FINAL REPORT

Update of Sierra Leone Hazard Profile and Capacity Gap Analysis

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This Report is a final, validated and peer reviewed deliverable from the Update of Sierra Leone Hazard Profile and Capacity Gap Analysis Project (hereafter, the Project) that is funded and supported by the UNDP Sierra Leone Country Office and the Global Environment Facility (GEF). The key Implementing Partners of the Project are the Sierra Leone Meteorological Agency (SLMA), prior to July 2017 the Sierra Leone Meteorological Department (SLMD) in the Ministry of Transport and Aviation (MTA); the Office of National Security – Disaster Management Department (ONS-DMD); the Ministry of Water Resources (MWR); and the Environment Protection Agency-Sierra Leone (EPA-SL).

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Cover photos courtesy of INTEGEMS. Top photo (a view of Sugar Loaf Hill, Regent, Freetown, Sierra Leone on 13 March 2017) and bottom photo (a view of Sugar Loaf Hill, Regent, Freetown, Sierra Leone on 15 August 2017, after the landslide event of 14 August 2017)

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Environment Protection Agency-Sierra Leone (EPA-SL)

Ministry of Water Resources (MWR)

LIST OF ABBREVIATION AND ACRONYMS

ACP- EU	Africa Caribbean Pacific – European Union
AER	Annual Equivalent Rate
AFP	Agenda for Prosperity
AHP	Analytical Hierarchical Process
AHZ	Active Hazard Zone
API	Application Program Interface
ASAL	Arid and Semi-Arid Lands
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
AWS	Automatic Weather Station
BEmONC	Basic Emergency Obstetric and Neonatal Care
BFE	Base Flood Elevation
BGS	British Geological Survey
BWMA	Bumbuna Watershed Management Authority
CAP	Community Action Plans
CBDM	Community Based Disaster Management
CBEWS	Community-Based Early Warning Systems
CBIS	Community-Based Information Systems
CBO’s	Community Based Organisation
CEmONC	Comprehensive Obstetric and Neonatal Care
CFM	Critical Facilities Mapping
CHC	Community Health Centre
CHP	Community Health Post
CHW	Community Health Workers
CIDMEWS-SL	Climate information Deserter Management Ealey warning systems
CIEWS	Climate Information Early Warning System
CMDRR	Community Managed Disaster Risk Reduction
CRC	Constitutional Review Committee
CRED EM-DAT	Centre for Research Epidemeology of Disasters Emergency Events Database
CSO	Civil society Organisations
CSS	Cascading Style Sheets
CZ	Coastal Zone
DaLA	Damage and Loss Assessment
DBMS	Database Management Systems
DC	District Council
DDMC	District Disaster Management Committee
DEM	Digital Elevation Model
DISEC	District Security Coordinator
DLG	Digital Line Graph

DM	Disaster Management
DMD	Disaster Management Department
DMIS	Disaster Management Information System
DMP	Disaster Management Policy
DMT	Disaster Management Team
DP	Demographic Profile
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DSAS	Digital Shoreline Analysis System
DSM	Digital Surface Model
DTA	Dangerous Thunderstorm Alert
DTM	Digital Terrain Model
EAP	Emergency Action Plan
EAS	Emergency Alert System
EENRM	Energy Environment and Natural Resource Management
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIS	Emergency Information System
EM	Electromagnetic
ENTLN	Earth Networks Total Lighting Network
EPA	Environmental Protection Act
EPA-SL	Environment Protection Agency –Sierra Leone
EPR	End Point Rate
ER	Emergency Relief
ESIA	Environmental and Social Impact Assessments
ESRI	Environmental System Research Institute
ETM	Enhanced Thematic Mapping
EVD	Ebola Virus Disease
EWS	Early Warning systems
FAO	Food Agricultural Organisation
FF	Flash Flood
FOSS	Free Open Source Software
FY	Fiscal Year
GCM	Global Climate Models
GCP	Ground Control Points
GDEM	Global Digital Elevation Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
GFDRR	Global Facility for Disaster Reduction Recovery
GIS	Geographical Information Systems

GRNP	Gola Rainforest National Park
GoSL	Government of Sierra Leones
GPS	Global Positioning Systems
GUI	Graphical User Interface
HARPIS	Hazard and Risk Profiles Information Systems
HARPIS-SL	Hazard and Risk Profiles Information Systems-Sierra Leone
HEC-HMS	Hydrologic Engineering Centre's Hydrologic Modelling System
HEP	Hydroelectric Plant
HFA	Hyogo Framework
HWM	High Water Mark
ICT	Information and communication technology
IEZ	Inshore Exclusive Zone
IFAD	International Fund for Agricultural Development
IFRC	International Red Cross and Red Crescent Society
IIRR	International Institute of Rural Reconstruction
INGO	International Non-Governmental Organisations
INTEGEMS	Integrated Geo-information and Environmental Management Services
IP	Internet Protocol
ISDR	International Strategy for Disaster Reduction
IT	Information Technology
ITCZ	Inter Tropical Convergence Zone
IUCN	International Union for Conservation of Nature
KPI	Key Performance Indicator
KPP	Key Performance Parameter
LHZ	Low Hazard Zone
LiDAR	Light Detection and Ranging
M&E	Monitoring & Evaluation
MAFFS	Ministry of Agriculture, Forestry and Food Security
MAPS	Mitigation Action Plans
MCHP	Maternal and Child Health Post
MDA's	Ministry Department and Agency
MDG	Millennium Development Goals
MEST	Ministry of Education Science and Technology
MHM	Multiple Hazard Maps
MIA	Ministry of Internal Affairs
MIS	Management Information Systems
MLCPE	Ministry of Lands Country Planning and the Environment
MLGRD	Ministry of Local Government and Rural Development
MLSS	Ministry of Labour and Social Services
MMRF	Ministry of Marine Resources and Fisheries

MoE	Ministry of Energy
MoHS	Ministry of Health and Sanitation
MSW	Municipal Solid Wastes
MSWGCA	Ministry of Social Welfare, Gender and Children's Affairs
MTA	Ministry of Transport and Aviation
MTCA	Ministry of Tourism and Cultural Affairs
MTCA	Ministry of Tourism and Cultural Affairs
MTI	Ministry of Trade and Industry
MWHID	Ministry of Works, Housing and Infrastructural Development
MWR	Ministry of Water Resources
NAPA	National Adaptation Programmes of Action
NASA	National Aeronautics and Space Administration
NBSAP	National Biodiversity Strategies and Action Plans
NDMP	National Disaster Management Policy
NDMWG	National Disaster Management Working Group
NGO's	Non-Governmental Organisation
NHA	National Hazard Assessment
NHAP	National Hazard Assessment Profile
NPP	National Polar-orbiting Partnership
NRIS	National Risk Information System
NSCC	National Secretariat for Climate Change
NSCIA	National Security and Central Intelligence Act
NSCIA	National Security and Central Intelligence Act
ODK	Open Data Kit
OKNP	Outamba Kilimi National Park
ONS	Office of National Security
ONS-DMD	Office of National Security-Disaster Management Department
OSM	Open Street Map
PAH	Polycyclic Aromatic Hydrocarbons
PAR	Pressure and Release
PCVA	Participatory Capacity Vulnerability Assessment
PDNA	Post Disaster Needs Assessment
PDRA	Participatory Disaster Risk Assessment
PET	Potential Evapotranspiration
PHC	Population and Housing Census
PHU	Peripheral Health Units
PM	Particulate Matter
PMSU	Programme Management Support Unit
PPP	Purchasing Power Parity
PROSEC	Provincial Security Coordinator

QA/QC	Quality Assurance /Quality Control
QGIS	Quantum Geographical Information Systems
RA	Risk Assessment
RDBMS	Relational Database Management Systems
REDD	Reducing Emissions from Deforestation and Forest Degradation
RH	Risk Hazard
RMS	Root Mean Square
RSLAF	Republic of Sierra Leone Arm Forces
RTA	Road Traffic Accidents
SDG	Sustainable Development Goals
SIA	Social Impact Assessment
SLAA	Sierra Leone Aviation Authority
SLEWRC	Sierra Leone Electricity and Water Regulatory Commission
SLEWRC	Sierra Leone Electricity and Water Regulatory Commission
SLMA[1]	Sierra Leone Maritime Agency
SLMA[2]	Sierra Leone Meteorological Agency
SLP	Sierra Leone Police
SLRA	Sierra Leone Roads Authority
SLTA	Sierra Leone Transportation and Aviation
SMCE	Spatial Multi-Criteria Evaluation
SOA	Service-Oriented Architecture
SOPs	Standard Operating Procedures
SPI	Standard Precipitation Index
SPM	Suspended Particulate Matter
SRTM	Shuttle Radar Topography Mission
SSL	Statistics Sierra Leone
SSR	Security Sector Reform
SST	Sea Surface Temperatures
TCP	Transmission Control Protocol
TOR	Terms Of Reference
UNDP	United Nation Development Program
UNICEF	United Nations International Children's Fund
UNISDR	United Nation International Strategy for Disaster Reduction
UNOPS	United Nations Office for Project Services
UNWTO	United Nations World Tourism Organisation
USACE	United States Army Corps of Engineers
USL	University of Sierra Leone
VCA	Vulnerability Capacity Assessment
VDC	Village Development Committee
VIIRS	Visible Infrared Imaging Radiometer Suite

VNIR	Visible–Near Infrared
WAP-NAP	Western Area Peninsula National Park
WDI	World Development Indicators
WFP	World Food Programme
WLR	Weighted Linear Regression
WMO	World Meteorological Organisation
WRA	Water Resource Areas
WRSI	Water Requirements Satisfaction Index
WSSD	World Summit on Sustainable Development

DEFINITION OF KEY TERMS

The terminology in hazard assessment and profiling, disaster risk reduction and management, and exposure and vulnerability assessment is comprehensive and broad. Hence, in this section a set of key terms which are referred to throughout the Report have been included. In order to aid comparability, this Report stays close to those used by the International Strategy for Disaster Reduction (ISDR). At the same time, this Report has adopted specific working definitions that guide the assessments and analyses undertaken.

Adaptation

The adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

Capacity

A combination of all the strengths and resources available within a community, society or organisation that can reduce the level of risk, or the effects of a disaster. Capacity may include physical, institutional, social or economic means as well as skilled personal or collective attributes such as leadership and management. Capacity may also be described as capability.

Climate Change

The Inter-governmental Panel on Climate Change defines climate change as: “a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.”

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. Disasters are often described as a result of the combination of: the exposure to a hazard; the conditions of vulnerability that are present; and insufficient capacity or measures to reduce or cope with the potential negative consequences. Disaster impacts may include loss of life, injury, disease and other negative effects on human physical, mental and social well-being, together with damage to property, destruction of assets, loss of services, social and economic disruption and environmental degradation.

Disaster Risk

The potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period. The definition of disaster risk reflects the concept of disasters as the outcome of continuously present conditions of risk. Disaster risk comprises different types of potential losses which are often difficult to quantify. Nevertheless, with knowledge of the prevailing hazards and the patterns of population and socio-economic development, disaster risks can be assessed and mapped, in broad terms at least.

Disaster Risk Management

The systematic process of using administrative decisions, organisation, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters. This comprises all forms of activities, including structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects of hazards

Disaster Risk Reduction

The concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events. A comprehensive approach to reduce disaster risks is set out in the United Nations endorsed Hyogo Framework for Action, adopted in 2005, whose expected outcome is “The substantial reduction of disaster losses, in lives and the social, economic and environmental assets of communities and countries.” The ISDR system provides a vehicle for cooperation among Governments, organisations and civil society actors to assist in the implementation of the Framework. Note that while the term “disaster reduction” is sometimes used, the term “disaster risk reduction” provides a better recognition of the ongoing nature of disaster risks and the ongoing potential to reduce these risks.

Early Warning System

The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organisations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss. This definition encompasses the range of factors necessary to achieve effective responses to warnings. A people-centred early warning system necessarily comprises four key elements: knowledge of the risks; monitoring, analysis and forecasting of the hazards; communication or dissemination of alerts and warnings; and local capabilities to respond to the warnings received. The expression “end-to-end warning system” is also used to emphasize that warning systems need to span all steps from hazard detection through to community response.

Exposure

People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses. Measures of exposure can include the number of people or types of assets in an area. These can be combined with the specific vulnerability of the exposed elements to any particular hazard to estimate the quantitative risks associated with that hazard in the area of interest.

Hazard

A dangerous phenomenon, substance, human activity or condition 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. There are hazards of natural origin and related environmental and technical hazard and risks. Such hazards arise from a variety of geological, meteorological, hydrological, oceanic, biological and technical sources, sometimes acting in combination. In technical settings, hazards are described quantitatively by the likely frequency of occurrence of different intensities for different areas, as determined from historical data or scientific analysis.

Mitigation

Structural and non-structural measures undertaken to limit the adverse impact of natural hazards, environmental degradation and technological hazards.

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 the flood caused by a hurricane or the tsunami that is created by an earthquake.

Preparedness

Activities and measures taken in advance to ensure 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’.

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.

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.

Resilience

The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions. The resilience of a community in respect to potential hazard events is determined by the degree to which the community has the necessary resources and is capable of organizing itself both prior to and during times of need.

Return Period

A return period, also known as a recurrence interval or repeat interval, is an estimate of the likelihood of an event to occur. It is a statistical measurement typically based on historical data denoting the average recurrence interval over an extended period of time. The theoretical period is the inverse of the probability that the event will be exceeded in any other year. For example, a 25 year flood has a 1/25 = 0.25 or 25% chance of being exceeded in any one year. Despite the connotations of the name “return period”, it does not mean that a 25 year flood will happen regularly every 25 years or only once in 25 years.

Risk

The combination of the probability of an event and its negative consequences.

Risk Analysis

The process to comprehend the nature of risk and to determine the level of risk (ISO 31010).

Risk Assessment

A methodology to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend. Risk assessments (and associated risk mapping) include: a review of the technical characteristics of hazards such as their location, intensity, frequency and probability; the analysis of exposure and vulnerability including the physical social, health, economic and environmental dimensions; and the evaluation of the effectiveness of prevailing and alternative coping capacities in respect to likely risk scenarios. This series of activities is sometimes known as a risk analysis process.

Single-risk assessments and multi-risk assessments Single-risk assessments determine the singular risk (i.e. likelihood and consequences) of one particular hazard (e.g. flood) or one particular type of hazard (e.g. flooding) occurring in a particular geographic area during a given period of time. Multi-risk assessments determine the total risk from several hazards either occurring at the same time or shortly following each other, because they are dependent from one another or because they are caused by the same triggering event or hazard; or merely threatening the same elements at risk (vulnerable/ exposed elements) without chronological coincidence.

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.

Vulnerability

The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. There are many aspects of vulnerability, arising from various physical, social, economic, and environmental factors. Examples may include poor design and construction of buildings, inadequate protection of assets, lack of public information and awareness, limited official recognition of risks and preparedness measures, and disregard for wise environmental management. Vulnerability varies significantly within a community and over time. This definition identifies vulnerability as a characteristic of the element of interest (community, system or asset) which is independent of its exposure.

EXECUTIVE SUMMARY

Background

In 2002 the Government of Sierra Leone (GoSL) enacted the National Security and Central Intelligence Act (NSCIA 2002) that mandates the Office of National Security (ONS) to coordinate disaster management at various levels through multi-sectoral platform to address the underlying issues of disaster preparedness, prevention, mitigation, response and recovery/rehabilitation. In 2004 the ONS established the Disaster Management Department (DMD) and gave it the central responsibility of coordinating the management of national emergencies. In a bid to urgently address disaster management issues in Sierra Leone, the ONS-DMD with funding from the United Nations Development Programme (UNDP) Sierra Leone Country Office commissioned a group of local consultants from the University of Sierra Leone (Fourah Bay College) in November 2004 to undertake a National Hazard Assessment (NHA) Study and develop profiles of natural and manmade hazards in Sierra Leone.

Results from the NHA Study revealed, amongst other things, that "…*Sierra Leone is endowed with abundant natural resources and that these resources have continued to determine the path and pattern of economic growth, depending on how they are managed; the economy largely depends on natural resources, and as such, understanding their nature, distribution and mode of exploitation is essential for their optimal utilisation without jeopardizing the environment; that if these resources are properly utilized and managed efficiently, environmental hazards, man-made disasters and to some extent, natural disasters can be minimized; and post war reconstruction, mining, fishing, agriculture and other economic activities continue to be poorly regulated and this is becoming a recipe for disasters*…".

Unfortunately, the 2004 NHA Study predates the Hyogo Framework of Action (HFA) 2005-2015: Building the Resilience of Nations and Communities to Disasters; the two recent GoSL's national development strategies (Agenda for Change: 2008-2012 and Agenda for Prosperity: 2013-2018); the 2015 Sierra Leone Population and Housing Census; the Sendai Framework for Disaster Risk Reduction 2015–2030; and the 2030 Agenda for Sustainable Development Goals (SDGs). The 2004 NHA also lacks hazard and background maps and comprehensive characterisation of hazards, disaster risks, exposure and population vulnerability at sub-national levels for effective disaster risk reduction (DRR) and disaster risk management (DRM) in Sierra Leone. Consequently, the lack of recent and comprehensive national hazard profiles and vulnerability and risk assessments of the major hazards (both natural and manmade) per region, their causes and how these can be adequately managed hinders the efficient DRR and DRM programmes in Sierra Leone.

After a very tough fight against the Ebola virus disease (EVD) crisis in 2014/2015, Sierra Leone is now experiencing a growing number of catastrophic disasters that are causing serious physical, social and economic damages and losses. The best known amongst these disasters are the catastrophic floods that occurred in September 2015 and August 2017; the devastating landslides and mudflows that occurred on 14 August 2017, mainly in the Western Area of the country; and the ever increasing tropical storms that constantly strike different parts of the country. Sierra Leone is experiencing these multiple natural disasters with severe impacts that are affecting human lives, disturbing human settlements and damaging properties.

Following these recent disaster events, the GoSL and its development partners are now more united in the belief that greater urgency is required to meaningfully address the factors that are driving the increase in disaster risks, such as rural poverty and vulnerability, unplanned and poorly managed urban growth and declining ecosystems. Urgent action is necessary not only to reduce disaster risks, but also to maintain momentum in achieving the targets and goals articulated by various national and global development strategies and programmes, including poverty reduction, adaptation to climate change and better health outcomes. Sierra Leone is now focusing on accelerated programmes of economic recovery, growth and social development but these programmes will be at serious risk if DRR and DRM measures are not adequately factored into Sierra Leone's development strategies, plans, programmes and projects at all levels and across all sectors sustainably.

It is in this context that in June 2017 the ONS-DMD and the UNDP Sierra Leone Country Office commissioned a local consultancy firm, Integrated Geo-innovations and Environmental Management

Services (INTEGEMS)[1], to undertake the "Update of Sierra Leone Hazard Profile and Capacity Gap Analysis" Project in order to comprehensively review and update the 2004 NHA Study and build a national hazard profile and develop a national risk information system for Sierra Leone.

Project Objective and Scope

The main objective of the "Update of Sierra Leone Hazard Profile and Capacity Gap Analysis" Project (hereafter, the Project) is to create a comprehensive hazard profile for Sierra Leone that covers all of the major natural hazards prevailing in Sierra Leone and to comprehensively map out all natural hazard prone areas at national and district levels based on historic disaster events and data and information. Specifically, the Project will identify, assess, map and profile the major natural hazards (i.e., landslides, floods, drought, coastal erosion, sea level rise, epidemics, storm surge, tropical storm and lightning & thunder) and disaster risks of the country and by this improve data, information and knowledge for decision making and ensure policies, strategies, plans, programmes and projects are appropriately risk-informed to make sound sustainable development decisions.

The new 2017 National Hazard Profile of Sierra Leone, covering only major natural hazards (i.e., landslides, floods, coastal erosion, drought, sea level rise, epidemics, tropical storms and lightning and thunders) in Sierra Leone is the first step towards developing the Hazard and Risk Profiles Information Systems (HARPIS) for Sierra Leone. HARPIS is being developed as a Web-based information system that integrates Geographic Information Systems (GIS) and Management Information System (MIS) systems with mobile data collection technology to provide a family of sophisticated tools, applications and Web services for collecting, managing, visualizing, mapping, analysing, monitoring, evaluating and reporting on various aspects of disaster risks, natural hazards, vulnerability, exposure and disaster management activities in Sierra Leone. It is hoped that all GoSL ministries, departments and agencies (MDAs), international and national non-governmental organisations (NGOs), United Nations (UN) Agencies and Funds, donors, humanitarian organisations, community based organisations (CBOs), academia and private sector agencies involved in DRR and DRM will align their strategies, plans, programmes and projects with the results and outcomes of this Project to ensure coherence in hazard, vulnerability and disaster risk identification, profiling, assessment and mapping in Sierra Leone, especially for DRR, DRM and sustainable development.

The Project was financially supported by the UNDP Sierra Leone Country Office through the Global Environment Facility (GEF) for Climate Information and Early Warning Programme. The project was implemented by a team of INTEGEMS Consultants in close collaboration with the Sierra Leone Meteorological Agency (SLMA), Sierra Leone Environment Protection Agency (EPA-SL) and the Ministry of Water Resources (MWR) with contributions from various government ministries, departments and agencies (MDAs), UN agencies, international and national non-government organisations (NGOs), including civil society and the private sector.

Project Methodological Framework

The selection of a methodological framework for this Project was dependent on the availability of reliable and quality data and information about hazards and disaster events, socio-economic and demographics, infrastructure and assets and their exposure and vulnerability from various third parties, including a wide range of geological, topographical, land use/land cover, climate and weather, disaster management and hydro-meteorological data and information. Expert judgements and qualitative techniques, sometimes coupled with additional scientific investigations (GIS and remote sensing analysis, assessments, modelling, mapping, etc.,) were used to investigate anecdotal evidences and/or incomplete datasets and trends.

The Project Team also employed various methods for identifying data and information on past hazards and disasters and their impacts on communities by reviewing and collating secondary information from newspaper reports and other historical disaster event records; reviewing existing ONS, GoSL MDAs and Local Council reports; consulting with the local experts, MDAs, international and national NGOs, civil society, academia and the private sector, as well as national, provincial and district disaster management officers. Valuable secondary data such as historic disaster events and record, maps,

[1] http://www.integems.com

images and photographs were also collated from various sources like local communities, ONS-DMD, GoSL MDAs, UN Agencies, NGOs, research papers on hazards, websites, DesInventar, Centre for Research Epidemeology of Disasters Emergency Events Database (CRED EM-DAT) and reports of academia.

The methodology for hazard, vulnerability and risk assessments differed per hazard but were generally done by overlaying geo-referenced inventory maps of elements at risk with hazard maps in ArcGIS applications. The spatial interactions between the elements at risk and the hazard footprints were depicted in GIS by sophisticated map overlaying of the hazard map with the elements at risk map. The elements at risk dataset were aggregated at both national and district levels, as required. The elements at risk considered in the assessment are: population, agriculture, health, education, building and transportation. The risk profiles are analyzed, mapped and presented at national and district levels.

Four Stakeholders Consultative Workshops and a Stakeholder Validation Workshop were conducted in the process of preparation of this Report, including the hazard profiles. The first consultative workshop was conducted on 26 July 2017 in Freetown by INTEGEMS in collaboration with UNDP, ONS-DMD, EPA-SL, SLMA and MWR to review and agree on methodologies developed by the Consultant agencies. It was held with the participation of resource persons from various MDAs, development partners, UN Agencies, academia and NGOs. Three more Stakeholders Consultative Workshops were held in Makeni City, Bo City and Kenema City on 15, 16 and 17 August 2017, respectively, to solicit further inputs into the Project as well as review and agree on the methodologies proposed by the Consultants. A Stakeholders Validation Workshop was held on 5 October 2017 in Freetown to review and finalize the methodologies and outputs with the participation of various MDAs, development partners, UN Agencies, academia and NGOs.

Based on the outcomes of the interactive group discussions at the Workshops, the Consultants found it prudent to mainly focus on the major natural hazards in Sierra Leone for the purpose of the Project. These Workshops help to get the views and contributions from the various stakeholders to update and improve the capacities of the main implementing agencies and also to facilitate the sharing of DRR, DRM, hazard and risk assessment data, information and knowledge.

Summary of Key Findings

Detailed hazard profiling and assessment of nine major natural hazards (i.e., landslide, flood, drought, epidemics, coastal erosion, sea level rise, storm surge, tropical storm and lightning and thunder) and five key man-made hazards (i.e., deforestation and land degradation, fire, accidents, waste disposal and pollution) in Sierra Leone has been undertaken to achieve the objectives of the Project. The comprehensive hazard and risk assessment mapping generated significant findings that pertains to the nine major natural and five man-made hazards that are currently or may potentially affect Sierra Leone as well as to the exposure and vulnerability of the country to these natural hazards, including some qualitative estimates of potential risks. Key findings from the Project will support the mainstreaming of disaster risk reduction and disaster risk management in planning, preventing, mitigating, responding and recovering from disasters, including investments, education and awareness, research and other interventions to achieve the goals of the UN SDGs and the Sendai Framework. This document contains a series of background and hazard-specific tables, maps and infographics, including hazard profile tables and maps, risk maps and base maps in the relevant sections and chapters.

Below is a summary of the key findings of the Project:

Natural Hazards

- The hazard assessment and mapping revealed that the country is highly prone to flood, landslide and coastal erosion, tropical storms and sea level rise hazards. The high level of population exposure to flood and landslide hazards and coastal erosion and sea level rise hazards is clearly evident in the hilly and low lying areas of the Western Areas and along the coastal areas in the Western Area and the Northern and Southern Provinces of Sierra Leone. For landslide hazards, the identified elements at risk in the study areas are: population, buildings, education facilities, health facilities and transportation (roads). For flood hazards, the identified elements at risk in the study areas are: population, buildings, agriculture sector (cultivated area and livestock), education facilities, health facilities and transportation (roads). It should be noted that the vulnerability and risk assessments were only undertaken for landslides and floods. The other seven hazards were not assessed in terms of vulnerability and risks due to inadequate data.

- The landslide hazard, vulnerability and risk assessment showed that the hilly and steep-sided slope areas in the Western Area, especially in Leicester, Regent, Granville Brook, Cline Town, Moa Wharf, Hill Court Road, Kissy Brook, Dwarzark, and Charlotte in the Mountain Rural District of the Western Area are prone to landslides due to their moderate to very high slope susceptibility and heavy precipitation received in the Wet Season.
- The flood hazard, vulnerability and risk assessment revealed that floods are more likely in areas around the ten catchments analysed close to the estuaries and along the entire coastline of Sierra Leone, based on a 10-year return period. In addition, based on historical flood events data, it also indicated that flood hazards are likely to occur in many different locations in the country; however, due to data limitations only analysis by catchment was possible for this study. Nonetheless, the study also revealed that parts of Freetown City, including Kaningo, Kamayama, Dwarzark, Kroo Bay, Congo Town, Kissy Brook, and Culvert community in Granville Brook are prone to floods due to their moderate to very high slope susceptibility and heavy precipitation received in the Wet Season.

Below is a synopsis of the results from the hazard assessment and mapping per hazard.

