure 7-47: Coastal Geomorphology of Shenge**

**Sandy beach flanked by vegetation cover**




**Sea wall adjacent Jetty that is under Construction**




**Medium Sand-clay cliff**




**Degraded high cliff along the northern coast**



**Figure 7-48: Elevation Profiles for Shenge**




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**Figure 7-49: Geomorphology Vulnerability Map of Shenge**

**Figure 7-50: Coastal Elevation Vulnerability Map of Shenge**

**Figure 7-51: Sea Level Rise Scenario Map of Shenge**

**Figure 7-52: Geological Vulnerability Map of Shenge**

**Figure 7-53: Coastal Slope Vulnerability Map of Shenge**

**Figure 7-54: Shoreline Change Vulnerability Map of Shenge**

**Figure 7-55: Shoreline Change Scenario Map of Shenge**

**Figure 7-56: Tidal Range and Mean Significantly Wave Height Vulnerability Map of Shenge**

**Figure 7-57: Coastal Vulnerability Index Map of Shenge**

**Figure 7-58: Land Use/Land Cover Vulnerability Map of Shenge**

**Figure 7-59: Population Vulnerability Map of Shenge**

**Figure 7-60: Critical Facilities Map of Shenge**

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## Legend

- Study Area
- Major Roads
- Rivers and Streams

### Geomorphology

**Geomorphology Vulnerability Ranking**

- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Coastal Geomorphology Vulnerability for Shenge

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.325 0.65 1.3 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

Shenge is characterised by pockets of sand beaches and low to high coastal cliffs of poorly consolidated clays and gravels. The community is also a low-lying coastal plain, with elevations less than 20m amsl, which extends inland from the coastline.

Man-made structures such as sea walls have been constructed along the Jetties to shield the associated infrastructure from the destructive action of waves.

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N W E S

S66 S67 S68 S65 S64 S63 S62 S61 S60 S59 S58 S57

Shenge

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## Legend

- Study Area
- Major Roads
- Coastline
- Rivers and Streams

**Coastal Elevation**

- 0 - 5m
- 6 - 10m
- 11 - 20m
- 21 - 30m
- > 30m

**Vulnerability Ranking**

- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Coastal Elevation Vulnerability for Shenge

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.225 0.45 0.9 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

The elevations of the study areas are relatively low, ranging from 0 – 250m amsl. Five coastal elevation vulnerability classes have been established for the study.

All the five vulnerability levels relative to coastal elevation are found within the communities at varying degrees.

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## Legend

- Study Area
- Major Roads
- Coastline
- Rivers and Streams

**Sea-Level Rise Scenarios**

**Elevation, m amsl**

- < 1
- 1-2
- 2-3
- 3-4
- 4-5

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Sea Level Rise Scenario for Shenge

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.225 0.45 0.9 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

Using the RCP8.5, SLR to 2050 in Sierra Leone is estimated to be +0.26m meaning that for a calm sea state at the highest astronomical tide, the sea level would be approximately 2m above the current global mean sea level. Therefore, the 2050 scenario sea-level is estimated to be 3 – 4m above the current global mean sea level. A conservative range of 1m – 2m can therefore be assumed for potential storm surge as a high-level estimate.

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876400 875500 874600 873700 872800

N W E S

Alluvium & beach sand

Sand, clay, clay sand, Lignite

Alluvium & beach sand

Sand, clay, clay sand, Lignite

S66 S67 S68

S65 S64 S63 S62 S61 S60 S59 S58 S57

Shenge

Alluvium & beach sand

Sand, clay, clay sand, Lignite

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## Legend

- Study Area
- Major Roads
- Coastline

### Coastal Geology

- Alluvium & beach sand
- Freetown Complex
- Sand, clay, clay sand, Lignite

### Geological Vulnerabiliy Ranking

- Very Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Geological Vulnerability Ranking of Shenge

**Figure No:** Figure 7-XX

**Map Scale:** 0 0.225 0.45 0.9 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

Shenge's geology is predominantly characterised by the prevalence of clay and sand-clay are responsible for the moderate vulnerability ranking and dotted by pockets alluvium and sand beaches.

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S66 S67 S68 S65 S64 S63 S62 S61 S60 S59 S58 S57

Shenge

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Rivers and Streams

**Coastal Slope Vulnerability**

- Very Low
- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Coastal Slope Vulnerability for Shenge

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.225 0.45 0.9 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

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**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI, NOAA

Coastal slope is an indicator of the relative risk of inundation and the potential speed of shoreline retreat. Coastal areas with gentle land slope are considered highly vulnerable, since they allow abundant penetration of seawater, whereas location with steeper slopes is assumed as areas of low vulnerability, providing greater resistance to inundation due to rising sea levels and storm surges.

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S66 S67 S68 S65 S64 S63 S62 S61 S60 S59 S58 S57

Shenge




## Legend

- Study Area
- Major Roads
- Rivers and Streams

**Shoreline Change Rate Vulnerability**

- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Shoreline Change Rate Vulnerability for Shenge

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.225 0.45 0.9 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI, NOAA

The historical shoreline positions have been for the years 2006, 2010, 2015, and 2020 have been digitised and superimposed for comparison.

The shoreline rate of change has been computed using the ArcGIS Generate Rubbersheet Links to calculate the distance between the baseline shoreline 2006 and the current shoreline 2020.

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N W E S

Shenge

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Rivers and Streams

### Shoreline Change Scenarios

- 2020 (Current)
- 2030
- 2050
- 2100

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Shoreline Change Scenarios for Shenge

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.225 0.45 0.9 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

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**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI, NOAA

The average rate of shoreline change along Shenge coastline has been 1.32 m/year. At this rate, Shenge's coastline could recede by 13.2 m by 2030, 39.6 m and 105.6 m in 2050 and 2021, respectively.

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N W E S

S66 S67 S68 S65 S64 S63 S62 S61 S60 S59 S55 S57

MSWH

Shenge

Tidal Range

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Rivers and Streams

**Mean Significant Wave Height and Tidal Range**

- Low
- Moderate

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** MSWH and Tidal Range Vulnerability for Shenge

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.225 0.45 0.9 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI, NOAA

Using the available data, five vulnerability categories based on mean significant wave height (MSWH) and tidal range have been established. The study area falls within low to moderate vulnerability categories based on significant wave heights.

With the exception of Tombo, all the coastal communities' mean tidal ranges fall into the moderate vulnerability category

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723322 724722 726122 727522 728922

876389 874989 873589 872189 870789

N W E S

Shenge

PVI

SVI

ICVI

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Coastline
- Rivers and Streams

### Vulnerability Index

- Very Low
- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Coastal Vulnerability Index of Shenge

**Figure No:** Figure 7-11

**Map Scale:** 0 0.3 0.6 1.2 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

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**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

The coastal vulnerability idex has been computed as a Integrated Coastal Vulnerability Index from physical and socio-economic variables that define likelihood of coastal hazard occurrence and impact as well as community sensitivity and adaptive capacity.

The ICVI has be computed as the arithmentic mean of the Physical and Social Vulnerability Indices computed using the Spatial Multi-Criteria Evaluation method.

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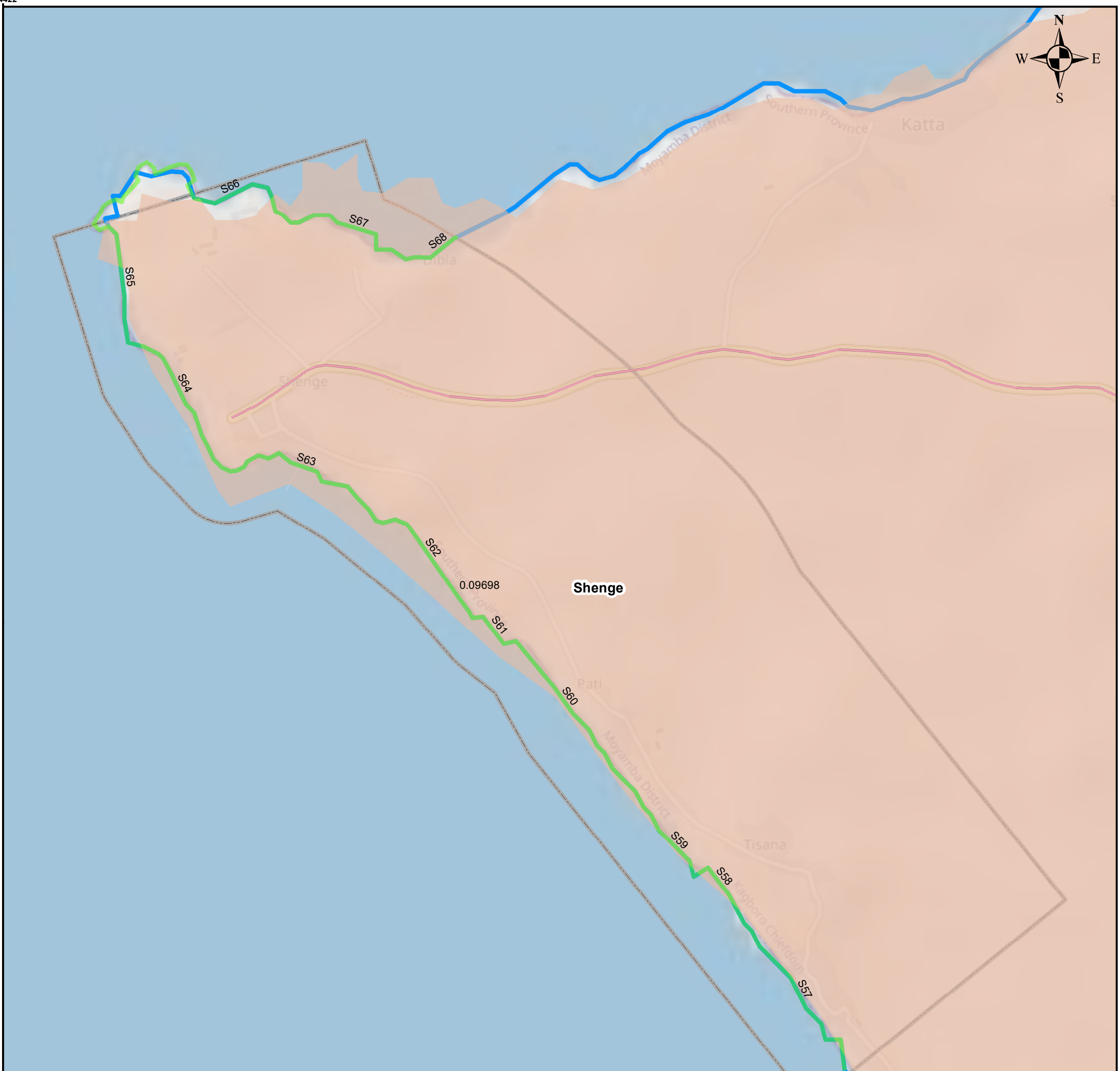


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**Population Density Vulnerability Ranking**

- Very low
- Low
- Moderate
- High
- Very High

**Population Density**

- 1 - 100
- 100 - 500
- 500 - 2000
- 2001 - 10000
- >10000
- Major Roads
- Rivers and Streams

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Population Density for Shenge

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.225 0.45 0.9 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

The Population densityt data used in this study come from a Stats SL 2015 Population housing Census. Using the available data, five vulnerability categories based on population densityt have been established.

The study area falls within low to moderate vulnerability categories based on Population density.

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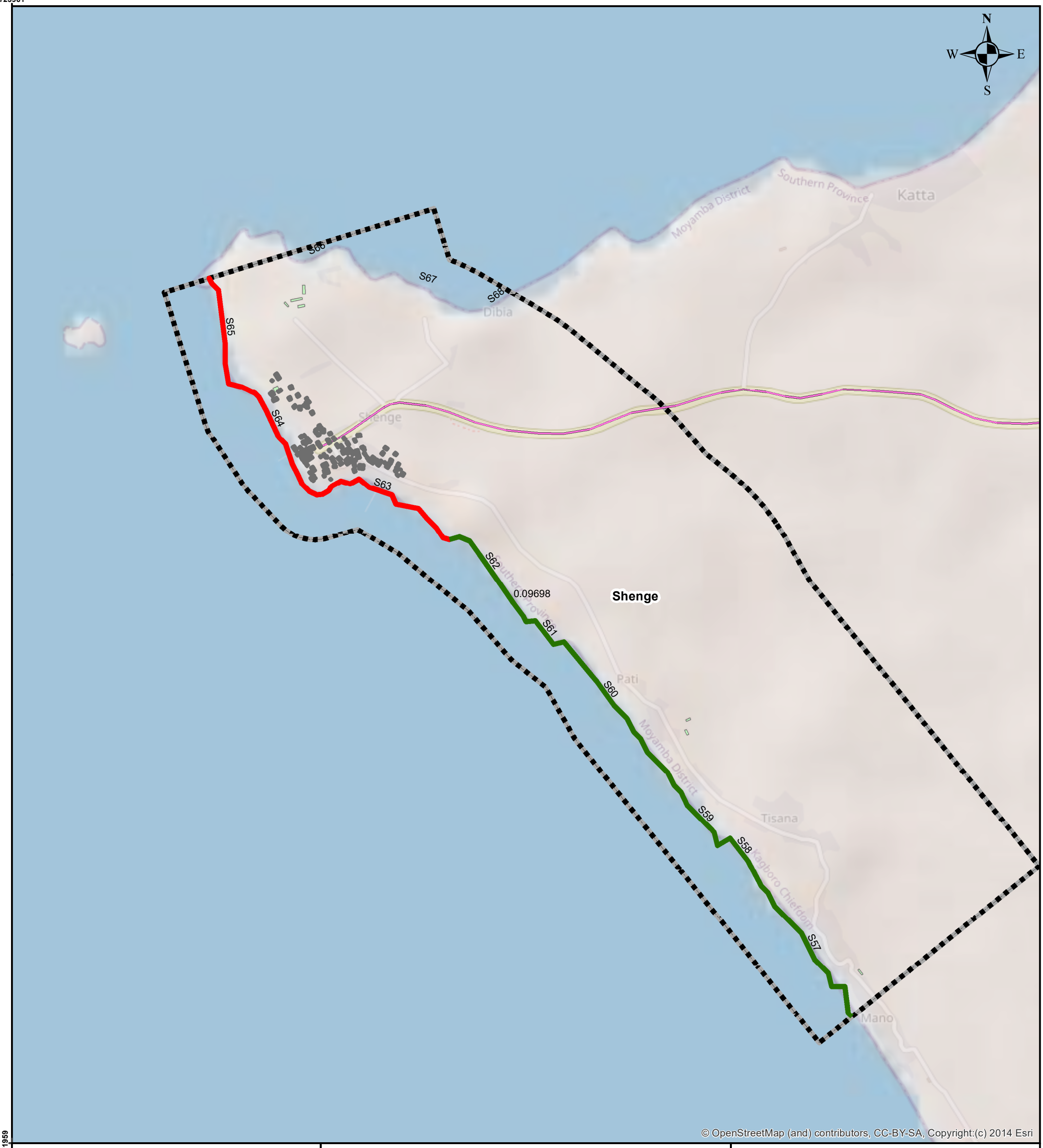


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**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Building Footprints of Shenge

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.225 0.45 0.9 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

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**Building Footprints Vulnerability Ranking**

- Very Low
- Very High
- Major Roads
- Rivers and Streams

The Building footprint data used in this study come from OSM and Drone Aerial photos. U ta, five vulnerability categories based onBuilding footprintst have been established.

The study area falls within very low to very high vulnerability categories based on proximity to the shoreline.

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### 7.3.6 Turtle Islands

**Coastal Geomorphology:** The Turtle Islands is an archipelago that consists of 8 Islands, scattered among the mangroves and sandbanks off the coast in the south of the country. The islands expand in a zone of about 13 km over shallow waters and white sandbanks (Lonely Planet, 2020). The islands are characterised by sand beaches and very low coastal cliffs (see Figure 7-61 and Figure 7-65).

**Coastal Geology:** The Turtle Islands all share the same geology and constitute recent unconsolidated beach sand and clay and are thus all of the moderate vulnerability (see Figure 7-68).

**Coastal Slope:** The Turtle Islands can be generalised as having high slope vulnerability. This is due to the beaches with a slope ranging from 5.5 - 11.5 and adjoining land slopes < 2.2. S50-S53, S26-S27, S14 (see Figure 7-69).

**Coastal Elevation:** The coastlines along Turtle Islands are mostly under high and very high vulnerability areas, 0–10 m, with over half of the Islands' landmass at risk of inundation for an SLR scenario of +4 m amsl (see Figure 7-66 and Figure 7-67).

**Shoreline Change Rate:** Shorelines change rate for Turtle Islands could not be obtained due to positional inaccuracies of satellite imagery between 2006 (Landsat 5) and 2020 (Landsat 8 Imagery). Intermediary years 2010 and 2015 could not be obtained due to data gaps associated with Landsat 7 imagery (see Figure 7-64). As such, INTEGEMS has assigned a shoreline change vulnerability ranking of 3 to the islands based on information acquired from field observations and stakeholder consultations.

**Physical Vulnerability Index:** The calculated PVI scores for Turtle Islands range from 2.63 (S23) to 4.23 (S06, S29) with a mean value of 3.72. Approximately 15.2 km (54.1%) of the 28.1 km Turtle Islands coastline is extremely vulnerable in physical terms (see Figure 7-72). About 9.5 km (33.8%) of the coastline is highly vulnerable, while the remaining 3.4 km (12.1%) is moderately vulnerable.

**Socio-economic Vulnerability Index:** The calculated SVI scores for Turtle Islands range from 2.58 (Multiple chainages) to 3.83 (S14) with a mean value of 2.79. Approximately 4.2 km of the 28.1 km coastline (14.9%) is highly vulnerable in social terms. Chainages S14, S24, S25, S26, S27, S28, S31, S32, S36, S48, S49, S50 scored very high vulnerability scores for access to electricity, access to telecommunication, building material quality and high vulnerability for access to critical infrastructure (see Figure 7-72). The remainder of the Turtle Islands coastline is moderately vulnerable owing mainly to the absence of settlements.

Turtle Islands' very high SVI rating, which is concentrated along the inhabited sections of its coasts are greatly influenced by its lack of adaptive capacity. Although the number of exposed buildings on the islands is relatively low (very low building exposure), the dwelling units are predominantly made of sub-standard building materials (such as mud and wattle walls; thatch roofs and mud floors) without resistant exterior finishing. Thus, making their vulnerability very high based on the quality of building materials.

The community neither have adequate access to healthcare nor education facilities. The only health facility within the islands is a Community Health Centre located in Chepo - the administrative headquarter of Dema Chiefdom and a makeshift health post located in Bumpetoke. The four schools on the islands covered by the assessment are all primary schools with temporary or dilapidated physical structures. Among the three islands, only Yele had a primary school with comparatively adequate physical infrastructure. However, this is not in use due to lack of financial resources to support the school's operations. The islands neither have access to the electricity grid (national or communal) nor mobile telecommunications coverage.

The poor access to critical infrastructures such as schools and healthcare facilities makes the community very vulnerable to social ills and health risks, which are exacerbated by the impact of climate change on livelihoods such as fishing and subsistence agriculture. The predominant land use types within the community include residential, agricultural and touristic along its sandy beaches. The very high exposure of these to sea-level rise and coastal erosion further increases the vulnerability of the islands.

**Integrated Coastal Vulnerability Index:** The calculated ICVI scores for Turtle Islands range from 2.61 (S23) to 3.71 (S50) with a mean value of 3.25. Approximately 26 km (91.67%) of the 28.1 km Turtle Islands coastline is highly vulnerable.

**Table 7-40: Length of Coastline and under different Vulnerability Categories in Turtle Islands**

| Variables | Length of Coastline, km | | | | | |
|---|---|---|---|---|---|---|
| | Very Low | Low | Moderate | High | Very High | Total |
| Coastal Geomorphology | 0 | 0 | 4.2 | 0 | 23.9 | 28.1 |
| Coastal Geology | 0 | 0 | 28.1 | 0 | 0 | 28.1 |
| Coastal Slope | 0 | 3.6 | 19.7 | 4.8 | 0 | 28.1 |
| Coastal Elevation | 0 | 0 | 0.6 | 9.2 | 18.3 | 28.1 |
| Shoreline Change Rate | 0 | 0 | 28.1 | 0 | 0 | 28.1 |
| Tidal Range | 0 | 0 | 28.1 | 0 | 0 | 28.1 |
| Mean Significant Wave Height | 0 | 0 | 28.1 | 0 | 0 | 28.1 |
| **Physical Vulnerability (PVI)** | **0** | **0** | **3.4** | **9.5** | **15.2** | **28.1** |
| Population density | 0 | 22.1 | 5.4 | 0.6 | 0 | 28.1 |
| Road network | 28.1 | 0 | 0 | 0 | 0 | 28.1 |
| Land use/land cover | 18.7 | 6.4 | 0.2 | 0.4 | 2.4 | 28.1 |
| Buildings numbers | 28.1 | 0 | 0 | 0 | 0 | 28.1 |
| Building construction material | 0 | 0 | 0 | 28.1 | 0 | 28.1 |
| Access to schools and health facilities | 0 | 0 | 0 | 0 | 28.1 | 28.1 |
| Access to electricity | 0 | 0 | 0 | 0 | 28.1 | 28.1 |
| Access to telecommunication | 0 | 0 | 0 | 0 | 28.1 | 28.1 |
| **Social Vulnerability (SVI)** | **0** | **0** | **23.9** | **4.2** | **0** | **28.1** |
| **Integrated Coastal Vulnerability (ICVI)** | **0** | **0** | **2.4** | **25.7** | **0** | **28.1** |