Landslides Hazard Assessment and Mapping

A background and brief description on the types of landslides, the causative factors, the frequency of landslides & impacts are given. The scope of the study describes the objectives of the study and the preparation of a series of maps for hazard profiling. The weighting technique was adopted in preparation of hazard profile and risk assessment and maps.

The impact of landslides and mudslides in Sierra Leone is highly concentrated in the Western Area where the combined effects of steep slopes, heavy rainfall, and unabated deforestation and construction provide a perfect recipe for mass movements. Landslide disasters in Sierra Leone as a whole accounted for 42 percent of nationally reported geophysical/geohazard mortalities between 1990 and 2014. The 14 August 2017 landslide disaster alone left over 500 people dead, some 600 missing, with about 50,000 directly or indirectly affected in the densely populated Freetown. The most severe disaster occurred in Regent and Lumley districts with a massive 6 kilometres mudflow submerging and wiping out over 300 houses along the banks of the Lumley Creek. Leicester, Regent, Granville Brook, Cline Town, Moa Wharf, Hill Court Road, Kissy Brook, Dwarzark, and Charlotte in the Mountain Rural District have been identified as areas prone to landslides.

Flooding Hazard Assessment and Mapping

A brief background on floods in Sierra Leone, including flood hazard mapping and its uses, classification of floods, causative factors of different kinds of floods and their impacts are provided. The section on flood vulnerable areas in the country is interpreted in the form of a flood risk map as well as using historic flood events to assess and map floods. The methodology used is mapping of areas inundated by actual floods. However due to the non-availability of higher resolution and relevant datasets, the simulation of inundation areas due to flooding using scientific models could not be performed.

The human, socio-economic and environmental impacts of floods in Sierra Leone has seen a skyrocketing trend over the last decades - Between 1980 and 2010, floods affected approximately 221,204 people, killing some 145 people. On 24 June 2017, heavy downpour of rain flooded two towns of Largor Jasawabu in the Nongowa Chiefdom and Foindu Mameima in the Lower Bambara Chiefdom, near Kenema. Torrential rainfall in the month of August 2017 led to widespread flooding across different parts of Freetown City, including Karningo, Kamayama, Dwarzark, Kroo Bay, Congo Town, Kissy Brook, and Culvert community in Granville Brook.

Coastal Erosion Hazard Assessment and Mapping

Includes a brief background on coastal hydrodynamics, coastal sediment balance, coastal geography and units, significance of coastal regions, causative factors for coastal erosion and accretion. It gives a brief description on its scope, methodology used in the study and finally a description of the coastal hazard profile developed through the proposed methodology.

Coastal erosion in Sierra Leone is accelerated due to anthropogenic activities and poorly planned coastal infrastructure development adding stresses on the coastal ecosystems. Coastal erosion has been and is still posing a serious problem for coastal management authorities and the population in along the coast of Sierra Leone. This phenomenon which is very evident along the Sierra Leone coastline has attained rates of some 4 -6 metres per year in some locations (e.g. Konakridee, Lumley, Lakka, Hamilton etc.).Other areas with visible erosion signs along coast include: Krim area, Shenge, Plantain Island, Katta and Bunce Island, Adonkia, Mahera beach in Lungi area, Bullom shores, Moa wharf, and Man of War Bay.

Sea Level Rise Hazard Assessment and Mapping

Discusses the role of global warming in sea level rise, the regions that are vulnerable to sea level rise, sea level rise predictions and causative factors. Methodology summarizes the usage of topographic data to identify the coastal areas due to sea level rise. The hazard profile describes the inundation areas of coastal regions of Sierra Leone predicted for 2100. The study recommends that the inundation assessment should be carried out repeatedly with improved DEM data and with revision of sea level rise prediction.

The effect of sea level rise induced by climate change is visible in coastal areas such as Yeliboya and Kortimor in the north, and in Shenge and Plantain Island in the south of the country. There are also visible signs of severe coastal erosion around Adonkia, Mahera Beach in the Lungi area, Conakridee and Eureka which resulted to the physical alteration of coastline and destruction of structures as well as displacement of people in coastal communities.

Drought Hazard Assessment and Mapping

Gives a definition to drought, causative factors and other characteristics of drought, the scope of the study, methodology adopted and the procedure followed in drought hazard assessment and mapping. Finally it gives a drought hazard map prepared considering the drought broadly as a hydro-meteorological hazard using time series of rainfall data.

With a very slow speed of onset (mostly months or in some cases years), droughts are becoming prevalent in some parts of Sierra Leone. The north-eastern parts of the country experiences longer usual dry spells at the peak of the normal dry season between February and March, with rainfall averaging below the normal expected downpours. This leads to reduction in the water table which eventually causes low moisture content and drought-like conditions. Crop failure, fresh water shortage, wildfires and disease outbreaks, have been attributed to longer dry spell periods, countrywide. Areas which have been identified as vulnerable to long dry spells are communities in the extreme north of Koinadugu District (Kabala) and Kono District.

Epidemics Hazard Assessment and Mapping

The Ebola Virus Disease (EVD) which broke out in Sierra Leone in 2014 is the most overwhelming disaster the country has faced in its post-conflict era. More than 14,000 Sierra Leoneans were infected, of whom nearly 4,000 died. Between 1980 and 2010 epidemics were the deadliest hazards in Sierra Leone. During those 30 years, epidemics were responsible of 83% of the total number of death due to disaster. From 1980 to 2010, epidemics killed 1,103 people and affected 13,447. Malaria, cholera and typhoid are the most regular and important killer diseases in the country, which is plagued with inadequate access to sanitation and clean water, ineffective waste management and pollution control mechanism, and inadequate household hygiene. Three people died of Lassa fever in Kenema during the second week of February 2017, with concerns of continued increase in the number of positive cases of Lassa fever.

Storm Surge Hazard Assessment and Mapping

Damage to life and property due to tropical storm-induced storm surges occur as a result of inundation of low-lying lands in the shore. Storm surge is primarily originated by pressure induced on ocean surface by high winds resulting in an unusual rise in water level causing coastal flooding. The storm surge hazard profile is intended for coastal disaster risk mitigation planning, evacuation planning and public education and awareness. Due to uncertainties associated with modelling the hazard profile is derived using expert judgment. Limitations of the study as well as recommendations for improving the storm surge hazard maps are provided as on output of this study.

Tropical Storm Hazard Assessment and Mapping

Tropical weather systems and the areas where tropical storms originates regularly, the causative factors of formation of tropical storms, and locations where they develop. Tropical storms are a part of tropical weather systems and has the potential to produce strong winds along with torrential rainfall and associated storm surge near the centre of the storm. Tropical storms can also be very destructive to coastal communities, infrastructure and ecosystems. The tropical storm hazard profile is expected to guide the formulation of disaster management practices and procedures, improve preparedness and target resources for disaster risk reduction.

Lightning and Thunder Hazard Assessment and Mapping

Describes lightning and thunder hazards in general and the causative factors, including information on the impacts on human casualties, secondary impacts and period of occurrence. Due to lack of relevant data, the methodology did not include any analysis or mapping using lightning and thunder hazards. Sierra Leone is more vulnerable to lightning and thunder due to more convective activities triggered by direct incidence of solar energy to the Earth surface. Modes of lightning strike include side flash, contact potential, step potential and surge propagation of lightning causes property damages and down time in data and communications are significant. In the lightning hazard profile data from eight automatic weather stations (AWS) were collected and analysed for spatial and temporal distribution lightning events. Potential regions with high frequency for lightning were identified.

Man-made Hazards

Man-made hazards are events that are caused by humans and occur in or close to human settlements. The events leading up to a man-made hazard may be the result of deliberate or negligent human actions, but their impact can be equally as devastating as natural hazards. There is close link between natural and man-made hazards and disasters.

Deforestation and land degradation

Deforestation and land degradation is caused by multiple forces, including extreme weather conditions particularly drought, and human activities that pollute or degrade the quality of soils and land utility negatively affecting food production, livelihoods, and the production and provision of other ecosystem goods and services. About 38% of Sierra Leone's remaining land covered by forest is decreasing, principally as a result of anthropogenic activities which can all be attributed to poverty as the underlying cause of much of the forest degradation and deforestation. The main drivers of deforestation in Sierra Leone are: urbanisation, mining and quarrying, agriculture slash and burn farming, fire wood and charcoal production and timber production.

Although degradation processes do occur without interference by man, these are broadly at a rate which is in balance with the rate of natural rehabilitation. The most frequently recognised main causes of land degradation include: deforestation, over-cultivation of cropland, overgrazing of rangeland, waterlogging and salinisation of irrigated land, and pollution and industrial causes. Within these broad categories a wide variety of individual causes are incorporated. These causes may include the conversion of unsuitable, low potential land to agriculture, the failure to undertake soil conserving measures in areas at risk of degradation and the removal of all crop residues resulting in 'soil mining' (i.e. extraction of nutrients at a rate greater than resupply). They are surrounded by social and economic conditions that encourage land users to overgraze, over-cultivate, deforest or pollute.

Fire

Among different types of man-made hazards, both wild/ bushfires and domestic fires constitutes a significant threat to life and property in urban and rural areas in Sierra Leone. Domestic fires are particularly prevalent in the urban communities, especially in the capital city Freetown, where there is steady increase in the number of lives it has claimed every year due to illegal and unprofessional connections, use of sub-standard building materials, carelessness etc. Wild or bushfires are one of the biggest causes of forest destruction and land degradation in the country particularly in the savanna grassland regions of the Northern Province and the forested areas of Southern and Eastern Provinces. From DesInventar data, over 11,000 people were affected by fires between 2006 and 2015. A total of 30 people were killed as a result of fire disasters nationwide, with almost half of that number from Western Area Urban alone. Some 1,356 houses were destroyed and 459 houses were damaged by fires nationwide.

Accident

Accidents are a great concern to the public in all 14 Districts of Sierra Leone. Transportation in Sierra Leone occur in three forms, land, marine, and air, all of which (save air) have recorded alarming rate of accident over the past few years. Traffic accidents result in life and financial loss to the society. In Sierra Leone, traffic fatalities are comparable to other leading causes of unnatural death.. Between 2006 and 2015, over 150 accidents were recorded, with over 40% of them occurring in Western Area Urban (Freetown) alone.

Road accident is one of the major causes of unnatural deaths and it is undeniably one of the leading causes of death in Sierra Leone. Even though the circumstances or the actual causes for each road accident may vary, the fact remains that quite a good number of people are killed by road accidents every other day.

Aviation accidents can be of natural, technical or human origin, such as mechanical breakdowns, negligence or terrorist attacks. The only aviation accident which has been recorded in the country over the last decade occurred on 3 June 2007, when members of the Togolese football team, including the country's Minister of Sports lost their lives, when a poorly maintained and unsafe commercial helicopter from Aberdeen Heliport crashed at the Lungi airport in Freetown.

Sea travelling is a common means of transportation on the islands along the coast of Sierra Leone. These islands normally use wooden ferries, boats or canoe to transport people and goods to nearby islands and inland thereby increasing the risk of maritime accident in the country. Severe weather condition, sub-standard ferries and overloading amongst others are the common causes of maritime accident in the country.

Waste Disposal

Poor waste management practices, in particular, widespread dumping of waste in water bodies and uncontrolled dump sites, exacerbates the problems of generally low sanitation levels across the country. The most affected areas are Freetown and other cities around the country like Bo, Kenema, and Makeni. Coping with the rapid rise in population and its corresponding demand to manage their waste has posed a major problem to occupants. Improper management of waste is a major concern in the Capital city, with only three major landfill sites; Granville Brook (Bumeh) & Bottom Oku in the east and Kingtom in the west where there is no base or top seal to prevent the flow of leachates to underground water or rivers or the infiltration of water into the waste.

Pollution

Water pollution (particularly drinking water) is a serious problem in the country. Almost half of the population of Sierra Leone has no access to safe drinking water and only 13% of the population has access to improved non-shared sanitation facilities. According to the Sierra Leone Water Company, on average only 35% of rural residents have access to safe drinking water. There are several causes of water pollution in Sierra Leone but, the most common is the sewage efflux and surface run-offs into boreholes, streams and rivers. In most parts of the country, boreholes and rivers are the means by which most of the water is supplied for drinking and domestic, agricultural, and industrial use.

Hazard and Risk Profile Information System (HARPIS)

Provides a background to the design, development and technology stack for the HARPIS-SL, which integrates GIS and Management Information System (MIS) systems and mobile data collection technology for disaster management in Sierra Leone. The HARPIS-SL Mapping Application (accessed via **http://www.harpis-sl.website**) is a GIS Web mapping application that provides easy and convenient ways to collect, map, explore, query, analyze and freely share available disaster risks, hazards, vulnerability, exposure and disaster management data and information resources from any device, anywhere, at any time. A primary goal of the HARPIS-SL is to allow people who are not GIS professionals to do self-service mapping on any device and share disaster risks, hazards, vulnerability, exposure and disaster management data and information resources about Sierra Leone. The ability of the ONS-DMD and various stakeholders to make sound disaster risks, hazards, vulnerability, exposure and disaster management decisions can be greatly enhanced by the cross-sectoral integration of information within the HARPIS-SL. The HARPIS-SL platform also allows collection of data through crowdsourcing with the use of mobile and Internet/Web enabled devices.

Capacity Gap Analysis

The capacity gap analysis is a structured analytical process designed to assess and evaluate various dimensions of capacity within the broader institutional as well as assessment of the capacity specific units and individual within the system. It has been structured according to the priority areas of the Sendai Framework for Disaster Risk Reduction (2015-2030) and took stock of the institution's existing capacities, needs and gaps and provides a set of prioritized recommendations for capacity development in areas identified as requiring adjustment. The assessment highlights the current need and gaps and presents a selected number of crucial recommendations on further capacity strengthening of the DRR and DRM system in the ONS-DMD, EPA-SL, SLMA and the MWR.

Conclusion

The updated natural hazard profiles and risk maps presented in this document are recommended to be used as base maps to identify potential hazards prone areas at national and district levels. The overall national hazard profile is a base document and provides guidance for future disaster prevention activities of the country such as disaster risk reduction and disaster risk management, including public education and awareness programmes. This is the first comprehensive national report prepared on natural hazard profiles of Sierra Leone and could be used to initiate detailed vulnerability and risk assessment studies on manmade hazards in Sierra Leone. At the end of this Project, the GoSL, particularly the ONS-DMD, will be well placed to better coordinate all disaster management related initiatives in a proactive manner at national and local levels, leading to the reduction of disaster risk across Sierra Leone.

Structure of this Report

This Report is divided into 15 chapters as outlined below:

Chapter 1 presents the contextual background to this Report. It describes the impacts of disaster risks on development in Sierra Leone; disaster management framework in Sierra Leone, including a synopsis of the 2004 NHA Study and the rationale for its update. The chapter also describes the project objectives, scope, project implementation organisations and stakeholders, expected project outcomes and application of the project results.

Chapter 2 presents country background and information necessary for contextualising the hazard profile and vulnerability and risk assessments described in this Report. It provides a synopsis of the geography, climate, administrative divisions, socio-economic and political contexts, demographic information and land cover/land use in Sierra Leone, including housing, health, education, fishery, agriculture, transportation, energy, tourism and mining sectors in Sierra Leone with their spatial distributions.

Chapter 3 provides a detailed understanding of hazard profiling, assessment and mapping; vulnerability assessment; and disaster risk assessment. The methodology discusses the concept, applications, process and challenges of hazard profiling, vulnerability and risk assessment and it involved a combination of historical data analyses and modelling of the hazard events in terms of their frequency, magnitude and geographical coverage.

Chapter 4 provides a very detailed description, assessment, mapping and analysis of the major natural hazards in Sierra Leone, including landslides, flood, drought, epidemics, coastal erosion, sea level rise, storm surge, tropical storm and thunder and lightning. The chapter gives a brief description of the hazards, the causative factors, the frequency of the hazards and their impacts, and the techniques adopted in preparation of the hazard maps.

Chapter 5 provides a succinct description of the key man-made hazards in Sierra Leone, including land degradation and deforestation, fire, accident, waste disposal and pollution. The chapter gives a brief background description of the hazards, their spatial and temporal distribution and their impacts.

Chapter 6 discusses landslide vulnerability and risk assessment. The chapter presents the methodology for vulnerability and risk assessments considering population, housing, education, health, transport and power sectors.

Chapter 7 presents flood vulnerability and risk assessment. The chapter reflects the methodology for floods vulnerability and risk assessment. Implication of floods hazards due to a 10-year return period are discussed with respect to some important physical assets, including population, housing, education and health sectors.

Chapter 8 elaborates on the profiles of the major natural hazards in Sierra Leone, including landslides, flood, drought, epidemics, coastal erosion, sea level rise, storm surge, tropical storm and thunder and lightning. The chapter provides maps, tables and brief descriptions of the hazards and their profiles at both national and district levels in terms of frequency, magnitude, rate of onset, duration, etc.

Chapter 9 describes the design and development of the National Risk Information System: Hazard and Risk Profile Information System – Sierra Leone (HARPIS-SL) - an integrated GIS and Management Information System (MIS) systems and mobile data collection technology to provide a family of sophisticated tools and Web services for collecting, managing, visualizing, mapping, analysing, monitoring, evaluating and reporting on various aspects of disaster risks, hazards, vulnerability, exposure and disaster management in Sierra Leone.

Chapter 10 concludes the Project Report with the results of the Capacity Gap Analysis, which has been structured according to the priority areas of the Sendai Framework for Disaster Risk Reduction (2015-2030). It also provides a synopsis of existing institutional capacities and gaps including a set of prioritized recommendations for capacity development in areas identified as requiring adjustment.

Chapter 11 provides the bibliography used in the compilation of this Report.

Chapter 12, Chapter 13, Chapter 14 and Chapter 15 contain appendices 1, 2, 3 and 4 conclude the Full Project Report with a summary of the proceedings of the Stakeholders Workshops held in Freetown, Bo, Makeni and Kenema in July/August 2017; summary tables of specific and relevant data and information from the Sierra Leone Population and Housing Census 2015; a detailed breakdown of historic hazard and disaster events in Sierra Leone; and a summary of the proceedings of the Stakeholders Validation Workshop held in Freetown on 5 October 2017.

1 INTRODUCTION

1.1 Disaster Management in Sierra Leone

Sierra Leone is at a junction where, having ended a 10 year long civil war (1990-2002) and a fight against the EVD crisis (2014-2015), it is now focusing on accelerated programmes of economic growth and social development. The country has already invested heavily on key sectors such as transport, agriculture, health, education and infrastructure with the vision of making Sierra Leone a green middle-income country where 80% of the population will be above the poverty line with gender equality; a well-educated and healthy population; good governance and rule of law; well-developed infrastructure; macroeconomic stability with private-sector and export-led growth generating wide employment opportunities; good environmental protection; and responsible natural resource exploitation.

However, the aforementioned vision and on-going development programmes will be at risk if DRR measures are not meaningfully factored into national development planning. This is especially so given that climate change patterns and various natural disasters, brought on by global warming, will have a more severe impact on poor and developing countries like Sierra Leone. A number of studies have demonstrated that unplanned urbanisation, deforestation and environmental degradation and inappropriate land use are they key factors contributing to the increase in disasters in Sierra Leone. Thus mainstreaming DRR and DRM concepts in Sierra Leone’s development strategies, plans, programmes and projects is crucial and imperative.

Sierra Leone is still recovering from multiple manmade and natural disasters: the civil war (1990–2002); the cholera epidemic (2012); and the EVD that devastated the country from May 2014 to November 2015, during which more than 14,000 Sierra Leoneans were infected, and more than 3,000 died of the disease. The EVD outbreak resulted in a huge and complex burden on the health system as well as causing ripple effects across the whole of the Sierra Leonean society. The impact of the EVD outbreak was seen in part in the fall in real gross domestic product (GDP) growth from 4.6% in 2014 to -20.6% in 2015 – though this also reflected a fall in global commodity prices and other factors.

In September 2015, sustained heavy downpours caused serious flooding that damaged homes and properties in Freetown, Western Area - 14,000 people were affected and 10 were reported dead. During this same period, torrential downpour of rain breached river banks in the Southern Province of Sierra Leone, causing serious destruction in eight communities in Bo District and two Chiefdoms in Pujehun District. The number of people affected by the floods in Bo District and Pujehun Districts were 2,630 and 272, respectively. In the early morning hours of 14 August 2017, torrential downpours alongside deforestation, unplanned and unregulated construction transformed a natural hazard into catastrophic floods, landslides and mudslide disasters in the Western Area of Sierra Leone that left an estimated 500 people dead, some 600 missing, affected over 50,000 people and caused widespread destruction. The floods, landslide and mudflows were the worst natural disaster ever to hit Sierra Leone, and one of West Africa's worst tragedies in recent times.

Such disasters are a potentially serious shock to a fragile economy like Sierra Leone and the urgency of building economic resilience to such hazards and disasters is underlined by the rapid increase in economic losses from such disasters. A Damages and Losses Assessment (DaLA) carried out by the World Bank Group and a group of consultants (ARUP and INTEGEMS) after the floods, landslides and mudflows of 14 August 2017 estimated the physical damage done by the disaster at more than US$ 30 million (about Le 230 billion). Destruction was done to health, education, transport, and housing facilities, among others. US$ 82 million is needed to support the recovery effort. The social sector represents more than 80% of the total damage and loss: Housing - 55%; Health - 11%; Social Protection - 10%; other affected were Water and Sanitation - 8%; Industry and Commerce - 3%; Environment and Debris Management - 6%; Education - 3%; Transport - 3%. On the short-term (0 – 3 months), US$ 15.1 million is estimated for urgent relief. For the medium-term (3 – 12 months), US$ 24.7 million is needed for early recovery, while for the long-term (1 – 3 years), US$ 42.2 million is projected for resilient recovery; making a total of US$ 82 million.

The aforementioned disaster events have the potential to destroy, stall or even reverse development and Sierra Leone’s economies, health and education facilities, public infrastructure, and cultural heritage sites. Furthermore, they also show that as people and assets concentrate in cities like Freetown and Bo, there is more to lose when hazards and disasters strike and that urban dwellers and central and local governments will be forced to cope with rising incidents of disasters in Sierra Leone. Many of Sierra Leone's urban poor bear the brunt of disasters because they live in high-density conditions in degraded slums, and lack access to basic services such as a water supply, sanitation, health and education. Unfortunately, the GoSL and development partners had previously focused their efforts on responding to disasters rather than preventing or minimizing their impacts.

Following the recent disaster events in the Western Area, the GoSL and development partners are now more united in the belief that greater urgency is required to address the factors that are driving the increase in disaster risks, such as rural and urban poverty and vulnerability, unplanned and poorly managed urban growth and declining ecosystems. Urgent action is necessary not only to reduce disaster risks, but also to maintain momentum in achieving the targets and goals articulated by various national and global development strategies and programmes, including poverty reduction, adaptation to climate change and better health outcomes.

1.2 Office of National Security (ONS)-Disaster Management Department

In 2002, the GoSL enacted the National Security and Central Intelligence Act (NSCIA 2002) and Section 18, sub-section IV of this Act mandates the ONS to be 'the GoSL's primary coordinator for the management of national emergencies such as disasters - both natural and man-made'. The ONS coordinates disaster management at various levels through multi-sectoral platform to address the underlying issues of disaster preparedness, prevention, mitigation, response and recovery/rehabilitation. The main strategic objectives of the ONS on risk and disaster management include improved identification and assessment of disaster risks, integrated disaster risk management into development effort, and the preparation of a National Disaster Management Plan (NDMP).

In 2004 the ONS established the DMD and gave it the central responsibility of coordinating the management of national emergencies. The ONS-DMD is the national coordinator for disaster risk reduction and it has the mission to develop a highly proficient mechanism for preventing, mitigating, securing, monitoring, recovering, and responding to disasters in a timely manner in order to promote management of natural and man-made disasters.

The key objectives of the ONS-DMD are to ensure the integration of disaster-risk management into sustainable development programmes and policies, ensuring a holistic approach to disaster management; improve the identification, assessment, monitoring, and early warning of risks; and improve effectiveness of response through stronger disaster preparedness. So far, the ONS-DMD has prepared a National Disaster Preparedness and Response Plan; the Sierra Leone Disaster Management Policy: Identification of Disaster-prone Areas in Freetown; and the Sierra Leone Disaster Management Policy (Final Draft) June 2006. The Disaster Management Plan covers disaster prevention, preparedness, and response and it clearly spells out the roles and responsibilities of agencies and institutions in disaster preparedness, mitigation and response.

The ONS-DMD also provides a coordinating role in establishing and implementing early warning programmes through development of a robust early warning system and capacity building of its staffs. This allows the ONS-DMD to partner with the Sierra Leone Meteorological Agency (SLMA) in the Ministry of Transport and Aviation (MTA), the Ministry of Water Resources (MWR), the Environment Protection Agency-Sierra Leone (EPA-SL) and various stakeholders involved in the end to end early warning system from community to national levels, sectoral MDAs, the Provincial Security Coordinator (PROSEC), District Security Coordinator (DISEC), community committees and humanitarian agencies as well as the Sierra Leone Red Cross Society. At the same time, investments have been made to improve the existing early warning system in Sierra Leone to make it more efficient and an integrated part of mainstream DRM by taking into account the activities and policies of Sierra Leone's line MDAs and strengthening its institutional and legal basis.

The ONS-DMD has established 12 District Disaster Management Committees (DDMC) across the country. These DDMC and the ONS in tandem develop response capacity according to a nationally agreed set of Standard Operating Procedures (SOPs) for each partner agency, at the time of a disaster. This collection of SOPs covers the activities around the occurrence of the hazard and the development and implementation of disaster management plans for provinces, districts and local authorities.

1.3 The ONS-DMD 2004 National Hazard Assessment (NHA) Study

In a bid to urgently address disaster management issues in Sierra Leone and in consonance with the World Summit on Sustainable Development[2] (WSSD), the ONS-DMD (with funding from the United Nations Development Programme) in 2004 commissioned a group of local consultants and researchers from the University of Sierra Leone (USL) to undertake a the NHA Study[3] and develop a profile of hazards in Sierra Leone. The commissioning of the NHA study marked one of the very first tasks of the National Disaster Management Working Group (NDMWG).

The NHA study looked at various types of disasters (both natural and manmade disasters) and identified various types of hazards, including: weather and climate hazards such as drought and tropical storms (strong winds), thunderstorms and lightening; hydrological hazards such as flooding; geological hazards involving earth movements, erosion (coastal and upland), landslides mud slips and rock fall; pest hazards, ecological hazards (deforestation, wild fires, wastes and pollution); social hazards which include accidents, civil strife, population movement (refugees and internally displaced persons), poverty and unemployment; and a chapter on vulnerability.

Results from the 2004 NHA study revealed, amongst other things, that *"…Sierra Leone is endowed with abundant natural resources and that these resources have continued to determine the path and pattern of economic growth, depending on how they are managed; the economy largely depends on natural resources, and as such, understanding their nature, distribution and mode of exploitation is essential for their optimal utilisation without jeopardizing the environment; that if these resources are properly utilized and managed efficiently, environmental hazards, man-made disasters and to some extent, natural disasters can be minimized; and post war reconstruction, mining, fishing, agriculture and other economic activities continue to be poorly regulated and this is becoming a recipe for disasters...".*

The lack of a recent and comprehensive national hazard assessment of the common hazards per region, their causes, profiles and the vulnerability per population and how these can be adequately managed hinders a proficient disaster management programme of action in Sierra Leone. Unfortunately, the 2004 NHA study predates the Hyogo Framework of Action (HFA) 2005-2015: Building the Resilience of Nations and Communities to Disasters[4]; the two recent GoSL's national development strategies (Agenda for Change: 2008-2012; and Agenda for Prosperity: 2013-2018[5]) and the Sendai Framework for Disaster Risk Reduction 2015–2030 [6] and the 2030 Agenda for Sustainable Development Goals [7] (SDGs). Furthermore, the 2004 NHA lacks maps and comprehensive

[2] Johannesburg Summit 2002 - the World Summit on Sustainable Development - brought together tens of thousands of participants, including heads of State and Government, national delegates and leaders from non-governmental organisations (NGOs), businesses and other major groups to focus the world's attention and direct action toward meeting difficult challenges, including improving people's lives and conserving our natural resources in a world that is growing in population, with ever-increasing demands for food, water, shelter, sanitation, energy, health services and economic security.

[3] Karim, A. B., Weekes, S. B., Briama, S. J., Sankoh, S. K. and Sesay, U. (2004) *National Hazard Assessment Profile - Prepared for the Office of National Security (ONS) Sierra Leone and Supported by UNDP*. Fourah Bay College, University of Sierra Leone, Freetown, Sierra Leone

[4] In January 2005, at the World Conference on Disaster Reduction, 168 Governments adopted the Hyogo Framework for Action (HFA); a 10 year plan to make the world safer from natural hazards. From the global blueprint for disaster risk reduction efforts, the HFA offered guiding principles, priorities for action and practical means for achieving disaster resilience for vulnerable communities.

[5] The Agenda for Prosperity (AFP) is Sierra Leone's Third Generation Poverty Reduction Strategy Paper-2013-2018. The AFP consists of eight pillars and it includes diversified economic growth, managing natural resources, accelerating human development, international competitiveness, labour and empowerment, social protection, governance and Public Sector Reform and gender and women's empowerment.

[6] The Sendai Framework for Disaster Risk Reduction 2015-2030 was adopted at the Third UN World Conference in Sendai, Japan, on March 18, 2015. It is the outcome of stakeholder consultations initiated in March 2012 and inter-governmental negotiations from July 2014 to March 2015, supported by the United Nations Office for Disaster Risk Reduction at the request of the UN General Assembly. UNISDR supports the implementation, follow-up and review of the Sendai Framework.

[7] 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. These included ending poverty and hunger, improving health and education, making cities more sustainable, combating climate change, and protecting oceans and forests. The SDGs emphasize the integration of the social, economic and environmental dimensions for supporting sustainable development and recognize that ending poverty must go hand-in-hand with strategies that build economic growth and address a range of social needs while tackling climate change and environmental protection

characterisation of hazards (including disasters, exposure and vulnerability) at sub-national levels for effective DRR and DRM in Sierra Leone.

Realizing the inadequacies and gaps in the 2004 NHA Study and in Sierra Leone's national and local disaster risk management systems, the UNDP Sierra Leone and the ONS-DMD commissioned the "Update of Sierra Leone Hazard Profile and Capacity Gap Analysis" Project. The overall objective of the project is to build a national hazard profile, including hazard identification, assessment and mapping; vulnerability, exposure and a national multi-hazard vulnerability and risk assessment. Calls for an update of the 2004 NHA Study demonstrates the emphasis being placed on reducing disaster risk nationally in the face of growing disaster losses and serves to highlight the broad appeal of the issue across policy arenas. Thus, it is imperative that the GoSL develops a comprehensive and up-to-date National Hazard and Risk Profile with the following specific objectives to:

1) Promote the collection, analysis, management and use of relevant data and practical information and ensure its dissemination, taking into account the needs of different categories of users, as appropriate;
2) Encourage the use of and strengthening of baselines and periodically assess disaster risks, vulnerability, capacity, exposure, hazard characteristics and their possible sequential effects at the relevant social and spatial scale, in line with national circumstances;
3) Develop, periodically update and disseminate, as appropriate, location-based disaster risk information, including risk maps, to decision makers, the general public and communities at risk of exposure to disaster in an appropriate format by using, as applicable, geospatial information technology;
4) Evaluate, record, share and publicly account for disaster losses and understand the economic, social, health, education, environmental and cultural heritage impacts, as appropriate, in the context of event-specific hazard-exposure and vulnerability information;
5) Make non-sensitive hazard-exposure, vulnerability, risk, disaster and loss-disaggregated information freely available and accessible, as appropriate;
6) Promote real time access to reliable data, make use of space and in situ information, including GIS, and use information and communications technology innovations to enhance measurement tools and the collection, analysis and dissemination of data;
7) Build the knowledge of government officials at all levels, civil society, communities and volunteers, as well as the private sector, through sharing experiences, lessons learned, good practices and training and education on disaster risk reduction, including the use of existing training and education mechanisms and peer learning;
8) Promote and improve dialogue and cooperation among scientific and technological communities, other relevant stakeholders and policymakers in order to facilitate a science policy interface for effective decision-making in disaster risk management;
9) Strengthen technical and scientific capacity to capitalize on and consolidate existing knowledge and to develop and apply methodologies and models to assess disaster risks, vulnerabilities and exposure to all hazards;
10) Promote the incorporation of disaster risk knowledge, disaster prevention, mitigation, preparedness, response, recovery and rehabilitation, in formal and non-formal education, as well as in civic education at all levels, as well as in professional education and training;
11) Promote national strategies to strengthen public education and awareness in disaster risk reduction, including disaster risk information and knowledge, through campaigns, social media and community mobilisation, taking into account specific audiences and their needs;
12) Apply risk information in all its dimensions of vulnerability, capacity and exposure of persons, communities, countries and assets, as well as hazard characteristics, to develop and implement disaster risk reduction policies; and
13) Enhance collaboration among people at the local level to disseminate disaster risk information through the involvement of community-based organisations and nongovernmental organisations.

In light of the aforementioned, the ONS-DMD together with the financial assistance of the UNDP has undertaken a project for the update of the 2004 Hazard Risk Assessment Report. In preparing this Report, the Consultants, together with the implementing partners (ONS-DMD, EPA-SL, SLMA and MWR) have involved various communities to develop district level hazard maps, based on their experience to identify communities and infrastructure vulnerable to hazards. The new 2017 National Hazard Profile of Sierra Leone, covering mainly natural hazards like landslides, floods, coastal erosion, drought, sea level rise, epidemics, tropical storms and lightning and thunders, is the first step towards developing the Hazard and Risk Profiles Information Systems (HARPIS). HARPIS is a Web-based information system that integrates GIS and Management Information System (MIS) systems and mobile data collection technology to provide a family of sophisticated tools and Web services for collecting, managing, visualizing, mapping, analysing, monitoring, evaluating and reporting on various aspects of disaster risks, hazards, vulnerability, exposure and disaster management in Sierra Leone.

Ensuring DRR and promoting Disaster Resilience has become the cornerstone of all long term and sustainable development initiatives. Incorporating DRR in all development planning is imperative not only because disasters have a negative impact on hard earned development gains but also because the impact of disasters is felt most strongly by communities that are socio- economically disadvantaged. Incorporating DRR into development planning requires a complex analysis of potential hazards to identify how they could affect the performance of policies, programs and projects. Such an analysis can lead to the adaptation of measures in reducing vulnerability and treating DRR as an integral part of the development planning process.

A vital component of this process is hazard profiling and risk assessment, a tool which forms the basis for incorporating DRR into development planning while initiating effective DRR programs at all levels. Risk assessment is based on the recognition that disaster risk is the result of the link between hazard, exposure to vulnerability and capacity to cope. The goal of risk assessment is to use the linkages to estimate and evaluate the possible consequences and impacts of extreme events on a particular community. The hazard profiles developed through this project will undoubtedly fill in a lacuna in the country by providing the evidence that is needed to mainstream DRR in development, especially in areas of land use planning, formulating guidelines, passing by-laws and other mandatory as well as voluntary regulations. These hazard profiles are expected to further strengthen the development planning, awareness and education, research, disaster insurance and risk transfer, ecosystem based risk reduction and hazard based permitting and approvals in Sierra Leone as well the global knowledge.

This will in tum contribute to reducing the impact of disasters on vulnerable populations and making these populations more resilient to coping with the impact of disasters. Furthermore, ongoing Climate Information and Early Warning (CIEW) projects such as the Climate Information, Disaster Management, and Early Warning System – Sierra Leone (CIDMEWS-SL) will be extensively benefitted by the results of this important and timely outcome. The ONS-DMD will use hazard profiles and maps to identify vulnerable communities and infrastructure to implement programmes with a view to reduce the disaster impacts and increases the resilient capacity of communities. Further the hazard profiles and maps would be a powerful tool in mainstreaming DRR in to land use planning, urban development, and development planning process.

However, the task of incorporating DRR into planning processes is not the responsibility of just one organisation, but the responsibility of all. Hence, the ONS-DMD will ensure that this updated National Hazard Profile of Sierra Leone – 2017 and associated hazard maps will be further developed and made available to all government ministries, departments, agencies, private sector agencies, provincial and local authorities, non-governmental agencies, academia and the communities at large for their use. DDR and Disaster Resilience should be promoted and mainstreamed into all development efforts, at all stages of economic and infrastructure development processes. The process of mainstreaming disaster concerns requires an in depth understanding of hazards, vulnerabilities and risks. It also presupposes the availability of scientific information so that policy makers can make informed decisions and target appropriate investments.

It is hoped that all MDAs, non-government, UN, donor and private sector agencies involved in DRR and DRM will align their programs with the results and outcomes of this project to ensure coherence of hazard identification, assessment and mapping and disaster management interventions and demonstrate their contribution in achieving national objectives.

1.4 Sustainable Development and Disaster Risks in Sierra Leone

The GoSL, through its national development strategies (Agenda for Change: 2008-2012; and Agenda for Prosperity: 2013-2018) and the Millennium Development Goals (MDGs) [8] has been able to accelerate the country's development programme and also meet some of the goals and targets set by the MDGs and the HFA. Furthermore, the GoSL is currently working to achieve the goals and target of the Sendai Framework and the SDGs.

DRR is an integral part of social and economic development and is essential if development is to be sustainable for the future. Disaster is closely linked with development in that disasters can both destroy development initiatives and create development opportunities and that development projects and programs can both increase and decrease disaster risks. Disasters can reverse gains made in poverty reduction, throwing large numbers of vulnerable and marginalised households, previously above the poverty line, into poverty. However, disasters can also become opportunities for building back better development practices - rebuilding after a disaster provides opportunities to implement positive changes to enhance the safety of urban communities, through revision and development of new policies, awareness raising activities, relocation, etc.

Sierra Leone faces multiple risks from natural and manmade hazards and climate change that threaten key economic sectors and increase the potential for wider environmental degradation. The socio-economic progress made after the end of civil war in 2002 was undermined by the EVD outbreak in 2014 and a contraction of mining activities, leaving the country in a weakened position to address the impacts of natural and man-made disasters and climate change. Sierra Leone is particularly vulnerable to the impacts of natural hazards and its impacts, especially on its chronically vulnerable communities. Even modest hazard impacts on communities with marginal food production and health care capabilities can overwhelm the capacity of the country to cope. Disasters affect the poor and vulnerable disproportionately, especially women, children, the elderly and those recovering from the impact of conflicts. Very often, it is those living on the fringe of society without adequate coping mechanisms (savings, insurance, social safety nets, family etc.) who are most vulnerable to the impacts of disasters, and are most likely to fall into poverty through the consequences of disasters.

Disasters will remain to be a major problem in Sierra Leone and a serious threat to sustainable development. Their impacts are diverse: as well as loss of life, injury and disease and the destruction of property and other assets, disasters can also cause social and economic disruption, loss of infrastructure and other services and damage to the environment. Poverty, increased population density, urbanisation, climate change and changes in building practices and materials and access to safe land are some of the many reasons why risk of hazard, disaster and human vulnerability are increasing in Sierra Leone. Both natural and manmade hazards damage and destroy property, assets, infrastructure and livelihoods, and disrupt economic activity. Disaster damages and losses take away the hard earned development gains. On the other hand, relief, compensation and rehabilitation/reconstruction needs after disaster events utilize the meagre resources that otherwise could be used for development, and provide for education, health and other long term social investments.

1.4.1 Millennium Development Goals (2000-2015)

Prior to the MDGs, Sierra Leone's capacity to timely respond to and manage disaster was very nominal because of the lack of a comprehensive disaster management strategy, lack of coordinated and clear lines of roles and responsibilities, lack of financial and material resources, poor capacity on the part of national and local government and poor integration of civil societies into effective disaster management. However, global calls for disaster management to become an integral part of sustainable development plus the bitter experience of prosecuting a ten-year civil conflict with an uncoordinated security approach served as a wake-up call for the GoSL to review its national security structure.

[8] The Millennium Development Goals (MDGs) were the eight international development goals for the year 2015 that had been established following the Millennium Summit of the United Nations in 2000, following the adoption of the United Nations Millennium Declaration. All 191 United Nations member states at that time, and at least 22 international organisations, committed to help achieve the following Millennium Development Goals by 2015. Sierra Leone implemented the MDGs during 2000-2015. The MDGs were operationalized within the framework of the country's national development plans, such as the poverty reduction strategy papers (PRSPs), which have been implemented since the end of the civil war in 2002.

Sierra Leone has concluded the implementation of the MDGs (2000 - 2015). The MDGs, which were integrated into the WSSD made particular reference to disaster reduction as necessary and integral factor to achieving the goals of sustainable development. It was believed that such a proactive approach to disaster management would go a long way in maximizing disaster risk reduction, which will ensure sustainable development. The WSSD encouraged an integrated, multi-hazard, inclusive approach to address vulnerability, risk assessment and disaster management, including prevention, mitigation, preparedness, response and recovery, as an essential element of a safer world in the 21st century.

Despite the country's weak start in the implementation of the MDGs, it recorded notable progress towards the achievement of a number of the MDG targets. Unfortunately, while the GoSL was on the verge of finalizing the implementation of the MDGs, EVD broke out in May 2014. This caused unprecedented devastation to the socio-economic fabric of the country until Sierra Leone was declared Ebola-free on 7 November 2015. This catastrophe certainly undermined the acceleration of progress made towards the achievement of the MDGs. Nonetheless, Sierra Leone has generally made laudable strides in the implementation of the MDGs, despite enormous remaining and emerging challenges.

While the need to tackle disasters was a feature of the original MDGs, it did not translate into a disasters goal, target or indicator in the MDGs. Furthermore, the MDGs framework was risk blind, not taking into account the impact of natural hazards, conflict and climate change on sustainable development. Disaster management and reducing vulnerabilities to hazards remain a high priority and it is recognised that Sierra Leone continues to grapple with both manmade and natural disasters, some of which are of increased intensity, including as a result of the effects of climate change.

1.4.2 Agenda for Change (2008-2012) and Agenda for Prosperity (2013-2018)

Both the GoSL's Agenda for Change (2008-2012) and the Agenda for Prosperity (2013-2018) have successfully raised popular and political support for poverty reduction in Sierra Leone and they represent tools for measuring development progress in Sierra Leone. One key factor supporting national development progress has been that the national priorities – as set out in the Agenda for Change, the Agenda for Prosperity, and most recently the National Ebola Recovery Strategy – all three have mirrored and complemented the MDGs. In line with sustained efforts to meet the MDGs for Sierra Leone, the government has revised and consolidated long-term targets for development as exemplified by the pillars of the Agenda for Prosperity, which include the following: Pillar 1 – Economic Diversification to Promote Inclusive Growth; Pillar 2 – Managing Natural Resources; Pillar 3 – Accelerating Human Development; Pillar 4 – International Competitiveness; Pillar 5 – Labour and Employment; Pillar 6 – Strengthening Social Protection Systems; Pillar 7 – Governance and Public Sector Reform; and Pillar 8 – Gender Equality and Women's Empowerment.

However, the increasing propensity for disasters and the failure of these national development strategies to reduce the impact of these disasters on society and the economy still remains unresolved. Sadly, exposure and vulnerability to hazards and disasters in Sierra Leone is rising as more people and assets are located in hazard-prone locations and the frequency and severity of most of these hazards are influenced by a range of factors, including population growth, deforestation and land degradation, urbanisation and climate change.

1.4.3 Hyogo Framework of Action (HFA) 2005-2015

In 2005, Governments around the world committed to take 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)[9], a 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

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

mutual learning with regards disaster management. Overall, the HFA was an important instrument for 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. While significant progress was made in implementing the HFA, much more needs to be done to integrate disaster risk reduction into sustainable development policies and planning.

1.4.4 Sendai Framework for Disaster Risk Reduction 2015–2030

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 introduces 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.

The Sendai Framework also articulates the following: the need for improved understanding of disaster risk in all its dimensions of exposure, vulnerability and hazard characteristics; the strengthening of disaster risk governance, including national platforms; accountability for disaster risk management; preparedness to “Build Back Better”; recognition of stakeholders and their roles; mobilisation of risk-sensitive investment to avoid the creation of new risk; resilience of health infrastructure, cultural heritage and work-places; strengthening of international cooperation and global partnership, and risk-informed donor policies and programs, including financial support and loans from international financial institutions.

Taking into account the experience gained through the implementation of the HFA, and in pursuance of the Sendai Framework’s expected outcome and goal, there is a need for the GoSL to meaningfully integrate DRR into its development agenda to reflect the following four priority areas:

- Priority 1: Understanding disaster risk.
- Priority 2: Strengthening disaster risk governance to manage disaster risk.
- Priority 3: Investing in disaster risk reduction for resilience.
- Priority 4: Enhancing disaster preparedness for effective response and to “Build Back Better” in recovery, rehabilitation and reconstruction.

1.4.5 2030 Agenda for Sustainable Development Goals (SDGs)

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 disaster risk reduction (DRR), disaster risk management (DRM) and hazard profiling. Specifically, the following SDG goals are directly related to DRR, DRM and hazards:

- 1.5: By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters
- 11.5: By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations
- 13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries

- 11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels.

1.5 Project Objectives

The main objective of this Project is to create a comprehensive hazard profile for Sierra Leone which covers all of the major natural hazards prevailing in Sierra Leone, including landslides, flood, coastal erosion, sea level rise, drought, epidemics, storm surge, tropical storm and lightning & thunder, and to map out hazard prone areas at the national and district level based on historic disaster events and to create a basis for comprehensive national risk assessment for Sierra Leone.

More specifically, the study objectives are to:

- Carry out a comprehensive desk review and collate disaster management, hazard, vulnerability, exposure, capacity, risk and socio-demographic datasets and information to develop a synthesis report on Sierra Leone's major hazards and disaster risks at the national and sub-national levels.
- Undertake hazard identification, assessment and mapping for vulnerability and risk assessments and map out hazard-prone and high risk areas with regards people, property, critical facilities, infrastructure and economic activities.
- Process historic data to build risk models for the creation of multi-hazard profiles in terms of hazards and risks to develop a comprehensive and up-to-date national risk profile of Sierra Leone, including the development of the Hazard and Risk Profile Information System (HARPIS) for Sierra Leone. The HARPIS-SL is being designed and developed to seamlessly integrate and interoperate with the CIDMEWS-SL Mapping Application[10]. Both the HARPIS-SL and the CIDMEWS-SL will be owned and managed by the ONS-DMD upon completion.
- Identifying institutional capacity gaps and making recommendations for institutionalizing DRR and DRM to prioritize risk mitigation investments and strengthen Sierra Leone’s disaster prevention, mitigation, preparedness, response and recovery systems.

Successful delivery of the aforementioned objectives could be used to identify programming gaps and opportunities that will enable the GoSL MDAs, humanitarian and development agencies to formulate disaster risk reduction plans and strategies.

1.6 Scope of Project

INTEGEMS worked under the guidance and supervision of the Director of ONS-DMD and in close collaboration with the Sierra Leone Meteorological Department (SLMD); Sierra Leone Environment Protection Agency (EPA-SL); Water Directorate, Ministry of Water Resources; and other relevant MDAs and local councils, in order to perform, inter-alia, the following tasks:

1. Review existing literature on vulnerability, hazard and poverty (based on reports, studies, analyses, assessments, and related documents (including grey literature).
2. Review the NHAP and other related documents that outline the hazards/disasters found in the country, their peculiars, and areas found. Also, provide technical analytical interpretation showing trends and disaster risk complexities.
3. Undertake stakeholder analysis (including capacity gap analysis) of key institutions and/or players in the DRM and humanitarian sectors in Sierra Leone.

[10] The CIDMEWS-SL Mapping Application (accessed via https://cidmews-sl.solutions) is a Geographic Information Systems (GIS) Web mapping application that provides easy and convenient ways to collect, map, explore, query, analyze and freely share available climate information, disaster management and early warning data and information resources from any device, anywhere, at any time.

4. Carry out field-based mapping of the natural hazard and/or hazard-prone areas for all major hazards for Sierra Leone, in particular detailing exposure to identified hazards.
5. Develop plausible hazard/events scenarios and hazard intensity maps for Sierra Leone.
6. Enhance national capabilities for the risk assessment and dynamic mapping by engaging national professionals in the exercise.
7. Integrate hazard data, models and maps into a National Risks Information System, a decision-making development planning; support system for risks management.
8. Review and/or develop conceptual model for hazard analysis and methodology for efficient management.
9. Make recommendations on how Sierra Leone can best be supported to implement her disaster management strategy (including the role(s) the DMD- ONS and other stakeholders should play in this.
10. Provide technical advice on how issues related to disaster preparedness and response can be systematically addressed in sector-wide strategic planning and management policies of both local and international partners.

1.7 Implementing Organisations and Partners

The Energy, Environment and Natural Resource Management (EENRM) Cluster of the UNDP Sierra Leone, in partnership with the ONS-DMD, contracted INTEGEMS (the Consultant), to undertake the "Update of Sierra Leone Hazard Profile and Capacity Gap Analysis" Project. In accordance with the Terms of Reference (TOR) of the Project, the Consultant is working under the guidance and supervision of the Director of ONS-DMD and in close collaboration with the Sierra Leone Meteorological Department (SLMD), Sierra Leone Environment Protection Agency (EPA-SL), and the Ministry of Water Resources (MWR).

The Consultants are also working in close association with the other relevant GoSL MDAs - Ministry of Agriculture, Forestry and Food Security (MAFFS); Ministry of Mines and Mineral Resources (MMMR); Ministry of Trade and Industry (MTI); Ministry of Energy (MoE); Ministry of Health and Sanitation (MoHS), Ministry of Lands, Country Planning and Environment (MLCPE); Ministry of Transportation and Aviation (MTA); Ministry of Internal Affairs (MIA); Ministry of Social Welfare, Gender and Children's Affairs (MSWGCA); Ministry of Labour and Social Services (MLSS); Ministry of Marine Resources and Fisheries (MMRF); Ministry of Local Government and Rural Development (MLGRD); Ministry of Tourism and Cultural Affairs (MTCA); Ministry of Works, Housing and Infrastructural Development (MWHID); National Minerals Agency (NMA); Sierra Leone Statistics (SSL); Sierra Leone Roads Authority (SLRA); and Sierra Leone Maritime Agency (SLMA), etc., in all aspects of project implementation and close linkages with these MDAs are ensured through ongoing partnership arrangements and previous experience in working with these organisations to facilitate secondary data collection, hazard specific information exchange and sharing of any other data relevant to the Project.

1.8 Stakeholders Involved in the Project

The Project has been associated with three types of stakeholders: Project Management Team, Project Implementation Partners (i.e., ONS-DMD, EPA-SL, MWR and the SLMD), and Project Beneficiaries (other associated agencies, the World Bank, UNDP, etc.). The Project Management Team comprises various multi-disciplinary and technical staff members from INTEGEMS, including other national and international professional experts in risk assessment, modelling and analysis.

The ONS-DMD is the focal point for advice, direction and evaluation as per the defined TOR, with support and advice from the EPA-SL, MWR and SLMD. The UNDP Sierra Leone Country Office provided the funds for the Project and financially supported the Project Management Team in convening the Stakeholders Workshops in Freetown, Makeni, Bo and Kenema and also facilitated logistics as per the TOR. The UNDP, aside from providing funding support to the project, have extensively provided technical guidance and assistance to the risk assessment process through its in-house disaster risk assessment expertise.

The ONS-DMD and the Project Management Team identified the key stakeholders and beneficiaries. The role of beneficiary stakeholders is to provide necessary data and information for the vulnerability, exposure and risk assessments of hazard impacts in the respective sectors. This class of stakeholders and beneficiaries includes the UN Programmes, Funds and Agencies (UNDP, WHO, FAO, UNOPS, WFP, etc.); relevant GoSL MDAs - Ministry of Agriculture, Forestry and Food Security (MAFFS); Ministry of Mines and Mineral Resources (MMMR); Ministry of Trade and Industry (MTI); Ministry of Energy (MoE); Ministry of Health and Sanitation (MoHS), Ministry of Lands, Country Planning and Environment (MLCPE); Ministry of Transportation and Aviation (MTA); Ministry of Internal Affairs (MIA); Ministry of Social Welfare, Gender and Children's Affairs (MSWGCA); Ministry of Labour and Social Services (MLSS); Ministry of Marine Resources and Fisheries (MMRF); Ministry of Local Government and Rural Development (MLGRD); Ministry of Tourism and Cultural Affairs (MTCA); Ministry of Works, Housing and Infrastructural Development (MWHID); National Minerals Agency (NMA); Sierra Leone Statistics (SSL); Sierra Leone Roads Authority (SLRA); and Sierra Leone Maritime Agency (SLMA); international and national NGOs, CBOs, academia and the private sector.

This Project is intended to benefit a range of stakeholders and potential users. Mainly, the key decision/policy-makers will be able to ensure policy making and decisions are based on robust risk information. The Hazard Profile will benefit donors and development partners by informing their respective project formulation and design and risk-proofing development interventions. It will also ensure a risk informed planning by Planners in the government institutions, non-government organisations and the private sector.

In addition, the academia is one of the expected beneficiaries and users of this Project, specifically as a basis or reference for further researches and academic papers. The private sector will also benefit from the Project as its findings could guide them in disaster risk proofing their investments. The humanitarian actors could also utilize the results of this Project as a guide in identifying hazard-safe areas where humanitarian interventions are implemented. The Districts and the Local Councils and local communities will by and large be the main beneficiaries and users of the Hazard Profile.

1.9 Project Outcomes

At the end of this Project, the GoSL, particularly the ONS-DMD, will be well placed to better coordinate all disaster management related initiatives in a proactive manner at national and local levels, leading to the reduction of disaster risk across Sierra Leone. The updated Hazard Profile will be useful for mainstreaming DRR in various sectors at different levels and its assessments will help various decision makers, policy makers and development agencies to prepare robust DRR plans as outlined below.