**Figure 7-61: Coastal Geomorphology of Turtle Islands**

**Sandy Beach along the inhabited coast of Yele**




**Grass Protected Sandy Beach along the northern coast of Bumpetoke**




**Sandy Beach Flanked Scattered Vegetation in Sei**

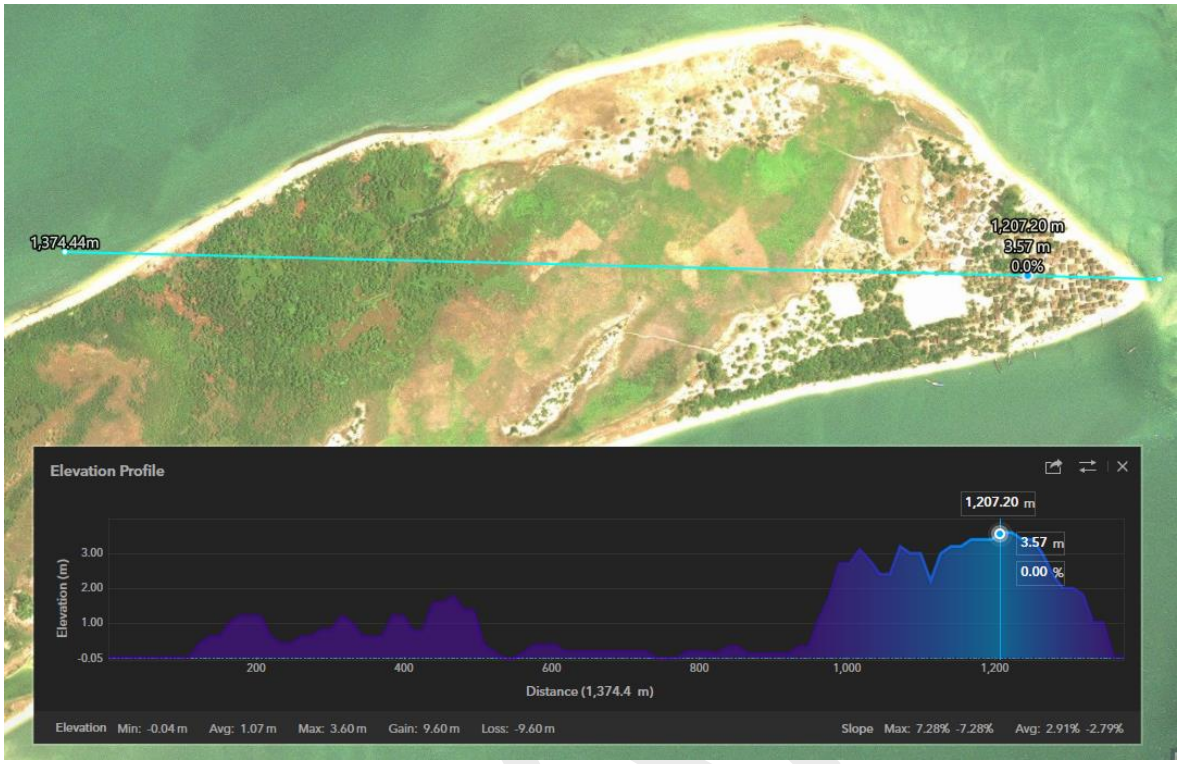


**Sandy Beach Southward toward Mangrove Swamps in Yele**



**Figure 7-62: Elevation Profiles for Turtle Islands (1/2)**

**Bumpetoke**




**Yele**

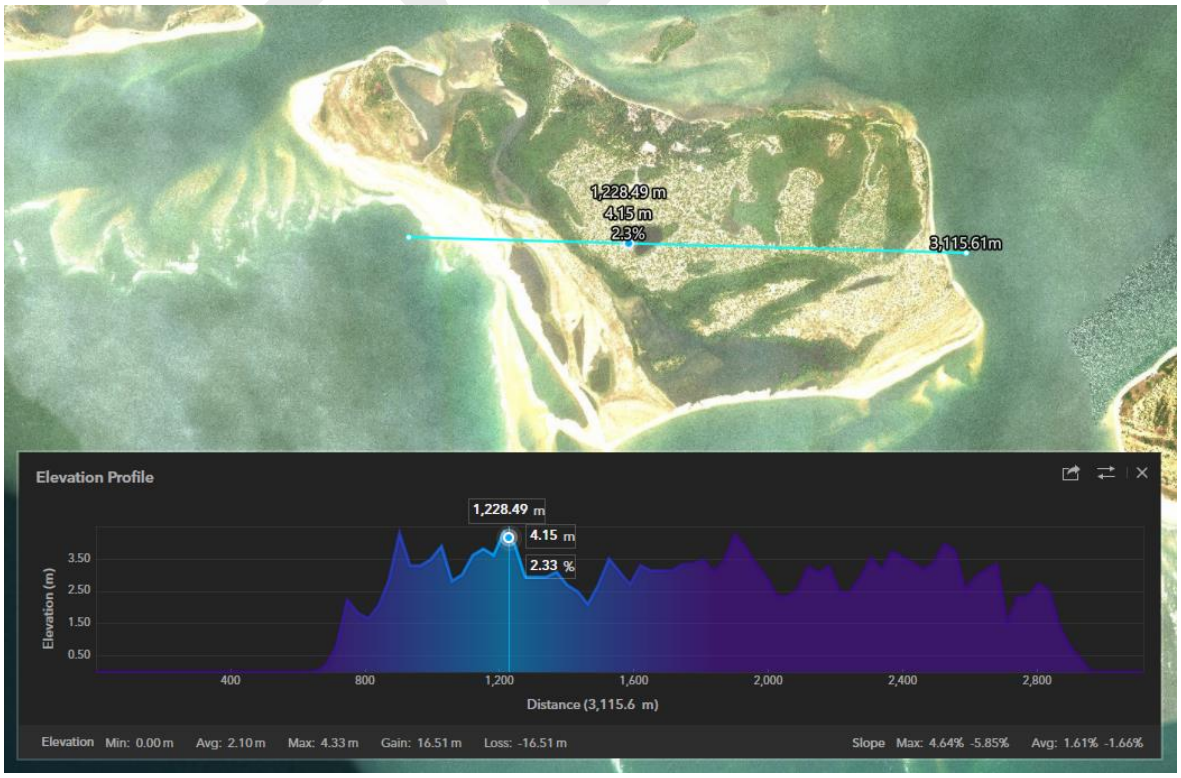


**Figure 7-63: Elevation Profiles for Turtle Islands (2/2)**

**Sei**

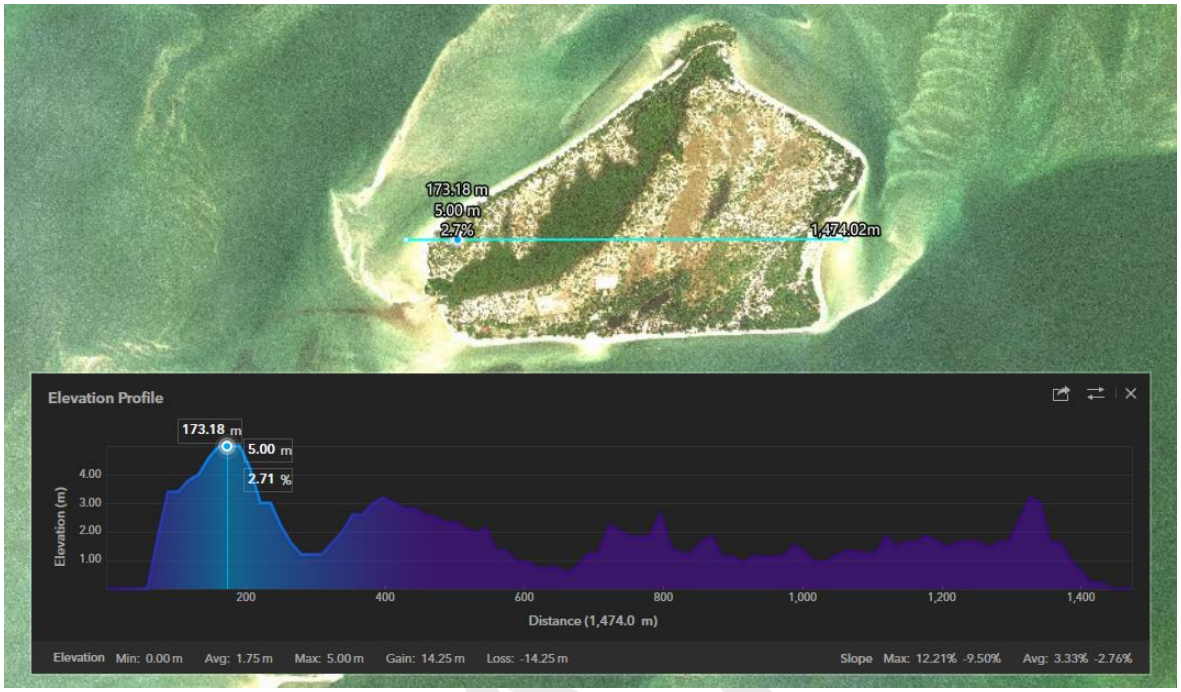



**Figure 7-64: Screenshot of Satellite Imagery Discrepancy for Turtle Islands**

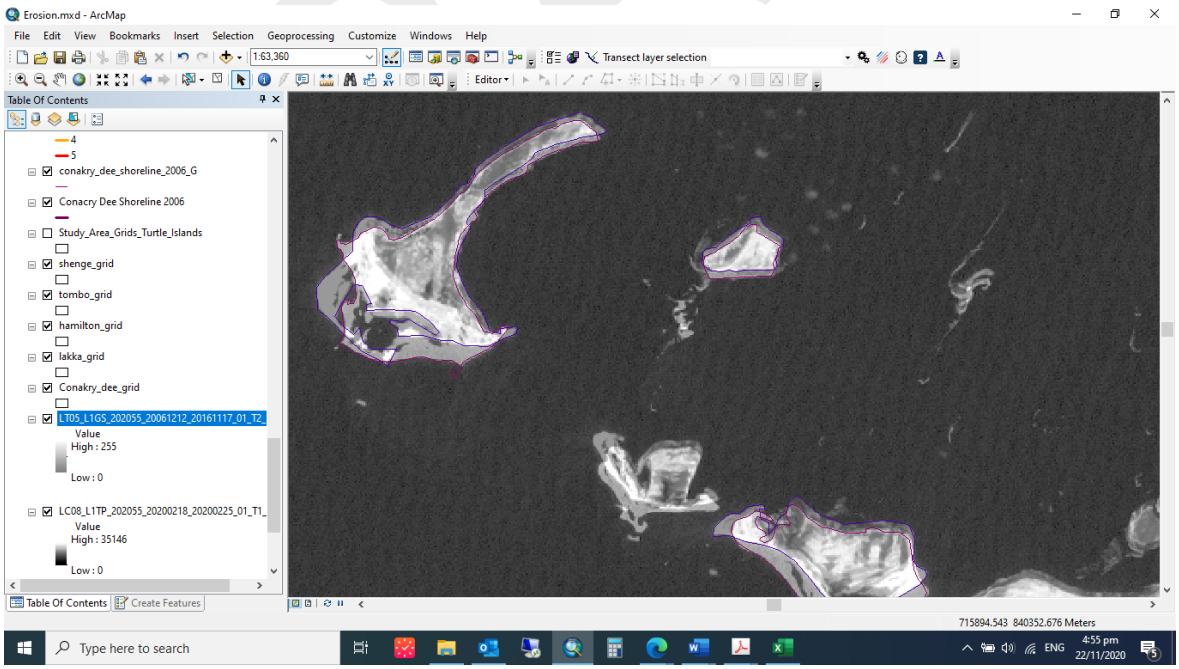


**Figure 7-65: Geomorphology Vulnerability Map of Turtle Islands**

**Figure 7-66: Coastal Elevation Vulnerability Map of Turtle Islands**

**Figure 7-67: Sea Level Rise Scenario Map of Shenge**

**Figure 7-68: Geological Vulnerability Map of Turtle Islands**

**Figure 7-69: Coastal Slope Vulnerability Map of Turtle Islands**

**Figure 7-70: Shoreline Change Vulnerability Map of Turtle Islands**

**Figure 7-71: Tidal Range and Mean Significantly Wave Height Vulnerability Map of Turtle Islands**

**Figure 7-72: Coastal Vulnerability Index Map of Turtle Islands**

**Figure 7-73: Land Use/Land Cover Vulnerability Map of Turtle Islands**

**Figure 7-74: Population Vulnerability Map of Turtle Islands**

**Figure 7-75: Critical Facilities Map of Turtle Islands**

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Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Rivers and Streams

### Geomorphology

**Geomorphology Vulnerability Ranking**

- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Coastal Geomorphology Vulnerability for Turtle Islands

**Figure No:** Figure 6-xx

**Map Scale:** 0 1 2 4 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

The Turtle Islands is an archipelago that consists of 8 Islands, scattered among the mangroves and sandbanks off the coast in the south of the country. The islands expand in a zone of about 13 km over shallow waters and white sandbanks.

The islands are characterised by sand beaches and very low coastal cliffs

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S33 S31 S34 S30 S29 S35 S28 S27 S26 S25

Yele

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## Legend

- Study Area
- Major Roads
- Coastline
- Rivers and Streams

**Coastal Elevation**

- 0 - 5m
- 6 - 10m
- 11 - 20m
- 21 - 30m
- > 30m

**Vulnerability Ranking**

- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Coastal Elevation Vulnerability for Turtle Islands

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.5 1 2 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

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The elevations of the study areas are relatively low, ranging from 0 – 250m amsl. Five coastal elevation vulnerability classes have been established for the study.

All the five vulnerability levels relative to coastal elevation are found within the communities at varying degrees.

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## Legend

Study Area

Major Roads

Coastline

Rivers and Streams

**Sea-Level Rise Scenarios**

**Elevation, m amsl**

- < 1
- 1-2
- 2-3
- 3-4
- 4-5

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Sea Level Rise Scenario for Turtle Islands

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.5 1 2 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

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Using the RCP8.5, SLR to 2050 in Sierra Leone is estimated to be +0.26m meaning that for a calm sea state at the highest astronomical tide, the sea level would be approximately 2m above the current global mean sea level. Therefore, the 2050 scenario sea-level is estimated to be 3 – 4m above the current global mean sea level. A conservative range of 1m – 2m can therefore be assumed for potential storm surge as a high-level estimate.

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Sand, clay, clay sand, Lignite

Bumpetoke

S33 S31 S34 S30 S35 S29 S24 S27 S26 S25

Sei

S12 S13 S14 S08 S09 S10 S15 S11 S17 S07 S06 S16 S04 S05 S03 S01 S02

Yele

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## Legend

- Study Area

### Coastal Geology

- Alluvium & beach sand
- Freetown Complex
- Sand, clay, clay sand, Lignite

### Geological Vulnerability Ranking

- Very Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Geological Vulnerability Ranking of Turtle Islands

**Figure No:** Figure 7-XX

**Map Scale:** 0 0.5 1 2 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

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The Turtle Islands all share the same geology and constitute recent unconsolidated beach sand and clay and are thus all of the moderate vulnerability

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S33 S31 S34 S30 S35 S29 S24 S27 S26 S25

Yele

S12 S13 S14 S08 S09 S10 S17 S07 S16 S15 S11 S06 S04 S03 S01 S02 S05

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Rivers and Streams

**Coastal Slope Vulnerability**

- Very Low
- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Coastal Slope Vulnerability for Turtle Islands

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.5 1 2 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

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**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI, NOAA

Coastal slope is an indicator of the relative risk of inundation and the potential speed of shoreline retreat. Coastal areas with gentle land slope are considered highly vulnerable, since they allow abundant penetration of seawater, whereas location with steeper slopes is assumed as areas of low vulnerability, providing greater resistance to inundation due to rising sea levels and storm surges.

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S33 S31 S34 S30 S35 S29 S24 S27 S26 S25

Yele

S12 S13 S14 S08 S09 S10 S17 S15 S11 S07 S16 S06 S04 S03 S01 S02 S05

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

- Study Area
- Major Roads
- Rivers and Streams

**Shoreline Change Rate Vulnerability**

- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Shoreline Change Rate Vulnerability for Turtle Islands

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.5 1 2 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

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**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI, NOAA

The historical shoreline positions have been for the years 2006, 2010, 2015, and 2020 have been digitised and superimposed for comparison.

The shoreline rate of change has been computed using the ArcGIS Generate Rubbersheet Links to calculate the distance between the baseline shoreline 2006 and the current shoreline 2020.

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## Legend

- Study Area
- Major Roads
- Rivers and Streams

**Significant Wave height**

**Significant Wave Height**

- Low
- Moderate

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** MSWH and Tidal Range Vulnerability for Turtle Islands

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.5 1 2 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

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**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

Significant wave height data used in this study come from a previous work by Anthony (1991). Using the available data, five vulnerability categories based on significant wave height have been established.

The study area falls within low to moderate vulnerability categories based on significant wave heights.

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## Legend

### Vulnerability Index

- Very Low
- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Physical Vulnerability Index of Turtle Islands

**Figure No:** Figure 7-15

**Map Scale:** 0 0.5 1 2 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

The coastal vulnerability idex has been computed as a Integrated Coastal Vulnerability Index from physical and socio-economic variables that define likelihood of coastal hazard occurrence and impact as well as community sensitivity and adaptive capacity.

The ICVI has be computed as the arithmentic mean of the Physical and Social Vulnerability Indices computed using the Spatial Multi-Criteria Evaluation method.

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Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

### Vulnerability Index

- Very Low
- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Social Vulnerability Index of Turtle Islands

**Figure No:** Figure 7-15

**Map Scale:** 0 0.5 1 2 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

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**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

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The ICVI has be computed as the arithmentic mean of the Physical and Social Vulnerability Indices computed using the Spatial Multi-Criteria Evaluation method.

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Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

## Legend

### Vulnerability Index

- Very Low
- Low
- Moderate
- High
- Very High

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Integrated Coastal Vulnerability Index of Turtle Islands

**Figure No:** Figure 7-15

**Map Scale:** 0 0.5 1 2 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

The coastal vulnerabilty idex has been computed as a Integrated Coastal Vulnerability Index from physical and socio-economic variables that define likelihood of coastal hazard occurrence and impact as well as community sensitivity and adaptive capacity.

The ICVI has be computed as the arithmentic mean of the Physical and Social Vulnerability Indices computed using the Spatial Multi-Criteria Evaluation method.

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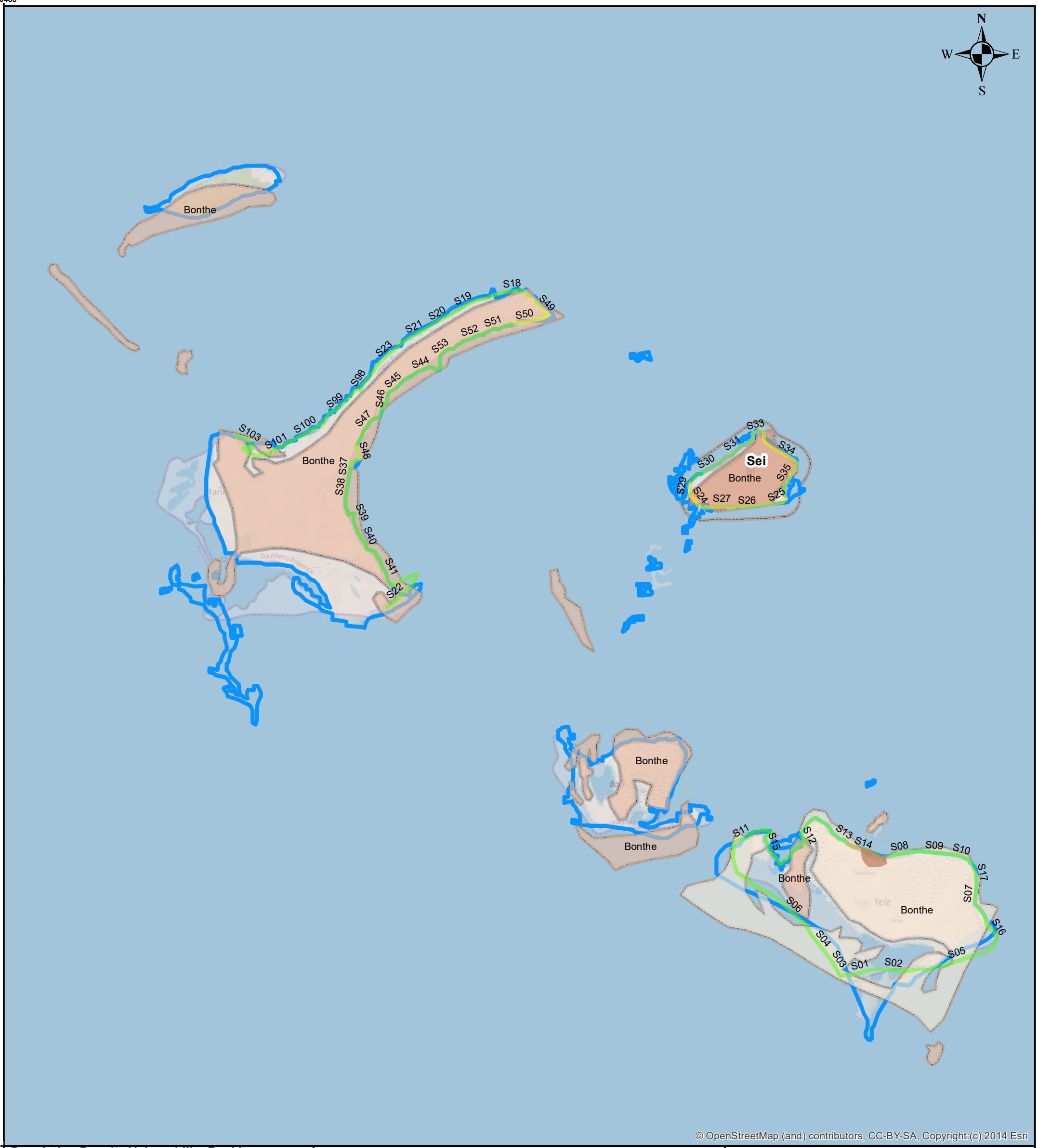


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**Population Density Vulnerability Ranking**

- Very low
- Low
- Moderate
- High
- Very High

**Population Density**

- 1 - 100
- 100 - 500
- 500 - 2000
- 2001 - 10000
- >10000
- Major Roads
- Rivers and Streams

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Population Density for Turtle Islands

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.75 1.5 3 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

The Population densityt data used in this study come from a Stats SL 2015 Population housing Census. Using the available data, five vulnerability categories based on population densityt have been established.

The study area falls within low to moderate vulnerability categories based on Population density.

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1895.196788
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1738.0003
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1921.8547
1317.95871
1838.12864
1474.55052
1799.85257
1390.11026
1199.00676
2446.52152
1420.11921
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900.738591
983.402106
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420.795078
2859.79272
1819.01909
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2236.62893
1233.09803
2194.89787
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352.943918
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Sei
358.739618
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1821.79182
1668.87667
1185.26915
261.157982
1487.19350
1297.76025
796.30595
459.595332
1089.26650
1372.18159
1212.97987
1781.74843
1973.75618
1878.33898
2294.34826
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2487.88718
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1099.58228
1905.68331
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642.355005
2349.13166
175.511756
874.946249
1254.99672
1660.91557
1799.40105
2824.49241
12000
1984.03467
91922.9411
2046.69205
969.014793
496.433544
1142.62070
1661.01996
1792.28106
2096.15856
S06
1807.23678
2000
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2000
1672.50884
262.650342
2343.77282
2116.25190
1296.10680
1674.37295
1841.24502
2077.77076
1718.42049
S04
2318.17207
1440.46552
1237.64582
S03
S01
S02
S05
270.979672
2319.55774
1826.59664
1665.09729
1337.18651
61430.1887
1863.42606
1052.66485
772.424518
1052.66485

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**Building Footprints Vulnerability Ranking**

- Very Low
- Very High
- Major Roads
- Rivers and Streams

**Project Title:** Coastal Vulnerability Assessment for UNDP-GEF Project

**Map Title:** Building Footprints of Turtle Islands

**Figure No:** Figure 6-xx

**Map Scale:** 0 0.75 1.5 3 Kilometers

**Coordinate System:** WGS 1984 UTM Zone 28N

**Date Created:** 18 November 2020

**Created By:** INTEGEMS Limited

**Sources:** INTEGEMS Limited, Stats-SL, USGS, ESRI

The Building footprint data used in this study come from OSM and Drone Aerial photos. U ta, five vulnerability categories based onBuilding footprintst have been established.

The study area falls within very low to very high vulnerability categories based on proximity to the shoreline.

Produced by INTEGEMS Limited: Contact us at info@integems.com if you have any queries or data updates which can improve future products.

The boundaries and names shown and the designations used on this map do not imply endorsement, acceptance or the expression of any opinion whatsoever on the part of INTEGEMS Limited

INTEGEMS
Integrated Geo-information and Environmental Management Services

UNDP

SLMet
Sierra Leone Meteorological Agency

### 7.3.7 Comparative Analysis

Overall, Turtle Islands is the most physically vulnerable community assessed with over 80% of its coastline ranked as highly or extremely (very high) vulnerable to either coastal erosion or inundation. Lakka is the second most vulnerable in physical terms as slightly less than 80% of its coastline is highly or extremely vulnerable. Lakka is followed by Hamilton and Conakry-Dee with 60-65% of both communities' coastline ranked as extremely or highly vulnerable to coastal erosion and inundation. The least physical vulnerability was assessed for Tombo and Shenge, whose coastlines are largely ranked from low to moderate vulnerability.

From a socio-economic perspective, the major differentiator among the coastal communities is whether or not they are rural or urban. Urban communities such as Lakka and Hamilton are moderately vulnerable in socio-economic terms. This vulnerability is mainly driven by the population, housing and sensitive land-use exposure, which were highly ranked. However, the major advantage for these communities is their access to critical infrastructure and their capacity for largely resilient building construction. The only rural community-ranked comparatively on the same scale as Hamilton and Lakka is Shenge. This is mainly due to its low population density and building exposure as well as its fair access to critical infrastructure such as health facility, schools and telecommunications network.

Tombo and Conakry-Dee are the most socio-economically vulnerable communities assessed with almost half of their coastline ranked as highly vulnerable. Tombo, while being an urban community, lacks electricity, which is considered critical for economic growth and disaster resilience. The community is the most densely populated of all the coastal communities assessed. The population of almost 50,000 inhabitants reside in a small area with a predominantly substandard housing infrastructure. Conakry-Dee, while having comparatively good access to critical infrastructure such as electricity from a communal solar grid, health facility and telecommunications network, is almost as highly vulnerable as Tombo. The community's vulnerability is greatly influenced by its population exposure and sub-standard building materials.