- At present, several MDAs, UN Family and development partners have carried out risk assessments for various parts of Sierra Leone at different scales. This study has developed a comprehensive risk assessment profile for the whole of Sierra Leone at the district level. It will serve to enhance the qualitative and quantitative aspects of the work previously conducted by other agencies.
- Tools for physical vulnerability assessments of various assets at the district level have been developed. These will aid in the identification of the most vulnerable sectors and the measures necessary to reduce disaster impacts.
- The study will bring out existing gaps in DRR strategies. In addition, it will recommend measures to build decision-making capacities. This report will be a useful tool in mainstreaming DRR into various sectors at all levels.
- The assessment will help district and regional decision-makers, policy-makers and development agencies in preparing disaster risk reduction planning.
- Based on the outcomes of this study, the GoSL may take actions toward capacity building for disaster risk reduction.
- The study developed a robust methodology for hazard, vulnerability and risk assessment in close collaboration with the ONS-DMD and other technical departments and agencies. These models may now be replicated in other countries and regions.
- Ideally, the study will encourage the financial support of international organisations for measures and actions that will reduce the risk associated with natural hazards in Sierra Leone.

1.10 Project Assumptions and Limitations

1. **Resources:** The Project was allocated limited funds by the UNDP Sierra Leone Country Office to cover project studies and scope. With limited resources, the Consultant has largely relied on secondary source data and information from third party, ranging from GoSL MDAs, UN Family, Development Partners, NGOs, CBOs, academia and research and technical organisations.
2. **Time limitation:** The time allocated for the Project was limited to six months, within which extensive hazard, vulnerability and risk assessment along with the development of the Hazard and Risk Profile Information System – Sierra Leone (HARPIS-SL) were carried out.
3. **Precision Standards:** The Project has ensured quality outcome with fairly adequate precision. In general, hazard assessments carried out using scientific tools were validated with field checks and statistical tools and methods.
4. **Availability of Data:** For assessment of hazards, vulnerability and associated risks, several geological, hydro-meteorological, geomorphological data, socio-economic data, census data and database of infrastructure were required. Several information were available, however, large data were missing. This limited the robustness of the modelling.
5. **Technical Methodology:** Development of methodology of the hazard, vulnerability and risk assessment have largely depended upon availability of data and resources.

1.11 Other Hazard and Disaster Management Studies in Sierra Leone

1.11.1 Support to Communication and Dialogue on Early Warning and Forecasting Products & Climate Information

In September 2016, the UNDP Sierra Leone (under a UNDP global initiative on Climate Information and Early Warning Systems and funded by the Global Environment Facility) commissioned INTEGEMS to support and improve climate monitoring and early warning systems through the enhancement of the technical and technology capacities of the relevant mandated institutions – ONS-DMD, SLMA, EPA-SL and the MWR.

The main objective of the Project ("*Support to Communication and Dialogue on Early Warning and Forecasting Products & Climate Information*") is to establish a functional network of meteorological and hydrological monitoring stations and develop and implement an integrated CIDMEWS-SL for disaster management, meteorological, climatological, hydrological and early warning information to help understand better the weather and climatic changes overtime and provide timely information to avert any weather and climate related disasters. The project commenced in September 2016 and is due for full completion in November 2017.

As part of the project deliverables, INTEGEMS developed and deployed (on hired dedicated servers in the Cloud) a robust, scalable, flexible and interoperable CIDMEWS-SL. The CIDMEWS-SL integrates GIS and Management Information System (MIS) systems and mobile data collection technology to provide a family of sophisticated tools and Web services for collecting, managing, visualizing, mapping, analysing, monitoring, evaluating and reporting on various aspects of climatological, hydro-meteorological, disaster management and early warning information in Sierra Leone. This integrated and holistic analysis puts the CIDMEWS-SL on a more sturdy foundation. The ability of the ONS-DMD and various stakeholders to make sound disaster management decisions – to analyse risks and decide upon appropriate counter-measures - can be greatly enhanced by the cross-sectoral integration of information within the CIDMEWS-SL.

The CIDMEWS-SL Mapping Application (accessed via https://cidmews-sl.solutions) is a GIS Web mapping application that provides easy and convenient ways to collect, map, explore, query, analyse and freely share available climate information, disaster management and early warning data and information resources from any device, anywhere, at any time. A primary goal of the CIDMEWS-SL is to allow people who are not GIS professionals to do self-service mapping on any device (i.e., desktop, tablets and smartphones using Internet browsers) and expand the creative use and sharing of climate information, disaster management and early warning data and information resources about Sierra Leone.

Thus, the CIDMEWS can be used with various data and information (e.g., national hazard profiles for coastal hazards, droughts, floods in key river basins, landslides, lightening, sea level rise, storm surges, census and statistics, etc.) to immensely support planning and decision making towards resource allocations for DRR. There is a wealth of information being generated or available under specific projects in Sierra Leone to complement mainstreaming of data use.

1.11.2 Multi-City Hazard Review and Risk Assessment in Sierra Leone.

To better understand and quantify natural hazard and disaster risk in Sierra Leone, the World Bank and Global Facility for Disaster Reduction and Recovery (GFDRR) are supporting, under Africa Caribbean Pacific – European Union (ACP-EU) funding, the development of new hazard and risk information in Sierra Leone for targeted cities namely, Freetown, Makeni and Bo. The World Bank in early 2017 commissioned a team of Ove Arup and Partners International Ltd (Arup), Integrated Geo-information and Environmental Management Services (INTEGEMS), JBA Risk Management (JBA) and the British Geological Survey (BGS) (collectively, the 'Project Team') to undertake the study (Multi-City Hazard Review and Risk Assessment in Sierra Leone"). The Project commenced in March 2017 is due for completion in December 2017.

The objective of the Project is to support the Government of Sierra Leone through the World Bank and GFDRR to develop city level natural hazard and risk assessments for three cities in Sierra Leone, namely Freetown, Makeni and Bo. The project specifically aims to better understand and quantify natural hazard and risk in three cities in Sierra Leone.

- Freetown: Flooding, Landslides, Sea Level Rise and Coastal Erosion
- Bo: Flooding, Landslides
- Makeni: Flooding, Landslides

The risk assessment commenced with a qualitative review of the risks to these cities as well as a review of the existing DRM and urban planning policies currently in place. This review will feed into quantitative risk assessment for flooding, landslides, sea level rise and coastal erosion.

The results of these risk assessments will be used to identify priority DRM investments through a high-level cost-benefit analysis. The results will also be used to feed into high-level DRM and urban planning policy recommendations within the wider context of urban master-planning for Freetown, Makeni and Bo. Within the wider context of building urban resilience against these hazards in Sierra Leone, it is the intention that the results of this project will be used to:

- Support provision and increased resilience against disasters;
- Contribute to urban planning by providing needed information and maps about disaster risks (flood, landslide, sea level rise and coastal erosion);
- Build city councils' capacity in term of natural hazard and risk knowledge;
- Lead to disaster prevention and resilience by recommending actions which strengthen DRR and DRM, in the form of high-level urban policy advice related to natural hazards and risks (flood, landslide, sea level rise and coastal erosion);
- Increase preparedness to strengthen urban communities' resilience against natural hazards; and
- Identify and prioritize DRR and DRM investments.

2 COUNTRY BACKGROUND

2.1 Geographical Context

Sierra Leone is a small country located on the West Coast of Africa with an area of about 72,000 km^2. It lies between latitudes 6^0 0' N and 10^0 0' N and longitude 10^0 16' W and 13^0 18' W. Bounded on the south-west by the Atlantic Ocean, it stretches along the coastline for approximately 400 km, by Guinea on the north and north-east, and by Liberia on the south-east (see Figure 2-1) . Sierra Leone is divided into four main physical regions, namely coastal plains, interior lowland plains, interior plateau, and hills and mountains (see Figure 2-2).

The landscape of Sierra Leone is characterised by topography ranging from mountainous slopes in the north-east to low relief floodplains in the southwest (Figure 2-3). The coastline or coastal plains is relatively gentle and comprises of estuarine swamps subject to tidal flooding; coastal terraces; alluvial plains are subject to freshwater flooding during the rainy season. Beach ridges, fringe the alluvial plains on the seaward side (Allan 1990). The interior lowland plains, the largest of the four physical regions, extend from the coastal terraces in the west to the east of Sierra Leone, occupying approximately 43% of the total land area. They rise gently from the coastal terraces to elevations of 200m in the east, where they are separated from the plateaux by distinct escarpments.

West of the plateau region and interior lowlands, is the Freetown Peninsula, which is also made up of dissected peaks, with the two highest peaks being the Sugar Loaf Hill and Picket Hill. The hills on the Freetown Peninsula are unique to this region, and found nowhere else in the sub-region. The rocks are resistant to erosion, resulting in dissected ridges of moderate to high relief. The high content of iron and aluminium results in the formation of laterites, either as a surface crust or as densely packed ironstone gravel.

At the edge of the lowland plains are the interior plateaux, which covers approximately 22% of the total land area and made up of granite that runs from the northeast of the country to the southeast. The plateau region seldom rises above 700 m and is comprised of alluvial ironstone gravel in the southeastern region, while the northern end is comprised of weathered outcrops of granitic rocks. Stretches of wooded hill country lead east and northeast to a plateau region generally ranging in elevation from 300 m to 610 m. The eastern and southern parts comprise of dissected hills. In the north and east of the country are two of the highest mountains, with the Loma Mountains being the highest in West Africa. The highest peak on the Loma Mountains is Bintumani, which rises to 1,945 m while Sankan Biriwa on the Tingi Hills, rises to 1,805 m.

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

Figure 2-2: Physical geography of Sierra Leone

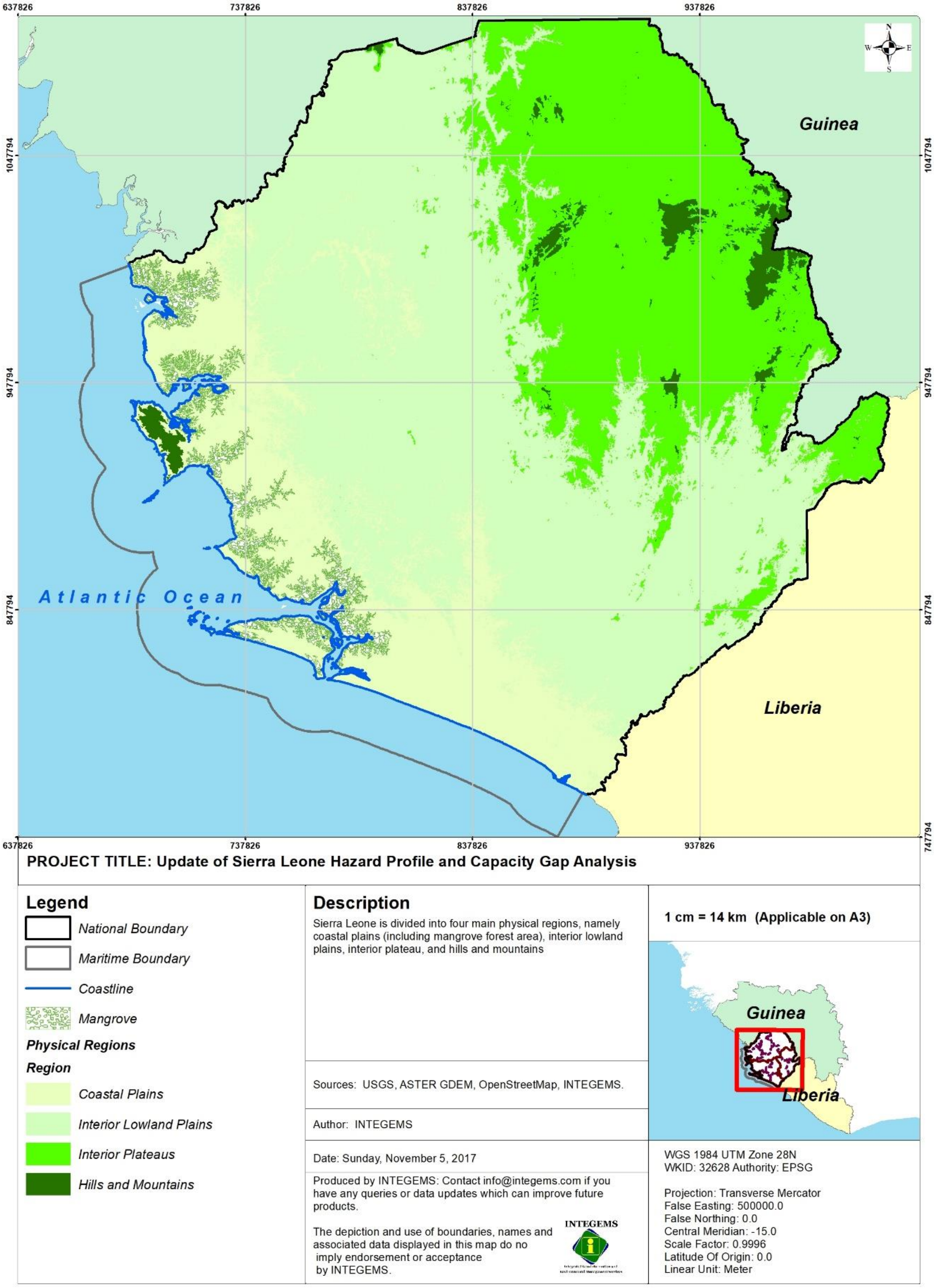
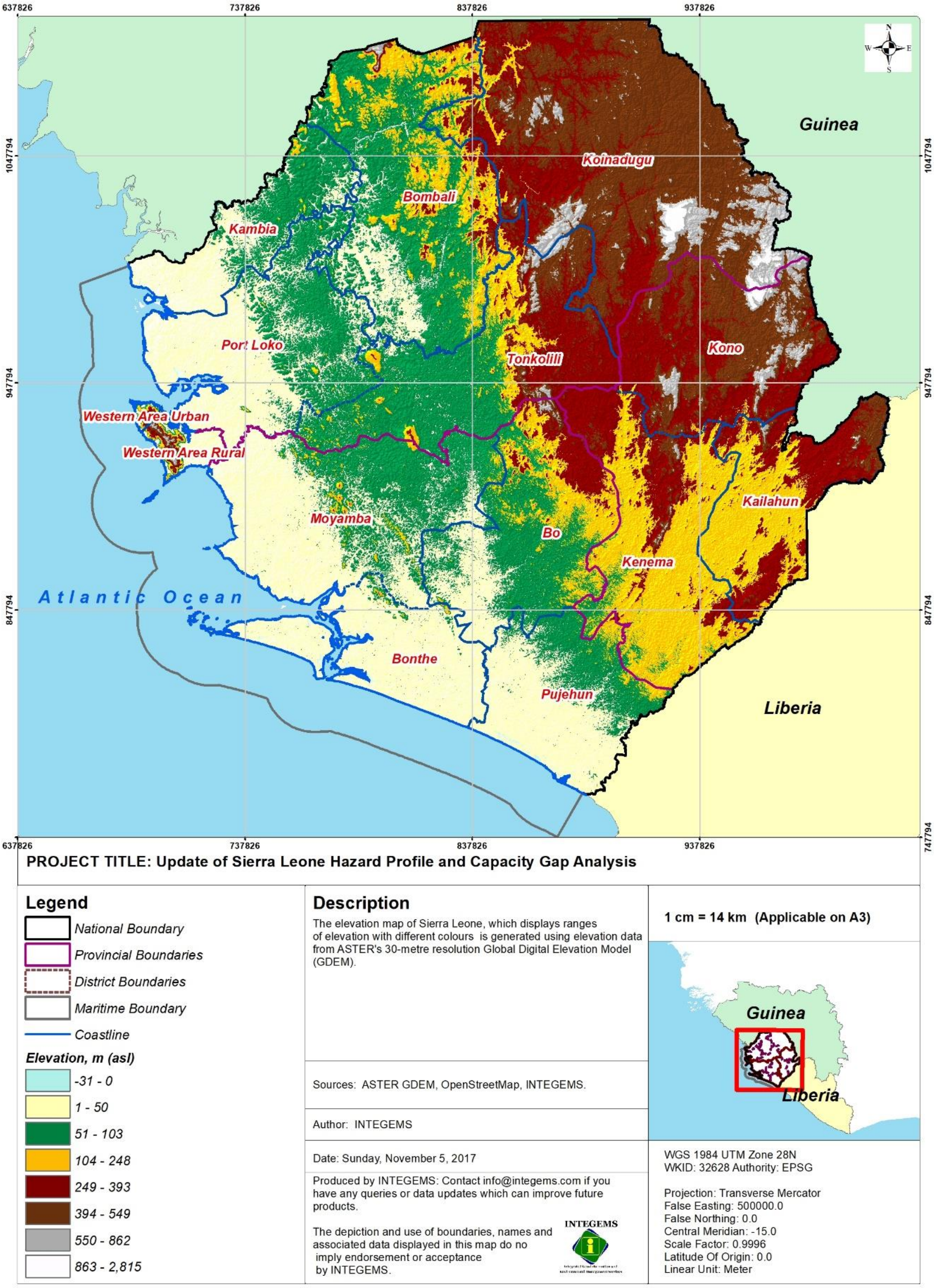


Figure 2-3: Elevation map of Sierra Leone



2.2 Land Cover/Land Use

Sierra Leone's land cover or vegetation zones can be broadly classified into forest, savannah woodland and the swamps or marsh. The country was originally a forested country with over 60% of its land covered by closed forest, the rest being woodland savannah of the guinea type[11]. Currently, about 70% of its forest has been lost due to human activities - clearing for use in 'slash-and-burn' or shifting cultivation farming, timber and firewood. Patches of rain forest can be found scattered in the northern, eastern and southern provinces

The most extensive land cover change in Sierra Leone was the loss of woodland and forested area across the country. Dense forest is rare and mainly found on hill slopes in the Montane Forest Zone. Even though the country is located within the Upper Guinean forest ecosystem, it is unlikely that it was ever heavily covered by dense forest (Munro and van der Horst, 2012) (see Figure 2-4). Between 1975 and 2013, Sierra Leone lost 30 % of its forest cover, or about 1,100 km^2, at an average annual rate of 0.8 %. However, this rate has slowed since the end of the civil war, averaging 0.4 percent of annual forest loss between 2000 and 2013. The main loss of forest occurred in the Tama-Tonkolili and Nimini Hills highlands.

In 1975, these tracts of dense forest were located among a patchwork of degraded forest, gallery forest, and woodland — none of which has been spared by deforestation. Degraded forest decreased by 26 percent, or about 2,000 km^2, and gallery forest by 22 %, or 700 km^2. Woodland is one of the dominant land cover types in Sierra Leone. It is found on the slopes and uplands of the Koinadugu and Kono Plateaus, and on the Interior and Coastal Plains, among the savannas and thickets. In 1975, woodland was the second largest land cover class in terms of area after the savannas, covering 15.5 percent of the country. Over the 38-year period, its area decreased by 48 %, or 5,400 km^2, shrinking to a mere 8 % of the country in 2013. Accounting for all the forest classes together, Sierra Leone lost a total 36 % of its forest and woodland habitats since 1975 (Tappan, 2016).

Cropland expansion, slash-and-burn agriculture, logging, mining, and cattle grazing activities were the dominant factors affecting vegetation and land use. Indeed, resulting from an increasing demand for forest products and food production, half of the lost forest and woodland habitats were converted to savannas, and one-third to agriculture. Shifting agriculture has long been practiced in Sierra Leone. Under this system, a patch of forest is burned, cleared and cultivated usually for a short period of time (1–2 years), after which it is left fallow for several years. The rate of cropland expansion quadrupled after the end of the civil war, going from an average of 32 km^2 per year in the 1975–2000 period to 130 km^2 per year between 2000 and 2013.

Overall, agricultural area progressed by 35 %, or 2,400 km^2, between 1975 and 2013, mostly in the Interior Plains and in the northern part of the Koinadugu and Kono Plateaus. In Sierra Leone, where water is an abundant resource, bottomland and flood recessional agriculture is also very common. Many of the wetland areas mapped in 1975 have been converted to cultivated bottomland which has doubled in area, reaching 1,180 km^2 by 2013 (see Figure 2-5 and Table 2-1).

Because a large part of the population in Sierra Leone obtains its substance from farming, agriculture expansion was mostly driven by population growth. Whereas population increased steadily from 2.7 million to 6.1 million, a rise of 123 %, the area occupied by settlements — towns and cities — only grew by 36 %, or 140 km^2, from 1975 to 2013.

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[11] Larbi Asamoah. (accessed via http://www.fao.org/ag/agp/agpc/doc/counprof/Sierraleone/Sierraleone.htm, 26 October 2017)

Figure 2-4: Vegetation and land cover types in Sierra Leone

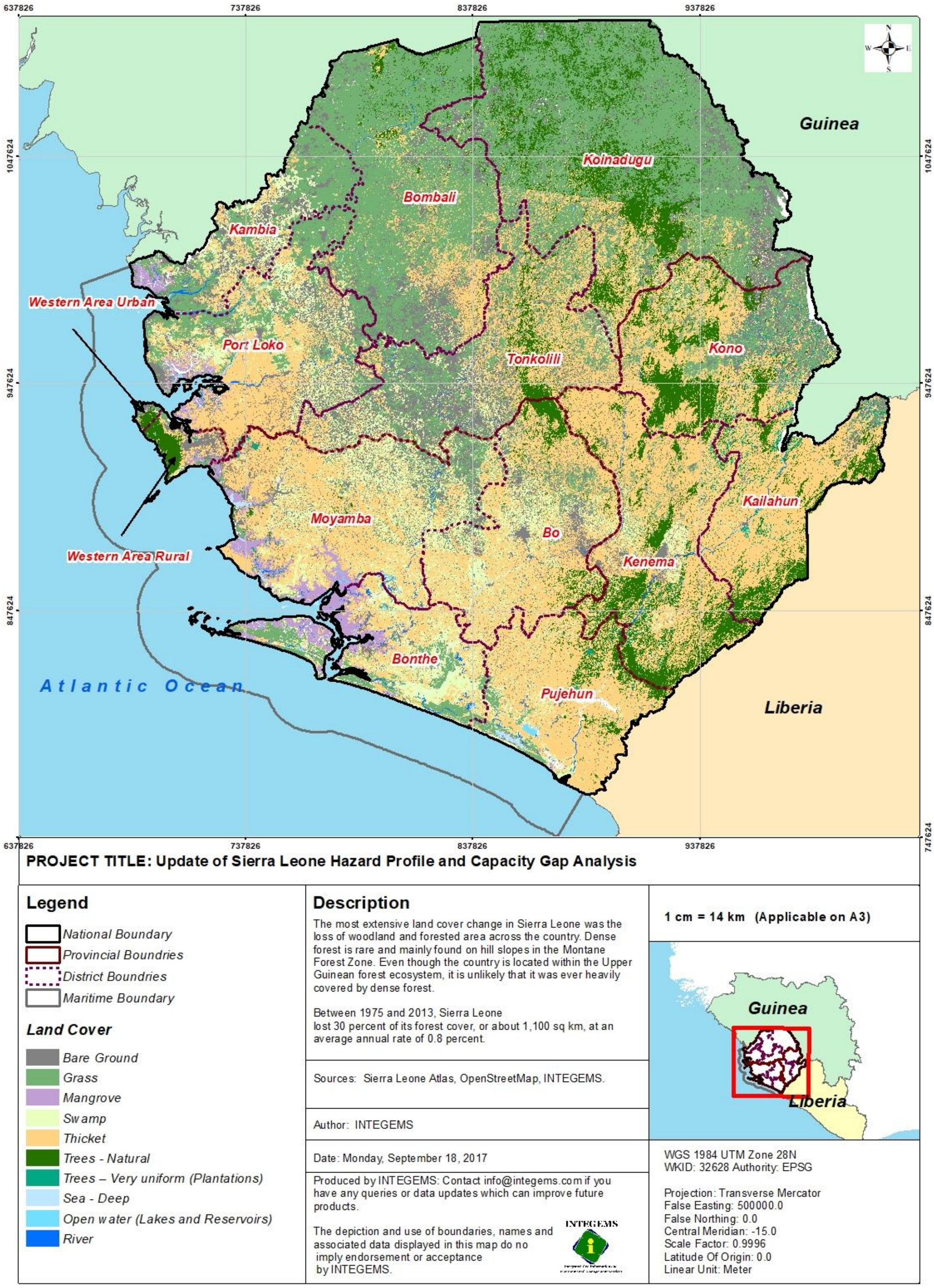
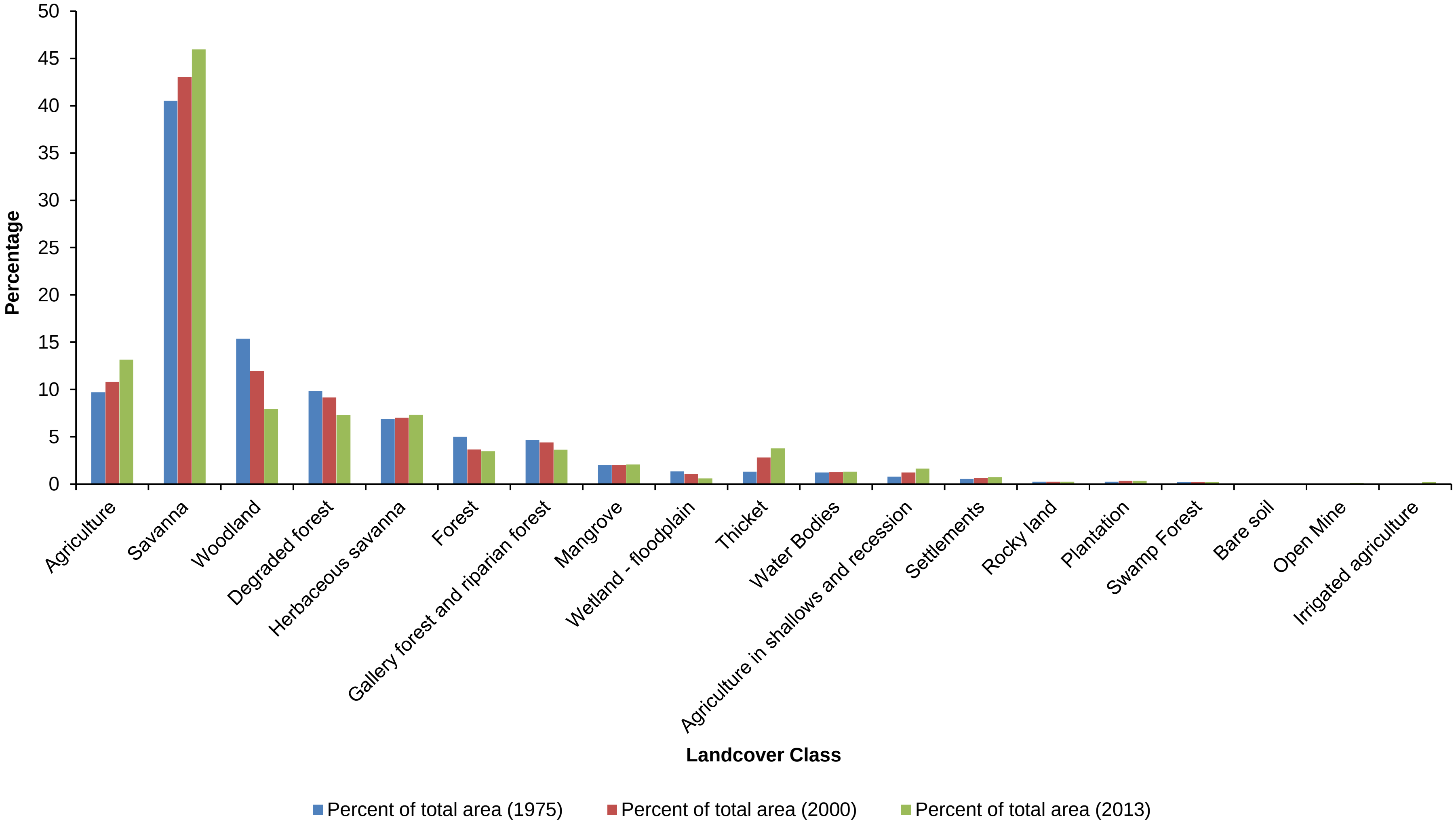


Table 2-1: Sierra Leone land use/land cover time series

Land cover classes	1975		2000		2013	
	Area (km^2)	Percent of total area	Area (km^2)	Percent of total area	Area (km^2)	Percent of total area
Agriculture	7,028	9.71	7,832	10.82	9,512	13.14
Agriculture in shallows and recession	576	0.80	888	1.23	1,188	1.64
Bare soil	32	0.04	32	0.04	24	0.03
Degraded forest	7,124	9.84	6,620	9.15	5,284	7.30
Forest	3,616	5.00	2,644	3.65	2,512	3.47
Gallery forest and riparian forest	3,360	4.64	3,180	4.39	2,620	3.62
Herbaceous savanna	4,980	6.88	5,080	7.02	5,304	7.33
Irrigated agriculture	20	0.03	40	0.06	140	0.19
Mangrove	1,460	2.02	1,460	2.02	1,496	2.07
Open Mine	24	0.03	28	0.04	72	0.10
Rocky land	184	0.25	184	0.25	180	0.25
Plantation	184	0.25	252	0.35	252	0.35
Savanna	29,320	40.52	31,156	43.05	33,252	45.95
Settlements	388	0.54	464	0.64	528	0.73
Swamp forest	140	0.19	144	0.20	140	0.19
Thicket	948	1.31	2,044	2.82	2,728	3.77
Water bodies	888	1.23	900	1.24	956	1.32
Wetland - floodplain	976	1.35	772	1.07	424	0.59
Woodland	11,120	15.37	8,648	11.95	5,756	7.95
Total mapped area (km^2)	**72,368**		**72,368**		**72,368**	

Figure 2-5: Land use/land cover time series (1975, 2000, and 2013)



2.3 Climate and Weather

Sierra Leone has a wet tropical climate, marked by distinct wet and dry seasons. The wet or rainy season extends from May to October and the dry season from November to April. Both seasons may have some variations in their commencement and duration. The wet season is dominated by the southwest tropical maritime monsoon which is a mass of moisture-laden air that originates over the south-Atlantic ocean. The rains fall steadily in the wet season with the heaviest in the months of July and August, with some months recording virtually no rain. The wet season has an average rainfall of 3,000 mm, with coastal and southern areas receiving from 3,000 to 5,000 mm annually and inland areas between 2,000–2,500 mm in the drier areas of the north–west to the north –east (see Figure 2-6).

Due to heavy rainfall in the wet season, discharges and runoff are high and ranges from 20% to 40% of total annual rainfall. Rivers overflow their banks during this period. 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. The dry season is prone to dusty and hot Harmattan winds and drought conditions. However, there is pronounced dry season from November to March when flows may be sufficiently reduced to be a constraint.

The temperatures are consistently high throughout the country, roughly averaging from 25–27°C, with slightly lower temperatures (22–25°C) during the wet season. Diurnal temperatures vary from 25°C to 34°C although they could be as low as 16°C at night during the Harmattan. Average annual temperature has increased by 0.8°C since 1960. Data is limited but available data shows significantly increasing trends in the frequency of ‘hot’ nights. The humidity, like the temperature is usually high as a result of the heavy rains coupled with high temperature and maritime influences. Humidity rises up to 93% in the wet season and decreases inland to about 47% as the rainfall declines.

There is little variation in the day length due to the near equatorial location, but sunshine hours are affected during the wet season. Sunshine is plentiful and varies substantially with the amount of cloudiness. During the dry season (November to March) mean monthly solar radiation is high, 380 cal/ cm^2/day (480 lux); mean hours of sunshine varies from 7-9, and pan evaporation is about 4.5 mm per day. The wet season is generally dull and cloudy with a mean monthly solar radiation of 280 cal/ cm^2/day, mean hours of sunshine is 3 hours/day in July and August, and pan evaporation generally less than 2.0 mm/day, due to high diurnal humidity.

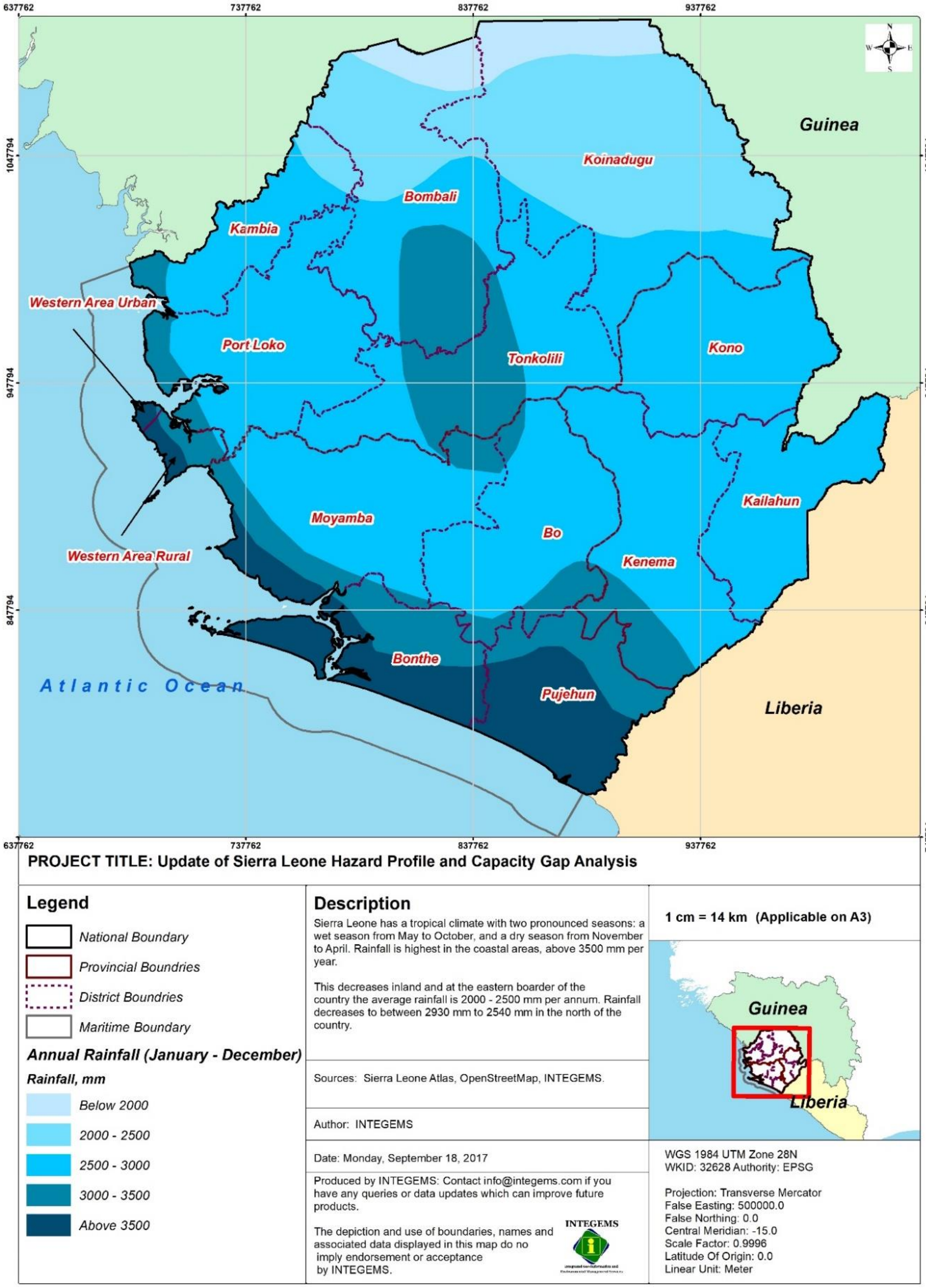
Key climate change trends since 1960 include:

- Higher temperatures (+0.8°C), an average increase of 0.18°C per decade.
- Increased night-time temperatures.
- Reduced annual precipitation overall, with significant decadal variability (1960s–1970s show increased rainfall while 1980s show drier conditions).
- Increased variability in the rainy season, with some observations suggesting a later onset/shorter duration and increased intensity of single rainfall events.

Projected changes include:

- Increase in temperatures of 1.0–2.5°C by 2060, with more rapid warming inland.
- Although rainfall projections are less certain, the trend will be toward an overall increase, particularly between July–December.
- The intensity of single rainfall events will continue to increase.
- The level of the Atlantic Ocean will rise (0.1– 0.56 m by 2100, relative to 1980–1999 levels), coupled with an increasing risk of storm surges from June to September.

Figure 2-6: Climate of Sierra Leone, Annual Average Rainfall



2.4 Administrative Divisions

Administratively, Sierra Leone is divided into four Regions. Eastern, Northern and Southern Provinces, and the Western Area, which is the peninsular on which the capital, Freetown, is situated. Each Region is subdivided into Districts, and the Districts further divided into Chiefdoms (see Figure 2-7 and Figure 2-8). Overall, there are 14 Districts and 149 Chiefdoms. In addition to this, the 2004 Local Government Act established 19 Local Councils, 5 City Councils, and 14 District Councils.

Table 2-2: Sierra Leone administrative entities

Province	Districts	Chiefdoms	Sections
Northern	Tonkolili	11	87
	Bombali	14	148
	Port Loko	11	152
	Koinadugu	11	106
	Kambia	7	64
Southern	Bo	16	111
	Bonthe	12	78
	Moyamba	14	142
	Pujehun	12	95
Eastern	Kailahun	14	89
	Kenema	17	105
	Kono	15	82
Western	Western Area Urban	8	64
	Western Area Rural	4	25

In 2017, the GoSL proclaimed the de-amalgamation of Chiefdoms and an attendant re-division of the Northern Region into two distinct Regions, namely: Northern Region and North-Western Region. The two new Northern Regions now consist of seven electoral Districts in place of the previous five. The North-West Region covers Port Loko, Karene and Kambia Districts, while the Northern Region covers Bombali, Tonkolili and Koinadugu 1, and Koinadugu 2 Districts.

Figure 2-7: Administrative divisions of Sierra Leone

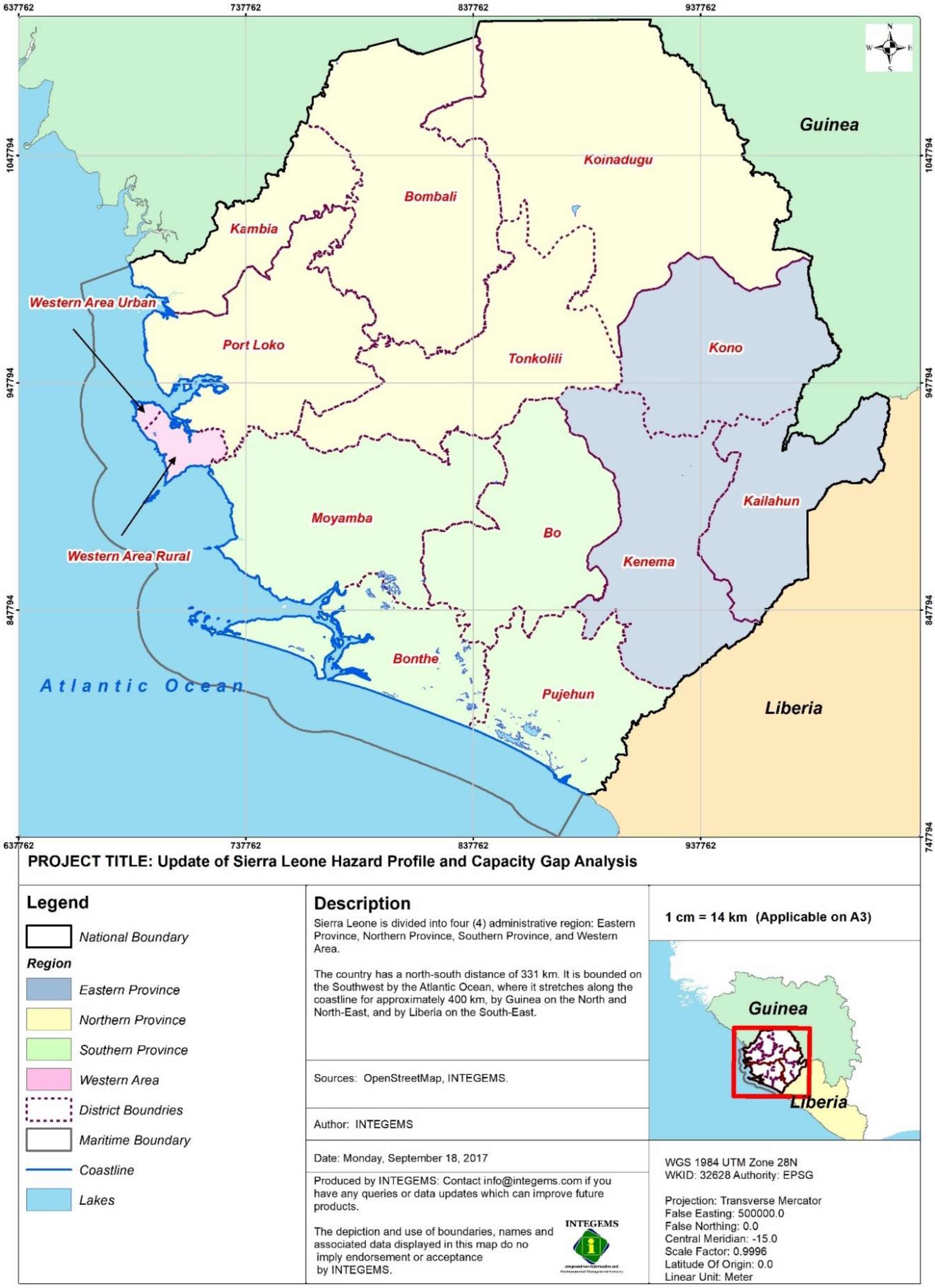
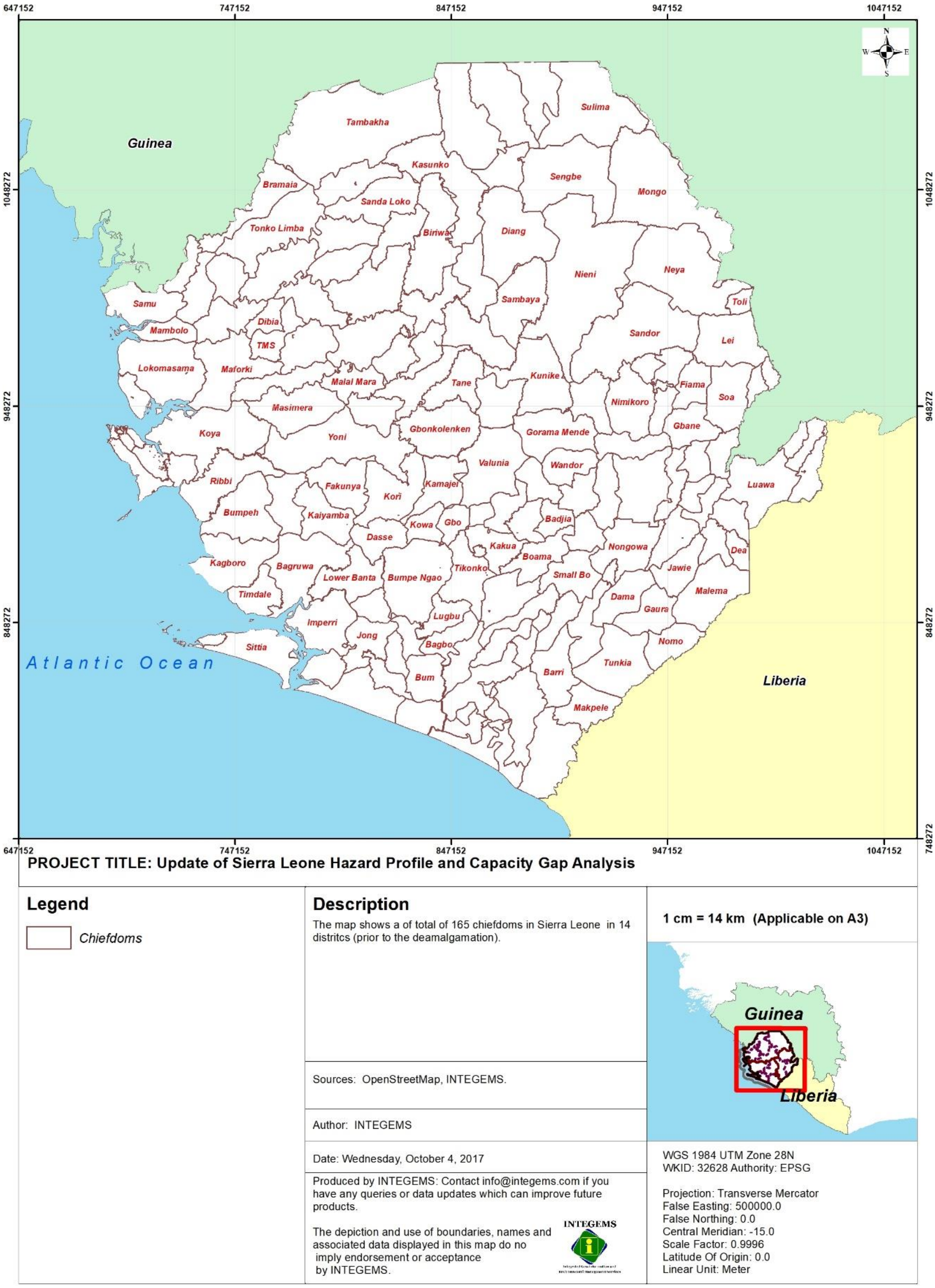


Figure 2-8: Administrative divisions of Sierra Leone – Chiefdom level



2.5 Political Context

Sierra Leone is a constitutional republic with a directly elected President and a unicameral legislature. The 1991 Constitution established three main branches of Government, namely an Executive, a Legislature and a Judiciary. The 1991 Constitution is being reviewed and a draft has been presented by the Constitutional Review Committee (CRC). Once Parliament has enacted the new Constitution, a referendum to vote on the new Law will take place.

The President, who is the head of state, the head of Government and the Commander-in-Chief of the Sierra Leone Armed Forces and the Sierra Leone Police, leads the executive branch. The President appoints and leads a cabinet of ministers, which Parliament approves. Popular vote elects the President for one or a maximum of two five-year terms. The Parliament of Sierra Leone has 124 seats and is Sierra Leone's legislature. Parliament includes representatives from all 14 districts, with 112 members elected for four-year terms through proportional representation; there are also twelve Paramount chiefs in Parliament. There are various parliamentary committees responsible for the main sectors including a health sector committee. Sierra Leone's highest court, the Supreme Court, leads the judicial branch. The President appoints judges on the advice of the Judicial and Legal Service Commission with the approval of Parliament. In 2012, Sierra Leone conducted its third democratic elections since the end of the 11-year civil war in 2002. President Ernest Bai Koroma is serving his second and final term, which ends in 2018. Elections will be held on 7 March 2018.

2.6 Socio-economic Context

Sierra Leone's civil war (1991-2002) eroded infrastructure and human capacity throughout the country. Over a decade after the war ended, the effect of the conflict on the health infrastructure and HRH remained prominent. Efforts made in the post conflict phase to improve the health sector suffered a major blow in the Ebola crisis (2014-2015), which created an additional burden on the health sector and the country as a whole. These two crises resulted in a range of social and economic challenges. As a result, real GDP growth in 2014 was 7.0%, compared to the pre-Ebola forecast of 11.3% (World Bank Group, 2016). As of 2015, GDP per capita in Sierra Leone was USD 653 (see Table 2-3). The 2015 UNDP's Human Development Index rank for Sierra Leone was 179 out of 187 countries (UNDP, 2016).

With or without Ebola, the lack of domestic resources in Sierra Leone, one of the world's poorest and least-developed countries, leaves the country dependent upon international support in terms of finance, technology and other forms of aid. Sierra Leone remains largely dependent upon its minerals economy, including iron, diamonds and rutile, which are major sources of foreign exchange. Sierra Leone boasts extensive natural resources, but these are under pressure from population growth, dependence on biomass for energy, 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 disasters and climate change impacts.

Sierra Leone suffer from mass poverty (more than half of the population lives under conditions of "severe" poverty), widespread malnutrition, high infant and child mortality rates, low life expectancy, deficient infrastructure, a poor education system, and insufficient availability of basic medical services to cope with tropical diseases malaria, cholera, tuberculosis, HIV/AIDS and EVD. While the majority of the population is poor, there is a high level of gender inequality, with women affected far more dramatically by the consequences of poverty than are men.

Table 2-3: Sierra Leone Country Profile

	1990	2000	2010	2016
World view				
Population, total (millions)	4.31	4.56	6.46	7.4
Population growth (annual %)	1.5	2.8	2.3	2.2
Surface area (sq. km) (thousands)	72.3	72.3	72.3	72.3
Population density (people per sq. km of land area)	59.7	63.2	89.5	103
Poverty headcount ratio at national poverty lines (% of population)	..	66.4	52.9	..
Poverty headcount ratio at $1.90 a day (2011 PPP) (% of population)	65.5	58.5	52.3	..
GNI, Atlas method (current US$) (billions)	0.8	0.66	2.73	3.61
GNI per capita, Atlas method (current US$)	190	140	420	490
GNI, PPP (current international $) (billions)	3.11	3.2	7.79	9.75
GNI per capita, PPP (current international $)	720	700	1,210	1,320
People				
Income share held by lowest 20%	..	6.6	7.9	..
Life expectancy at birth, total (years)	37	39	48	51
Fertility rate, total (births per woman)	6.7	6.3	5.2	4.6
Adolescent fertility rate (births per 1,000 women ages 15-19)	182	159	133	117
Contraceptive prevalence, any methods (% of women ages 15-49)	3	4	11	17
Births attended by skilled health staff (% of total)	..	37	61	60
Mortality rate, under-5 (per 1,000 live births)	264	236	160	120
Prevalence of underweight, weight for age (% of children under 5)	25.4	24.7	21.1	18.1
Immunisation, measles (% of children ages 12-23 months)	..	37	81	83
Primary completion rate, total (% of relevant age group)	..	..	75	66
School enrollment, primary (% gross)	51.9	67.7	125	128
School enrollment, secondary (% gross)	18	27	44	43
School enrollment, primary and secondary, gender parity index (GPI)	1	1	1	1
Prevalence of HIV, total (% of population ages 15-49)	0.4	1	1.7	1.7
Environment				
Forest area (sq. km) (thousands)	31.2	29.2	27.3	30.4
Terrestrial and marine protected areas (% of total territorial area)	0.9	2.6	..	3.8
Annual freshwater withdrawals, total (% of internal resources)	0.2	0.1	0.1	0.1
Improved water source (% of population with access)	37	47	57	63
Improved sanitation facilities (% of population with access)	10	11	13	13
Urban population growth (annual %)	2.2	3.5	3.1	3.1
Energy use (kg of oil equivalent per capita)	..	..	..	..
CO_2 emissions (metric tons per capita)	0.11	0.09	0.11	0.18
Electric power consumption (kWh per capita)	..	..	..	..
Economy				
GDP (current US$) (billions)	0.65	0.64	2.62	3.67
GDP growth (annual %)	3.3	6.7	5.4	6.1
Inflation, GDP deflator (annual %)	70.6	3.3	17.2	4.2
Agriculture, value added (% of GDP)	47	58	55	61
Industry, value added (% of GDP)	19	28	8	6
Services, etc., value added (% of GDP)	34	13	37	33

	1990	2000	2010	2016
Exports of goods and services (% of GDP)	35	18	17	24
Imports of goods and services (% of GDP)	34	39	34	54
Gross capital formation (% of GDP)	13	1	31	18
Revenue, excluding grants (% of GDP)	5.6	11.4	9.7	9.8
Net lending (+) / net borrowing (-) (% of GDP)	..	..	-6.1	-3
States and markets				
Domestic credit provided by financial sector (% of GDP)	36.3	54.4	17.1	18.1
Tax revenue (% of GDP)	5.3	10.2	8.9	8.6
Military expenditure (% of GDP)	1.9	3.7	1	0.8
Mobile cellular subscriptions (per 100 people)	0	0.3	34.8	97.6
Individuals using the Internet (% of population)	0	0.1	0.6	11.8
High-technology exports (% of manufactured exports)	..	28	..	0
Overall level of statistical capacity (scale 0 - 100)	..	..	52	63
Global links				
Merchandise trade (% of GDP)	44	25	42	60
Net barter terms of trade index (2000 = 100)	..	100	71	44
External debt stocks, total (DOD, current US$) (millions)	1,197	1,248	931	1,378
Total debt service (% of exports of goods, services and primary income)	10.1	76.4	2.7	2.3
Net migration (thousands)	-450	500	-21	..
Personal remittances, received (current US$) (millions)	0	7	44	59
Foreign direct investment, net inflows (BoP, current US$) (millions)	32	39	238	519
Net official development assistance received (current US$) (millions)	59.3	181	458	946

Source: *World Development Indicators database, World Development Indicators: 09/18/2017*
Figures in blue refer to periods other than those specified.

2.7 Demography

The 2015 Census revealed a population of 7,092,113 spread across four administrative regions. Sierra Leone's population has been on the increase since 1963 census. It increased from 2,180,355 in 1963 to 2,735,159 in 1974 and 3,515,812 in 1985. Sierra Leone 2015 Population and Housing Census, conducted in December 2015, is the second post-war enumeration exercise conducted by the GoSL with financial and technical support from UNFPA and partners. 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 percent. At the regional level, the growth rate followed the same pattern since 1963. Between 2004 and 2015, the growth rates per region were as follows: Eastern Region - 2.9 %; Northern Region – 3.3 percent; Southern Region – 2.5 percent and Western Area – 4.2 percent. The population figures for the Districts are outlined in Table 2-4 below.

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 percent are less than 15 years, and only 3.5 percent are 65 years and above. The working age population (15-64 years) represents 55.6 percent. 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%) (see Table 2-4 - Table 2-7).