While being extremely vulnerable in physical terms, the Turtle Islands is moderately vulnerable in socio-economic terms, mainly due to very low population density and building exposure. However, inhabited areas along the three islands assessed are highly vulnerable in socio-economic terms.

**Table 7-41: Summary of Coastline Length under different Vulnerability Categories**

| Variable/Community | Length of Coastline, km | | | | | |
|---|---|---|---|---|---|---|
| | Very Low | Low | Moderate | High | Very High | Total |
| **Physical Vulnerability (PVI)** | | | | | | |
| Conakry-Dee | 0 | 0 | 1.2 (40%) | 0.7 (20%) | 1.4 (40%) | 3.5 |
| Lakka | 0 | 0 | 0.5 (21.7%) | 0.3 (13.1%) | 1.5 (65.2%) | 2.3 |
| Hamilton | 0 | 0 | 1.5 (37.5%) | 0.5 (12.5%) | 2 (50%) | 4 |
| Tombo | 0 | 0.5 (15.9%) | 1.15 (36.5%) | 1 (31.7) | 0.5 (15.9%) | 3.15 |
| Shenge | 0 | 0 | 4.14 (63.7%) | 1.36 (20.9%) | 1 (15.4%) | 6.5 |
| Turtle Islands | 0 | 0 | 3.4 (12.1%) | 9.5 (33.8%) | 15.2 (54.1%) | 28.1 |
| **Social Vulnerability (SVI)** | | | | | | |
| Conakry-Dee | 0 | 0 | 2 (57%) | 1.5 (43%) | 0 | 3.5 |
| Lakka | 0 | 0 | 2.3 (100%) | 0 | 0 | 2.3 |
| Hamilton | 0 | 1.5 (37.5%) | 2.5 (62.5%) | 0 | 0 | 4 |
| Tombo | 0 | 0 | 1.65 (52.4%) | 1.5 (47.6%) | 0 | 3.15 |

| Variable/Community | Length of Coastline, km | | | | | |
|---|---|---|---|---|---|---|
| | Very Low | Low | Moderate | High | Very High | Total |
| Shenge | 0 | 0.86 (13.2%) | 5.64 (86.8%) | 0 | 0 | 6.5 |
| Turtle Islands | 0 | 0 | 23.9 (85.1%) | 4.2 (14.9%) | 0 | 28.1 |
| **Integrated Coastal Vulnerability (ICVI)** | | | | | | |
| Conakry-Dee | 0 | 0 | 0.5 (14.3%) | 2.5 (71.4%) | 0.5 (14.3%) | 3.5 |
| Lakka | 0 | 0 | 0.8 (34.8%) | 1.5 (65.2%) | 0 | 2.3 |
| Hamilton | 0 | 0 | 1.5 (37.5%) | 2.5 (62.5%) | 0 | 4 |
| Tombo | 0 | 0 | 1.15 (36.5%) | 2 (63.5%) | 0 | 3.15 |
| Shenge | 0 | 0 | 4.5 (69.2%) | 2 (30.8%) | 0 | 6.5 |
| Turtle Islands | 0 | 0 | 2.4 (8.5%) | 25.7 (91.5%) | 0 | 28.1 |

DRAFT

# 8 ADAPTATION ACTION PLAN

The accelerating impacts of climate change, and the need to avoid much larger impacts in the future, bring urgency to scaling up action on adaptation and resilience (World Bank, 2019). According to the IPCC, Adaptation is the process of adjustment to actual or expected climate and its effects in order to either lessen or avoid harm or exploit beneficial opportunities. Adaptation can contribute to the well-being of current and future populations, the security of assets and the maintenance of ecosystem goods, functions and services now and in the future. Adaptation is place- and context-specific, with no single approach for reducing risks, appropriate across all settings (IPCC, 2014).

Coastal adaptation and risk management refer to a wide range of human activities related to the social and institutional processes of framing the adaptation problem, identifying and appraising adaptation options, implementing options, and monitoring and evaluating outcomes. The governance of this process is challenging due to the complex, non-linear dynamics of the coastal socio-ecological systems as well as the presence of multiple management goals, competing preferences of stakeholders, and social conflicts involved.

Effective risk reduction and adaptation strategies consider vulnerability and exposure and their linkages with socio-economic processes, sustainable development, and climate change. Therefore, the first step towards adaptation to future climate change is reducing vulnerability and exposure to present climate variability. Taking the communities history of flooding, demographics, and geography into account, there is a need to begin preparing now for future conditions and impacts. These communities can improve their resiliency to these coastal hazards through planning, preparation and implementation of adaptation and mitigation strategies. Often, these actions are in the form of behavioural changes or structural changes such as designing buildings to withstand higher force winds.

The following sections identify the set of adaptation strategies recommended for the communities. These options presented here have been developed based on the consultations with stakeholders and the local community, findings from the assessments, literature review, expert knowledge and best practice proposed by the IPCC, UNDP, World Bank and other scientific research studies referenced in this Report. The plan builds on the threefold approach first proposed by IPCC CZMS (1990), representing examples of the Protect, Accommodate/Planned and Retreat approaches and other cross-cutting measure typologies for adaptation.

The plan describes the tools relevant to adaptation in coastal areas, options for adaptation of coastal systems, and interventions designed to reduce risks to natural and human coastal systems as a consequence of climate change. It presents the strengths and shortcomings of each strategy or options as well as the trade-offs and considerations for implementation.

The plan, however, does not represent an exhaustive list of the adaptation technologies and/or strategies that are available, but presents the technologies and/or strategies that are most widely used/considered in the coastal zone. The plan is therefore subject to refinement and widespread application as future climate changes.

## 8.1 Objectives

The ultimate goal of the adaptation plan is to provide an initial set of measures to build the adaptive capacities of women and men in the study communities, increase the resilience of the vulnerable individuals, groups, sectors and natural ecosystems to climate change, and optimize mitigation opportunities towards sustainable development. This plan is intended to be a practical guide providing information that may be used by key stakeholders and decision-makers for future planning, preparedness and risk mitigation and adaptation.

## 8.2 Identification of Adaptation Strategies

Adaptation strategies have been identified based on the consultations with stakeholders, the local community, findings from the assessments, expert knowledge and best practice for reducing the adverse impacts of coastal vulnerabilities in the study communities. It has also taken into consideration the suitable approach related to the characteristics of the communities and the means necessary for implementation.

For each adaptation strategy proposed, the following issues are addressed: definition and description; technical advantages and disadvantages; institutional and organisational requirements; potential benefits and costs; and barriers to implementation.

Each adaptation technique has widely varying advantages and shortcomings. As such, selection of measures has been undertaken on a case-by-case basis, which accounts for local conditions. It is widely accepted that the most appropriate adaptation options will vary from area to area. In some cases, adaptation technologies can be complementary; hence, the development of appropriate portfolios of measures should be considered where appropriate (Zhu, et al., 2010)

In deciding which adaptation option to implement, it is important to consider the main purpose and core objectives of the adaptation option. In addition, there is a need to identify and agree upon a set of criteria that will be used to assess the identified adaptation options against the agreed objectives. The objectives may vary between the different communities, and trade-offs will need to be made between adopting all possible measures and living with the risks.

The three main typologies of adaptation approaches by IPCC CZMS are:

1. **Protection**: Protection aims at advancing or holding existing defence lines by means of different options such as land claim; beach and dune nourishment; the construction of artificial dunes and hard structures such as seawalls, sea dikes, and storm surge barriers; or removing invasive and restoring native species.
2. **Accommodation**: Accommodation is achieved by increasing flexibility, floodproofing, flood-resistant agriculture, flood hazard mapping, the implementation of flood warning systems, or replacing armoured with living shorelines.
3. **Retreat**: Retreat options include allowing wetlands to migrate inland, shoreline setbacks, and managed realignment by, for example, breaching coastal defences allowing the creation of intertidal habitat.

While the selection of a protect, accommodate or retreat approach is important, it is essential to note that coastal adaptation consists of more than just implementing one of the three basic interventions. Rather, adaptation is a policy and implementation process involving complementary measures which include comprehensive decision making and technology.

### 8.2.1 Protection Approach

Protection strategies typically employ engineered structures or other measures to protect existing development (or other resources) in its current location without changes to the development itself. Protection strategies can include both hard and soft measures. A hard approach is usually an engineered structure and can be located either alongshore such as a seawall, revetment, or offshore breakwater, or cross-shore such as a groyne, groyne field, or jetty.

A “soft” protection approach may be to nourish beaches, restore sand dunes, or to develop a “living shoreline” which entails the creation of a stabilised sand and cobble complex that would be vegetated with local, native species.

It is important to note that most protection strategies are costly to construct, require increasing maintenance costs, and have secondary consequences to recreation, habitat, and natural defences. Many of these are forms of maladaptation, especially if applied as a long-term solution.

#### 8.2.1.1 Hard Protection Approach

Hard coastal protection is designed for typical local wave and water level conditions, and as such, it is potentially less flexible than soft protection in terms of adaptation to climate change. Hard measures or approach can be particularly applied for concern of erosion along sandy or rocky coasts and essentially include physical measures designed to stop erosion or fix the coastline. These are referred to as “hard” because they generally modify the environment by disrupting natural processes.

Hard engineering opportunities are appropriate where coastal erosion poses the greatest threat of economic loss. These costlier measures should be reserved for sections of coastline where the threat is imminent and where soft engineering measures would not offer enough protection quickly enough. (Arup, INTEGEMS, JBA Risk, BGS, 2019). Hard coastal protection structures are applied with the objective to:

- interrupt the longshore sediment transport;
- dissipate the energy of waves and currents and associated sand transport;
- protect the shore against erosion and flooding; and
- protect the shore against sliding (bluffs, cliffs, dunes).

Examples of hard defences are groynes, detached breakwaters, seawalls, sea dikes and revetments.

#### 8.2.1.1.1 Groyne System

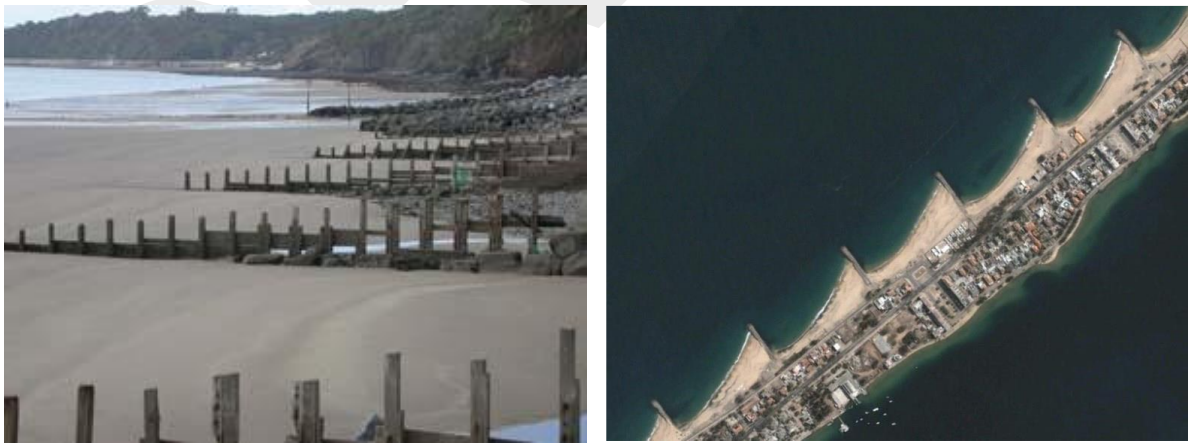
A groyne is a shore protection structure built perpendicular to the shoreline of the coast (or river), over the beach and into the shoreface (the area between the nearshore region and the inner continental shelf), to reduce longshore drift and trap sediments. A groyne field or system is a series of groynes acting together to protect a beach[18].

Groynes have been found to be very effective in stabilizing eroded beaches, particularly in the Republic of Togo, West Africa. Groynes trap sediments from longshore drift so that the coast behind the sand layer is protected from erosion. Their effectiveness depends on the type and their extension into the river or sea. As any other systems acting on the long-shore drift, they can negatively affect the transportation and sedimentation pattern of underflow areas, causing downdrift erosion. Other adverse effects (especially for rivers) can be an increase in current velocity in the constricted flow area, with increasing bed erosion and a deepening of the bed level.

Groynes can be constructed from different materials such as rock, wood, steel, rubble-mound and sand and reinforced concrete. Rock groynes are generally preferred as they are more durable and absorb more wave energy due to their permeable nature.

Timber groynes may be used for temporary structures and are often used to counteract coastal erosion of gravel beaches, possibly in combination with gravel nourishments. The advantage of using wooden/timber groynes with respect to standard rocky groynes is that it is easy to build and fairly cost-effective as it can be constructed with local materials, if damaged they can be repaired locally, and they are generally attractive in terms of appearance. However, their life expectancy is shorter than rock groynes and maintenance costs are higher than for standard groynes.

**Figure 8-1: Examples of Groynes Courtesy Thames-Coromandel District Council – New Zealand[19]**



[18] https://climate-adapt.eea.europa.eu/metadata/adaptation-options/groynes-breakwaters-and-artificial-reefs

[19] https://www.tcdc.govt.nz/Your-Council/News-and-Media/News-and-Public-Notices/News-Archived-Articles/December-2015/November-2015/Trial-groyne-for-Buffalo-Beach-and-update-on-other-coastal-protection-works/

#### 8.2.1.1.2 Breakwater System

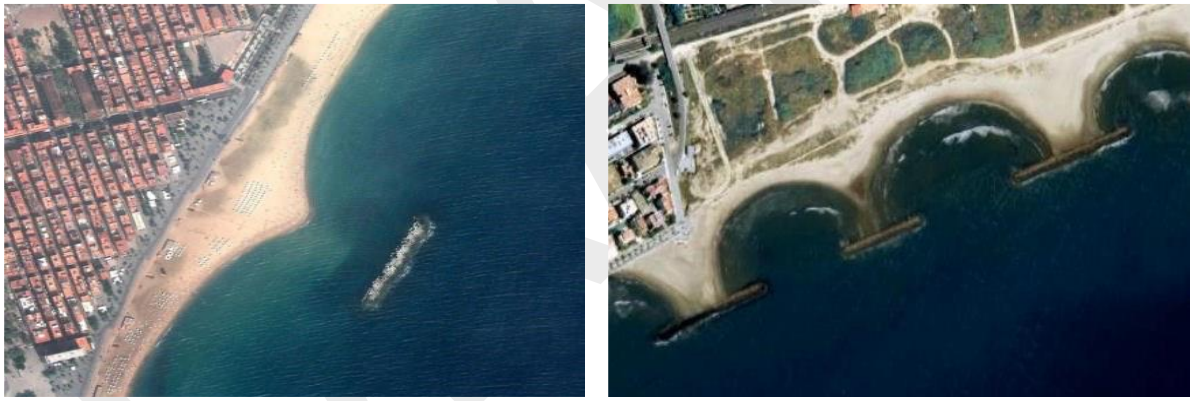
The breakwater system is a shoreline stabilization technique that could be useful in the protection of the beaches along the coast. Breakwater systems have the ability to reduce the strength of breaking waves coming onshore, reduce their impact on the shorelines and thus reduce the quantity of sand eroded.

Detached breakwaters are offshore structures parallel to the shore protecting a section of the shoreline by forming wave-shielded areas (reduction of incident wave energy). There can be many variants in the design of detached breakwaters, including single or segmented, emerged (crest above the high water surface) or submerged (crest below the water surface), narrow or broad-crested, etc. The crest elevation determines the amount of wave energy transmitted over the top of the breakwater. (GFDRR, et al., 2016)

The coastal response depends on the spacing between the structures, the ratio between the breakwater lengths and their distance to the shore, and the level of the breakwater crests. For relatively short emerged breakwaters at a considerable distance from the shore '*salients'* (slight protrusions of the coastline behind the breakwater) will develop. This type of scheme may bypass part of the longshore transport, and therefore lee-side erosion may remain limited. If relatively long breakwaters are constructed close to the shore '*tombolos'* may develop. In this case, sand accumulates behind the structure until the shoreline and structure become connected. This type of scheme tends to interrupt the longshore transport, thus resulting in lee-side erosion similar to a groyne system.

Detached breakwaters are often applied if – in addition to local beach widening – wave height reduction in the nearshore zone is desired. The response of the coast to detached breakwaters is more difficult to predict than for groynes, and therefore this type of structures has a higher risk of being ineffective (or of creating unforeseen adverse effects).

**Figure 8-2: Example of a 'salient' (left) and a series of 'tombolos' (right) (Courtesy of Google)**



#### 8.2.1.1.3 Seawalls and Bulkhead

Seawalls and Bulkhead are shore-parallel structures armouring the shore to protect the land behind it against episodic storm-induced erosion and/or long-term chronic erosion by the sea.

According to UNFCCC 1999, Seawalls are hard engineered structures with a primary function to prevent further erosion of the shoreline. They are built parallel to the shore and aim to hold or prevent sliding of the soil while providing protection from wave action. Although their primary function is erosion reduction, they have a secondary function as coastal flood defences.

The physical form of these structures is highly variable; seawalls can be vertical or sloping and constructed from a wide variety of materials. Seawalls form a defining line between sea and land. They are frequently used in locations where further shore erosion will result in excessive damage, e.g. in Shenge and Tombo when roads and buildings are about to fall into the sea. However, while they prevent further shoreline erosion, they do not deal with the causes of erosion.

Seawalls range in type and may include steel sheet pile walls, monolithic concrete barriers, rubble mound structures, brick or block walls or gabions. Seawalls are typically, heavily engineered, inflexible

structures and are generally expensive to construct and require proper design and construction supervision (UNFCCC, 1999).

The main advantage of a seawall is that it provides a high degree of protection against coastal flooding and erosion. A well maintained and appropriately designed seawall will also fix the boundary between the sea and land to ensure no further erosion will occur – this is beneficial if the shoreline is home to important infrastructure or other buildings of importance.

However, seawalls are subjected to significant loadings, as a result of wave impact. These loadings increase with water depth in front of the structure because this enables larger waves close to the shoreline. Seawalls are designed to dissipate or reflect incoming wave energy and as such, must be designed to remain stable under extreme wave loadings. The effects of SLR increased wave heights, and increased storminess caused by climate change must also be taken into account.

Bulkheads are normally constructed in the form of a vertical wall built in concrete, stone, steel or timber. The concrete, steel or timber walls can be piled and anchored walls, whereas the concrete and stone walls can also be constructed as gravity walls. The function of a bulkhead is, in protected environments, to retain or prevent the sliding of land at the transition between the land, filled or natural, and the sea. Bulkheads function well as a separation between land and sea in marina basins, and along protected shorelines. They are used along natural shorelines and along with filled areas, where a well-defined separation between land and sea is required.

**Figure 8-3: Example of Seawall (L) Courtesy - Google and Bulkhead in Lakka ® Courtesy - INTEGEMS)**



#### 8.2.1.1.4 Rock Amour Revetments

The rock armour is typically formed from boulders/large pieces of rock engineered to form a revetment (seaward facing slope). The toe of the revetment has to be dug down to allow for future beach lowering (Bradbury, 1980). It may be necessary to provide supportive coastal structures such as groynes (or offshore breakwaters to retain some of the sand on the beach and prevent long term undermining of the revetment. A rock armour revetment is designed to 'hold the line' against any further coastal erosion.

This measure could be suitable where areas of coast have buildings located at the top of the beaches and the consequences of further erosion and/or wave overtopping are unacceptably high. Since it is a long-term measure and requires design, this option is costlier than riprap and should be used in more vulnerable/higher risk areas, such as along Conakry-Dee and Shenge. Revetments take up more space but provide wave absorption on erodible coastal-front compared to the fully reflective vertical seawalls.

**Figure 8-4: Rock Amour Revetments at Tombo (L) and Conakry Dee ® Courtesy of INTEGEMS)**







#### 8.2.1.1.5 Sea Dikes

The primary function of sea dikes is to protect low-lying, coastal areas from inundation by the sea under extreme conditions (Pilarczyk, 1998a). Dikes are not intended to preserve beaches which may occur in front of the structure or any adjoining, unprotected beaches. These structures have a high volume which helps to resist water pressure, sloping sides to reduce wave loadings and crest heights sufficient to prevent overtopping by floodwaters. They may also be referred to as dykes, embankments, levees, flood banks and stopbanks.

It is a predominantly earth structure consisting of a sand core, a watertight outer protection layer, toe protection and a drainage channel. These structures are designed to resist wave action and prevent or minimise overtopping.

**Figure 8-5: Embankments at Shenge (L) and Hamilton (R)**






#### 8.2.1.1.6 Storm Surge Barriers

Storm surge gates/flood barriers are fixed installations that allow water to pass in normal conditions and have gates or bulkheads that can be closed against storm surges or spring tides to prevent flooding. They can close the sea mouth of a river or waterway. These barriers can be major infrastructure systems involving high costs for construction and are often linked with other flood protection measures, such as dikes, seawalls and beach nourishment. Storm surge barriers are normally used to protect urban settlements and infrastructure heavily affected by storm surges and sea flooding. Due to their expense and potential impacts, storm surge gates/flood barriers are relatively rare. They are built to protect urban areas and infrastructure where storm surges and sea flooding could have major impacts ( ClimateADAPT, 2020).

Storm surge barriers and closure dams provide a high degree of protection against coastal flooding by preventing storm surges from entering low-lying estuarine areas. Although permanently closing off the estuary mouth using a closure dam, would achieve the same outcome, the use of a movable barrier allows waterways to remain open during normal conditions. This can be beneficial to trade if the estuary also acts as a trading port and is also valuable for estuarine species reliant on brackish water conditions.

**Figure 8-6: Examples of Storm Surge in the Netherlands (Courtesy of Google)**





### 8.2.1.2 Soft Protection

A soft solution uses natural processes and materials for protection that focus on the preservation of the coastline's existing natural defence features. Examples of soft protection approaches are sand or gravel nourishments, vegetation planting and coral reef restoration. Application of soft defences helps to maintain the natural landscape and habitat function of the coast. By working with natural processes, the environmental impact can be minimised, and new environmental opportunities can be created. However, a key consideration when applying soft engineered measures is that these solutions require ongoing and regular monitoring, maintenance and engineering (GFDRR, et al., 2016).

#### 8.2.1.2.1 Beach and Dune Nourishment

Beach and dune nourishment is the process of adding sand to enlarge and enhance the beach and dune features along the coast. With this measure, sand is mechanically placed at the coast to advance the shoreline or restore the amount of sand in the littoral system. This measure leaves the beach in a natural state and preserves its recreational value. Planting grasses and native vegetation is often included with dune nourishment to enhance the habitat value and stabilize the dune feature.

If performed well, the benefits of nourishment are many and varied. Most importantly, beach nourishment reduces the detrimental impacts of coastal erosion by providing additional sediment which satisfies erosional forces. Shoreline erosion will continue to occur, but the widened and deepened beach will provide a buffer to protect coastal infrastructure and other assets from the effects of coastal erosion and storm damage.

On shorelines with little or no beach area such as Tombo and Turtle Island, waves will break against the backshore area or in the nearshore zone with the run-up to the backshore. The energy in these waves and the run-up can be significant enough to damage backshore developments through flooding, erosion, scour, and water damage. This type of adaptation option is also well suited for the Hamilton where the beach and dune area are limited, and it's highly likely that the beach will be covered by rising sea level or eroded by waves and currents. The volume of sand and rate of nourishment can be modified and adjusted to adapt to rising sea level.

Nourishment is not a permanent solution to shoreline erosion. Periodic re-nourishments or replenishments will be needed to maintain effectiveness; otherwise, the beach nourishment will gradually disappear due to erosion.

Two main sources have and will continue to provide the sand for great beach nourishment efforts. These are sand from dredging and sand from an offshore excavation. The key considerations in implementing this option are:

i. the sediment type of the dredged material and that of the beach must be compatible.