Table 2-4: Distribution of population by type, district and sex

District	Total Population			Household Population			Institutional Population		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Kailahun	526,379	260,586	265,793	525,674	260,060	265,614	705	526	179
Kenema	609,891	301,104	308,787	609,427	300,755	308,672	464	349	115
Kono	506,100	252,751	253,349	505,491	252,295	253,196	609	456	153
Bombali	606,544	296,683	309,861	605,741	296,123	309,618	803	560	243
Kambia	345,474	165,541	179,933	344,095	164,749	179,346	1,379	792	587
Koinadugu	409,372	204,498	204,874	408,687	203,951	204,736	685	547	138
Port Loko	615,376	294,954	320,422	612,920	293,456	319,464	2,456	1,498	958
Tonkolili	531,435	263,152	268,283	531,140	262,910	268,230	295	242	53
Bo	575,478	280,569	294,909	574,026	279,640	294,386	1,452	929	523
Bonthe	200,781	99,014	101,767	200,771	99,007	101,764	10	7	3
Moyamba	318,588	153,699	164,889	318,002	153,467	164,535	586	232	354
Pujehun	346,461	168,869	177,592	346,366	168,803	177,563	95	66	29
Western Area Rural	444,270	221,351	222,919	443,068	220,536	222,532	1,202	815	387
Western Area Urban	1,055,964	528,207	527,757	1,050,711	523,881	526,830	5,253	4,326	927
Total Country	**7,092,113**	**3,490,978**	**3,601,135**	**7,076,119**	**3,479,633**	**3,596,486**	**15,994**	**11,345**	**4,649**

Table 2-5: Distribution of total population by region, district, sex and area of residence

District	Total Population	Male	Female	Rural	Urban	Share Of Population (%)	Proportion Urban	Sex Ratio
Province								
Eastern	1,642,370	814,441	827,929	1,092,723	549,647	23.2	33.5	98.3
Northern	2,508,201	1,224,828	1,283,373	1,893,227	614,974	35.4	24.5	95.3
Southern	1,441,308	702,151	739,157	1,157,428	283,880	20.3	19.7	94.9
Western	1,500,234	749,558	750,676	43,638	1,456,596	21.1	97.1	99.3
Total Country	**7,092,113**	**3,490,978**	**3,601,135**	**4,187,016**	**2,905,097**	**100**	**41**	**96.8**
District								
Kailahun	526,379	260,586	265,793	373,093	153,286	7.4	29.1	97.9
Kenema	609,891	301,104	308,787	338,192	271,699	8.6	44.5	97.4
Kono	506,100	252,751	253,349	381,438	124,662	7.1	24.6	99.6
Bombali	606,544	296,683	309,861	433,486	173,058	8.6	28.5	95.6
Kambia	345,474	165,541	179,933	244,630	100,844	4.9	29.2	91.9
Koinadugu	409,372	204,498	204,874	335,847	73,525	5.8	18	99.6
Port Loko	615,376	294,954	320,422	455,159	160,217	8.7	26	91.9
Tonkolili	531,435	263,152	268,283	424,105	107,330	7.5	20.2	98
Bo	575,478	280,569	294,909	380,397	195,081	8.1	33.9	95
Bonthe	200,781	99,014	101,767	162,796	37,985	2.8	18.9	97.3
Moyamba	318,588	153,699	164,889	295,891	22,697	4.5	7.1	93.3
Pujehun	346,461	168,869	177,592	318,344	28,117	4.9	8.1	95.1
West Area Rural	444,270	221,351	222,919	43,638	400,632	6.3	90.2	99.1
West Area Urban	1,055,964	528,207	527,757	1,055,964	0	14.9	100	99.4
Total Country	**7,092,113**	**3,490,978**	**3,601,135**	**4,187,016**	**2,905,097**	**100**	**41**	**96.8**

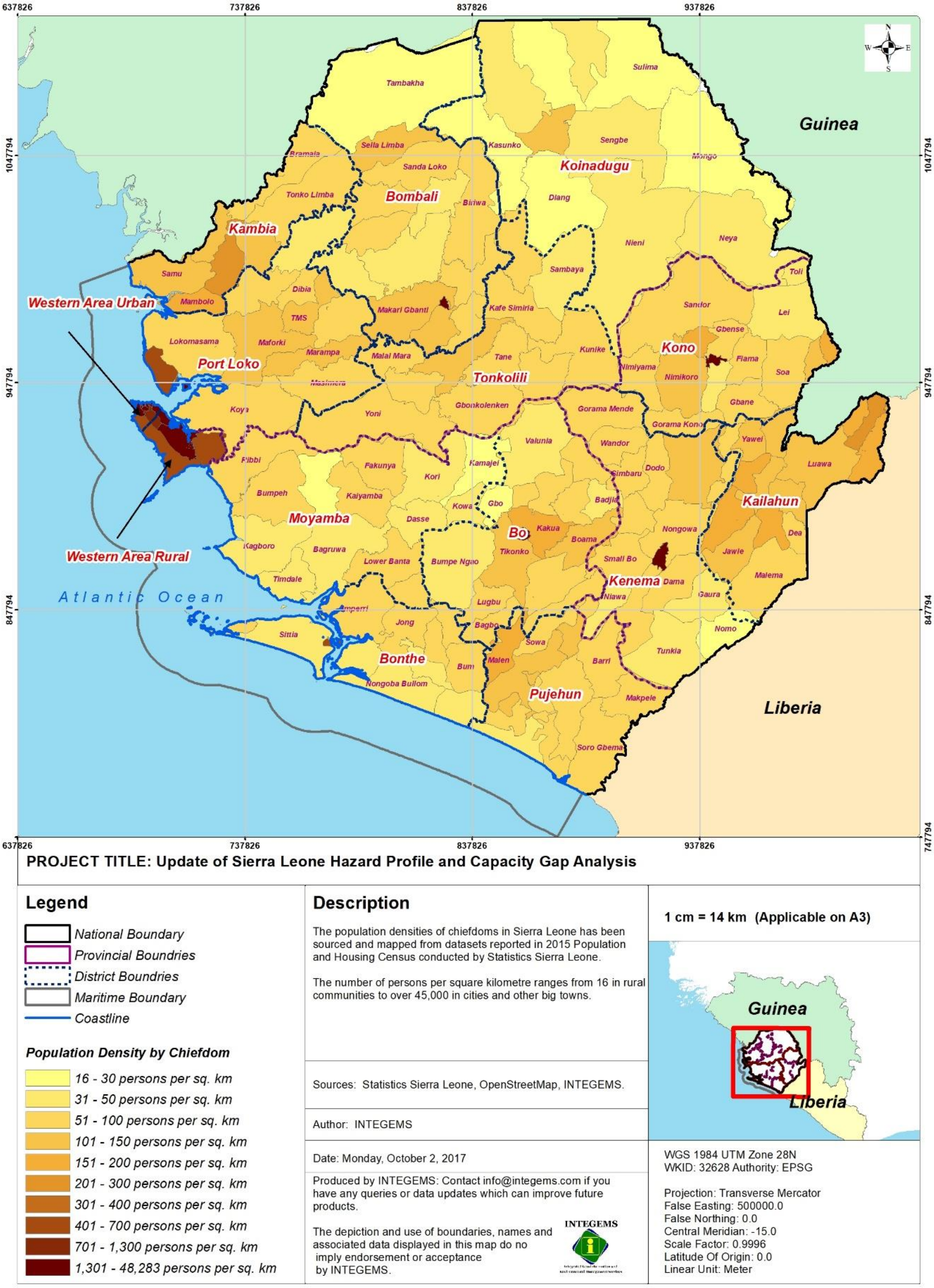
Table 2-6: Distribution of total population by type, district and sex

District	Both Sexes			Male			Female		
	Total	Household	Institutional	Total	Household	Institutional	Total	Household	Institutional
Kailahun	526,379	525,674	705	260,586	260,060	526	265,793	265,614	179
Kenema	609,891	609,427	464	301,104	300,755	349	308,787	308,672	115
Kono	506,100	505,491	609	252,751	252,295	456	253,349	253,196	153
Bombali	606,544	605,741	803	296,683	296,123	560	309,861	309,618	243
Kambia	345,474	344,095	1,379	165,541	164,749	792	179,933	179,346	587
Koinadugu	409,372	408,687	685	204,498	203,951	547	204,874	204,736	138
Port Loko	615,376	612,920	2,456	294,954	293,456	1,498	320,422	319,464	958
Tonkolili	531,435	531,140	295	263,152	262,910	242	268,283	268,230	53
Bo	575,478	574,026	1,452	280,569	279,640	929	294,909	294,386	523
Bonthe	200,781	200,771	10	99,014	99,007	7	101,767	101,764	3
Moyamba	318,588	318,002	586	153,699	153,467	232	164,889	164,535	354
Pujehun	346,461	346,366	95	168,869	168,803	66	177,592	177,563	29
Western Area Rural	444,270	443,068	1,202	221,351	220,536	815	222,919	222,532	387
Western Area Urban	1,055,964	1,050,711	5,253	528,207	523,881	4,326	527,757	526,830	927
Total	**7,092,113**	**7,076,119**	**15,994**	**3,490,978**	**3,479,633**	**11,345**	**3,601,135**	**3,596,486**	**4,649**

Table 2-7: Total Population by age group, district and sex

Age Group/Sex	Total	Kailahun	Kenema	Kono	Bombali	Kambia	Koinadugu	Port Loko	Tonkolili	Bo	Bonthe	Moyamba	Pujehun	Western Area Rural	Western Area Urban
Total Country															
0-4	938,453	61,120	79,417	64,030	83,325	54,951	49,993	95,349	81,322	77,864	28,098	50,919	44,476	57,353	110,236
4-9	1,108,715	90,907	94,476	83,385	98,712	59,813	77,175	97,810	94,514	89,943	34,408	50,906	61,038	57,148	118,480
10-14	847,292	67,171	71,741	65,438	73,921	39,550	57,265	72,912	62,375	67,609	23,291	35,186	44,153	51,078	115,602
15-19	873,620	72,956	79,007	64,033	72,356	39,566	55,929	66,800	62,610	71,159	24,055	32,653	47,510	54,023	130,963
20-24	662,819	45,341	55,526	42,726	53,828	27,312	35,590	49,761	44,404	52,822	17,326	23,725	29,774	50,424	134,260
25-29	607,983	40,765	50,165	41,678	49,155	26,278	29,965	50,020	43,851	46,659	15,495	23,751	26,419	44,784	118,998
30-34	434,203	31,331	37,537	29,375	34,544	19,272	22,275	35,942	29,684	33,755	12,149	17,817	20,376	29,926	80,220
35-39	421,172	30,335	37,005	31,928	33,606	18,595	20,490	36,521	29,713	34,279	11,076	19,076	19,433	28,624	70,491
40-44	299,215	21,463	26,476	21,299	24,545	14,015	16,356	26,205	20,438	23,858	8,484	14,166	13,854	19,800	48,256
45-49	242,188	18,029	21,561	18,487	20,829	11,021	12,747	20,962	17,231	20,137	6,493	12,084	10,676	15,391	36,540
50-54	186,793	12,685	16,161	12,807	16,112	9,094	9,581	17,032	13,199	15,595	5,283	9,675	8,195	11,530	29,844
55-59	110,449	7,259	9,320	7,298	10,097	5,412	5,069	10,428	7,357	9,364	3,008	6,236	4,279	6,746	18,576
60-64	112,682	8,700	10,213	7,121	10,568	6,303	6,047	10,758	7,724	9,418	3,567	6,395	5,106	5,815	14,947
65-69	73,722	5,263	6,507	5,151	7,278	3,855	3,359	6,864	4,680	6,649	2,187	4,394	3,117	4,052	10,366
70-74	65,568	5,115	5,874	4,119	6,464	3,756	3,223	6,971	4,562	5,836	2,038	4,138	3,044	3,090	7,338
75-79	39,728	2,773	3,317	2,874	4,244	2,127	1,588	3,953	2,699	3,785	1,218	2,693	1,782	1,916	4,759
80-84	31,359	2,430	2,650	1,944	3,311	2,112	1,312	3,378	2,382	3,003	1,189	2,192	1,466	1,181	2,809
85-89	15,888	1,158	1,288	1,062	1,678	1,000	597	1,615	1,159	1,559	527	1,118	742	694	1,691
90-94	9,984	847	803	661	1,018	693	436	1,088	741	984	441	680	522	312	758

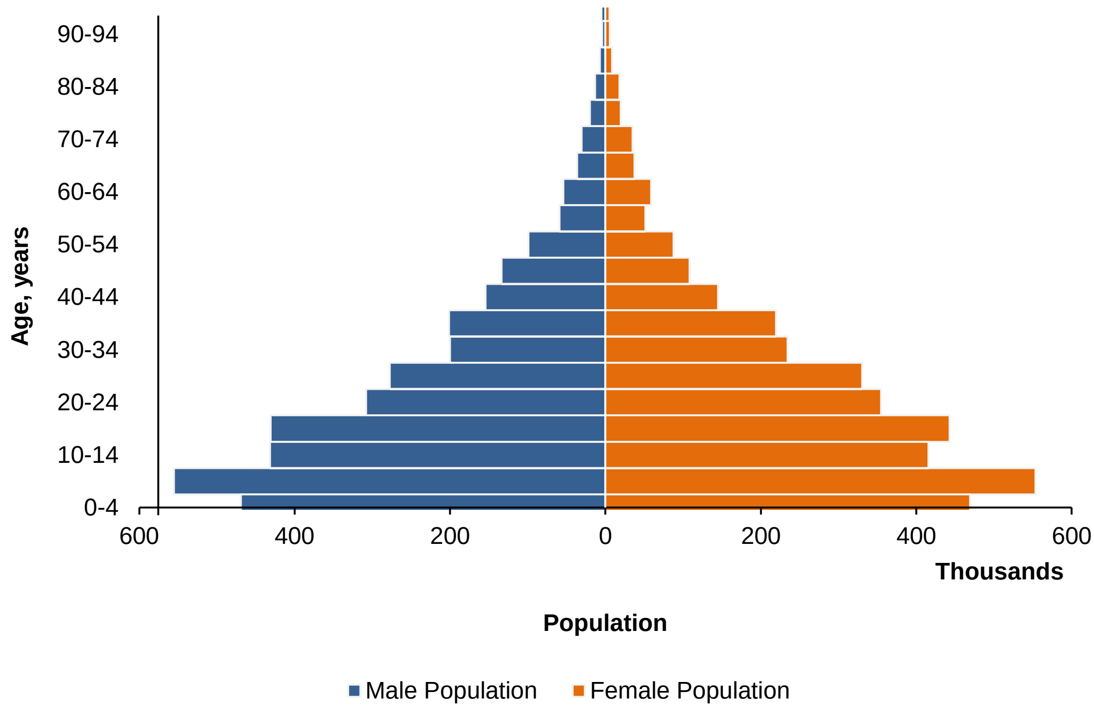
Figure 2-9: Population density at Chiefdom level in Sierra Leone



The aged dependency ratio is an important indicator of population structure and is defined as the number of aged persons (65+ years) and children under 14 years of age per 100 persons of age 15 to 64 years. This indicator assists in understanding the situation of the aged population in the country. The aged 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.

Information of age dependency can help on disaster management to reach efficient assessment and relief when disaster occurred.

Figure 2-10: Population pyramid of Sierra Leone (Population and Housing Census 2015)



2.8 Housing Infrastructure

The 2015 PHC results reveal 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 region counts for 21.8 % of the stock of houses, Northern region 34.3 % Southern region 22.7 % and Western Area 21.1 percent. The population per house is 8.8 persons and ranges from a low of 7.9 persons in the Southern region to a high of 9.4 persons in the Eastern region. On average, Sierra Leone has 1.6 households per house and ranges from a low of 1.4 in the Southern region to a high of 1.9 in the Western Area (see Table 2-8).

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 accounts most of the wall construction followed by mud & wattle ,cement blocks, clay bricks and zinc. In the urban areas, the predominant material used for 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 percent, followed by thatch (13.3%), asbestos (2.0%), concrete (1.6%) and the rest accounting for 1.4%. The data also shows that the use of zinc is high in rural (73.3%) and urban (92.1%) areas, followed by thatch (23.4%) in rural areas and concrete (3.2%) in urban areas. The use of mud floors nationally is 46.4%, followed by cement (44.0%), tiles (6.4%) and others (3.2%) (Table 2-9). In the rural area, 74.4 % of floors are made of mud, followed by cement (21.2%) and tiles (0.8%). In the urban areas, 72.0 % of the floors are cement, followed by tiles (13.3%) and mud (12.0%).

Table 2-8: Stock of houses and households by Region, District and area of residence

Region/ District/ Urban-Rural	Household Population	Number of Houses	Number of Household	Percentage Distribution of Houses	Households per House	Population per House	Average Household Size
Eastern	**1,640,592**	**174,687**	**281,201**	**21.80**	**16**	**94**	**58**
Kailahun	525,674	53,166	83,348	6.60	16	99	63
Kenema	609,427	64,751	111,734	8.10	17	94	55
Kono	505,491	56,770	86,119	7.10	15	89	59
Northern	**2,502,583**	**275,225**	**414,377**	**34.30**	**15**	**91**	**60**
Bombali	605,741	71,056	105,902	8.90	15	85	57
Kambia	344,095	37,870	53,826	4.70	14	91	64
Koinadugu	408,687	42,029	56,108	5.20	13	97	73
Port Loko	612,920	69,675	111,701	8.70	16	88	55
Tonkolili	531,140	54,595	86,840	6.80	16	97	61
Southern	**1,439,165**	**182,075**	**248,655**	**22.70**	**14**	**79**	**58**
Bo	574,026	69,009	102,723	8.60	15	83	56
Bonthe	200,771	27,129	32,538	3.40	12	74	62
Moyamba	318,002	53,516	61,880	6.70	12	59	51
Pujehun	346,366	32,421	51,514	4.00	16	107	67
Western	**1,493,779**	**169,430**	**321,235**	**21.10**	**19**	**88**	**47**
Western Area Rural	443,068	63,087	91,284	7.90	14	70	49
Western Area Urban	1,050,711	106,343	229,951	13.30	22	99	46
Rural	4,182,489	485,664	697,706	60.60	14	86	60
Urban	2,893,630	315,753	567,762	39.40	18	92	51
Total Country	**7,076,119**	**801,417**	**1,265,468**	**100.00**	**2**	**9**	**6**

Table 2-9: Households by major material for construction of wall

Region/ District/ Area of Residence	Major Material for Construction of Wall											
	Total	Stone	Cement Blocks	Clay Bricks	Sand	Zinc	Timber	Mud Bricks	Poles/Reed	Tarpaulin	Burned Bricks	Mud & Wattle	Other
Total Country													
Number	1,265,468	2,815	2,815	313,454	9,765	79,482	9,421	543,495	5,938	11,874	4,897	187,936	5,156
Percent	100	0.20	24.80	7.20	0.80	6.30	0.70	42.90	0.50	0.90	0.40	14.90	0.40
Region													
Eastern	281,201	446	43,905	25,427	2,116	7,113	1,589	145,587	1,392	1,848	1,907	48,949	922
Northern	414,377	976	58,171	23,592	2,149	12,641	2,072	264,330	2,223	6,799	1,359	38,497	1,568
Southern	248,655	481	33,735	20,559	2,601	3,398	1,653	81,338	2,158	1,803	1,393	98,454	1,082
Western	321,235	912	177,643	21,657	2,899	56,330	4,107	52,240	165	1,424	238	2,036	1,584
Urban/Rural													
Rural	697,706	1,536	44,986	46,075	4,498	18,939	3,602	383,353	5,420	8,485	3,759	173,851	3,202
Urban	567,762	1,279	268,468	45,160	5,267	60,543	5,819	160,142	518	3,389	1,138	14,085	1,954
District													
Kailahun	83,348	108	6,165	6,388	555	2,439	567	55,113	378	661	627	10,214	133
Kenema	111,734	236	24,762	11,868	1,039	2,274	508	39,045	751	593	827	29,401	430
Kono	86,119	102	12,978	7,171	522	2,400	514	51,429	263	594	453	9,334	359
Bombali	105,902	263	23,789	6,677	835	2,477	294	63,175	231	2,325	240	5,347	249
Kambia	53,826	55	5,413	1,787	173	2,158	338	40,982	75	1,023	55	1,561	206
Koinadugu	56,108	55	2,623	4,662	244	1,563	192	39,259	293	2,243	220	4,320	434
Port Loko	111,701	364	18,968	5,832	615	3,658	307	75,390	743	570	322	4,682	250
Tonkolili	86,840	239	7,378	4,634	282	2,785	941	45,524	881	638	522	22,587	429
Bo	102,723	202	24,123	9,050	1,575	1,459	603	31,328	578	652	350	32,540	263
Bonthe	32,538	39	2,187	3,691	159	335	212	12,572	125	193	208	12,500	317
Moyamba	61,880	124	4,585	4,845	251	947	346	22,988	383	613	412	26,137	249
Pujehun	51,514	116	2,840	2,973	616	657	492	14,450	1,072	345	423	27,277	253
West Area Rural	91,284	231	36,998	8,389	893	10,511	867	30,774	70	896	101	1,141	413
West Area Urban	229,951	681	140,645	13,268	2,006	45,819	3,240	21,466	95	528	137	895	1,171

2.9 Health Sector

The Ministry of Health and Sanitation is the major health care provider in Sierra Leone and operates all government health facilities in the country. Sierra Leone is divided into 13 health districts that correspond to the districts of Sierra Leone except for the Western Area Rural and Western Area Urban districts which are combined into the Western Area Health district. Each district has a health management team and an average of 50 peripheral health units (PHU) and over 100 technical staff. 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 delivery system starts from the peripheral health units (PHU) which are recognized and standardized. At the base, community health workers (CHWs) work out in the community providing a fixed package of health promotion and health care services, as well as conducting surveillance activities.

The primary care system comprises three levels of progressively larger facilities with increasingly skilled HCWs. 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 in Freetown 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.

Sierra Leone suffered a devastating and historic Ebola outbreak in 2014 (see Figure 2-12). The major contributing factor to the failure to contain the epidemic as rapidly as other countries was the severe weakness it's health care system. The country simply lacked the knowledge, the human resource capacity as well as infrastructure to spot, track and control the epidemic. Although the first in scale and length of the epidemic, two years earlier, Sierra Leone experienced the country's largest cholera outbreak in fifteen years, revealing the serious weaknesses in the country's health system.

Table 2-10: Number of health facilities by District, July 2015

Organisation Unit	MCHP	CHP	CHC	Government Hospital	Private Clinic	Private Hospital	Total
Bo	69	24	28	1	2	3	127
Bombali	55	32	15	1	5	3	111
Bonthe	15	26	14	1	4	2	62
Kailahun	18	42	14	1	1	1	77
Kambia	40	15	13	1	2	1	72
Kenema	60	33	26	1	2	2	124
Koinadugu	43	18	10	1	2	0	74
Kono	44	25	16	1	1	0	87
Moyamba	55	26	18	1	2	1	103
Port Loko	70	21	15	2	1	2	111
Pujehun	49	14	13	1	0	0	77
Tonkolili	75	15	12	1	1	2	106
Western Area	39	28	39	11	22	10	149
Total	632	319	233	24	45	27	1,280

Source: Sierra Leone Basic Package of Essential Health Services (2015-2020)

Figure 2-11: Health facilities in Sierra Leone

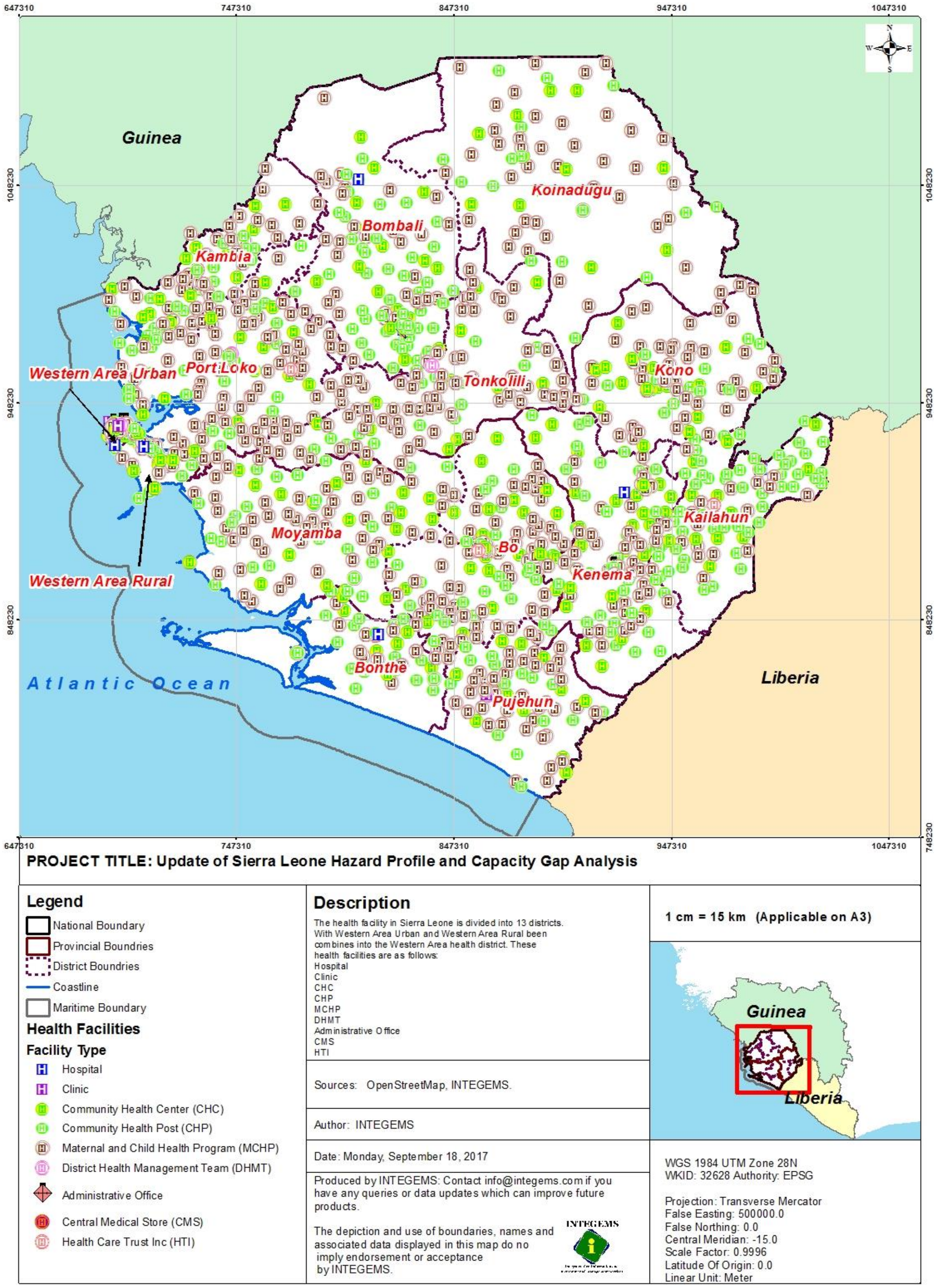
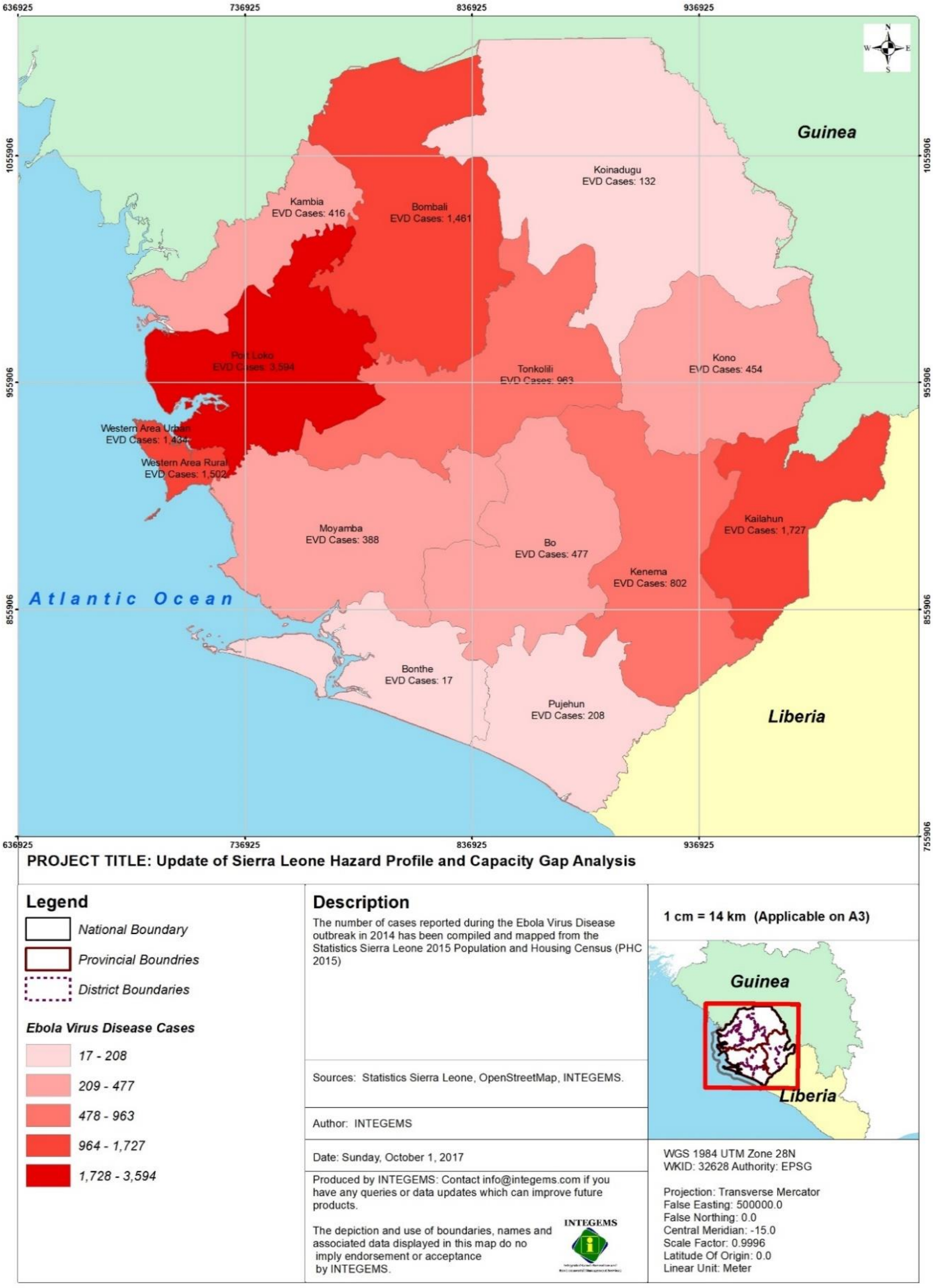


Figure 2-12: Ebola Virus Disease (EVD) cases in Sierra Leone



2.10 Education Sector

In 1993 the government adopted a four stage approach 6-3-3-4 education system and created the National Commission for Basic Education. The 6-3-3-4 education system is composed 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(colleges, universities, polytechnics and teacher training).