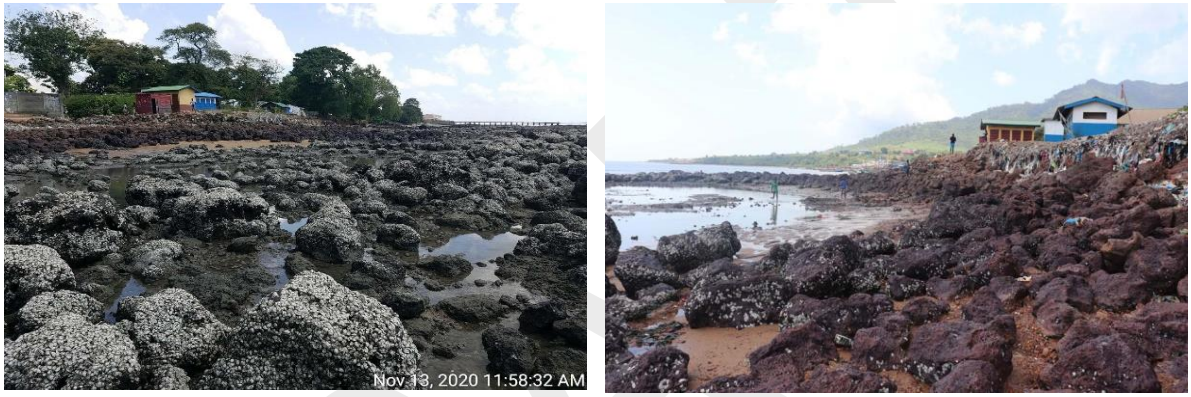
ii. the dredged sediments must be pollutant-free.

iii. when using dredged material to create/enhance dunes or intertidal/subtidal habitats, it is necessary to plant vegetation. This serves dual functions. It creates high-quality habitat and stabilizes the sediment.

#### 8.2.1.2.2 Riprap

Riprap consists of wide graded relatively small pieces of rock placed at the top of beaches. This measure does not prevent coastal erosion, but it will slow the process and help stabilise the crest/top of the beach. The beach will continue to lower, and the riprap will lower with it. Riprap is an appropriate measure for areas of the coast that comprise sandy beaches, but that also have buildings located at the top of the beaches as in Lakka. It may be necessary to top up the riprap from time to time, and one negative of using riprap is that it may restrict access to the beach. It is therefore not effective in the medium term but a quick cheap, and easily implemented short term measure. This option is less costly than the rock armour revetment option so should be used in less vulnerable/lower-risk areas (Arup, INTEGEMS, JBA Risk, BGS, 2019).

**Figure 8-7: Examples of Rip Rap shown in Tombo, Courtesy- INTEGEMS**




#### 8.2.1.2.3 Coastal Restoration Using Vegetation

Vegetation such as salt marshes, mangroves and seagrasses in the coastal zone attenuates wave energy and may reduce the impact of storm surges. In addition, it stabilizes the bed against erosion and may induce sedimentation. Moreover, it provides habitats for fish, birds and insects. Especially in muddy areas vegetation can be an effective coastal measure, since in such areas potential large volumes of sediment can be trapped. Hard structures may enhance erosion in such areas and collapse, which results in high construction and maintenance costs. The natural structure becomes part of the dynamic behaving systems induced by natural cycles such as seasons and succession and dynamic forcing of the boundary conditions such as sea level, wave energy and sediment availability.

Saltmarshes are areas of land covered principally by salt-tolerant, grass-like vegetation and inundated by the tides. Mangroves are woody trees or shrubs that occur naturally in brackish waters or estuarine wetlands along sheltered tropical and subtropical shores and estuaries. Seagrasses are flowering, underwater plants that are typically found in marine or estuarine waters continuously flooded by the sea. The effectiveness of vegetation as a coastal defence depends largely on the type, height and density of the vegetation, the underlying topography, the height and period of the incoming waves, and the water depth (WorldBank, 2016).

### 8.2.2 Accommodation Approach

The accommodation approach involves the continued occupancy and use of vulnerable zones by increasing society's ability to cope with the effects of extreme events (IPCC, 1990). A distinction can be made between two technologies:

1. Technology with physical changes to accommodate the flooding and/or erosion, e.g. flood-proofing and wetland restoration.
2. Information systems which enhance our understanding and awareness of coastal risks and enable coastal populations to undertake appropriate responses to minimise the impact of these events. e.g. flood hazard mapping and early warning systems.

Flood-proofing, floating agricultural systems and wetland restoration represent the first approach, while flood hazard mapping and flood warnings are the second approaches.

#### 8.2.2.1 Floodproofing

The primary objective of flood-proofing is to reduce or avoid the impacts of coastal flooding upon structures. This may include elevating structures above the floodplain, employing designs and building materials which make structures more resilient to flood damage and preventing floodwaters from entering structures in the flood zone, amongst other measures.

Two types of flood-proofing are widely recognised: wet and dry. Wet flood-proofing reduces damage from flooding in three ways; (1) allowing floodwaters to easily enter and exit a structure in order to minimise structural damage; (2) use of flood damage-resistant materials; and (3) elevating important utilities. According to FEMA, 2010, wet flood-proofing measures typically include structural measures, such as properly anchoring structures against flood flows, using flood-resistant materials below the expected flood depth, protection of mechanical and utility equipment and use of openings or breakaway walls to allow passage of floodwaters without causing major structural damage.

On the other hand, dry flood-proofing is the practice of making a building watertight or substantially impermeable to floodwaters up to the expected flood height (FEMA, 2008). A dry flood-proofed structure is made watertight below the expected flood level in order to prevent floodwaters from entering in the first place. Making the structure watertight requires sealing the walls with waterproof coatings, impermeable membranes, or a supplemental layer of masonry or concrete, installing watertight shields on openings and fitting measures to prevent sewer backup. Flood-proofing can be applied in residential and non-residential buildings, and the principles of flood-proof design can also be applied to other important infrastructures such as electricity substations and sewage treatment works. Obviously, the decision to choose wet or dry flood-proofing should be influenced by the use of the structure being protected and the compatibility with floodwaters.

One of the main advantages of flood-proofing is that it avoids the need to elevate, demolish or relocate structures and as a result, is often a much more cost-effective approach to reducing flood risk. Floodproofing measures are also much more affordable than the construction of elaborate flood protection works such as seawalls and dike systems.

**Figure 8-8: Example floodproofing Google Image (L), Tombo ( R)**





### 8.2.2.2 Wetland Restoration

The primary objective of wetland restoration can be three-fold. These projects can serve to reduce coastal flooding and erosion and can also provide new habitats and environmental benefits. The term 'wetland' refers to a diverse range of shallow water and intertidal habitats, which occur in various locations around the world. Wetland restoration relates to the rehabilitation of previously existing wetland functions from a more impaired to a less impaired or unimpaired state of overall function.

According to Brampton, 1992, the most commonly restored wetland ecosystems for coastal protection are saltmarshes and mangroves. Seagrasses may also be employed as coastal defence, to dampen waves but on their own, they are seldom considered an adequate shore protection alternative. Wetland habitats are important because they perform essential functions in terms of coastal flood and erosion management. They induce wave and tidal energy dissipation and act as a sediment trap for materials, thus helping to build land seawards. Wetland restoration re-establishes these advantageous functions for the benefits of coastal flood and erosion protection.

Wetland restoration is also likely to require a degree of expertise, especially in locations where wetland recolonisation has to be encouraged by transplanting wetland plants. Some wetland habitats will no doubt be more difficult to recreate than others and could require greater expertise.

### 8.2.2.3 Floating Agriculture

Floating agriculture is a way of utilising areas which are waterlogged for long periods of time in the production of food. The technology is mainly aimed at adapting to more regular or prolonged flooding. The approach employs beds of rotting vegetation, which act as compost for crop growth. These beds are able to float on the surface of the water, thus creating areas of land suitable for agriculture within waterlogged regions like the Turtle Islands. Scientifically, floating agriculture may be referred to as hydroponics.

**Figure 8-9: Examples of Floating Agriculture Google Images.**



### 8.2.2.4 Flood Hazard and Risk Mapping

Flood hazard mapping is an exercise to define those coastal areas which are at risk of flooding under extreme conditions. As such, its primary objective is to reduce the impact of coastal flooding. However, mapping of erosion risk areas may serve to achieve erosion risk reduction. It acts as an information system to enhance the understanding and awareness of coastal risk.

Flood Hazard Mapping is a vital component for appropriate land use planning in flood-prone areas. It creates easily-read, rapidly-accessible charts and maps which facilitate the identification of areas at risk of flooding and also helps prioritise mitigation and response efforts (Bapulu & Sinha, 2005).

Hazard and risk maps are easily-read charts and maps identifying areas which are at risk of flooding under extreme conditions. It acts as an information system to enhance the understanding and awareness of coastal risks. It also facilitates administrators and planners to identify areas of risk and prioritise their mitigation/ response efforts. Flood hazard mapping is often carried out by means of numerical models since records on extreme coastal events, and flooding extents are sparse.

#### 8.2.2.5 Flood Warnings

A flood warning system is a way of detecting threatening events in advance. This enables the public to be warned so that actions can be taken to reduce the adverse effects of the event. As such, the primary objective of a flood warning system is to reduce exposure to coastal flooding.

Flood warnings are a highly important adaptive measure where protection through large scale, hard defences, is not desirable or possible. This may be the case if defences would cause adverse environmental or social problems, or where the cost of defence construction would be prohibitive.

A flood warning process has two distinct stages: flood warning and response. These stages are composed of a number of sub-stages and are linked through the dissemination of warnings. The flood warning stage requires constant monitoring of meteorological conditions. This allows the detection and assessment of threatening events to take place before it hits a community. Forecasts may also be made to help decision-makers model how an event is likely to develop, how significant it will be upon arrival, and what sections of the population are likely to be at risk. This is necessary because the simple detection of an event will not provide enough time to undertake appropriate responses. To achieve monitoring and forecasting, it is likely that a flood warning system will include meteorological and tidal detection systems and river and coastal flood forecasting models.

#### 8.2.2.6 Water Resource Management and Protection

Many of the impacts of climate change will be related to water, either too much of it or not enough. A number of the measures can be used to help protect coastal communities from too much water—sea level rise and other types of inundation, in particular. This category includes measures that can be taken to manage stormwater, shallow urban flooding that tends to result from heavy precipitation events rather than rising waters and to manage water supplies in anticipation of dry periods and corresponding water shortages. These are activities that, along with floodplain management, would benefit from being managed together as part of a comprehensive, integrated water resources management program. This includes stormwater management and water supply management.

In general, the purpose of stormwater management is to control the number of pollutants, sediments, and nutrients entering water bodies through precipitation generated runoff. However, it also plays an important role in preventing damage to the built environment and the natural systems that protect it. Existing drainage systems may be ill-equipped to handle the amount of stormwater runoff that will accompany the more intense rainfall events expected in the future. Those in low-lying areas such as Lakka and Hamilton will be further challenged by losses in elevation attributed to rising sea levels.

To accommodate these changes, coastal communities may need to modify and enhance the capacity of their drainage systems and should consider climate change when implementing and updating existing stormwater management plans. Modifications may include limiting/removing impervious surfaces; acquiring easements for new and wider drainage ditches; implementing and enforcing stream dumping regulations; improving carrying and storage capacity of streams, channels, and basins through ongoing maintenance; and installing larger pipes and culverts amongst others (NOAA, 2010).

#### 8.2.2.7 Diversified Livelihoods

According to Ellis, 1998, Livelihood diversification is defined as the process by which rural families construct a diverse portfolio of activities and social support capabilities in their struggle for survival and in order to improve their standards of living. This may involve Fisheries Sector Good Practices and Tourism Best Management Practices. Fisheries is an important sector that supports livelihoods, food security and marine biodiversity in the study communities. Good practices in fisheries management, including production, infrastructure, operations, and ecosystem protection can be used or adapted to help address the likely impacts of climate change on this vitally important sector. Tourism development best management practices (BMPs) provide the tourism sector with practical tools for both adapting to climate change conditions and mitigating greenhouse emissions. Climate change will directly impact many tourism activities within these communities.

### 8.2.3 Retreat Approach

Processes such as sea-level rise, coastal erosion and flood risk can cause hazards to life and property. A possible solution is to relocate the populations at risk away from the at-risk area. The retreat approach refers to planned actions to relocate or remove existing development out of hazard areas and limit the construction of new development in vulnerable areas. These strategies include creating land use designations and zoning ordinances that encourage building in less hazardous areas, establishing 'setback' area, which creates a buffer between the hazard origin and buildings and infrastructure, or gradually remove and relocate existing development. Acquisition and buy-out programs, transfer of development rights programs, and removal of structures are examples of strategies designed to encourage retreat.

Another retreat approach is deliberately reshaping existing flood defences in order to set back the coastline; this is called 'managed realignment'. By managing the flooding of a currently defended area, negative impacts are avoided, and an intertidal habitat between the old and new defence is created.

This category of coastal management approach is concerned with both coastal flooding and coastal erosion and includes measures ranging from an action on an individual building to increasing the resilience of society, including the strategic retreat. These measures, therefore, generally involve significant socio-economic and institutional issue.

#### 8.2.3.1 Managed Realignment

Managed realignment is able to reduce both coastal flooding and erosion. It is the deliberate process of altering flood defences to allow flooding of a presently defended area. Managing this process helps to avoid uncertain outcomes and negative impacts. A number of terms may be used as an alternative to managed realignment. These include managed retreat, dike realignment, dike (re)opening, de-embankment and de-polarisation. Managed realignment generally involves setting back the line of actively maintained defences to a new line, inland of the original or preferably, to rising ground. Doing so should promote the creation of intertidal habitat between the old and new defences. In most cases, the objective of realignment is to create saltmarshes. Saltmarshes develop between mean high-water springs (MHWS) and mean low water springs (MLWS), in areas shaped predominantly by tidal processes and where silts and mud are predominant.

The benefit of creating intertidal habitats lies in the fact that they are highly effective at attenuating wave energy. This helps to reduce offshore sediment transport and therefore, erosion. Managed realignment may involve deliberate breaching or the complete removal of a current coastal defence. The process can be planned through abandonment or relocation of existing defences or unplanned through the abandonment of defences if, for example, financial resources for maintaining defences are not available.

One of the biggest drawbacks of managed realignment is that the option requires land to be yielded to the sea. This may require the relocation of important infrastructure or buildings, potentially at a high cost. Alternatively, the land may be able to be used in other ways, such as for recreation. In both instances, valuable land on the seafront is required to be relinquished.

#### 8.2.3.2 Coastal Setbacks

Coastal setbacks are a prescribed distance to a coastal feature such as the line of permanent vegetation, within which all or certain types of development are prohibited. A setback may dictate a minimum distance from the shoreline for new buildings or infrastructure facilities or may state a minimum elevation above sea level for development. Elevation setbacks are used to adapt to coastal flooding, while lateral setbacks deal with coastal erosion. Setbacks provide a highly effective method of minimising property damage due to coastal flooding and erosion by removing structures from the hazard zone. They provide a low-cost alternative to shoreline erosion or flood protection works such as seawalls or dikes, which have their own disadvantages.

Unlike hard structures, setbacks help to maintain the natural appearance of the coastline and preserve natural shoreline dynamics. Setbacks also help to maintain shoreline access by preventing development immediately on the seafront as well as providing open space for the enjoyment of the natural shoreline (NOAA, 2010). Over time, SLR will reduce the size of the buffer zone between structures and the sea. As a result, setbacks will need to be periodically reviewed to ensure that buffer zones continue to provide sufficient protection.

### 8.2.4 Complementary Approach

Different types of approach may be appropriate in different locations and for different hazard management and resource protection goals, and potentially different time horizons. The effectiveness of different adaptation strategies will vary across both spatial and temporal scales. In many cases, a hybrid approach that uses strategies from multiple categories described above will be necessary, and the suite of strategies chosen may need to change over time.

This category includes measures that can be part of any adaptation management approach. They are essentially socio-economic or institutional measures, which are not specifically aimed at fulfilling the conditions of a particular management method but are often necessary to provide a framework and optimum conditions for implementing a particular type of adaptation measure/option. They can be targeted to improving knowledge, education and or providing information for citizens. (ELSEVIER, 2020).

This sort of approach should be locally driven so that it can address both climate change impacts and development deficits for the vulnerable poor and strengthen the adaptive capacity of local people to climate and non-climate risk factors. It should involve all relevant stakeholders, especially local communities and should be developed through active participatory processes.

#### 8.2.4.1 Public Awareness and Outreach Activities

Public awareness and outreach activities through which the public is informed of the danger of living in coastal lowlands that are at risk of being affected by sea-level rise (SLR) impacts and risks could be a cost-effective means of reducing future expenditures.

Awareness-raising and education campaigns help convey information about the impacts of climate change and gain consensus on adaptation options. Governments need to engage more actively with the scientific community and provide easily accessible and up-to-date climate change information relevant to the needs of coastal sectors.

#### 8.2.4.2 Knowledge and Capacity Building

Central to a successful adaptation effort is the need to build knowledge and capacity of all stakeholders involved. Stakeholders include individuals who can effect change, have relevant knowledge or skills, represent the interests of particular groups, and/or will be affected by climate change. They will include the members of the government institutions (state and local), coastal landowners and the general public.

This knowledge will allow climate change considerations to be built into the initial design of an adaptation project. This is beneficial because designing and building a robust system which offers sufficient protection from the beginning, is also less expensive than building a less robust system which requires periodic upgrades to cope with climate change.

#### 8.2.4.3 Community-Based Disaster Risk

Community-based disaster risk management is a strategy comprised of structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects of natural hazards. Communities engage in a systematic process of administrative decisions, apply organizational and operational skills, and implement policies and strategies to enhance their coping capacities to the impacts of hazards and related disasters.

#### 8.2.4.4 Capturing Local Experience

Coastal adaptation in a specific place or area builds practical experience and a sense of ownership for those living and working there. This experience can be shared amongst different actors at the national level to build capacity. Linkages between local communities and government strengthen community voice in planning and national policy-making for coastal adaptation to climate change.

#### 8.2.4.5 Integrated Coastal Zone Management (ICZM)

ICZM is a dynamic, multidisciplinary and iterative process to promote sustainable management of coastal zones. The ICZM seeks over the long-term, to balance environment, socio-economic, cultural and recreational objectives all within limits set by natural dynamics. It covers the full cycle of information collection, planning, decision making, management and monitoring of the implementation in the coastal zone.

#### 8.2.4.6 Adaptation Monitoring

Monitoring is an important aspect of adaptation because it helps to assess whether the adaptation has achieved its goals and can also yield new insights and information which give rise to strategy adjustments as appropriate.

Monitoring requirements will largely be dictated by the goals of the project. Common goals are likely to include coastal defence and habitat creation/improvement. The goals of adaptation should be clear before a project goes ahead, and monitoring should collect appropriate information to help determine whether the project has achieved these goals. Because monitoring requirements vary with the project goals, it is foreseeable the application of one adaptation technology at two different sites could have very different monitoring requirements, if the project goals are different.

## 8.3 Benefits and Drawbacks of Adaptation Options

Deciding on the best course of adaptation action is not always easy. Issues are complex, and there is a lot of uncertainty. Community leaders, Governments, Development Partners, Business and individuals find themselves grappling with questions like:

- How will sea-level rise and increased storm surge affect my community?
- What can we do to adapt?
- What is the best adaptation strategy?
- What is the cost of adapting?
- What is the cost of doing nothing?
- How much will it cost to keep my community safe?

Once the community understands the severity of the risk and vulnerabilities from coastal hazards, the next step is to explore how to adapt to these risks. By understanding the costs and benefits of different adaptation strategies, decision-makers can make more fully informed decisions that are fiscally responsible in the short, medium and long terms.

More importantly, economically informed decision-making will lead to safer, more responsible, economically sound communities. In the long run, the entire community benefits by investing in adaptation efforts. Up-front investments can help ensure a successful future. By accounting for the full costs of adaptation, decision-makers can make strategic choices about where, when, and how to make investments in adaptation to maximize benefits and minimise risk.

The costs of adaptation can vary significantly depending on the unique characteristics of the community (local conditions and circumstances); non-economic factors such as legal challenges or public outreach needs (which can increase the resources needed to implement an option); and the severity of future events.

In addition, it can be challenging to include reliable estimates of things that are valuable but not valued in markets: for example, the costs and benefits often associated with issues such as environmental goods and services and social or cultural values. This can mean that non-market costs and benefits are excluded, and consequently, the results of the analysis are misleading.

The table below shows the list of adaptation options assessed above with the benefits and drawbacks of each option and applying estimated cost values for implementation. Some of these adaptation options can be implemented as a combination or standalone. Some may be more geared to an entire community, and others are more applicable to protecting priority infrastructure. The financial cost is not the only criterion on which adaptation should be judged –might result in a more expensive option being favoured, especially where multiple benefits results.

**Table 8-1: Benefits and Drawbacks of Adaptation Options**

| Adaptation Option/Measure | Benefits | Disadvantage/Drawbacks | Considerations for The Implementation |
|---|---|---|---|
| **Protection Approach** | | | |
| **Groyne System** | • Prevents longshore drift moving beach material along the coast.<br>• Allows the build-up of a beach which not only protects the coastline but can also be good for tourism. | • They can be unattractive.<br>• Costly to build and maintain. | • Foster's beach widening, which helps maintain an attractive beach environment that is valuable for recreation and tourism. This is particularly the case when applied along with beach nourishment<br>• Traps sediment, leading to beach widening, reduced erosion and greater wave energy dissipation.<br>• Serves as a robust structure (if designed and maintained properly) that can be used for long-term stabilization of coastlines used for societal activities |
| **Breakwater System** | • They reduce the effects of erosion.<br>• They offer recreational opportunities.<br>• Don't interfere with habitat access. | • They are not always effective for high energy waves.<br>• They can create a new set of environmental dangers. | • Detailed hydrographic survey of the site<br>• Geotechnical investigation of the sea bed<br>• Wave height investigation or hindcasting<br>• Material needs assessment; and the cross-sectional design of the structure. |
| **Seawalls and Bulkhead** | • Provides a high degree of protection against coastal flooding and erosion.<br>• Potential to fix the boundary between the sea and land to ensure no further erosion will occur.<br>• Seawalls also have a much lower space requirement than other coastal defences such as dikes. | • Scour at the foot of a seawall is a particular problem with vertical seawall designs.<br>• Because seawalls are immovable defences, they can also interfere with natural processes such as habitat migration.<br>• Seawalls obstruct the natural inland migration of coastal systems in | • Design height is a major factor affecting costs per unit length of seawall. Height affects the volume of materials required for construction and the build time<br>• Anticipated wave loadings will affect how resilient the structure needs to be; deeper waters and exposed coasts cause higher wave loadings which will |

| Adaptation Option/Measure | Benefits | Disadvantage/Drawbacks | Considerations for The Implementation |
|---|---|---|---|
| | • May promote investment (encourage recreation and tourism) and development of the area.<br>• Provides defence against high waves, storms surges, and flooding. | response to SLR, therefore causing coastal squeeze.<br>• In estuaries, seawalls also cause changes to the area inundated by the tides, thus, reducing the available area for occupation by water on a high tide.<br>• The appearance of seawalls can be aesthetically displeasing which can further negatively affect beaches dependent upon a tourist economy | mean the structure needs to be more robust, thus higher costs.<br>• Single or multi-stage construction; costs are lower for single stage.<br>• Selected seawall design and the standard of protection desired. Certain design features will increase costs and more robust seawalls will be more costly.<br>• Construction materials required are rubble blocks, pre-cast concrete elements, metal, soil, etc.<br>• Proximity to and availability of raw construction materials.<br>• Availability and cost of human resources including expertise. |
| **Rock Amour Revetments** | • Protect a scarp, embankment, or other shoreline feature against erosion.<br>• Allows water to pass through the structure and prevents the underlying soil from being washed through the armour.<br>• They are relatively low maintenance. | • Revetments are expensive to build but cheaper than floodwalls.<br>• They can have a big visual impact on the landscape.<br>• They can make some beaches inaccessible to locals and tourists.<br>• Erosion at the base of the structure can cause structural failure.<br>• They can disrupt natural dune processes. | • Construction costs for revetments are mainly dependent on structure dimensions<br>• Availability of suitable rock and transport methods. |
| **Sea Dikes** | • Dikes provide a high degree of protection against flooding in low-lying coastal areas.<br>• | • Dikes require high volumes in order to resist high water pressures on their seaward faces. | • Land availability and cost.<br>• Selected dike design and in-built margin for safety. This can affect the volume of the structure and the required materials |

| Adaptation Option/Measure | Benefits | Disadvantage/Drawbacks | Considerations for The Implementation |
|---|---|---|---|
| | | • Dikes require large footprints that the shallow slopes applied to facilitate dissipation of wave energy.<br>• The area of land take can be problematic as coastal areas often have high associated land values. | • Anticipated wave loadings; higher wave loadings require more robust and expensive structures.<br>• Proximity to and availability of raw construction materials<br>• Availability and cost of human resources including expertise |
| **Storm Surge Barriers** | • Provide a high degree of protection against coastal flooding by preventing storm surges from entering low-lying estuarine areas.<br>• Reduce the height of extreme water levels in the area behind the barrier, if closed in a timely fashion.<br>• Provide additional benefits by forming a permanent barrier between freshwater and the sea. | • High capital and maintenance costs.<br>• Landward flooding occurs as a result of water backing up on the landward side of the barrier due to the obstruction of continued river discharge by the barrier.<br>• Potential to change the chemical, physical and biological properties of estuarine systems by altering the inflow and outflow. | • Type of barrier.<br>• Local soil characteristics.<br>• The desired height of the barrier.<br>• Required hydraulic head for the structure.<br>• Anticipated wave loadings; higher wave loadings require more robust and expensive structures.<br>• Proximity to and availability of raw construction materials<br>• Availability and cost of human resources including expertise. |
| **Beach and Dune Nourishment** | • Reduces the detrimental impacts of coastal erosion.<br>• Positively impact adjacent areas which were not directly nourished.<br>• Complement hard protection measures such as seawalls which may continue to be used as a last line of defence.<br>• Help retain the natural landscape of the beach. | • Nourishment is not a permanent solution to shoreline erosion.<br>• Periodic re-nourishments will be needed to maintain effectiveness.<br>• Require regular re-investment but can be viewed as a maintenance cost.<br>• May disrupt beach and ocean habitats such as bird and sea turtle nesting.<br>• Nourishment may cause direct mortality to sessile organisms in the target area by burying them under the new sand. | • Availability and proximity of appropriate construction material from onshore or offshore sites.<br>• Dredger type, size and availability.<br>• Requirement for planting new dunes with vegetation.<br>• Frequency with which the dune needs to be artificially replenished.<br>• Number of journeys required between the dredge site and nourishment area |

| Adaptation Option/Measure | Benefits | Disadvantage/Drawbacks | Considerations for The Implementation |
|---|---|---|---|
| | • Has the potential to promote recreation and tourism through beach widening. | Imported sand may contain material toxic to local species. | • Estimated material losses. |
| **Riprap** | • Dissipates wave energy.<br>• Effective for many years.<br>• Can be very cheap and easy to maintain. | • Can be visually unattractive.<br>• Can make the beach inaccessible.<br>• Not effective in stormy conditions and cannot protect adjacent flooding.<br>• | • Stone size, weight, durability, and the gradation and thickness of the riprap blanket.<br>• Stream characteristics also strongly affect the stability of riprap revetments |
| **Accommodation Approach** | | | |
| **Flood Proofing** | • Avoids the need to elevate, demolish or relocate structures and as a result, is often a much more cost-effective approach to reducing flood risk.<br>• Affordable than the construction of elaborate flood protection works such as seawalls and dike systems.<br>• Does not require the additional land that would be needed to offer the same degree of flood protection through seawalls or dikes.<br>• Flood-proofing can also be undertaken by individuals, rather than requiring funding from central or local government bodies. | • Flood-proofing measures require the current risk of flooding to be known and communicated to the public earlier.<br>• Flood-proofing measures are most effective when applied in areas where flood depth is low.<br>• Flood shields are not aesthetically pleasing.<br>• If design loads are exceeded, walls may collapse, floors buckle and homes may even float. This has the potential to cause more damage than if the home were just allowed to flood. | • The size of the structure.<br>• The height of the flood protection elevation.<br>• Types of sealant and shield materials used.<br>• Number of openings that have to be covered by shields.<br>• Plumbing measures required to prevent water back-up. |
| **Wetland Restoration** | • Reduces the energy of incoming wave and tidal energy by enhancing energy dissipation in the intertidal zone. | • The restoration of natural ecosystem services, including flood and erosion protection benefits, largely outweighs any disadvantages.<br>• Wetland restoration is likely to require a degree of expertise, especially in locations where wetland recolonisation has to be encouraged by transplanting wetland plants. | • Type of wetland to be restored, expertise availability, and consequent chances of success.<br>• Degree of wetland degradation and consequent restoration requirements<br>• Land costs if a land purchase is required to convert to wetlands<br>• Labour costs |

| Adaptation Option/Measure | Benefits | Disadvantage/Drawbacks | Considerations for The Implementation |
|---|---|---|---|
| | | | • Transportation distance between seedling source and planting site.<br>• Scale of post-implementation monitoring operations. |
| **Floating Agriculture** | • The practice helps to mitigate land loss through flooding, by allowing cultivation of these areas to continue.<br>• Floating agriculture also helps supplement the income of local communities and contributes to the alleviation of poverty.<br>• Because the system is fairly labour intensive, it also has the capacity to provide employment opportunities within communities. | • It is unclear how this technology may be affected by SLR and increases in salinity, which are likely to occur under scenarios of climate change.<br>• The methods used in floating agriculture have the drawback of encouraging insect and rodent infestation, which may cause health problems.<br>• Although this technology provides the advantage of maintaining food production, it may be difficult to transport produce to market because the area remains waterlogged most of the time. | • The technology currently works well in certain areas, but it is unclear how it may be affected by sea-level rise and salinity increases, which are likely to occur due to climate change |
| **Flood Hazard and Risk Mapping** | • The identification of flood risk areas will also help in the location of flood shelters for evacuees.<br>• Flood hazard mapping will allow quantification of what is at risk of being flooded, such as the number of houses or businesses.<br>• The creation of flood hazard maps should promote greater awareness of the risk of flooding.<br>• Flood hazard maps can support planning and development by identifying high-risk locations and steering development away from these areas. | • More advanced, accurate flood hazard maps are likely to rely on complex numerical models due to the lack of observed extreme event data. This requires a degree of expertise to implement, which sometimes is not readily available.<br>• If information on what to do in the event of an emergency is not provided, flood hazard maps may serve only to increase fear and anxiety as residents are more aware of the risk of flooding. | • External expertise on numerical modelling of flood risk.<br>• Flood hazard mapping relies on the availability of topographic, and long-term extreme event data and complex numerical modelling techniques<br>• Historic costs of collecting extreme event data such as water levels, wave heights, etc.<br>• Cost of employing a Geographic Information System (GIS) |

| Adaptation Option/Measure | Benefits | Disadvantage/Drawbacks | Considerations for The Implementation |
|---|---|---|---|
| **Flood Warnings** | • Time information is provided to avoid or minimise the risk to life and damage to properties.<br>• Timely operation of flood control structures (e.g. storm surge barriers, temporary flood defences, etc.) to prevent inundation of property and land<br>• Installation of flood resilience measures (e.g. sandbags, property flood barriers). | • A flood warning system is not sufficient on its own to reduce risk; people's reactions to warnings – their attitude and the nature of their response – has an important bearing upon the effectiveness of a warning system.<br>• It is also essential that the flood warning system is accurate – system inaccuracies may lead to complacency if previous warnings were unfounded, or fear by causing unnecessary anxiety. | • Extent of meteorological monitoring network.<br>• Cost of sourcing meteorological data.<br>• Set up costs of warning dissemination system and its degree of sophistication.<br>• Training and employment costs of meteorological data analysts. |
| **Water Resource Management and Protection** | • It helps to control the amount of pollutants, sediments, and nutrients entering water bodies through precipitation generated runoff.<br>• It also plays an important role in preventing damage to the built environment and the natural systems that protect it. | | • Limiting/removing impervious surfaces<br>• Acquiring easements for new and wider drainage ditches.<br>• Implementing and enforcing stream dumping regulations.<br>• Improving carrying and storage capacity of streams, channels, and basins through ongoing maintenance<br>• Installing larger pipes and culverts<br>• Develop and maintain a water resources inventory<br>• Develop and implement a water conservation and efficiency program |
| **Retreat Approach** | | | |
| **Managed Alignment** | • Managed realignment can significantly reduce the cost of providing a given level of protection against coastal flooding and erosion. | • Requires land to be yielded to the sea. This may require the relocation of important infrastructure or buildings, potentially at significant cost.<br>• Managed realignment is also likely to be highly disruptive and expensive if | • Cost of the land where managed realignment will be performed.<br>• Requirement for compensation to land owners/occupiers. |

| Adaptation Option/Measure | Benefits | Disadvantage/Drawbacks | Considerations for The Implementation |
|---|---|---|---|
| | • Result in reduced defence maintenance costs.<br>• The coastal zone is less reliant on engineered hard defences for reducing coastal flood and erosion risk.<br>• Increases the coastal zone's natural flood and storm buffering capacity.<br>• Significantly reduce the need for coastal defences in the future and generally enhances resilience to unexpected changes.<br>• Managed realignment contributes toward the reinstatement of intertidal habitats which are important to specialised birds, plants and commercially exploited fish and shellfish | relocation of relocation of coastal infrastructure is required. | • The need to dismantle human-made structures present on the site to prevent marine pollution. |
| **Coastal Setbacks** | • Setbacks provide a highly effective method of minimising property damage due to coastal flooding and erosion, by removing structures from the hazard zone.<br>• Unlike hard structures, setbacks help to maintain the natural appearance of the coastline and preserve natural shoreline dynamics. This allows natural erosion/accretion cycles to occur and helps to maintain the local sediment budget.<br>• Setbacks also help to maintain shoreline access by preventing development immediately on the seafront as well as providing open space for the enjoyment of the natural shoreline.<br>• Minimum elevation setbacks also provide higher levels of protection when compared to hard defences. | • Setbacks will need to be periodically reviewed to ensure that buffer zones continue to provide sufficient protection.<br>• Setback does not guarantee that the coast in question will be shielded from strong storms and the associated coastal flooding and erosion.<br>• Problems may arise as a result of setback review. For example, reviews may reclassify coastal areas as no-build zones. This could create conflict if these areas have already been purchased with development in mind.<br>• Good quality scientific or historic data are required to establish setbacks is not always readily available.<br>• Setbacks do not serve to protect existing structures in the hazard zone. | • They accommodate seasonal and long term fluctuations in the shoreline profile.<br>• Setbacks can reduce current and potential future adverse impacts to coastal development situated in erosion or flood-prone areas.<br>• They protect sensitive areas from the impacts of development.<br>• They can help reduce the need for costly, and often damaging, structures to control shoreline erosion.<br>• They also help maintain natural shore dynamics and shorefront access—both of which are critical in changing shoreline conditions |

| Adaptation Option/Measure | Benefits | Disadvantage/Drawbacks | Considerations for The Implementation |
|---|---|---|---|
| **COMPLIMENTARY APPROACH** | | | |
| **Public Awareness and Outreach Activities** | • Increase enthusiasm and support, stimulate self-mobilisation and action, and mobilise local knowledge and resources.<br>• Increase concern, informing the targeted audience, creating a positive image, and attempts to change their behaviour.<br>• Helps to manage the impacts of climate change, enhance adaptive capacity, and reduce overall vulnerability.<br>• Addresses the knowledge of individuals and organisations. | • Benefits, largely outweighs any disadvantages.<br>• | |
| **Knowledge and Capacity Building** | • Increase the sustainability and institutionalisation of information and knowledge about climate change adaptation.<br>• Helps local people to take action on local issues themselves.<br>• Fosters a sense of ownership and empowerment so that community people gain greater control over their own future development. | • Benefits, largely outweighs any disadvantages. | |
| **Capturing Local Experience** | • Local adaptation solutions are more likely to be effective because communities approach adaptation holistically.<br>• Embedding local knowledge in adaptation measures makes them more inclusive, eases uptake and makes them more sustainable, while boosting communities' sense of ownership.<br>• The benefits of local adaptation outweigh the estimated costs. | • Benefits, largely outweighs any disadvantages. | |

| Adaptation Option/Measure | Benefits | Disadvantage/Drawbacks | Considerations for The Implementation |
|---|---|---|---|
| **Integrated Coastal Zone Management** | • Dynamic, multidisciplinary and iterative process to promote sustainable management of coastal zones.<br>• ICZM seeks over the long-term, to balance environment, socio-economic, cultural and recreational objectives.<br>• ICZM Reduces ecosystem degradation; and also conserves and maintains existing ecosystems from potential climate change impacts.<br>• Manages/protects coastal resources in a sustainable way.<br>• Involvement of local communities or stakeholders participation in decision of sustainable environmental management. | • Benefits, largely outweighs any disadvantages. | |

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## 8.4 Criteria and Process of Adaptation Prioritisation

The selection of the adaptation technology options of the coastal zone will be based on the technology's potential to reduce vulnerability to climate change, and social, economic, and environmental benefits using the Technology Needs Assessment TNA "Multi-Criteria Analysis (MCA). The MCA provides a structured framework for comparing a number of technologies against multiple criteria.

This requires a decision-making framework to compare and select between the possible options. This is necessary because there is a need to evaluate all the costs, benefits and physical and environmental impacts associated with coastal adaptation options over the affected area. This is because few coastal adaptation schemes have a totally local and short-term impact. As such, they cannot be regarded as truly stand alone.

The prioritization exercise will be undertaken with the stakeholders during the stakeholder consultation and validation workshop to developed detail information regarding cost, benefits and risk for each of the options that have been identified. The process will consider the national developmental goals to improve resilience to climate change impacts, socio-economic and environmental sustainability in the coastal zone sector with respect to their cost and benefits.

## 8.5 Identified Adaptation Options for the Study Communities

The selection of adaptation strategies depends on the local environment, community values and priorities, and in other instances, a combination of strategies could be implemented simultaneously. The factors considered to select the suitable adaptation strategies or approach includes the environmental, social, economic and governance factors.

**Table 8-2: Identified Adaptation Option**

| Community | Protection | Accommodation | Retreat | Complementary |
|---|---|---|---|---|
| Lakka | Sea wall /Bulkhead<br>Groyne<br>Riprap<br>Rock Amour Revetment<br>Beach and Dune Nourishment<br>Coastal Restoration | Flood Proofing<br>Wetland Restoration<br>Flood Hazard and Risk Mapping<br>Flood Warnings<br>Water Resource Management<br>Diversified Livelihood | Managed Realignment<br>Coastal Setbacks | Public Awareness and Outreach<br>Knowledge and Capacity<br>Community-Based Disaster Risk<br>Local Experience<br>Integrated Coastal Zone Management<br>Adaptation Monitoring |
| Hamilton | Bulkhead<br>Groyne<br>Riprap<br>Rock Amour Revetment<br>Beach and Dune Nourishment<br>Coastal Restoration | Flood Proofing<br>Wetland Restoration<br>Flood Hazard and Risk Mapping<br>Flood Warnings<br>Water Resource Management<br>Diversified Livelihood | Managed Realignment<br>Coastal Setbacks | Public Awareness and Outreach<br>Knowledge and Capacity<br>Community-Based Disaster Risk<br>Local Experience<br>Integrated Coastal Zone Management<br>Adaptation Monitoring |
| Tombo | Groyne<br>Riprap<br>Rock Amour Revetment | Wetland Restoration<br>Flood Hazard and Risk Mapping<br>Flood Warnings | Managed Realignment<br>Coastal Setbacks | Public Awareness and Outreach<br>Knowledge and Capacity<br>Community-Based Disaster Risk |

| Community | Protection | Accommodation | Retreat | Complementary |
|---|---|---|---|---|
| | Beach and Dune Nourishment<br>Coastal Restoration | Water Resource Management<br>Diversified Livelihood | | Local Experience<br>Integrated Coastal Zone Management<br>Adaptation Monitoring |
| Shenge | Sea wall /Bulkhead<br>Riprap<br>Rock Amour Revetment<br>Beach and Dune Nourishment<br>Coastal Restoration | Wetland Restoration<br>Hazard and Risk Mapping<br>Water Resource Management<br>Diversified Livelihood | Managed Realignment<br>Coastal Setbacks | Public Awareness and Outreach<br>Knowledge and Capacity<br>Community-Based Disaster Risk<br>Local Experience<br>Integrated Coastal Zone Management<br>Adaptation Monitoring |
| Conakry Dee | Sea wall /Bulkhead<br>Riprap<br>Rock Amour Revetment<br>Beach and Dune Nourishment<br>Coastal Restoration | Wetland Restoration<br>Floating Agriculture<br>Flood Hazard and Risk Mapping<br>Flood Warnings<br>Water Resource Management<br>Diversified Livelihood | Managed Realignment<br>Coastal Setbacks | Public Awareness and Outreach<br>Knowledge and Capacity<br>Community-Based Disaster Risk<br>Local Experience<br>Integrated Coastal Zone Management<br>Adaptation Monitoring |
| Turtle Islands | Beach and Dune Nourishment<br>Coastal Restoration | Wetland Restoration<br>Floating Agriculture<br>Flood Hazard and Risk Mapping<br>Flood Warnings<br>Water Resource Management<br>Diversified Livelihood | Managed Realignment<br>Coastal Setbacks<br>Resettlement | |

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## 8.6 Synergies, Limits and Trade-offs in Adaptation

Studies have shown that there are limits to the extent to which natural and human coastal systems can adapt even to the more immediate changes in climate variability and extreme events, including in more developed countries. For purposes of adaptation, no single category or specific strategy should be considered the best option as a rule. Different types of strategies/measures may be appropriate in different locations and for different hazard management and resource protection goals, and potentially different time horizons. The effectiveness of different adaptation strategies will vary across both spatial and temporal scales. In many cases, a hybrid approach that uses strategies from multiple categories will be necessary, and the suite of strategies chosen may need to change over time. Nonetheless, it is useful to think about the general categories of adaptation strategies to help frame the discussion around planning and adaptation.

There are also important trade-offs in adaptation. For instance, while hard protection can greatly reduce the impacts of sea level and climate change on socio-economic systems, this is to the detriment of associated natural ecosystems due to coastal squeeze (Knogge et al., 2004; Rochelle-Newall et al., 2005). Managed retreat is an alternative response, but at what cost to socio-economic systems? Stakeholders will be faced with difficult choices, including questions as to whether traditional uses should be retained, whether invasive alien species or native species increasing in abundance should be controlled, whether the planned retreat is an appropriate response to rising relative sea level or whether measures can be taken to reduce erosion.

Hard defences are likely to be particularly important in protecting coastal urban areas against erosion and flooding in regions where sand is scarce. Soft defences are more suitable for application to sedimentary coasts composed of beaches, in areas where sufficient sand is available at a short distance from the area to be protected, and at muddy coasts. Combinations of soft and hard defences may in many cases, be the most economical measure.

Generally, groynes, detached breakwaters and artificial reefs are built in urban areas to significantly reduce coastal beach erosion and to maintain a minimum beach for recreation. Preferably, structures should be built at transition locations from increasing to decreasing longshore transport to prevent lee-side erosion. Groynes and breakwaters are, however, no remedy for dune erosion during conditions with relatively high surge levels (above the dune toe level). Seawalls and revetments are sometimes applied to stop dune erosion completely for reasons of coastal defence in urban areas.

Hard structures require relatively high capital investments plus the continuous costs of maintenance works (storm damage, subsidence, scour problems, redesign, etc.) and costs of supplementary beach nourishments to deal with local erosion problems (for example opposite to gaps and along the downdrift side). The costs for coastal protection work on small remote islands can also be much higher, especially when all the aggregate for construction needs to be imported.

Adaptation efforts necessitate access to a range of robust and transparent assessment approaches to enable decision-makers to efficiently allocate scarce resources. Socio-economic and cultural conditions also frequently present barriers to choosing and implementing the most appropriate adaptation measures. Therefore, for adaptation to be successful, it should take into account social, economic as well as ecological concerns and legal and political lines of thinking. Ideally, it should be undertaken within a comprehensive and iterative process of social, institutional and organizational learning and change and should be participatory and inclusive, integrating all relevant stakeholders in a way that is culturally appropriate. Assessing the costs and benefits of adaptation options is an important part of the process to assist adaptation planners and practitioners in identifying the most appropriate interventions for reducing vulnerability, enhancing adaptive capacity and building resilience (UNFCCC, 2011).

Regarding coastal areas, it is widely recognized that biophysical limitations arise, for example, in small island developing states where adaptation through a retreat to the increasing impact of sea-level rise in conjunction with storm surges and flooding is not an option due to limited high land availability, creating a temporary and eventually permanent human displacement from low-lying areas (Pelling and Uitto, 2001; medium evidence, high agreement). Nicholls et al. (2011) show that only a limited number of adaptation options are available for specific coastal areas if sea level exceeds a certain threshold (1 m) at the end of the century.

# 9 RECOMMENDATIONS

The results of the assessments have highlighted a number of recommendations and key suggestions important for action in addressing climate change issues for coastal resilience. The recommendations are based on the three main components of the study to better understand and adapt to coastal vulnerabilities. The recommendations are designed to be mutually reinforcing, but each could also be implemented separately with consideration on the specific component. The recommendations are grouped by the three components as central themes:

- Component 1: Generating sound scientific knowledge and access to information.
- Component 2: Climate information internalised into coastal development policy and plans.
- Component 3: Awareness and alternative, innovative activities to support adaptation in the coastal zone.

## 9.1 Recommendation for Component 1: Generating sound scientific knowledge and access to information.

Successful adaptation and resilience work rely heavily on access to actionable data about climate impacts, risks and vulnerabilities, and to information on effective strategies to address those risks. Data, combined with the capacity to interpret and apply it in risk assessment, planning, design and other management contexts, is a foundation for climate-informed decision making. These recommendations address both the need for more comprehensive datasets as well as how that information can be more effectively communicated and used by the public.

### 9.1.1 Update Baseline Data and Information to Understand Climate Impacts and Response.

Data needed to inform climate decision making is not evenly available and accessible. While some data is available that serves as a baseline for coastal resources and assessing vulnerabilities, there are significant gaps in these data, which limits prudent management decisions related to coastal management, protection and adaptation. Some other existing data/information are very much outdated. There is, therefore a need to invest in more data collection to update baseline data and information in to understand localized climate impacts and responses order to make prudent management decisions.

Funding should be dedicated to collect data to ensure data is updated and available for existing conditions and projected future conditions. Data on existing conditions should include coastline and inland elevation mapping, local bathymetry (depth of ocean) data, shoreline models, and wetlands information and inventory, jurisdictional boundaries amongst others. These data should be integrated with traditional ecological knowledge and social science information about risk perceptions and human responses to climate impacts to inform robust adaptation planning and action.

### 9.1.2 Communicate Climate Data and Information for Public Use

Many research activities and projects are undertaken primarily focused on the production of data and information (i.e. about the impacts and vulnerabilities) without much guidance on how the data can be used within the decision-making process. Consequently, there has not been a great deal of uptake into management and actions. Many communities, institutions, consultants and individuals require technical support to apply data and information to their specific context and needs.

The institutions are already communicating certain datasets to the public; however, these efforts are limited and should be continued and built upon. Data should be accompanied by their specific context for understanding the problems and identifying key priorities for adaptation. Technical support that accompanies access to data and information can enable communities to plan and implement adaptation measures that would otherwise be out of reach.

### 9.1.3 Establish Climate Change Observation, Monitoring and Surveillance Network

Observation, monitoring and surveillance networks will need to be established or strengthened at various levels of action to ensure thorough measurements of climate activities, as well as the development of tools and methodologies for translating such knowledge into useful information resources to help decision-makers improve coastal adaptation planning. Chiefdom and District Surveillance Groups could be formed, so a network of local observers and monitors will work together to document and share observations on climate trends, impacts, and consequences using a blend of local knowledge and scientific methodologies and tools. Generally, observation, monitoring and surveillance network will help in hazard and risks awareness-raising.

### 9.1.4 Develop Coastal Information and Early Warning Systems

A good system for managing coastal data and information would maximize time and resources for conducting research and data gathering. It would enable users to see what data is available and what data is needed. Geographic information systems (GIS) are the best way to handle, and make available, the fundamental data needed for such a system. Well-managed and accessible information systems with the necessary fundamental datasets can be used for multiple purposes. In the case of Coastal Information systems, it will require clear exposition of priorities in order to ensure that the most needed datasets are addressed first. It will also be necessary to consider the best data format for information, and this will be partly scale-dependent. Interagency and intergovernmental collaboration will be essential if the necessary data sets are to be integrated and widely available.