The Ministry of Education Science and Technology changed the 6-3-3-4 system of education to 6-3-4-4 after the government white paper on the recommendation of the Professor Gbamanja Commission of Inquiry was revealed in 2010. Additionally, the Ministry of Education, Science and Technology has focused on pre-primary education in the past few years because of the overwhelming evidence that early childhood care, health, and education profoundly influence events later in life. There are four universities in Sierra Leone: The Fourah Bay College, University of Sierra Leone (1827); Njala University (1910 and became a university in 2005); University of Makeni (2005); and Limkokwing University of Creative Technology (2016) (see Figure 2-13).

The 2015 Census revealed that out of the 6,589,838 people aged 3 years and above, 55.4 % have attended school and 44.2 % have never attended school. Whereas of those persons 3 years and above who ever 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%).

2.11 Fishery Sector

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. Based on these resources, the fisheries sector provides direct employment to an estimated 100,000 persons and indirect employment to some 500,000 persons (almost 10 percent of the population) (Ministry of Fisheries and Marine Resources, 2016) More specifically, in coastal areas an estimated 25 percent of the male population of working age are reported to be involved in fishing at least part-time. The sector contribute almost 10 % to the country’s Gross Domestic Products (GDP)[12].

The fisheries sector in Sierra Leone constitute of 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 variety of dugout and planked canoes which employs 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, out- side the Inshore Exclusive Zone (IEZ) and it is characterized by multinational fleet which include trawlers, shrimpers, long liners, canoe support vessels (mother ship) and carriers. It is largely export–oriented.
- Inland Fishing and Aquaculture: Inland fishery operates in rivers, a few lakes, flood plains and swamps. Aquaculture is mostly practiced in inland valley swamps and wetlands and has great potential for development.

[12] (Government of Sierra Leone, 2013)

Figure 2-13: Educational institutions in Sierra Leone

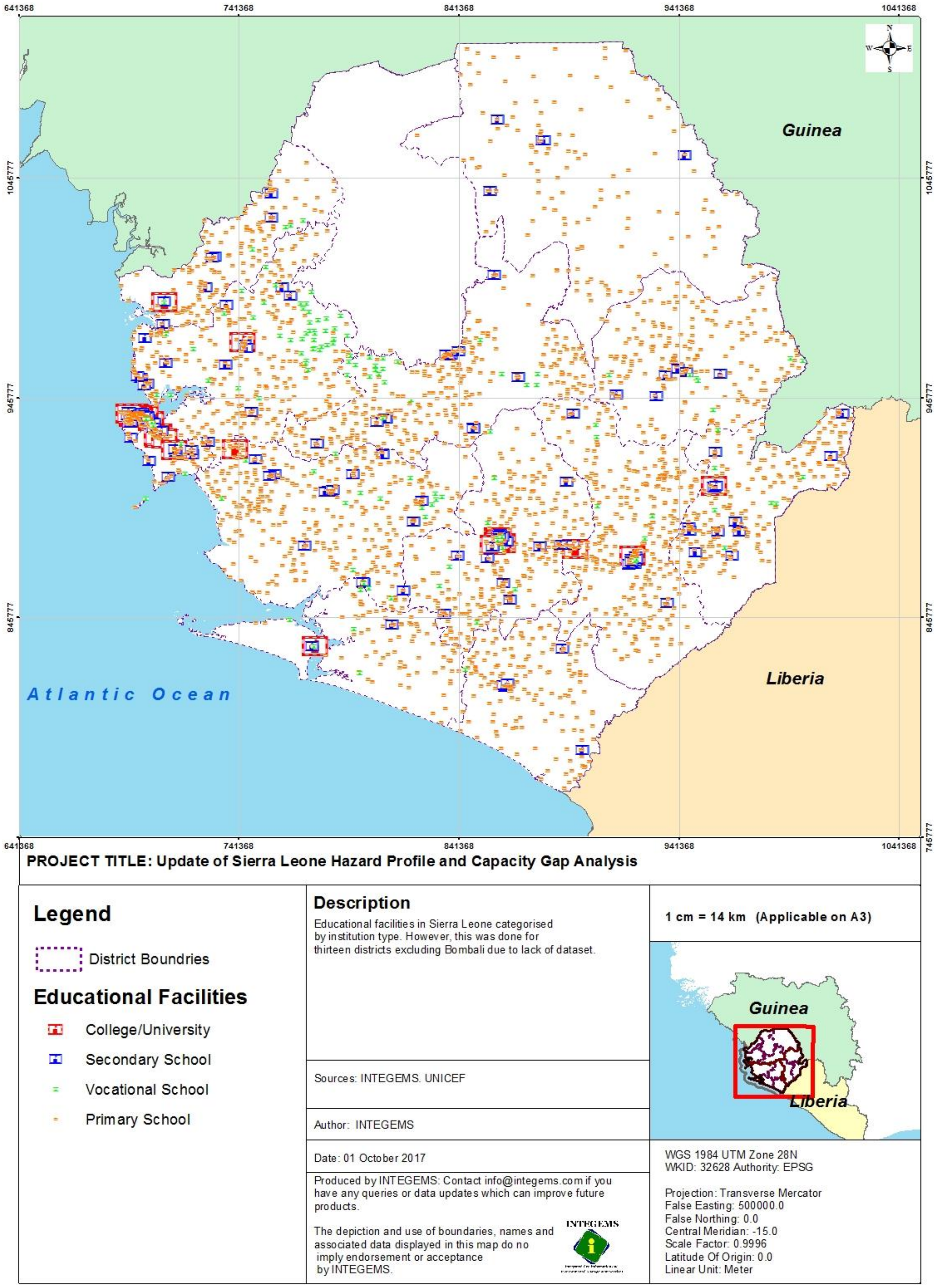


Table 2-11: Households engaged in fishery by type of fish farming

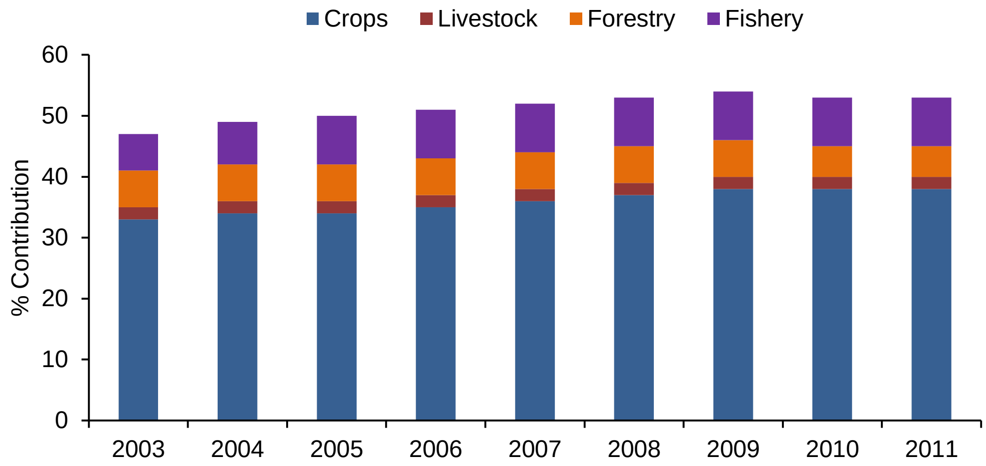
Province/District/ Type of Residence	Total	Fish Pond	Artisan Fishing	Coastal fishing
Total Country				
Total	245,957	18,876	212,938	14,143
Rural	227,709	17,312	199,310	11,087
Urban	18,248	1,564	13,628	3,056
Province				
Eastern				
Total	75,175	3,219	70,117	1,839
Rural	67,529	2,621	63,411	1,497
Urban	7,646	598	6,706	342
Northern				
Total	81,943	11,685	63,890	6,368
Rural	76,320	11,084	60,141	5,095
Urban	5,623	601	3,749	1,273
Southern				
Total	84,428	3,578	76,432	4,418
Rural	82,997	3,504	75,162	4,331
Urban	1,431	74	1,270	87
Western				
Total	4,411	394	2,499	1,518
Rural	863	103	596	164
Urban	3,548	291	1,903	1,354
Districts				
Kailahun				
Total	28,318	1,122	26,552	644
Rural	23,597	665	22,473	459
Urban	4,721	457	4,079	185
Kenema				
Total	28,423	1,041	26,707	675
Rural	25,783	934	24,327	522
Urban	2,640	107	2,380	153
Kono				
Total	18,434	1,056	16,858	520
Rural	18,149	1,022	16,611	516
Urban	285	34	247	4
Bombali				
Total	10,626	1,593	8,583	450
Rural	10,225	1,556	8,233	436
Urban	401	37	350	14
Kambia				
Total	11,896	3,912	6,216	1,768
Rural	10,262	3,591	5,603	1,068
Urban	1,634	321	613	700
Koinadugu				
Total	22,417	489	21,327	601
Rural	20,941	428	19,966	547

Province/District/ Type of Residence	Total	Fish Pond	Artisan Fishing	Coastal fishing
Urban	1,476	61	1,361	54
Port Loko				
Total	16,821	3,351	10,687	2,783
Rural	15,704	3,269	10,107	2,328
Urban	1,117	82	580	455
Tonkolili				
Total	20,183	2,340	17,077	766
Rural	19,188	2,240	16,232	716
Urban	995	100	845	50
Bo				
Total	28,356	878	26,961	517
Rural	27,792	826	26,477	489
Urban	564	52	484	28
Bonthe				
Total	11,345	478	9,761	1,106
Rural	11,027	477	9,462	1,088
Urban	318	1	299	18
Moyamba				
Total	26,127	1,499	23,232	1,396
Rural	25,840	1,482	22,999	1,359
Urban	287	17	233	37
Pujehun				
Total	18,600	723	16,478	1,399
Rural	18,338	719	16,224	1,395
Urban	262	4	254	4
Western Area Rural				
Total	3,498	315	1,977	1,206
Rural	863	103	596	164
Urban	2,635	212	1,381	1,042
Western Area Urban				
Total	913	79	522	312
Rural	-	-	-	-
Urban	913	79	522	312

2.12 Agriculture Sector

Agriculture has been the backbone of the Sierra Leone economy for several decades. It contributes 40 to 50% of GDP, about 10% of exports, and provides employment to approximately two-thirds of the population. Whilst agricultural growth has significant poverty reduction effects, the sector is characterized largely by smallholders, practicing mainly subsistence agriculture. In recent years, efforts have been made to introduce mechanized farming practices, through provision of tractors, power tillers and other agricultural tools to farming communities. In 2011, 56.6% of households in Sierra Leone were crop-producing households compared with 65.3% in 2003 (see Figure 2-14).

Figure 2-14: Contributions of agriculture to Gross Domestic Product (%) by subsector



Source: Statistics Sierra Leone, 2013

2.13 Transportation Sector

Table 2-12: Length of roads by District

District	Length of Road, km					
	Trunk	Primary	Secondary	Tertiary	Residential	Total Length
Bo	66.8	37.5	137.1	298.8	333.5	**873.7**
Bombali	0	128	268	422.7	175	**993.7**
Bonthe	0	0	54.9	151.2	56.8	**262.9**
Kailahun	111.3	106.1	217.9	406.3	118.8	**960.4**
Kambia	28	0	84	487	81	**680**
Kenema	146.6	74.8	171.5	478.3	301.1	**1172**
Koinadugu	0	125.5	181.8	402.3	99.9	**809.5**
Kono	0	198.4	77.2	371.3	167.1	**814**
Moyamba	48.7	0	267.6	304	69.7	**690**
Port Loko	136.3	119.2	91	349.1	221.1	**916.7**
Pujehun	53.7	67	161.7	269.1	17	**568.5**
Tonkolili	55.1	80.4	159.5	166.6	69.7	**531.3**
Western Area Rural	41	65.3	7.2	131.2	570.1	**814.8**
Western Area Urban	10.4	55.6	35.4	44.7	525.2	**671.3**
Total	**697.9**	**1057.8**	**1914.8**	**4282.6**	**2806**	**10759**

Figure 2-15: Length of roads by District

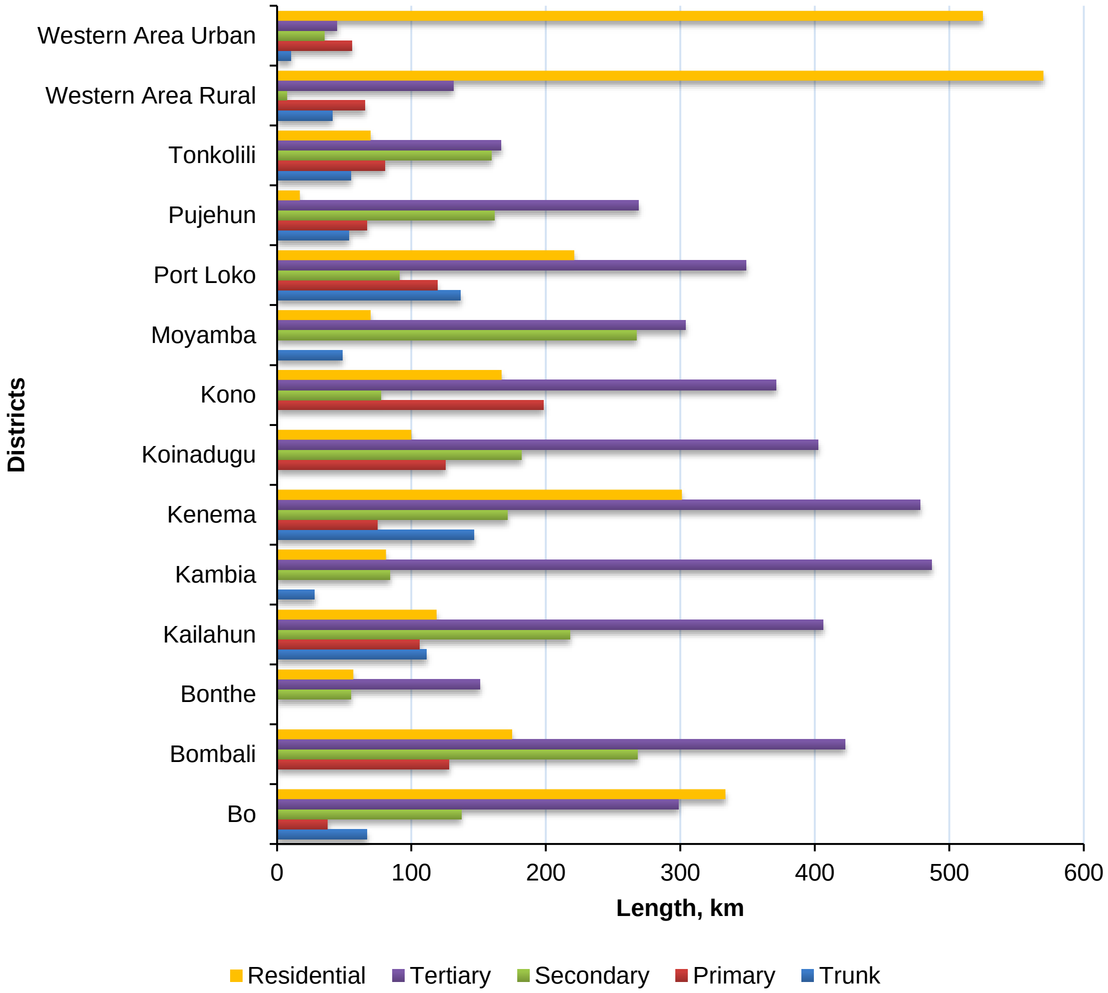
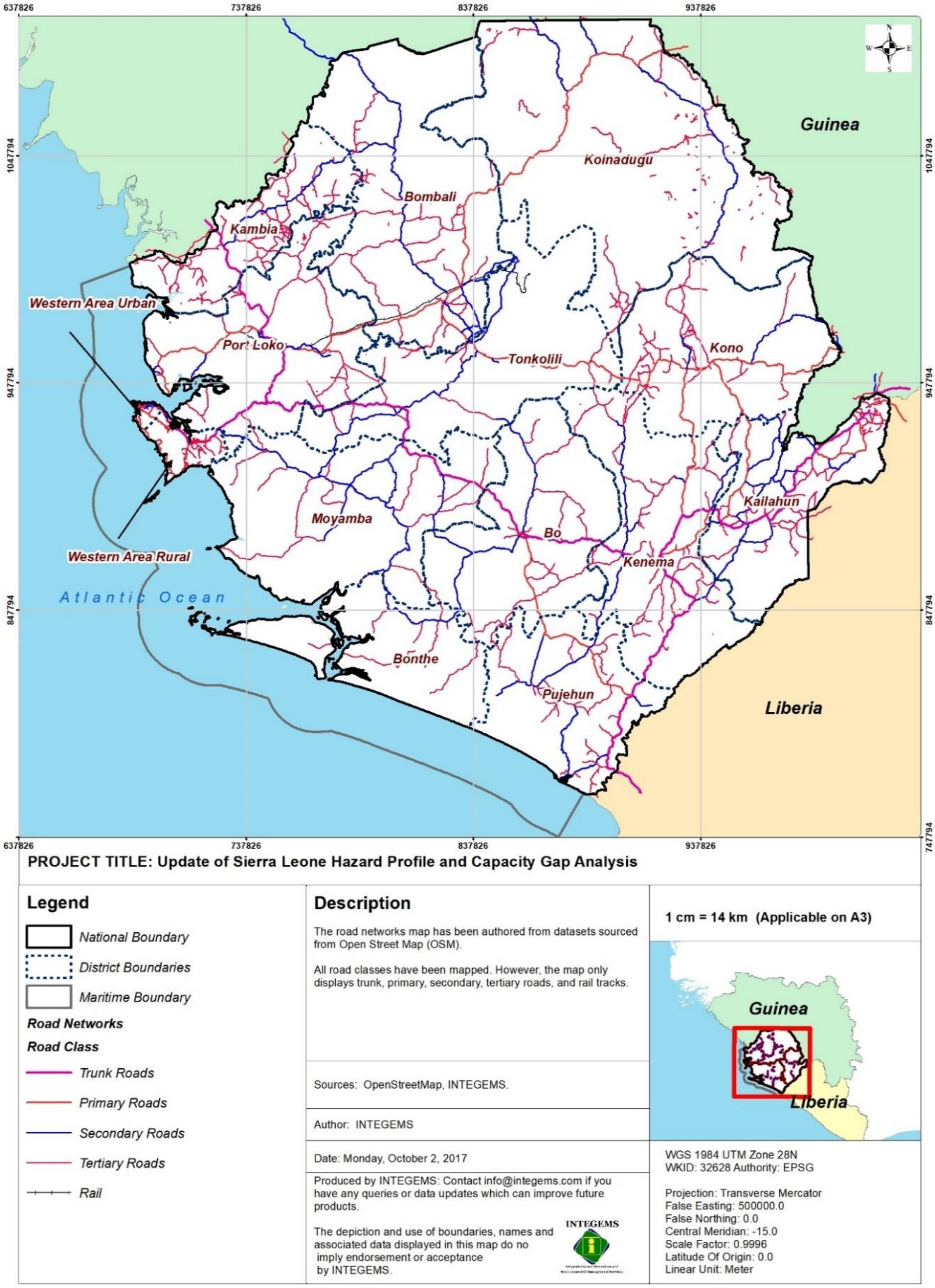


Figure 2-16: Road network in Sierra Leone



2.14 Energy Sector

Sierra Leone is reasonably well endowed with energy resources, particularly biomass energy (forestry), hydroelectricity and other renewable energy sources (e.g. solar energy). There is an extensive network of rivers and tributaries that provide a large hydroelectric power potential conservatively estimated at 1,200 MW. Technically and economically, the most promising site is at Bumbuna on the Seli River, whose development started with a 50 MW installed capacity (first stage), and an ultimate installed capacity of about 300 MW.

The energy situation in Sierra Leone is significant improved over the last five years but still short of meeting the country demand. Over the past years, the sector is being transformed and reformed to meet the ever increasing demand of our time and moving towards the productions of clean form of energies with the daunting challenge to make energy reliable and accessible. Energy consumption in Sierra Leone is dominated by biomass, mainly in the form of fuel wood and charcoal which accounts for over 83% of energy used. Imported petroleum products are the next largest source of power at approximately 15.8%. Grid-generated electricity accounts for the remainder of the power supplied to the country's citizens. Currently, the electricity sub-sector in Sierra Leone faces challenges with less than 13% access. Currently, there are operational hydro power dam– Dodo (6MW) a regional grid linking thermal power plants in Bo and Kenema in the south-east and Bumbuna Falls (50MW in the wet & 18MW in the dry) in the north its supply Makeni and also linked to the Freetown electricity grid. The current installed capacity of solar PV is about 25 kW, which provides solar systems for hospitals, schools, domestic and commercial use.

Efficiency and access are constrained by high technical losses on the transmission and distribution network, which are further compounded by low voltage quality due to overburdening of infrastructure by illicit users. The stock of energy efficient appliances and equipment also remains low. Further, the development and use of renewable energy from hydro, solar, biomass and other facilities has been a slow process but there has been meaningful interventions with the contributions from DFID and UNDP.

Table 2-13: Sources of energy & power generated

Region	Solar	Biomass	Heavy Fuel Oil	Diesel	Hydro	Coal	Total
Western Area			26.5	25.0			51.5
Northern Province		30.25	6.0	7.18	50.3		93.73
Southern Province				10.0			10.0
Eastern Province				2.0	6.0		8.0
Total	**0**	**30.25**	**32.5**	**44.18**	**56.3**	**0**	**163.2**

Source (Mainstreaming Of Energy Policy within Sustainable Development Goals (SDGs) In Sierra Leone; John Angel Turay and Rev.Ing. Paul Charles Saffa, June 27th-29th, 2016.

2.15 Tourism Sector

The Ministry of Tourism and Cultural Affairs is one of the key Ministries in Sierra Leone because of its mandate of promoting, developing, and preserving tourism and cultural activities in Sierra Leone. As the central authority for the promotion and development of tourism in Sierra Leone, the Ministry supervises and controls the component branches of the sector and generates policy guidelines and objectives for growth management and marketing and devise strategies to achieve objectives, particularly provision of tourism amenities/facilities and attraction.

Estimates indicate that tourism's annual contribution to GDP was around $25 million in 2007, growing to around $37 million in 2011. Tourist arrivals (which include all arrivals of foreigners into Sierra Leone) almost doubled from 32,000 in 2007 to 60,000 in 2012. In 2012, of the 59,730 visitors who arrived at Lungi International Airport, 23,619 were on business, 14,074 were visiting friends and relatives, 9,464 visited for leisure purposes, 6,034 for conferences, and 6,539 for other reasons. Visitors from Europe accounted for 26% of arrivals in 2012, compared to 21% from ECOWAS countries, 18% from the Americas, and the remaining 35% from elsewhere.

The tourism sector accounted for $42 million of Government revenue generated in 2012, coming from local hotel accommodation, restaurants, transportation, and souvenirs. The number of employees in the tourism sector reached an estimated 5,600 in 2012, and if the sector's potential is unleashed, employment is projected to reach close to 10,000 people in the near future. Over the last few years, Government has developed a seven-year strategic plan for tourism, a marketing programme, and a tour guide training programme, among other activities.

Sierra Leone, according to the latest report released by the United Nations World Tourism Organisation (UNWTO), has earned the status of the fastest growing tourist destination in the world, following its recording 310 per cent more overseas arrivals in 2016 compared with 2015, a rise that has been attributed to the country being declared Ebola free in November 2015. In 2015 the country recorded 24, 000 visitors but UNWTO indicated that about 74,400 visited the country last year. There is clear potential for growth of Sierra Leone's tourism industry, but it is being held back by several challenges including limited infrastructure, Sierra Leone's international image ,relatively high costs of travelling to Sierra Leone and weak institutional and legislative frameworks for the sector.