Furthermore, the dataset will feed into the coastal early warning system to strengthen institutional capacity in meteorological and hydrological monitoring and in diffusing reliable and timely weather information to the general public. This system will be designed to also provide accurate and timely forecast to improve safety in communities at risk.

### 9.1.5 Improve Existing Knowledge and Best Practises and Promote Local Innovations

Climate change issues have become a high priority for research activities over the years. Nonetheless, many knowledge gaps still exist. Having enough knowledge on the science, issues and risks as well as appropriate capacity to address the issue of climate change are critical components for adaptation and to building resilient communities and ecosystems. To improve on or build knowledge for this, there is a need to conduct scientific research, inventory, and monitoring activities to gather data and improve understanding of climate and weather phenomena affecting coastal communities. Local communities must also be encouraged to come up with their own solutions to have a more holistic portfolio that includes other hard infrastructure and nature-based solutions to address climate change in their communities.

### 9.1.6 Operationalize the CIDMEWS for Hazard and Risk Communication and Early Warning

The ability to access data when needed is important to improving efficiencies as well as communicating risks and hazards to the public for early warning. Information for coastal risks, hazards and management should be available to all especially the communities through a centralised system that makes it easier, faster, and less expensive for all levels of government and the public to access, visualise and share for the better management of vulnerabilities. Therefore, there is a need to operationalize the CIDMEWS[20] for Hazard and Risk Communication and Early Warning.

Hazard and risk maps should be integrated into the system to identify areas which are at risk under extreme conditions. The system enhances the understanding and awareness of coastal risks and facilitates administrators and planners to identify areas of risk and prioritize their mitigation/ response efforts.

[20] Climate Information, Disaster Management and Early Warning System (CIDMEWS) (Accessed via: https://www.cidmews-sl.solutions/)

## 9.2 Recommendation for Component 2: Climate Information Internalised into Coastal Development Policy and Plans

### 9.2.1 Improve Community Engagements on Climate Adaptation and Resilience Work

Community consultations and engagements on projects are fairly common; however, these consultations often happen after most decisions are made. It is important that communities, especially those that are vulnerable, where climate impacts have hit worse, are consulted and meaningfully engaged earlier in the adaptation and resilience planning process. Meaningful community engagement requires designing planning processes, outreach, and project outputs with the community in order to meet the community's specific needs and desires. This means ensuring that community members are educated about the particular issues at stake, relevant laws and government processes. Also, decision-makers and other local partners should allocate time to learn about and from the communities to gain indigenous knowledge and determine culturally appropriate climate adaptation measures that can be included in adaptation planning. This will ensure that project outputs are designed with the community intended to use them and will also help to reduce the considerable emotional and financial cost of climate adaptation.

### 9.2.2 Develop and Operationalise Coastal Management Plans and Policies

The future for our coasts is complex; climate change dependent and holds many uncertainties. Long-term, strategic approaches are therefore needed in coastal governance. It is therefore essential to develop a coastal management plan that will set out a sustainable approach to coastal management to manage the impacts of coastal hazards due to climate change and identify risks to safety and set a long-term plan to manage the coastline. The Plan should set out the State's and communities' interests for the protection of the coastal environment and management of coastal hazards and should also provide the tools to trigger development for assessment.

A Technical coordination Working Group should be established to operationalize the plans and policies upon which all coastal management and adaptation will be rooted. The technical working group should consist of professionals from different institutions (government ministries & agencies, private, NGOs, businesses, and etc.) to identify and prioritize technology and adaptation options to reduce vulnerabilities and enhance social, economic, and environmental benefits.

### 9.2.3 Integrate Climate Vulnerability Assessments into Existing Management Tools

Findings from vulnerability assessments such as this should be integrated into existing management tools to provide government and partners with clear, science-based guidance for adaptation planning and allocation of limited funding.

For example, if there is an infrastructure asset that is of very low priority, but that is extremely vulnerable, the decision-makers may reconsider spending maintenance funds on that asset. On the other hand, if an asset is critically important to the community, and it is vulnerable, then adaptation and resilience projects should be devised to make that asset viable under future climate conditions. In these cases, vulnerability assessments provide the data to support the decision and the development of proposals for these adaptation and resilience projects.

### 9.2.4 Policy Mainstreaming and Enforcements of Regulations

This includes, for example, prioritising adaptation in national planning and budgeting; harmonizing sectoral policies; creating national coordination committees and providing the financial and technical support necessary for adaptation measures to succeed.

Physical planning and building control measures and regulations should be instituted and implemented. These will include enforcements of policies that allow the use of high-risk areas as natural preserves or for low-value use. Policies that may lead to relocation from high-risk areas will also be very vital to reduce the need and cost of disaster relief in the future.

### 9.2.5 Strengthen Institutional Capacity to Better Understand the Impacts Of Climate Change

There is a shortage of skilled and professional coastal planners, managers and engineers. Most of the personnel in both government and private organizations are not well versed in climate change issues and coastal management. Often, they also do not clearly understand how they can contribute to climate change adaptation. A first step toward changing this is to create an understanding of the impacts of climate change, the need for adaptation, and the actions that can be taken by the individual and their institutions/agencies.

At the simplest, this could be to provide information on the climate change that can help policy and decision-makers justify new or intensified use of certain adaptation measures; conduct specifically tailored training to build competencies and develop a workforce for coastal management as well as environmental management and climate change, and provide the required equipment for conducting inspections and monitoring. It can also involve the need to develop and expand networks to share knowledge and experience on climate change and coastal management among coastal scientists and practitioners.

## 9.3 Recommendation for Component 3: Awareness and Alternative, Innovative Activities to Support Adaptation in the Coastal Zone

These recommendations rely on state planning and development to prepare for future climate impacts. They include to rules for set-back lines minimize damages to property, and to eliminate the construction of new structures.

### 9.3.1 Awareness Raising for the Local Communities

Awareness and knowledge about climate threat and possible solutions is a first step in the adaptation process and the basic condition for the development of an adequate adaptive capacity. A considerable number of projects have been conducted in the six coastal communities to raise awareness on climate change risk and vulnerabilities. However, it was noted that the level of awareness is limited to few of the community local authorities and leaders such as the headmen and local councillors. Awareness of climate change in women is still very low. The reasons for this are varied, but they are generally the result of social and economic challenges faced by the communities.

In order to plan, implement, and respond promptly to adaptation measures, awareness must be equally rooted in the socioeconomic and scientific disciplines, in government agencies, and in the public-at-large. There should be dedicated actions taken to raise awareness of the local effects of climate change and the need for adaptation.

### 9.3.2 Land Use Planning and Zoning

A significant proportion of the coastal property is at risk in the coming years, including private property and critical infrastructure (i.e. roads, hospitals, communications and energy facilities). Most of these infrastructures are not adequate to withstand current climate conditions. To avoid catastrophic property damage from coastal hazards, save lives and reduce losses, new planning and development processes and new infrastructure must be constructed based on future climate conditions to prevent the development and/or minimise further development in hazard-prone areas.

The Government should put in place regulations with plans measures to encourage communities and individuals to build infrastructure in anticipation of the climate of the future, rather than based on the climate record of the past. This must be done in a way to re-envision how coastal lands are being used to decrease community climate vulnerability. These plans should include delineating areas that must not host any future construction and areas that are currently built out but should be subject to relocation planning.

### 9.3.3 Utilize Nature-Based Solutions as Part of Long-Term Coastal Resilience Solutions

Adaptation and resilience solutions should be extended to include nature-based solutions. Planners and decision-makers should incorporate nature-based solutions into their programs or as alternatives in project environmental assessments. Beaches, dunes and wetlands are all the critical natural infrastructure that provides protection and resilience to the communities and infrastructure by attenuating wave action and containing flooding.

### 9.3.4 Better Evaluation of Costs and Benefits of Adaptation

There is very little analysis on evaluating the cost and benefits of adaptation in the country. Analysing the whole value chain of adaptation can help to best determine which options are most suitable to implement. None of the institutions/agencies consulted has any detailed standard to determine or evaluate the costs of implementing adaptation measures. Often, at the point when these institutions are looking to implement coastal adaptation measures, there has not yet been a determination of the costs of implementing those measures, nor has there been a projection of the costs of doing nothing. This lack of cost information makes it difficult to reach agreement on moving forward with adaptation efforts It is extremely important to calculate the economic effect of expected climate change impacts on the local economy. This approach expands the consideration of environmental and social goals as well as nature-based solutions when developing projects and selecting preferred alternatives.

### 9.3.5 Develop a Funding Plan

Climate change poses enormous financial challenges, and the combined cost of mitigating and adapting can be very high. Even the simplest of measures requires funding and effort to first put it into action and then to maintain it. The lack of resources makes it difficult for communities and government to make significant gains in adaptation on their own due primarily to lack of funding.

Financial governance, planning, management, and investment are therefore required to effectively plan for and adapt to the impacts of climate change. Partnerships and dialogue between government, international nongovernmental organizations, the local community, private institutions and development partners will be essential in developing and implementing sound adaptation strategies and measures. Partnerships also help tap into complementary programs such as coastal management programs, fisheries projects, and livelihood initiatives. Theses partners can also undertake assessments of resource needs and analysis to develop a funding plan for coastal adaptation. The objective of the funding plan will be to achieve an understanding of the financial arrangements and requirements to establish and sustain the adaption options that will be implemented. Once the plan has been developed, it should be linked to the strategic plans by giving resource mobilisation due to attention during the strategic planning process. The funding should be designed so that communities have control over how funding is spent in their communities within the parameters of the funding goals, which is enhancing climate adaptation and resilience.

### 9.3.6 Relocation of People and Infrastructure

Shorelines change over time, and rising sea levels will necessitate relocation for many coastal communities. The government must develop a framework and plan to prepare vulnerable communities for possible relocation. One disaster event can destroy enough infrastructure to make rebuilding an impossible option, causing unplanned, permanent displacement. Some communities like turtle islands are already anticipating relocation as encroaching water levels make long-term plans to stay untenable; others have already started the relocation process.

### 9.3.7 Training

There is a shortage of skilled and professional coastal planners, managers and engineers. Capacity building programmes such as training and courses should be developed and funded with the aim to train professionals and develop a workforce in the area of coastal management and adaptation while simultaneously equipping the local community with the necessary skills to undertake climate change risk assessments at the local level. The training should be tailored to build competencies for coastal management as well as environmental management and climate change.

# 10 CONCLUSIONS

The rising number of coastal disasters along Sierra Leone's coastlines necessitates the need for the coastal vulnerability assessment. The assessment was undertaken to identify, comprehensively analyse and document existing factors that are contributing to the climate vulnerability of coastal communities in Sierra Leone and ensuring the availability of sufficient information that will help determine the type and scale of interventions to enhance coastal resilience in the future.

The findings presented are based on a review of existing data and information, previous studies, stakeholder engagements, household surveys, field observations, GIS mapping and analysis and drone mapping and photogrammetry. The study utilizes the ICVI method, which consists of identifying and classifying qualitative and quantitative physical and socio-economic factors as vulnerability variables, to understand the sensitivity of the coast and access the vulnerabilities of the coastal communities to climate change-induced hazards.

It is concluded that the study areas are a high-risk environment that faces challenges posed by coastal hazards exacerbated by the impact of climate change and compounded by low levels of economic development and adaptive capacity. The most recurrent climate-related hazards within the study areas are coastal erosion, storm surge and sea-level rise induced flooding along the rivers and torrential rains. The CVA highlights that the communities, especially Conakry-Dee, Lakka and the Turtle Islands, are highly vulnerable to coastal disasters due to their geographical location and socio-economic make-up. The predicted sea-level rise and temperatures are likely to result in the loss of residential and agricultural land, an upsurge in salinity and the decline of water quality, especially in agricultural fields, with predominantly negative impacts on the economy and population of the coastal communities.

On average, the physical vulnerability of the coastal communities is influenced by geomorphology, elevation and slope, which influences the likelihood of the occurrence of coastal hazards such as coastal erosion and coastal flooding (inundation). From a socio-economic perspective, the communities' vulnerability is greatly reflective of weak adaptive capacity due to lack of critical infrastructure and increasing population and building exposure to varying degrees of coastal hazards and risks. Particularly low-lying areas such as Turtle Islands and Conakry-Dee (northern coast) are significantly exposed to sea-level rise or storm surge-induced coastal flooding, while areas of relatively higher relief such as Shenge, Lakka and the southern coast of Conakry-Dee are significantly predisposed to coastal erosion. Currently, the coastal slopes of the study area are rapidly being eroded leading to the destruction of properties (e.g. in Lakka, Conakry-Dee and Shenge), while low-lying areas such as Turtle Islands are currently threatened by rising sea levels and higher tides.

Adaptive capacities of the communities vary depending greatly on their ability to mobilise resources and implement sustainable community development initiatives. In urban areas such as Lakka, Hamilton and Tombo, the communities have implemented some coastal protection actions with some success. However, these are undermined by lack of development planning and unsustainable livelihood practices such as sand and stone mining. Coastal protection actions in rural areas are mostly championed by non-governmental organisations. Thus, several constraints to improving the communities resiliency still remain; these include limited budget; populations demographics, location and limited human capacity and resources. These constraints make it more challenging to successfully address climate change issues. The communities also acknowledge that climate change is a concern, but they have not yet developed a comprehensive strategy to deal with it. There are some established plans and policies, but institutional barriers to changes in management and individuals' behaviour have been a major impediment to implementation.

It is conceivable that with the changing climate, the communities will face increased impacts and will have to make harder choices, including retreating from some high-risk areas. Consequently, the study has identified a number of measures and options for adaptation, that if undertaken, would mitigate some of the impacts and improve the overall resiliency of the communities. Some of these options may be potentially difficult and costly to implement, and there may be some much easier solutions, but the sooner they are implemented, the easier and perhaps cheaper they will be compared to the costs of inaction. More work is needed to evaluate the feasibility of options, better define the cost-effectiveness, and provide additional guidance for adaptation options.

Proactive planning and implementation are required now to help these communities make important strides towards adapting to climate change. It is recommended that a comprehensive assessment of coastal hazards is undertaken every five to ten years to update planning and preparations.

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# 12 APPENDICES

## Appendix I: Maps

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# Appendix II: Summary of KIIs

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# Appendix III: Summary of FGDs

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# Appendix IV: Photos from Stakeholder Engagement

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# Appendix IV: Photos from Stakeholder Engagement

**Photos from Stakeholder Engagement Exercises (1/3)**

**Focus Group Discussion with Local Authorities in Lakka**




**Focus Group Discussion with Fishermen in Lakka**




**Focus Group Discussion with Sand miners in Lakka**




**Focus Group Discussion with Business People along the Beach in Lakka**



**Focus Group Discussion with Local Authorities in Hamilton**



**Focus Group Discussion with Fishermen in Hamilton**



## Photos from Stakeholder Engagement Exercises (2/3)

**Focus Group Discussion with Sand Miners in Hamilton**



**Focus Group Discussion with Women Group in Hamilton**



**Focus Group Discussion with Local Authorities and Elders in Tombo**




**Focus Group Discussion with Fishermen in Tombo**




**Focus Group Discussion with Fish Mongers and Petty traders in Tombo**




**Focus Group Discussion with Elders in Conakry Dee**



## Photos from Stakeholder Engagement Exercises (3/3)

**Focus Group Discussion with Fishermen and Fish Mongers in Conakry Dee**




**Focus Group Discussion with Women's Group in Conakry Dee**




**Focus Group Discussion with Fishermen and Fish Mongers in Shenge**




**Focus Group Discussion with Women's Group in Shenge**




**Focus Group Discussion with Mixed-Group of Stakeholders in Yele- Turtle Island**




**Focus Group Discussion with Men Group-Bumpetok, Turtle Island**



**Household Surveys**

















# Appendix V: Sample of Stakeholder Notification Letters

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INTEGEMS
Integrated Geo-information and Environmental Management Services

**INTEGEMS Ltd**
8G Technical Institute Drive
Off Main Motor Road
Congo Cross
Freetown
Sierra Leone

Email: info@integems.com
Website: www.integems.com

29 September 2020

The Honorable Minister
Ministry of Tourism and Cultural Affairs
28B Kingharman Road
Freetown

Dear Sir,

**Re: Request for Consultative Meeting for the Implementation of Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project**

United Nation Development Programme (UNDP), Sierra Leone is implementing a five-year GEF funded Project "Adapting to climate change-induced coastal risk management in Sierra Leone" with the aim to strengthening the ability of coastal communities to systemically manage climate change risks and impacts on physical infrastructures and economic livelihoods. The intended outcome of the Project is to help the Government of Sierra Leone (GoSL) to become more climate-resilient while contributing to achieving Sustainable Development Goals (SDGs).

The Project is implemented in six (6) communities: Lakka, Hamilton, Tombo, Conakry Dee, Shenge and Turtle Islands, and focuses on three (3) thematic components:

- **Component 1:** Generating sound scientific knowledge and access to information;
- **Component 2:** Climate information internalized into coastal development policy and plans;
- **Component 3:** Awareness and alternative, innovative activities to support adaptation in the coastal zone.

Through these components, the Project will work towards the update of those policies and any informational barriers that are currently preventing Sierra Leone from systematically managing coastal risks. This will contribute to reducing the vulnerability of both coastal communities and ecosystems and in the process strengthen institutional capacity and adaptation planning. The goal is to inform the design of future interventions (hard, soft and hybrid) to safeguard both communities and infrastructures at the targeted locations from the impact of climate change.

UNDP has therefore contracted Integrated Geo-Information and Environment Management Services (INTEGEMS) Limited to conduct the CVA for the six selected communities along the Project defined coastal zone of Sierra Leone. The assessment seeks to identify, comprehensively analyse and document existing factors that are contributing to the climate vulnerability of these targeted coastal communities and to ensure the availability of sufficient information that will help determine the type and scale of interventions to enhance coastal resilience in the future.

Your institution has been identified as one of the key stakeholders for this Project and we would like to request a schedule for a formal meeting with you or a representative of your institution to further discuss the Project and provide INTEGEMS or its representatives with the necessary data/information. We are proposing anytime between **5 October and 9 October 2020,** but we are more willing to adjust to your earliest convenient date and time of your choice.

INTEGEMS
Integrated Geo-information and Environmental Management Services

**INTEGEMS Ltd**
8G Technical Institute Drive
Off Main Motor Road
Congo Cross
Freetown
Sierra Leone

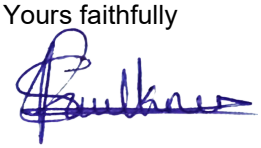
Email: info@integems.com
Website: www.integems.com

We assure you that the data/information provided will be kept highly confidential and used solely for the purpose of achieving the Project objectives in an efficient and timely manner.

Should you require any clarifications on this please do not hesitate to contact Samuella Faulkner, via email sm.faulkner@integems.com or phone +232 79 628 526.

We thank you in advance for your continued support.

Yours faithfully



Samuella Faulkner, **Managing Director/Principal Consultant,** INTEGEMS Limited

**Attached: UNDP cover letter**

**United Nations Development Programme**

Empowered lives.
Resilient nations.

**TO WHOM IT MAY CONCERN**

**Subject: Request for support to Integrated Geo-information and Environmental Management Services Limited (INTEGEMS Ltd) for Implementation of Consultancy on Coastal Vulnerability Assessment (CVA) for the UNDP Coastal Project**

The United Nation Development Programme (UNDP) Sierra Leone has contracted Integrated Geo-Information and Environment Management Services Limited (INTEGEMS Ltd) to provide consultancy services on Coastal Vulnerability Assessments (CVA) for the UNDP-Global Environment Facility (GEF) Funded Coastal Risks Management Project.

The Project is implemented in six communities; Hamilton, Tombo, Conakry dee, Shenge and Turtle Island and focuses on three thematic components;

- Component 1: Generating sound scientific knowledge and access to information;
- Component 2: Climate information internalized into coastal development policy and plans;
- Component 3: Awareness and alternative, innovative activities to support adaptation in the coastal zone.

Through these components, the project work towards the update of those policies and any informational barriers that are currently preventing Sierra Leone from systematically managing coastal risks. This will contribute to reducing vulnerability of both coastal communities and ecosystems and in the process strengthen institutional capacity and adaptation planning.

The Project seeks to identify, comprehensively analyse and document existing factors that are contributing to the climate vulnerability of coastal communities in Sierra Leone and to ensure the availability of sufficient information that will help determine the types and scale of interventions to enhance coastal resilience in to the future. The goal is to inform the design of future project interventions (hard, soft or hybrid) to safeguard both communities and infrastructures at the targeted locations from the impacts of climate change.

As major partner, your institution has been identified as one of the key stakeholders for this Project, and UNDP is hereby requesting you/your institution to provide INTEGEMS or its representatives, with the required support to enable them collect the necessary information to achieve the Project objectives in an efficient and timely manner.

Should you require any clarification on this, please do not hesitate to contact, Tanzila Sankoh, by email at tanzila.sankoh@undp.org or on mobile at +23279961450

We thank you in advance for your continued support.

Yours Sincerely,

Samuel Doe (Ph.D.)
Resident Representative

# Appendix VI: Stakeholder Engagement Attendance List

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INTEGEMS

## Key Informant Interviews: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1. | Joseph M. Lahai | Project Manager | Ministry of Youth | 08/10/2020 | 078-239686 | |
| 2 | S. T. Bellay | Admin + Fin Manager | MOYA | 08/10/2020 | 078-301226 | |
| 3 | Theresa T. Dick | Project Manager | MOYA | 08/10/20 | 87667688 | |
| 4 | Abdul Malik Kamara | Town Planning Officer | MTCA | 08/10/20 | 077 500 649 | |
| 5 | WIK Robinson | Dep. MTCA | MTCA | 08/10/20 | 078-646396 | |
| 6 | Henry David Bayoh | SPDO/Head of CC NTB | NTB | 14/10/20 | 076-879222 | |
| 7. | BASHIRU GORORA | PDO NTBSL | NTB | 14/10/2020 | 078658092 | |
| 8. | Peter Rogers | Climate Change officer | SL MET | 19/10/2020 | 076758781 | |
| 9. | Gabriel Kpaka | DDG | SL MET | 19/10/2020 | 079667742 | |

INTEGEMS

## Key Informant Interviews: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1. | Dr. Raymond G. Johnson | Director | IMBO | 14.10.20 | 0766293 55 traymond12001@yahoo.com | |
| 2. | Dr. Reynold G. Johnson | Head of Dept. | Department of Geography, FIBC | 14.10.20 | 0766290 40 treynold12001@yahoo.com | |
| 3 | Iyesha Josiah/Camara | Programmes | WONES | 19/10/20 | kamaraiyesh@gmail.com 0767113422 | Kamara |
| 4 | David Monoh Konuwa | Field officer | WONES | 19/10/20 | 076-283744 gmail.com david.monoh.duwa@ | |
| 5 | Gertrude Karimu | National Coordinator | WONES | 19/10/20 | Gertrudekarimu1@yahoo.com | Karimu |
| 6 | Abdul-Alim Allen | Ag. Chairman | SLAAFU | 19/10/2020 | israeloalleno@yahoo.com | |
| | Alhaji Sandy | Sec gen | SLAAFU | | Slaafu@yahoo.com | |
| | Abdul Malik Kamara | Tourist Officer | MTCA | 20/10/20 | 077500649 | |
| | Mohamed Falloh | Director of Tourism | MTCA | 20/10/20 | 076522838 | |

INTEGEMS

## Key Informant Interviews: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | Harry S. Mustapha | Island Development Consultant | Island Aid S/L | 20/10/2020 | 076-614 500<br>034-100 486 | [signature] |
| 2 | Julius Robinson | Island development Consultant | Island Aid S/L | 20/10/2020 | 088-777303<br>076 662781 | [signature] |
| 3 | Dura Koroma | Island Aid develop Consultant | Island Aid S/L | 20/10/2020 | 079458328 | [signature] |
| 4 | MRS Hawa Koroma | Programme Coloni | Island aid | 20/10/2020 | 078049499 | [signature] |
| 5 | TAMBA J.S. LAMINA | MINISTER | MLGRD | 20/10/2020 | | [signature] |
| 6 | Edward Sesay | Programme Manager | CSSL | 23/10/2020 | 078452553 | [signature] |
| 7) | Baindu Dassama Kamara | Minister | MOSW | 23/10/2020 | 03043 6363 | [signature] |
| 8. | Edward P. Bendu | Ag. Director | MoEnv | 23/10/2020 | 076-749024 | [signature] |
| 9 | Joseph Rahall | Executive Director | Green Scenery | 4/11/2020 | 076601979 | [signature] |

INTEGEMS

## Key Informant Interviews: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

**ATTENDANCE REGISTER** Tombo Community 10/11/2020

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | Mohamed S. Bah | Youth Leader | Tombo Community | 10/11/2020 | 088531788 | |
| 2 | Hawanatu Turay | Women's Leader | Tombo Community | 10/11/2020 | 088566482 | |
| 3 | Sarah Bah | Head Man | Tombo Community | 10/11/2020 | 030833001 | |
| 4 | Tommy Samanda | Secretary General | Tombo Community Harbor | 10/11/2020 | 077 242211 | |
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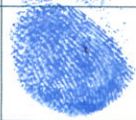
INTEGEMS

## Key Informant Interviews: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 01 | Mma Kamara | Women's Leader | Konakry Dee | 06/11/2020 | — |  |
| 02 | Fadi Kalley Samah | Town Chief | Konakry Dee | 06/11/2020 | — |  |
| 03 | Max Campbell | Harbour Master | Shenge | 08/11/2020 | 099-244482 | |
| 04 | Lilian Pieh | Chair Lady | Shenge | 08/11/2020 | 076-530913 | |
| 05 | Christiana Lebbie | Women's Leader | Yele Community | 10/11/2020 | 076-049814 | |
| 06 | FRANCIS SESAY | TOWN CHIEF | Yele Community | 10/11/2020 | 080-067899 | |
| 07 | MOHAMED TUA | HARBOUR MASTER | Yele Community | 10/11/2020 | 076 758578 | |
| 08 | ABDUL RAHMAN SHERIFF | DEPUTY TOWN CHIEF | BUMPETOKE | 11/11/2020 | 030-502754 | |
| 09 | SOKO KOROMA | HARBOUR MASTER | BUMPETOKE | 11/11/2020 | |  |

INTEGEMS

## Key Informant Interviews: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 10 | Sarah Kaffay | Chairlady | Bumpeh Town | 10/11/2020 | 099270681 |  |
| 11 | Rukiatu Conteh | Women's Leader | Seh Community | 11/11/2020 | — |  |
| 12 | Saffa Nallo | Town Chief | Seh Community | 11/11/2020 | 077-139888 |  |
| 13 | Sheriff Pujeh | Habour Master | Seh Community | 11/11/2020 | 078-1259932 |  |
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INTEGEMS

## Key Informant Interviews: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | Ebenezer Johnson | H. Master | Lakka Community | 06-11-2020 | 077351116 | [signature] |
| 2 | FODAY TUCKER | HEADMAN | " | 6/11/2020 | 078104575 | [signature] |
| 3 | Derick K. Turner | Youth Leader | Hamilton | 6/11/2020 | 078-433-811 | [signature] |
| 4 | Rex Moore | H. master | Hamilton | 6/11/2020 | 033590301 | [signature] |
| 5 | Ruth M. Samura | Womens Leader | Hamilton | 6/11/2020 | 030792177 | [signature] |
| 6 | Morlai Coutch | Headman | Hamilton Committee | 6/11/2020 | 088339045 | [signature] |
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INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

Women's Group

| | | | |
|---|---|---|---|
| **Date:** | 11 NOVEMBER 2020 | | |
| **Venue:** | SEI COMMUNITY | | |
| **Start Time:** | | **End Time:** | |

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | Binna Kpaka | Women | Sei Community | 11/11/2020 | — | |
| 2. | Mariatu Macfoi | ✓ | ✓ | ✓ | — | |
| 3 | Isatu Charley | ✓ | ✓ | ✓ | — | |
| 4. | Musu Kamara | ✓ | ✓ | ✓ | 033 448170 | |
| 5 | Hajaratu Jalloh | ✓ | ✓ | ✓ | 030 87 197 1917 | |
| 6. | Jenaba Charley | ✓ | ✓ | ✓ | — | |
| 7. | Fatmata Sfarad | ✓ | ✓ | ✓ | — | |
| 8. | Mariama Turay | ✓ | ✓ | ✓ | — | |
| 9 | Sama Bayo | ✓ | ✓ | ✓ | — | |
| 10 | Musa Lesay | ✓ | ✓ | ✓ | — | |

INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

Men's Group

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | ALHAJI KING | Fisherman | Seh Community | 11/11/2020 | 030-133658 | |
| 2 | MOHAMED THALLAY | Fisherman | SEH Community | 11/11/2020 | 030-524578 | |
| 3 | ABDUL JUNIOR STEVEN | Fisherman/Student | SEH Community | 11/11/2020 | 099-737047 | |
| 4 | KENNIE HARDING | Fisherman | SEH Community | 11/11/2020 | 077-461515 | |
| 5 | TOMMY NALLO | Fisherman | SEH Community | 11/11/2020 | — | |
| 6 | BOCKARIE KOROMA | OKADA RIDER | SEH Community | 11/11/2020 | 077-766724 | |
| 7 | FODAY KAMARA | BUSINESS MAN | SEH Community | 11/11/2020 | 080-785466 | |
| 8 | ABDULAI STEVENS | FISHERMAN | SEH Community | 11/11/2020 | 099-737047 | |
| 9 | AMARA BANGURA | FISHERMAN | SEH Community | 11/11/2020 | — | |
| 10 | JUSTIN KANYAGBA | TEACHER | SEH Community | 11/11/2020 | 076-469932 | |
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INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

Men

| | | | |
|---|---|---|---|
| **Date:** | 11 – 11 – 2020 | | |
| **Venue:** | Bumpetoke Community | | |
| **Start Time:** | | **End Time:** | |

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| | IBRAHIM SHERIFF | Fisherman | Bumpetoke | 11 – 11 – 2020 | 076 733625 | |
| | MUSA BANGALIE | Fisherman | Bumpetoke | 11/11/2020 | 088 55 8766 | |
| | MUSA ARUNA | Imam | Bumpetoke | 11/11/2020 | 075 910759 | |
| | BOBOR JOE-QUEE | Stakeholder | Bumpetoke | 11/11/2020 | 076 905548 | |
| | MOHAMED KOROMA | Fisherman | Bumpetoke | 11/11/2020 | — | |
| | ABDUL B SINNAH | Trader | Bumpetoke | 11/11/2020 | 076 840817 | |
| | OSMAN CHALLAY | Fisherman | Bumpetoke | 11/11/2020 | 030 – 477085 | |
| | SHARKA SEIKEH | Trader | Bumpetoke | 11/11/2020 | 077 – 311401 | |
| | MOHAMED KABBO | Fisherman | Bumpetoke | 11/11/2020 | — | |
| | ABU SESAY | Fisherman | Bumpetoke | 11/11/2020 | — | |

INTEGEMS

**Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project**

Tombo Community **ATTENDANCE REGISTER** Local Authorities

| | | | |
|---|---|---|---|
| **Date:** | | | |
| **Venue:** | | | |
| **Start Time:** | | **End Time:** | |

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 13 | Aminu Kamara | Stake holder | Tombo Local authority | 13-11-20 | — | |
| 14 | Ibrahim Kamara | Stake holder | ✓ | 13-11-20 | — | |
| 15 | Saidu Kamara | youth | ✓ | 13-11-20 | — | |
| 16 | Bobor Konyeo | | ✓ | 13-11-20 | — | |
| 17 | Fatmah B. Kamara | youth | ✓ | 13-11-20 | 030595487 | |
| 18 | Abdulramon Kamara | Stake holder | ✓ | 13-11-20 | — | |
| 19 | Theresa Lansana | | Police officer | 13-11-2020 | 030 63-81-79 | |
| 20 | Francis Conteh | Stake holder | Tombo Local Authority | 13-11-20 | — | |
| 21 | Saffa Konyeo | Stake holder | ✓ | 13-11-20 | — | |
| 22 | James Conteh | Stake holder | ✓ | 13-11-20 | — | |

INTEGEMS

**Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project**

Tombo Community **ATTENDANCE REGISTER** Fish Mongers & Petty Traders

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| P1 | Jalikatu Alie | Fisheries Officer | MFMR | 12/11/2020 | 078880541 | |
| P2 | Kadiatu Z. Fofanah | Chair Lady Fish Monger Org. | Tombo Community | 12/11/2020 | 033 207142 | |
| P3 | Mabinty K Sankoh | Fish Monger | Tombo Community | 12/11/2020 | 07753 1715 | Sankoh |
| P4 | Isata J Kamara | Fish Monger | Tombo Community | 12/11/2020 | 088 045899 | |
| P5 | Bobby Alhaji | Fish Monger | Tombo Community | 12/11/2020 | 088789606 | |
| P6 | Hawa Sesay | Petty Trader | Tombo Community | 12/11/2020 | 080489557 | |
| P7 | Bealay Kamara | Petty Trader | Tombo Community | 12/11/2020 | ——— | |
| P8 | Fatmata Sankoh | Fish Monger | Tombo Community | 12/11/2020 | 088 428857 | |
| P9 | Yalie Koroma | Fish Monger | Tombo Community | 12/11/2020 | 030543446 | |
| P10 | Hawa Bundu Sa | Petty Trader | Tombo Community | 12/11/2020 | 080038808 | |
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INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

**ATTENDANCE REGISTER** Fisher Men – Tombo Community

| | No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|---|
| P | 1 | Kelvin F. Bell | Volunteer | MFMR. | 12/11/20 | 076.185274 | [signature] |
| P | 2 | Abass M. Kamara | | MFMR | 12/11/20 | 077-862625 | [signature] |
| P | 3 | Umaro Kamara | | ✓ | 12/11/20 | 088-24-10-46 | [signature] |
| P | 4 | Abass B. Kargbo | F.A | M.F.M.R | 12/11/20 | 099-685670 | [signature] |
| P | 5 | Abu-S. KAMARA | FISHMAN | MF-MR | 12/11/20 | 088-96-41-22 | [signature] |
| P | 6 | Ahusine Fofonah | FishMan | Tombo | 12/11/20 | 088 84 14 81 | [signature] |
| P | 7 | Musa Bangura | Fishermen | ✓ | 12/11/020 | 076-74-72-73 | [signature] |
| P | 8 | MOHAMED-MORRAY | FISHERMAN | ✓ | 12/11/20 | 079-04-20-75 | [signature] |
| P | 9 | Osman Sankoh | Fisherman | ✓ | 12/11/020 | 030-65-97-01 | |
| P | 10 | Arthur Smith | Fisherman | ✓ | 12/11/020 | 030-72-79-05 | |
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INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

Women's Group

| | | | |
|---|---|---|---|
| **Date:** | 06 November 2020 | | |
| **Venue:** | Conakry Dee | | |
| **Start Time:** | | **End Time:** | |

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | Emmah Kamara | House Wife | Conakry-Dee | 6th Nove | 099-95.00.90 | |
| 2 | Fatmata M. Sumah | House wife | Conakry-Dee | 6th/11/2020 | 075 477037 | |
| 3 | Juliana S. Kamara | ✓ | ✓ | ✓ | 07520088 | |
| 4 | Mabinty Kargbo | ✓ | ✓ | ✓ | — | |
| 5 | Fatmata Kargbo | ✓ | ✓ | ✓ | — | |
| 6 | N'mah L.M. Kamara | ✓ | ✓ | ✓ | — | |
| 7 | Isata Sumah | ✓ | ✓ | ✓ | — | |
| 8 | Masary Sumah | ✓ | ✓ | ✓ | 077 57[illegible]758 | |
| 9 | Sallamatu Sumah | ✓ | ✓ | ✓ | — | |
| 10 | Aminata Conteh | ✓ | ✓ | ✓ | 088 172749 | |

INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 11 | Adamsay Koroma | - | Conakry Dee | 06/11/2020 | 099259966 | |
| 12 | Fatmata Fofanah | - | - | - | - | |
| 13 | Hawa Sesay | - | - | - | - | |
| 14 | Isata Kamara | - | - | - | 033201502 | |
| 15 | Fatmata Sumah | - | - | - | 087723374 | |
| 16 | Fatmata Sesay | - | - | - | - | |
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INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

Women's Group

| | | | |
|---|---|---|---|
| **Date:** | 11 NOVEMBER 2020 | | |
| **Venue:** | SEI COMMUNITY | | |
| **Start Time:** | | **End Time:** | |

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | Binna Kohn | Women | Sei Community | 11/11/2020 | — | |
| 2. | Mariatu Macfoi | ✓ | ✓ | ✓ | — | |
| 3 | Isatu Charley | ✓ | ✓ | ✓ | — | |
| 4. | Musu Kamara | ✓ | ✓ | ✓ | 033 448170 | |
| 5 | Hajiyatu Jalloh | ✓ | ✓ | ✓ | 030 87 1917 | |
| 6. | Jeneba Charley | ✓ | ✓ | ✓ | — | |
| 7. | Fatmata Sfarad | ✓ | ✓ | ✓ | — | |
| 8. | Mariama Turay | ✓ | ✓ | ✓ | — | |
| 9 | Sama Barrie | ✓ | ✓ | ✓ | — | |
| 10 | Musa Leray | ✓ | ✓ | ✓ | — | |

INTEGEMS

Integrated Geoinformation and Environmental Management Services

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

Women

| | | | |
|---|---|---|---|
| **Date:** | 11 NOVEMBER, 2020 | | |
| **Venue:** | Bumpetoke | | |
| **Start Time:** | | **End Time:** | |

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | Baindu Bendu | Fish Monger/women | Bumpetoke | 11/11/2020 | 080-124669 | |
| 2 | Marie Tua | Fish Monger/women | ✓ | ✓ | — | |
| 3. | | | ✓ | | — | |
| 3. | Hawa Tua | F Housewife | ✓ | ✓ | — | |
| 4. | Musu Bangali | Fish Monger | ✓ | ✓ | 080252781 | |
| 5. | Aminata Taylor | House wife | ✓ | ✓ | — | |
| 6. | Isatu Khalil | House Wife | ✓ | ✓ | 079399857 | |
| 7 | Teneh Lee | Fish Monger | ✓ | ✓ | — | |
| 8. | Hawa Sheriff | Petty trader | ✓ | ✓ | — | |
| 9. | Makinty Sheriff | Soap Seller | ✓ | ✓ | — | |

INTEGEMS

Integrated Geoinformation and Environmental Management Services

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 10 | Tenneh Sheriff | Fishmonger / business woman | Bumpetoke | 11/11/2020 | 080 906252 | |
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INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

Women in Fisheries

| | | | |
|---|---|---|---|
| **Date:** | 08/11/2020 | | |
| **Venue:** | Shenge | | |
| **Start Time:** | | **End Time:** | |

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | Mabinty Leomie | Shenge ↔ | Women in Fisheries | 08/11/2020 | 079620853 | |
| 2 | Abi Row | Women in Fisheries | Shenge | 08/11/2020 | 077004531 | |
| 3 | Binta Jalloh | Women in Fisheries | Shenge | 08/11/2020 | 076406366 | |
| 4 | Patient Hamilton | Women in Fisheries | Shenge | 08/11/2020 | 088359413 | |
| 5 | Catherine Konima Barlay | Women in Fisheries | Shenge | 08/11/2020 | 078 809 147 | |
| | Fatu Fullah | Women in Fisheries | Shenge | 08/11/2020 | N/A | |
| | Kama Caulker | Women in Fisheries | Shenge | 08/11/2020 | 097 300 838 | |
| | Augusta Barlay | Women in Fisheries | Shenge | 08/11/2020 | 099 041 428 | |
| | Kadieta Kafay | Women in Fisheries | Shenge | 08/11/2020 | N/A | |
| | Juliana Lahai | Women in Fisheries | Shenge | 08/11/2020 | 079 63 1975 | |

INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

Community Elders

| | | | |
|---|---|---|---|
| **Date:** | 08/11/2020 | | |
| **Venue:** | Shenge | | |
| **Start Time:** | | **End Time:** | |

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | Charles M. Barlay | PRO CDC | Shenge | 08/11/2020 | 07635 3372 | |
| 2 | Thomas Caulker | Chairman CDC | ✓ | ✓ | 030-195607 | |
| 3 | Eric J. Lewis | CDC Sec. | ✓ | ✓ | 076213711 | |
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INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

Fishermen and Fishmongers

| | | | |
|---|---|---|---|
| **Date:** | ~~15.36~~ 08.11.2020 | | |
| **Venue:** | Shenge | | |
| **Start Time:** | 15.36 | **End Time:** | 17.06 |

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | ALPha Conteh | Fishermen | Shenge | 08/11/2020 | 0784/9016 | |
| 2 | Idriza Stevens | " | ✓ | ✓ | 088294312 | |
| 3 | Junisa Cole | " | ✓ | ✓ | — | |
| 4 | Swaibu Stevens | " | ✓ | ✓ | — | |
| 5 | Cyril Manley | Fish processor | ✓ | ✓ | 07657668 | |
| 6 | Messie Coulter | " " | ✓ | ✓ | 030447396 | |
| 7 | Mariama Coulter | " " | ✓ | ✓ | 075-954996 | |
| 8 | Mariama Kamara | " " | ✓ | ✓ | 07685-5675 | |
| 9 | Hawa Jalloh | " " | ✓ | ✓ | 030668045 | |
| 10 | Marianna Somasa | " " | ✓ | ✓ | | |

INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 11 | Mustapha Caulker | Fisherman | Shenge | 08/11/2020 | 079657258 | |
| 12 | Boima Luke | Fish processor | ✓ | ✓ | 0305356558 | |
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INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | MARIE KAMARA | WDC | Stakeholder | 10/11/20 | 030 505949 | |
| 2 | Santigie Kamara | Community Member | Stakeholder | 10/11/20 | 077201897 | |
| 3 | Thoreau Kargbo | Teacher | Teacher | 10/11/20 | 099-112208 | |
| 4 | Alie Kanu | Head Teacher | H.P.S | 10/11/20 | 099-992013 | |
| 5 | Abu B. Sesay | Harbour Mst | Harbour Mst | 10/11/20 | 031-28705 | |
| 6 | Emmanuel Shyllon | Stake holder | Stake holder | 10/11/20 | 030-51-0832 | |
| 7 | Rex - Moore | Stake holder | Stake holder | 10/11/20 | 033-57-030 | |
| 8 | George Dallis | Stake holder | Stake holder | 10/11/20 | 030-89-4566 | |
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INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | David S. Shyllon | Sand miner ~~Youth~~ | Hamilton | 10/11/2020 | 030 08 9951 | |
| 2 | TeJan Kamara | Sand miner | Hamilton | 10/11/2020 | 076 330 442 | |
| 3 | TeJan Turay | Sandminer | Hamilton | 10/11/2020 | 077 338130 | |
| 4 | Ishmael Conteh | Sandminer | Hamilton | 10/11/2020 | 088 208211 | |
| 5 | Yusuf Fofanah | Sandminer | Hamilton | 10/11/2020 | 079 08 2718 | |
| 6 | Daniel Turay | Sandminer | Hamilton | 10/11/2020 | 080 828632 | |
| 7 | Patrick Kanneh | Sandminer | Hamilton | 10/11/2020 | 077 90 80 61 | |
| 8 | Foday Koroma | Sandminer | Hamilton | 10/11/2020 | 030 16 20 45 | |
| 9 | Alimamy Bangura | Sandminer | Hamilton | 10/11/2020 | 033 957352 | |
| 10 | Kamanda Dumbuya | Sandminer | Hamilton | 10/11/2020 | 077 85 6079 | |
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INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

| | | | |
|---|---|---|---|
| Date: | 11 November 2020 | | |
| Venue: | Paul's Beach Bar & Restaurant | | |
| Start Time: | 17:05 | End Time: | 18:13 |

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | Paul P. Bangura | Business Owner | Lakka | 11/11/2020 | 076-727377 | |
| 2 | THOMAS SHYLLON | Business owner | LAKKA | 11/11/2020 | 077 292358 | |
| 3 | TAMBA KOROMA | Manager (S.T.S) | Lakka | 11th/11/2020 | 078-842722 | Koroma |
| 4 | Ibrahim Bah | Manager | Palm Beach Club | 11/11/2020 | 079-342425 | |
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INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

Tombo Community. **ATTENDANCE REGISTER** Local Authorities

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | Abdul K Mansaray | Secretary to Hon. | Tombo Local Authority | 13-11-20 | 077-288108 | [signature] |
| 2 | Po Brima Sesay | Stake holder | ✓ | 13-11-20 | 030-457480 | [signature] |
| 3 | Mohamed Okon | Stake holder | ✓ | 13-11-20 | 076-281109 | [signature] |
| 4 | Samuel Billie Kamu | Stakeholder | ✓ | 13-11-20 | 077404289 | [signature] |
| 5 | Ibrahim K. Kamara | Stakeholder | ✓ | 13-11-20 | 0333-1580 | [signature] |
| 6 | Alieu Smith | Youth | ✓ | 13/11/2020 | 030 80 77 84 | [signature] |
| 7 | Abdulrahman | Konama Youth | ✓ | 13/11/2020 | 077-99-4967 | [signature] |
| 8 | Mohamed Loko | Stake holder | ✓ | 13-11-2020 | — | [signature] |
| 9 | Mohamed Kom | Stake holder | ✓ | 13-11-20 | — | [signature] |
| 10 | Alpha Bedor Sesay | Stake holder | ✓ | 13-11-2020 | — | [signature] |
| 11 | Momoh Kamara | Stake holder | ✓ | 13-11-20 | — | [signature] |
| 12 | Mortai Kamara | Stake holder | ✓ | 13-11-20 | — | [signature] |

INTEGEMS

Integrated Geo-Information and Environmental Management Services

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

Sand Miners

| | | | |
|---|---|---|---|
| Date: | 06/11/2020 | | |
| Venue: | Conakry-Dee | | |
| Start Time: | 13:55 | End Time: | |

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | Foday I. Sunah | San minnos | Conakry-D | 6 | 088263712 | [signature] |
| 2 | Tejan Jalloh | San minnos | Konakry-dee | 6/11/20 | 088676003 | [signature] |
| 3 | IBrahim Bangura | ✓ | ✓ | 6/11/20 | 088088168 | [signature] |
| 4 | Foday Kamara | ✓ | ✓ | 6/11/20 | 077582536 | [signature] |
| 5 | Alhassan A. Conteh. | ✓ | ✓ | 6/11/20 | 030898192 | [signature] |
| 6 | Adikalie F. Sankoh | ✓ | ✓ | 6/11/20 | ← | [signature] |
| 7 | Abdulai Mansaray | ✓ | ✓ | 6/11/20 | ← | [signature] |
| 8 | Alhajie A. Sumah | " | " | 6/11/20 | 080793435 | [signature] |
| 9 | Sorie Fallah Kamara | " " | " " | 6/11/2020 | 030497762 | [signature] |
| 10 | Ibrahim A. Mansaray | " " | " " | 6/11/2020 | 080394556 | [signature] |

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

INTEGEMS

### ATTENDANCE REGISTER

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 11 | Mohamed A. Dumbuya | Sand Miner | Conakry-Dee | 6/11/2020 | 07707 9902 | |
| 12 | Yendo K. Kargbo | Sand Miner | Conakry-Dee | 6/11/2020 | 075 45 2202 | |
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INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

Community Leaders/Elders

| | | | |
|---|---|---|---|
| **Date:** | 06 November 2020 | | |
| **Venue:** | Conakry - Dee | | |
| **Start Time:** | 12:00 | **End Time:** | 12:40 |

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | Mohamed Suma | Primary sch. Teacher | Islamic PS | 06/11/2020 | 088729699 | |
| 2. | Momoh Suma | Fisherman | Conakry Dee | ✓ | | |
| 3. | Lamin M. Kamara | Farmer | Conakry Dee | ✓ | 088147210 | |
| 4. | Pa Sesmodu Suma | Chief Imam | Central Mosque | ✓ | 077524322 | |
| 5. | Mohamed Dumbuya | Youth Chairman | Conakry Dee | ✓ | 088724647 | |
| 6. | Mohamed T. Dumbuya | Tailor | Conakry Dee | ✓ | 099482920 | |
| 7. | Ibrahim Kaybo Jonneh | Master Fisherman | Port Loko District | ✓ | 080362770 | |
| 8 | Sheik Hamza A. Secay | Section Chief Imam | Mayaia Section | ✓ | 030857651 | |
| 9. | Alhaji Sosor Suma | Chief Rep/Elder | Conakry Dee | ✓ | 0 | |
| 10 | Kapu Dumbuya | Elder/Fisherman | Conakry Dee | ✓ | 099887964 | |

INTEGEMS

Integrated Reconfirmation and Environmental Management Services

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 11 | Saiso Suma | Elder (Eldest) | Conakry Dee | 06/11/2020 | — | |
| 12 | Abdul Rashid Kanu | Rep. Principal | ✓ ✓ | ✓ ✓ | 099031783 | [signature] |
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INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

Fishermen and Fishmongers

| | | | |
|---|---|---|---|
| Date: | 06/11/2020 | | |
| Venue: | KONAKRY DEE | | |
| Start Time: | | End Time: | |

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | Alie O. Kargbo | Fisherman | Conakry Dee | 06/11/2020 | 088-677-369 | [signature] |
| 2 | Abu Bakar Tun | Fisherman | Conakrydee | ✓ | 088434535 | [signature] |
| 3 | Abrahim B. Conteh | Fisherman | ✓ | ✓ | 033557470 | |
| 4 | Abdul Karim Sunda | Fisherman | ✓ | ✓ | 036-19-1461 | [signature] |
| 5 | Santigue Ratis Kumara | Fisherman | ✓ | ✓ | 088-49-6947 | [signature] |
| 6 | Maree Kargbo | Fish mode | ✓ | ✓ | — | |
| 7 | N'MAH KILLO | Fish mode | ✓ | ✓ | 033-558104 | |
| 8 | Memuna Fofanah | ✓ | ✓ | ✓ | 088-723374 | |
| 9 | N'mah Sesay | ✓ | ✓ | ✓ | 030-25/4043 | |
| 10 | Fatmata Fofanah | ✓ | ✓ | ✓ | | |

INTEGEMS

Integrated Geo-Information and Environmental Management Services

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 11 | Hawa Turay | Conakryde. | Fish Monger | 06/11/2020 | — | |
| 12 | KADAH-K-Sumar | ✓ | ✓ | ✓ | — | |
| 13 | N'Mar Yullah Kamara | ✓ | ✓ | ✓ | — | |
| | | ✓ | ✓ | ✓ | — | |
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INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

Fishermen and Fishmongers

| | | | |
|---|---|---|---|
| **Date:** | 10th / Nov. / 2020 | | |
| **Venue:** | Yele | | |
| **Start Time:** | | **End Time:** | |

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | Solomon Leblie | Fisherman | Yele | 10/11/2020 | — | |
| 2 | Adama Kamara | Fish Monger | ✓ | ✓ | — | |
| 3 | Abu Bakar Koroma | Fisherman | ✓ | ✓ | — | |
| 4 | Osman Beah | Fisherman | ✓ | ✓ | — | |
| 5 | Alusine Kain | Fisherman | ✓ | ✓ | 033 667765 | |
| 6 | Memuna Koroma | Fish Monger | ✓ | ✓ | 076517233 | |
| 7 | | | ✓ | ✓ | — | -Memuna |
| 8 | Jeneba Sesay | Gardner/Fish Monger | ✓ | ✓ | — | |
| 9 | Suba Charley | Fish Monger | ✓ | ✓ | — | |
| 10 | Hassah Barthalomeow | Cookery Seller | ✓ | ✓ | — | |

INTEGEMS

Integrated Environmental Information and Environmental Management Services

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 11 | Salamatu Abdulrahman Habib | Business women | Yele Community | 10/11/2020 | — | |
| 12 | Junisa Charlie | Fisherman | ✓ | ✓ | 078 594 797 | |
| 13 | Abdul Manaff Kenara | Fisherman | ✓ | ✓ | — | |
| 14. | Tommy Charly | Fisherman | ✓ | ✓ | — | |
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INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

| | | | |
|---|---|---|---|
| Date: | 10/11/2020 | | |
| Venue: | Hamilton Community Center | | |
| Start Time: | 11:30 am | End Time: | 12:32pm |

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1. | Lucian Sesay | Business Woman | Hamilton | 10/11/2020 | 088-942051 | LS |
| 2 | marian pratt | Trader | Hamilton | 10/11/2020 | 099 66 8186 | |
| 3 | Tabeh Brewah | Petty Trader | Hamilton | 10/11/2020 | 034-065391 | TB |
| 4 | Zainah Sheriff | Petty Trader | Hamilton | 10/11/2020 | 077-747492 | |
| 5 | Sidaty Koroma | Petty Trader | Hamilton | 10/11/2020 | 030-411922 | |
| 6 | Sarah Conteh | Petty Trader | Hamilton | 10/11/2020 | 030-415783 | |
| 7 | Teneh Koroma | Petty Trader | Hamilton | 10/11/2020 | 099-030643 | |
| 8 | Lucy Sam | Petty Trader | Hamilton | 10/11/2020 | 033-484299 08 | |
| 9 | Esther Fofanah | Petty Trader | Hamilton | 10/11/2020 | 080-685290 | |
| 10 | Ruth M. Samura | Teacher | Hamilton | 10/11/2020 | 030-792177 | |

INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | John Bennet | Fisherman | Hamilton | 10/11/2020 | | |
| 2 | Martha Komba | Fish trader | Hamilton | 10/11/2020 | 030-012213 | |
| 3 | Mohamed Sesay | Fisherman | Hamilton | 10/11/2020 | | |
| 4 | Sulaiman Hae | Fisherman | Hamilton | 10/11/2020 | | |
| 5 | Luis Lahai | Fisherman | Hamilton | 10/11/2020 | 099-751682 | |
| 6 | Clifford May-Collier | Fisherman | Hamilton | 10/11/2020 | 078-534954 | |
| 7 | Francess P. Turner | Fish Trader | Hamilton | 10/11/2020 | 034-665120 | |
| 8 | Bai Kargbo | Student/ Fisherman | Hamilton | 10/11/2020 | 030-417058 | |
| 9 | Yussif Bangura | Fisherman | Hamilton | 10/11/2020 | 030-782063 | |
| 10 | Momoh Turay | Fisherman | Hamilton | 10/11/2020 | 099-694257 | |
| | | | | 10/11/2020 | | |
| | | | | 10/11/2020 | | |

# Fishermen Group

**Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project**

INTEGEMS

## ATTENDANCE REGISTER

| | | | |
|---|---|---|---|
| **Date:** | 30-10-2020 | | |
| **Venue:** | Lakka Community Centre | | |
| **Start Time:** | 12:25 | **End Time:** | 13:22 |

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| | ~~Sand Miners~~ | | Lakka Community | 30/10/20 | | |
| 01 | Mohamed Lamin Koroma | Fisherman | " | " | 030-85-2358 | |
| 02 | John Yainkain | Fisherman | " | " | 077452408 | |
| 03 | Andrew Millimas | Fisherman | " | " | 088997-313 | |
| 04 | ABU BAKARR KANU | Fisherman | " | " | 077498160 | |
| 05 | Mohamed L. Jalloh | Fisherman | " | " | 088496461 | |
| 06 | Tommy Johnson | Fisherman | " | " | 09994582 2 | |
| 07 | Eric Bendu | Fisherman | " | " | 080 75 63 80 | |
| 08 | Ebenezer Johnson | Fisherman | " | " | 077-35-11-16 | |
| 09 | SOBA GBANA | Fisherman | " | " | 030781261 | |

INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 10 | ABDUL KABIA | Fisherman | Lakka Community | 30/10/20 | 03080319 6 | |
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INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

| | | | |
|---|---|---|---|
| **Date:** | 30.10.2020 | | |
| **Venue:** | Lakka Community Centre | | |
| **Start Time:** | | **End Time:** | |

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | Fredrick Kargbo | Sand miner | Lakka | 30/10/20 | 030151497 | |
| 2. | Elizabeth A. Johnson | Sand miner | Lakka | 30/10/2020 | 076243665 | |
| 3. | James Martin | Sand Miner | Lakka | 30/10/2020 | 033-834482 | |
| 4 | Albert Caulker | Sand miner | Lakka | 30/10/2020 | 099 881218 | Caulker |
| 5 | Eddie Browne | Sand Miners | Lakka | 30/10/2020 | 030 211523 | |
| 6 | Ibrahim Kamara | Sand miner | Lakka | 30/10/22-030 | | |
| 7 | Isatu Mansaray | Sand Miner | Lakka | 30/10/2020 | 088-989748 | |
| 8 | William | NHO | Lakka | 30/10/2020 | 080593181 | |
| 9 | Francisco Palmer | Sand Miner | Lakka | 30/10/2020 | - - - | |
| 10 | Morlai Kargbo | sand miner | Lakka | 30/10/2020 | 033564707 | |

INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

| | | | |
|---|---|---|---|
| **Date:** | 30 – 10 – 2020 – Fish Mongers | | |
| **Venue:** | Lakka Community Center | | |
| **Start Time:** | | **End Time:** | 13:00 |

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1 | Honoria Cole | Fish Monger | Lakka Community | 30/10/2020 | 033-542537 | Cole |
| 2. | Aminata Koroma | ✓ ✓ | ✓ ✓ | ✓ | — | |
| | Hawanatu Kabbia | ✓ ✓ | ✓ ✓ | ✓ | 030-465175 | |
| | Matilda Massaquoi | ✓ ✓ | ✓ ✓ | ✓ | 030-389174 | |
| | Aminata Kamiah | ✓ ✓ | ✓ ✓ | ✓ | 079-750314 | |
| | Sarian Macauley | ✓ ✓ | ✓ ✓ | ✓ | 033-691711 | |
| | Alice Kamara | ✓ ✓ | ✓ ✓ | ✓ | 033-691597 | |
| | Hannah Turay | ✓ ✓ | ✓ ✓ | ✓ | 079-167901 | |
| | Rosamond Martin | ✓ ✓ | ✓ ✓ | ✓ | 033-687366 | |
| | Hannah Sesay | ✓ ✓ | ✓ ✓ | ✓ | 099-855759 | |

INTEGEMS

## Focus Group Discussion: Coastal Vulnerability Assessment (CVA) for UNDP-GEF Project

### ATTENDANCE REGISTER

| | | | |
|---|---|---|---|
| **Date:** | 30th October, 2020 | | |
| **Venue:** | LAKKA COMMUNITY CENTRE | | |
| **Start Time:** | 12:00 | **End Time:** | |

| No | Name | Designation | Institution | Date | Phone/Email | Signature |
|---|---|---|---|---|---|---|
| 1) | Aminata Sylla | Sub-head | Lakka | 30-10-20 | 078 381468 | |
| 2) | Christiana M-Kargbo | Youth Leader | Lakka | 30-10-2020 | 075-012656 | |
| 3) | Abiodu Williams | ELDER | LAKKA | 30/10/20 | 080217499 | Abiodu |
| 4) | TAMMY TUCKER | Elder | Lakka | 30/10/20 | 077217724 | |
| 5 | Dennis Bundu | Enterpreneur | Lakka | 30/10/20 | 077652189 | |
| 6 | BESSY TUCKER | Trader | Lakka | 30/10/20 | 076700697 | |
| 7 | Patrick J. Bangura | Activist | Lakka | ✓ | 0889 | |
| 8 | RAMATU KAMARA | KAMARA | LAKKA | 301020 | | RA |
| 9 | Francis Bendu | CDMC | Lakka | 30/10/2020 | 076333867 | |
| 10 | Hannah Douglas | Elder | Lakka | 30/10/20 | 076 95-5509 | |

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# Appendix VII: Survey Questionnaires

DRAFT

# CVA Socio-economic Survey1

* Clicking the "OK" button below indicates your consent to participate in this survey

- ◯ OK

## Section 1: RESPONDENT'S DETAILS

**1.1 Name of community**

- ◯ Lakka
- ◯ Hamillton
- ◯ Tombo
- ◯ Konakry Dee
- ◯ Shenege
- ◯ Turtle Island

**1.2 Respondent's name**

*Please write the name in full (eg. Musu Conteh)*

_____

**1.3 Respondent's gender**

- ◯ Male
- ◯ Female

**1.4 Respondent's age**

_____

**1.5 Respondent's ethnicity**

- ◯ Kono
- ◯ Temne
- ◯ Mende
- ◯ Fullah
- ◯ Limba
- ◯ Madingo
- ◯ Sherbro
- ◯ Kissi
- ◯ Kuranko
- ◯ Susu
- ◯ Yalunka
- ◯ Loko
- ◯ Krio
- ◯ Gola
- ◯ Kru
- ◯ Vai
- ◯ Krim
- ◯ Galina
- ◯ Others

**1.6 Respondent's marital status**

- ◯ Single
- ◯ Married
- ◯ Divorced
- ◯ Separated
- ◯ Cohabiting
- ◯ Widow
- ◯ Widower

**1.7 Respondent's religion**

- ◯ Islam
- ◯ Christianity
- ◯ African Traditional Religion
- ◯ Other

**1.8 Respondent's level of education**

- ◯ No Formal Education
- ◯ Primary
- ◯ Junior Secondary
- ◯ Senior Secondary
- ◯ Vocational
- ◯ Undergraduate
- ◯ Postgraduate
- ◯ Other

**1.9 Respondent's phone number**

_____

**1.10 Respondent's main occupation**

- ◯ Fisherman
- ◯ Fishmonger
- ◯ Sandminer
- ◯ Gardener
- ◯ Formal Employment
- ◯ Boatmaking
- ◯ Student
- ◯ Unemployed
- ◯ Skilled Trade
- ◯ Other

**1.11 Household ID**

_____

**1.12 Enumerator ID**

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7
- ◯ 8
- ◯ 9
- ◯ 10
- ◯ 11
- ◯ 12

## Section 2: HOUSEHOLD DEMOGRAPHY

**2.1 Are you the head of the household?**

- ◯ Yes
- ◯ No

**2.2 What is your relationship with the head of the household**

- ◯ Spouse
- ◯ Son/Daughter
- ◯ Sister/Brother
- ◯ Nephew/Niece
- ◯ Cousin
- ◯ Parent
- ◯ Uncle/Aunt
- ◯ In-Law
- ◯ Grand Parent
- ◯ Grand Child
- ◯ Step Son/Daughter

**2.3 What is the gender of the household head?**

- ◯ Male
- ◯ Female

**2.4 Is the household head an indigene of this community?**

- Yes
- No

**2.5 What is the major reason did household head moved here?**

- Friends/family live here
- Access to improved standard of living
- Agricultural purpose
- Marital purpose
- Business
- Employment
- Don't know
- Other

**2.6 Are you an indigene of this community?**

- Yes
- No

**2.7 Why did you move and settle here?**

- Friends/family live here
- Access to improved standard of living
- Agricultural purpose
- Marital purpose
- Business
- Employment
- Don't know
- Other

**2.8 What type of family is this?**

- Extended Family Household
- Nuclear Family Household

**2.9 What is the total number of people living in this household?**

_____

**2.10 How many of them are male?**

*(Please equate the number of male to the total number of household members)*

_____

**2.11 How many of them are female?**

*(Please equate the number of female to the total number of household members)*

_____

**2.12 How many of them fall between age 0 to 14**

_____

**2.13 How many of them fall between age 15 to 17**

_____

**2.14How many of them fall between age 18 to 35**

_____

**2.15 How many of them fall between age 36 to 64**

_____

**2.16 How many of them are age 65 and Above**

_____

## Section 3: HOUSING AND INFRASTRUCTURE

**3.1 What type of dwelling unit is this?**

- ◯ Huts
- ◯ Single unit house
- ◯ Semi-detached house (Adjoining house)
- ◯ Flat/Apartment
- ◯ Improvised home (kiosk, Tent, container, board pan-body)
- ◯ Uncompleted building

**3.2 What is the ownership status of the house?**

- ◯ Owned
- ◯ Rent
- ◯ Family house
- ◯ Friend's house
- ◯ Lease

**3.3 How many bedroom(s) does your household occupy?**

- ◯ One room
- ◯ Two rooms
- ◯ Three rooms
- ◯ Four rooms
- ◯ Five rooms and above

**3.4 How many other household(s) are in this house?**

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4

**3.5 What is the major construction material of the roof?**

- ◯ Zinc
- ◯ Thatch
- ◯ Tarpaulin/Plastic
- ◯ Concrete
- ◯ Asbestos

**3.6 What is the major construction material of the wall?**

- ◯ Mud and Wattle
- ◯ Mud Brick
- ◯ Cement blocks
- ◯ Zinc
- ◯ Tarpaulin/Plastic
- ◯ Timber (wood or board)
- ◯ Stone
- ◯ Thatch
- ◯ Other

**3.7 What is the major material of the floor?**

- ◯ Concrete
- ◯ Mud
- ◯ Tile
- ◯ Timber
- ◯ Stone
- ◯ Other

**3.8 What type of toilet that is mainly used in your household?**

- ◯ Pit latrine (private)
- ◯ Pit latrine (shared)
- ◯ VIP latrine (private)
- ◯ VIP latrine (shared)
- ◯ Flush toilet (private)
- ◯ Flush toilet (shared)
- ◯ Bush
- ◯ River/Stream
- ◯ none

**3.9 What is the main source of lighting in your dwelling?**

- ◯ Local electricity grid (Communal Generator)
- ◯ Solar Grid
- ◯ National electricity grid (EDSA)
- ◯ Private generator
- ◯ Private Solar
- ◯ Battery/Rechargeable light
- ◯ Candle
- ◯ kerosene lamp
- ◯ Other

**3.10 Which type of fuel do you often use for cooking?**

- ◯ Firewood
- ◯ Charcoal
- ◯ Gas
- ◯ Sawdust
- ◯ Kerosene
- ◯ Electricity
- ◯ Other

## Section 4: EMPLOYMENT AND INCOME

**4.1 Who is the main income earner in your household?**

- ◯ Parents
- ◯ Children
- ◯ Relatives

**4.2 Are there any other member(s) in your household employed or engage in economic activity(s)**

- ◯ Yes
- ◯ No

**4.3 How many household members are engaged in income generating activities?**

_____

**4.4 What are the income generating activities?**

- [ ] Fishing
- [ ] Fishmongering
- [ ] Sandmining
- [ ] Gardening
- [ ] Formalemployment
- [ ] Boatmaking
- [ ] Pettytrading
- [ ] Business
- [ ] Skilled trade
- [ ] Other

**4.5 Does the household receive additional income from any other source?**

- ◯ Yes
- ◯ No

**4.6 What are the sources of the additional income?**

- ◯ Relative
- ◯ Friend
- ◯ Charity organisation(s)
- ◯ From other business I do
- ◯ Rent
- ◯ Other

**4.7 What is the total monthly household income (net income after taxes benefit deductions)?**

- ◯ le250,000 or less
- ◯ le251,000 - le500,000
- ◯ le501,000 - le1,000,000
- ◯ le1,001,000 - le2,500,000
- ◯ le2,501, 000 - le5,000,000
- ◯ Above le5,000,000

**4.8 How much do you spend per month?**

- ◯ Nothing
- ◯ le1000 - le50,000
- ◯ le51,000 - le100,000
- ◯ le101,000 - le150,000
- ◯ le151,000 - le200,000
- ◯ le201,000 - le250,000
- ◯ Above le250,000

**4.9 Do you save some money after spending for the month?**

- ◯ Yes
- ◯ No

**4.10 How much do you save per month?**

- ◯ Nothing
- ◯ le1000 - le50,000
- ◯ le51,000 - le100,000
- ◯ le101,000 - le150,000
- ◯ le151,000 - le200,000
- ◯ le201,000 - le250,000
- ◯ Above le250,000

## Section 5: LAND OWNERSHIP AND LAND USE

**5.1 Do you own land in this community?**

◯ Yes ◯ No

**5.2 How was the land acquired?**

◯ Inheritance ◯ Purchased ◯ Leasehold
◯ Gift ◯ other

**5.3 What is the land used for?**

☐ Residential
☐ Agricultural
☐ Tourism/Recreation
☐ Cultural
☐ Nothing
☐ Other

## Section 6: EDUCATION

**6.1 How many members of your household have attained primary school education?**

_____

**6.2 How many members of your household have attained junior secondary school education?**

_____

**6.3 How many members of your household have attained senior secondary school education?**

_____

**6.4 How many members of your household have attained tech-voc education?**

_____

**6.5 How many members of your household have attained tertiary education?**

_____

**6.6 How many members of your household have not gain any formal educational?**

_____

## Section 7: HEALTH AND SANITATION

**7.1 What are the common illnesses that your household suffer from?**

- [ ] Malaria
- [ ] Diarrhoea
- [ ] Typhoid Fever
- [ ] Cholera
- [ ] Yellow Fever
- [ ] Cold
- [ ] Others

**7.2 Where does your household seek medical attention?**

- [ ] Hospital
- [ ] Clinic
- [ ] Pharmacy
- [ ] Hometreatment
- [ ] Traditional
- [ ] None

**7.3 Do your household use traditional health services?**

- ◯ Yes
- ◯ No

**7.4 What is the main source of water for your household?**

- ◯ Public taps
- ◯ Hand pump
- ◯ River, stream, lake, pond
- ◯ Plumbing outside the house
- ◯ Protected spring
- ◯ Protected well
- ◯ Communal water tank
- ◯ Rain water
- ◯ Unprotected spring
- ◯ Unprotected well
- ◯ Plumbing inside the house

**7.5 What are the other sources of water for your household?**

- [ ] Public taps
- [ ] Protected spring
- [ ] Unprotected spring
- [ ] Hand pump
- [ ] Protected well
- [ ] Unprotected well
- [ ] River, stream, lake, pond
- [ ] Communal water tank
- [ ] Plumbing inside the house
- [ ] Plumbing outside the house
- [ ] Rain water

**7.6 How do you manage or dispose your waste?**

- ◯ Communitytrash
- ◯ Burning
- ◯ Bush
- ◯ Openpit
- ◯ Drainages

## Section 8: SPECIAL NEEDS PEOPLE

**8.1 Do you have anyone with special needs in your household?**

- ◯ Yes
- ◯ No

**8.2 What type of special needs do they have?**

*(Please tick as much as relevant)*

- ◯ Aged
- ◯ Physically Challenged

## Section 9: Climate Change Knowledge and Understanding

**9.1 Have you heard about Climate Change?**

- ◯ Yes
- ◯ No

**9.2 How did you know about Climate Change?**

*(Please tick as much as relevant)*

- [ ] Radio
- [ ] Television
- [ ] Newspaper
- [ ] Socialmedia
- [ ] Religious House
- [ ] Families and Friends
- [ ] Public Sensitization
- [ ] Place of Work
- [ ] School
- [ ] Other

**9.3 What do you know about Climate Change?**

---

**9.4 Would you like to learn about climate change?**

◯ Yes ◯ No

**9.5 What changes have you observed in your environment?**

- [ ] Late Rain
- [ ] Early Rain
- [ ] Too Much Heat
- [ ] Heavy Rain
- [ ] Frequent Floods
- [ ] Frequent High Tides
- [ ] other

**9.6 How do you think climate change is affecting your community?**

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**9.7 What are you doing to stop it?**

---

**9.8 What do you do to adapt to the changes in your community?**

---

**9.9 Has your household been affected by a disaster?**

- ◯ Yes
- ◯ No

**9.10 What type of disaster?**

- ☐ Flood
- ☐ Fire
- ☐ Windstorm
- ☐ Erosion
- ☐ other

**9.11 How was your household affected?**

- ☐ Property Damage
- ☐ Loss of Lives
- ☐ Loss of Property
- ☐ Injuries
- ☐ Other

**9.12 How did you respond to the disaster?**

_____

**Collect GPS cordinate**

latitude (x.y °)

_____

longitude (x.y °)

_____

altitude (m)

_____

accuracy (m)

_____



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