2.16 Mining Sector

Sierra Leone has historically been a significant producer of iron ore and diamonds. The country's mineral resources also include rutile, bauxite, ilmenite, zircon, gold and coltan. 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 recently mining activities have begun in Tonkolili. Gold is mined artisanally and presently production comes from alluvial deposits (see Figure 2-17). Iron-ore projects are seen as key contributors to Sierra Leone's GDP growth with over US$ 1bn in exports in 2013 (Bank of Sierra Leone). Diamond is one of the country's largest exports. There is large scale mining operations in diamonds, rutile and bauxite and continued small-scale and artisanal mining of gold and diamonds.

Figure 2-17: Location of mining operations in Sierra Leone

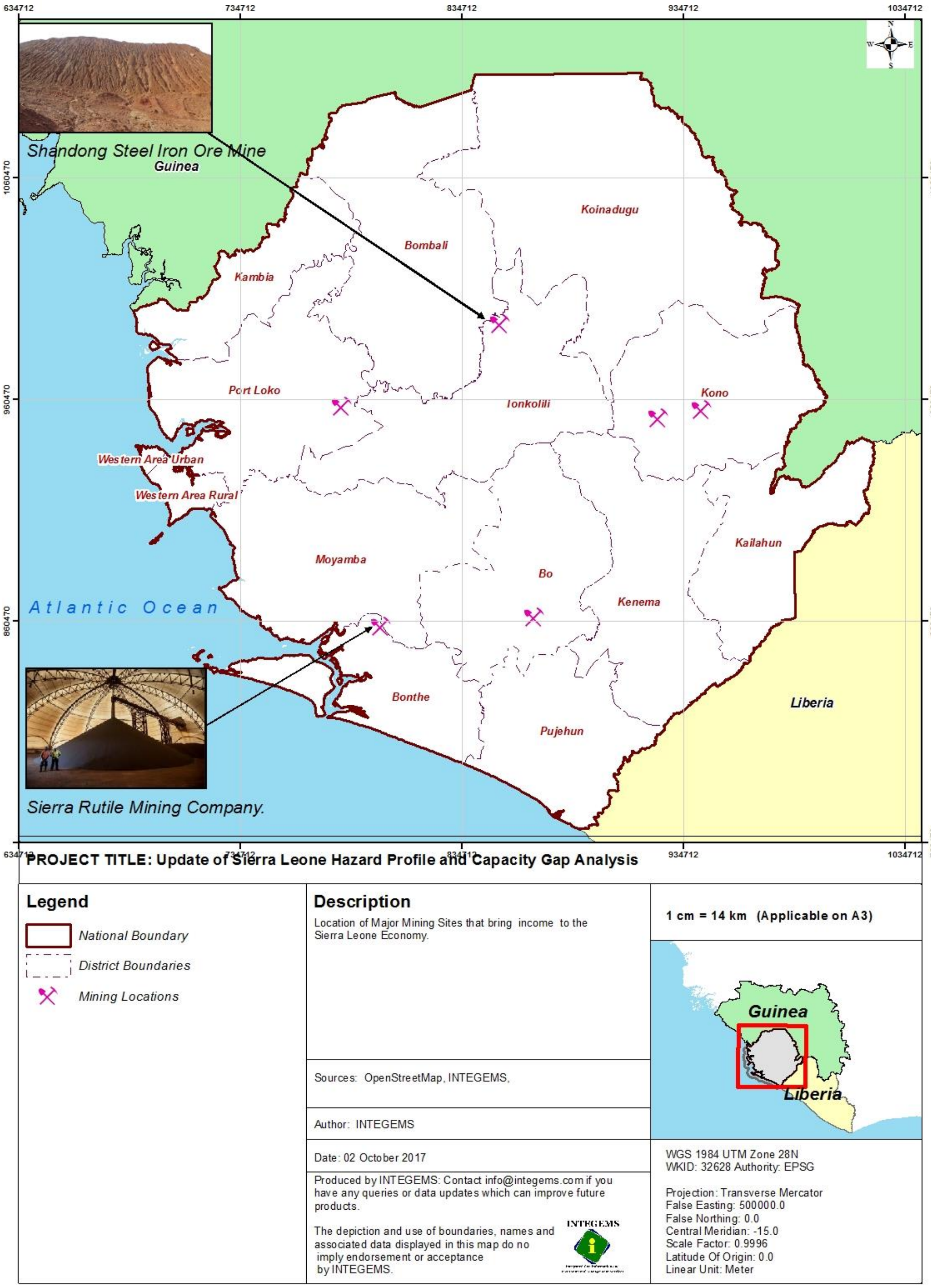


Table 2-14: Major operations in the mining sector

Name of Mine/Project	Owner(s)	Location	Type Of Mineral	Project Phase
Koidu Diamond Mine	Octea Mining (Koidu Ltd)	Kono	Diamond	Production
Tonkolili Iron Ore	-African Minerals -- Shandong Iron & Steel Group (25%)	Bumbuna, Mabonto & Bendugu In Tonkolili District	Hematite Concentrate Iron Ore	Production
Marampa Project	Cape Lambert	Lunsar	Iron Ore	Exploration
Komahun	Nimini (90%) Plinian (10%)	Kono	Gold	Development
Baomahun Gold Project	Cluff /Amara Plc	Baomahun	Gold	Exploration
Sierra Rutile Natural	Iluka Sierra Rutile Ltd	Lanti, Gangama & Sembehun	Rutile	Production
Vimetco Sierra Minerals Holding	Sierra Minerals/ Vimetc O N.V	Upper Banta, Lower Banta, Dasse, Bumpe Kpanda Kemoh	Bauxite	Production

Source: Sierra Leone Extractive Industries' Transparency Initiative (SIEITI) 2013 Report: Feb 2016

3 HAZARD PROFILE AND RISK ASSESSMENT METHODOLOGY

3.1 Background Context: Hazard and Disaster

3.1.1 Hazards

Hazard is a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Thus, a hazard is a threat or a future source of danger that has the potential to cause harm to:

- People - death, injury, disease and stress
- Human activity – economic, educational etc.
- Property - property damage, economic loss
- Environment - loss of fauna and flora, pollution, loss of amenities.

Hazards can be categorized in various ways but, based on the origin, hazards in this document have been basically grouped in two broad headings:

- Natural Hazards (hazards with meteorological, geological or even biological origin)
- Manmade Hazards (hazards with human-caused or technological origin)

Although humans can do little or nothing to change the incidence or intensity of most natural phenomena, they have an important role to play in ensuring that natural events are not converted into disasters by their own actions. Thus, it is important to understand that:

- Human intervention can increase the frequency and severity of natural hazards. For example, when the toe of a landslide is removed to make room for a settlement, the earth can move again and bury the settlement.
- Human intervention may also cause natural hazards where none existed before. Landslides occur periodically, but it is not until the slopes and toes are occupied by human settlements that they are considered hazardous.
- Human intervention reduces the mitigating effect of natural ecosystems.

This study considered the following factors in understanding the nature and behaviour of various hazards and profiling them:

- **Origin:** The cause of a hazard, which can be natural or human-made.
- **Warning Signs and Signals:** Scientific and indigenous indicators that a hazard is likely to occur, e.g. rainfall duration, intensity and quantity; speed of wind; temperature; movement of animals, insects and birds
- **Forewarning:** Time gap between warning signs and the impact of hazard
- **Force:** Factors: that determine the power of hazards, e.g. intensity and magnitude of a landslide, or flow discharge in river determining the force of a flood
- **Rate of Onset:** The rapidity or slowness of hazard arrival and impact, e.g. an earthquake is a rapid onset hazard and drought is a slow onset hazard
- **Frequency:** Time-related patterns of occurrence of hazards
- **Seasonality:** Occurrence of a hazard in a particular time of the year
- **Zone of Impact:** Area coverage or the zone of influence of the hazard that will create an impact

The process of identifying or collecting these information is called hazard identification. The process of analysing the likelihood of occurrence of natural or manmade hazards in a specific future time period, including their intensity and area of impact is called hazard assessment.

3.1.1.1 Hazard Event

It is the physical parameter of the hazard event that causes the harm. Environmental events become hazards once they threaten to affect society and/or the environment adversely. A physical event, such as a landslide, that does not affect human beings is a natural phenomenon but not a natural hazard. A natural phenomenon that occurs in a populated area is a hazardous event. A hazardous event that causes unacceptably large numbers of fatalities and/or overwhelming property damage is a natural disaster. In areas where there are no human interests, natural phenomena do not constitute hazards nor do they result in disasters. When more than one hazard event impacts the same area, there arises a multiple hazard situation. These different hazard events may occur at the same time or may be spaced out in time.

Hazard events of all types can have primary, secondary, and tertiary effects.

- **Primary Effects** occur as a result of the process itself. For example water damage during a flood or collapse of buildings during an earthquake, landslide, or hurricane.
- **Secondary Effects** occur only because a primary effect has caused them. For example, fires ignited as a result of landslide, disruption of electrical power and water service as a result of flooding caused by a landslide into a lake or river.
- **Tertiary Effects** are long-term effects that are set off as a result of a primary event. These include things like loss of habitat caused by a flood, permanent changes in the position of river channel caused by flood.

3.1.1.2 Return Period

Majority of hazards have return periods on a human time-scale. Examples are five-year flood, fifty-year flood and a hundred year flood. This reflects a statistical measure of how often a hazard event of a given magnitude and intensity will occur. The frequency is measured in terms of a hazard's recurrence interval. For example, a recurrence interval of 100 years for a flood suggests that in any year, a flood of that magnitude has a 1% chance of occurring. Such extreme events have very low frequencies but very high magnitudes in terms of destructive capacity. This means that an event considered being a hundred year flood would cause severe damage compared to a five-year flood.

3.1.2 Disaster

Disaster is defined as a serious disruption of the functioning of a society, causing widespread human, material, or environmental losses which exceed the ability of the affected society to cope using its own resources. A disaster is the product of a hazard such as landslide or flood coinciding with a vulnerable situation which might include communities, cities or villages. There are two main components in this definition: hazard and vulnerability. Without vulnerability or hazard there is no disaster. A disaster occurs when hazards and vulnerability meet. Disasters result from a combination of factors: the nature of the particular hazard or hazards; the extent to which people and their possessions are exposed to them; the vulnerability of those people and assets; and their capacity to reduce or cope with the potential harm. Many different kinds of hazard can contribute to disasters. These may be natural (e.g. floods, landslides, windstorms, etc.), or manmade (e.g., industrial and transportation accidents, riots, terrorist incidents and conflict). They can act in combination, as well as individually: intense rainfall can both trigger flooding and landslides.

Disasters take place in time as well as in space. They can be short- or long-term in their duration. They can be sudden events (or shocks), such as the EVD outbreaks, storms, landslides and conflict, but they can also arise from the accumulation of stresses, such as long-running drought, the degradation of natural resources, unplanned urbanisation, climate change, political instability and economic decline. Disasters are generally seen as extreme events in their scale or impact, requiring some form of external assistance. However, small-scale, lower-intensity hazard events can also have significant impacts locally. These small, recurrent events are usually referred to as 'extensive risks'. Poor people also often face high levels of everyday risk, for example from lack of clean water and sanitation, poor healthcare, pollution, occupational injuries, road accidents, domestic fires, violence and crime.

It is important to understand that the hazard itself does not result in a disaster. A tropical storm that surges over an uninhabited island does not result in a disaster; however, it would be a disaster if it hit a populated coast and caused extensive loss of lives and property. Disasters are caused by one or more hazards such as landslide, storm and flooding. However, some of these events are not caused by a natural phenomenon. Each hazard type has unique characteristics that can impact a community. For example, a landslide can cause buildings to crumble, heavy rain can produce the floods that drown people, and drought diminishes the water supply. A hazard type can produce different effects depending on its magnitude, duration and intensity. In addition, the same hazard events will affect different communities in different ways, based on geography, level of development, population distribution, age of buildings, the extent of community preparedness, etc.

It is argued that in Sierra Leone the most perverse hazards are man-made and they relate to the low level of development, resulting in poor housing, infrastructure and hygienic conditions. Many of these manmade hazards tend to be higher in densely populated places such as Freetown where many people have settled in precarious conditions, not worrying about resistance of their housing against adverse weather conditions. As a result, floods and landslides regularly cause substantial damage in the city of Freetown. Deforestation and erosion aggravate the risk of floods and landslides. Deforestation is a serious concern for Sierra Leone as it has an impact on the prevalence of flooding, mudslides, landslides, erosion, and water shortage. It is also important to know that natural phenomena are extreme climatological, hydrological, or geological, processes that do not pose any threat to persons or property. A massive landslide in an unpopulated area, for example, is a natural phenomenon, not a hazard. It is when these natural phenomena interact with the manmade environment or fragile areas which causes wide spread damage or disaster.

3.2 Hazard Profiling

Sierra Leone is experiencing multiple natural disasters with severe impacts that are affecting human lives, disturbing human settlements and damaging properties. Therefore, the development of a hazard profile for the country has become an urgent and a timely need. Detailed hazard profiling of nine major natural hazards (i.e., landslide, flood, drought, epidemics, coastal erosion, sea level rise, storm surge, tropical storm and thunder and lightning) in Sierra Leone has been undertaken to support the mainstreaming of disaster risk reduction and disaster risk management in planning, preparedness, investments, education and awareness, research and other interventions to achieve the goals of the UN SDGs and the Sendai Framework.

3.2.1 Desk Review

The study employed various methods for identifying data and information on past hazards and disasters and their impacts on communities:

- Perused and collated newspaper reports and other historical disaster event records
- Reviewed existing ONS, GoSL MDA and Local Council plans and reports.
- Talked to the local experts working in GoSL MDAs, international and national NGOs, civil society, academia and the private sector, as well as national, provincial and district disaster management officers, Red Cross staff and emergency management personnel.
- Talked to community members, particularly the elderly, for myths or legends related to the impact of natural forces.
- Datasets required for the hazard profile were collected from the ONS-DMD, GoSL MDAs, UN Agencies, NGOs, research papers on hazards, websites, DesInventar, CRED EM-DAT and reports of academia. Limited primary data on floods and landslides were collected through the field surveys by the Consultant. The secondary data such as maps, images and aerial photographs were collated from various sources.

A variety of well-established scientific tools and techniques have been used together with datasets and information collated from various hazard, disaster, vulnerability and risk assessment reports and hydrometeorological and geological databases and online repositories. The ONS-DMD with UNDP Sierra Leone along with the EPA-SL, SLMA and MWR and a large number of stakeholders joined hands to develop the hazard profiles on landslides, floods, coastal erosions, sea level rise, tropical storms, storm surge, epidemics, lightning and thunder at both national and district levels.

3.2.2 Stakeholders Consultation Workshops

Four Stakeholders Workshops were conducted in the process of preparation of the hazard profiles. The first workshop was conducted on 26 July 2017 in Freetown by INTEGEMS in collaboration with UNDP, ONS-DMD, EPA-SL, SLMA and MWR to review and agree on methodologies developed by the Consulting Firm. It was held with the participation of resource persons from various MDAs, development partners, UN Agencies, academia and NGOs. Based on the interactive discussions conducted at the Workshop, it was decided to develop both manmade and natural hazard profiles of the country, as outlined below. Three more Stakeholders Workshops were held in Makeni City, Bo City and Kenema City on 15, 16, 17 August 2017, respectively, to solicit inputs and review and agree on methodologies proposed by the Consultants.

A Stakeholders Validation Workshop was held on 5 October 2017 in Freetown to review and finalize the methodologies and Draft Project Report with the participation of various MDAs, development partners, UN Agencies, academia and NGOs. These workshops helped to get the maximum contribution from the relevant stakeholders to update and improve the capacities of the main implementing agencies and also to facilitate the sharing of data and information to a certain extent.

The users of the hazard profiles are encouraged to add value and propose potential improvements that can be adopted in the development and update of the next national hazard profile. Also the users are urged to be mindful of the limitations in the national level information. For example, care should be taken if this information is to be used at community level due to the coarse spatial resolution.

3.2.3 Determining the Hazard Profiles

The major natural hazards were profiled using the following parameters (see Table 3-1):

- **Frequency:** The return interval of hazards of certain sizes. If the hazard is a less frequent strong event, then it is going to have a bigger impact. If a location is hit by multiple hazards that the impact can be more severe. For example hazard hotspots like the Western Area of Sierra Leone can be hit by landslides and flooding all simultaneously.
- **Magnitude:** This is the strength of a hazard. Generally speaking, the stronger the hazard the more severe the hazard is.
- **Duration:** The length of time that a hazard lasts for. As a general rule the longer the hazard the more severe it is likely to be. For example and earthquake that lasts 1 minute is likely to be more severe than one that last two seconds and a drought that lasts ten years is likely to be more severe than one that last three months.
- **Areal extent:** If a hazard covers a large area e.g. a drought covering the whole of Sierra Leone, then the severity of the hazard is likely to be more severe.
- **Spatial Predictability:** Some hazards are easier to predict than others. For example, volcanoes normally give warning signs before they erupt and tropical storms can be tracked from development to landfall. However, others like landslides are much harder to predict. Generally speaking, hazards that hit with no warning are going to be more serious.
- **Speed of onset:** If the peak of the hazard arrives first or arrives quickly e.g. a landslide, then the effects are likely to be worse than one that arrives slowly e.g. a drought.
- **Spatial Dispersion:** Where hazards are located or centered. For example earthquakes tended to be focused along plate boundaries, whereas tropical storms tend to be located in coastal areas in the tropics. Hazards that are located in known areas can be better prepared for and managed better.
- **Importance:** Importance of hazard depends on the characteristics of the expected impact and its importance in decision-making; i.e., importance of the impacts (in context of value, vulnerability, sensitivity and recoverability).

Table 3-1: Scheme for Hazard Profiling

Parameters	Hazard Profile Scale				
	1	2	3	4	5
Frequency	*Very Rarely*	*Rarely*	*Sometimes*	*Often*	*Frequently*
Magnitude	*Trivial*	*Small*	*Moderate*	*Large*	*Very Large*
Duration	*Very Short*	*Short*	*Average*	*Long*	*Very Long*
Areal Extent	*Limited*	*Very Sparsely*	*Sparsely*	*Densely*	*Widespread*
Spatial Predictability	*Highly Predictable*	*Predictable*	*Likely*	*Randomly*	*Very Randomly*
Speed of onset	*Very Slow*	*Slow*	*Moderate*	*Fast*	*Very Fast*
Importance	*Not Important*	*Somewhat Important*	*Moderately*	*Important*	*Very Important*
Spatial Dispersion	*Very Concentrated*	*Concentrated Moderately*	*Moderately*	*Diffused*	*Widely Diffused*

3.3 Hazard Assessment

The hazard assessment relied heavily on available scientific information with obvious variations in the degree of accuracy, including geologic, geomorphic, and soil maps; climate and hydrological data; and topographic maps, aerial photographs, and satellite imagery. It also leveraged historical information, both written reports and oral accounts, from various stakeholders and local communities. The hazard assessment was undertaken to estimate, for defined areas, the probabilities of the occurrence of potentially-damaging phenomenon of given magnitude within a specified period of time. This was done to determine the following:

- When and where hazard events or disaster have occurred in the past;
- The severity of the physical effects of past hazard events and disasters (magnitude);
- The frequency of occurrence of hazard events and disasters;
- The likely effects of a hazard event or disaster of a given magnitude if it were to occur now; and
- Making all these data and information available in a form useful for making decisions in event of a disaster.

3.3.1 Quantitative

Hazards were quantified using variables, and the impacts of hazard events were assessed and expressed as numerical data. Where applicable, mathematical functions were used to denote relationships between variable considered to quantify the hazard or to forecast future hazard events or disasters. An example is the probable flood that a particular rainfall could cause within a watershed area. Flood dimensions such as depth of flood and area of inundation depend on the volume of water that flows into the stream or river. Surface run-off, soil permeability and vegetation cover were used to determine this. Furthermore, empirical data collected from historical records as well as theoretical data from basic principles of physics were also used to derive the relationship between variables as well as to forecast future events or disasters. However, this approach was not possible for all the natural hazard types due to lack of available data and/or the difficulty in assigning a numerical value to the variable.

3.3.2 Qualitative

A qualitative ranking such as Very High, High, Moderate, Low and Very Low were extensively used to assess most of the natural hazards. Where there was a lack of sufficient data for quantitative evaluation, or where certain variables could not be expressed numerically, these qualitative rankings were used for hazard assessment and mapping, including vulnerability and risk assessments. This approach is good for comparative assessment of hazards between various communities and for awareness creation.

3.3.3 Deterministic

Deterministic approaches were also used to select and describe past hazard events and disasters, including associated characteristics and the consequences. Past hazard events and disasters data were combined with current conditions and possible exposure levels to map and visualize the recurrence of such past hazard events and disasters for community awareness and to determine the risks (e.g., slope stability calculations in landslide studies).

3.3.4 Probabilistic

To a limited extent, probabilistic approach was used to identify hazards and estimate the probability of each hazard affecting an area or region. Probability of occurrence were calculated through research on past hazard events or disasters to estimate and categorize probability for each hazard as Very High, High, Moderate, Low and Very Low.

3.4 Hazard Mapping

Extensive hazard mapping using GIS was undertaken to establish geographically (at national and sub-national scales) where and to what extent particular hazard events are likely to pose a threat to people, property, infrastructure and economic activities in Sierra Leone. The use of maps is one way to depict the spatial location, size and frequency of hazards in the country and they also provide clear and attractive pictures of the geographic distribution of potential hazard sources and impacts, including motivations for risk management actions that would be difficult to obtain without a compelling visualisation. Sophisticated GIS and remote sensing allowed a more comprehensive mapping of not only hazards but also exposure, vulnerabilities, and disaster risks to better support decision-making.

Various hazard mapping techniques were used in this project:

3.4.1 Mapping Techniques and Tools

3.4.1.1 Community Knowledge

A simple mapping of local experience was achieved using local knowledge and rural development activities such as Participatory Rural Appraisal (PRA) and Rapid Rural Appraisal (RRA). These methods were cost effective and the outcome reflects the local perception of hazard.

3.4.1.2 Surveys on Historic Events

Various reports were compiled on historic hazard events and disasters in Sierra Leone from DesInventar, EM-DAT, ONS-DMD and other GoSL MDAs, UN Agencies, INGOs and NGOs, CBOs, academia, research publications and printed media.

3.4.1.3 Scientific investigation and research

This was carried out through consultations with experts from an array of disciplines. Each discipline provided tools and techniques, including GIS modeling and remote sensing. These were extensively used to synthesize data on hazards and disasters and to combine these with socio-economic and demographic datasets. For example, vulnerability, exposure and risk maps for mitigation, preparedness, response and recovery were formulated better when hazards are mapped against the location of buildings, schools, critical infrastructure (hospitals, schools, bridges, airports), power lines, storage facilities, etc.

3.4.2 Multiple Hazard Mapping (MHM)

The multiple hazard map (also called a composite, synthesis, or overlay map) were used for fomenting an awareness of natural hazards and for analyzing vulnerability and disaster risk, especially when combined with the mapping of critical facilities. Information from several layers were combined in a single map to give a composite picture of the magnitude, frequency, and area of impact of the major natural hazards. The benefits of using the multiple hazard mapping approach include the following:

- Characteristics of the natural hazards and their possible impacts were synthesized from different sources and placed on a single map.
- It called attention to hazards that may trigger others (as heavy sustained downpours trigger landslides) or exacerbate their effects.
- A more precise view of the effects of natural hazards on a particular area were obtained. Thus, common mitigation techniques can be recommended for the same portion of the study area.
- Sub-areas requiring more information, additional assessments, or specific hazard-reduction techniques were identified.
- Decisions could be based on all hazard considerations simultaneously.

3.4.3 Critical Facilities Mapping (CFM)

The term "critical facilities" means all man-made structures or other improvements whose function, size, service area, or uniqueness gives them the potential to cause serious bodily harm, extensive property damage, or disruption of vital socioeconomic activities if they are destroyed or damaged or if their services are repeatedly interrupted (e.g., power stations, bridges, hospitals, telecommunication and transmission lines, etc.,). The primary purpose of a critical facilities map (CFM) is to convey clearly and accurately to decision-makers the location, capacity, and service area of critical facilities. An extensive number of such facilities are presented at the same time in most of the maps produced in this project. Also, when combined with a multiple hazard map, a CFM can show which areas require more information, which ones require different hazard reduction techniques, and which need immediate attention when a hazard event or disaster occurs. Some of the benefits of a CFM are:

- The uniqueness of service of facilities in the area (or lack of it) is made clear.
- Facilities that may require upgrading and expansion are identified.
- The impact of potential development on existing infrastructure can be assessed before a project is implemented.
- Any need for more (or better) hazard assessment becomes apparent.

3.4.4 Combined Critical Facilities Maps and Multiple Hazard Maps

Both CFM and MHM were combined in some areas to clearly visualize the interrelationship between various facilities and hazards. The benefits obtained by combining a CFM and an MHM include:

- Decision-makers are made aware of hazards to existing and proposed critical facilities prior to project implementation.
- The extent to which new development can be affected by the failure or disruption of existing critical facilities as a consequence of a natural hazard event can be determined.
- More realistic benefit-cost ratios for new development are possible.
- Sub-areas requiring different assessments, emergency preparedness, immediate recovery, or specific vulnerability reduction techniques can be identified.

3.5 Vulnerability Assessment

In a hazard prone area, people, property and systems, or other elements are exposed to potential losses, but they are not all vulnerable to the hazard in the same way. Vulnerability is a condition determined by physical, social, economic, and other factors, which increases or decreases the susceptibility of communities, individuals, and even physical structures or the environment, to the impact of the hazard. Since the process of reducing disaster risk is largely focused on reducing vulnerabilities and enhancing capacities, this study provides an understanding of vulnerability, vulnerability assessment, capacity and capacity assessment as well as which elements are most at risk from the major natural hazards that have been identified in this study, and why.

3.5.1 Vulnerability

Vulnerability is the result of the whole range of economic, social, cultural, institutional and political factors that shape people's lives and create the environments that they live and work in. Development processes play a key role in exposing people to hazards, as well as shaping their vulnerability to potential disasters. For example, the fact that large numbers of people live in corrugated zinc houses in hazard-prone areas could result from a combination of several factors: poverty (itself a symptom of local, national and even global economic forces), population growth, displacement due to economic development (e.g. loss of smallholdings to commercial agriculture), migration to towns and cities (which has a variety of socioeconomic causes, including livelihood opportunities), legal and political issues, such as lack of land rights, government macro-economic and other policies and other political features, including weak government and civil society institutions.

A family living on the coastline is more exposed to storms than another family whose house is located further away on higher land. But for a family living in a poorly constructed house along the coast, they are more vulnerable to storms than a family living in a strong house in the same area. Where families are living, whether their houses are strong, and their ability to anticipate, cope with, resist and recover from the impact of a hazard, are determined by a complex set of conditions that contribute to vulnerability.

Vulnerability can be grouped into three categories:

- **Physical and material vulnerability:** Weakness of the built environment and lack of access to resources, i.e. proximity and exposure to specific hazard (living on a hazard prone areas or in unsafe buildings), and lack of resources, savings and assets.
- **Social and organisational vulnerability:** Inequality in social systems that discriminate against and marginalize certain groups of people from accessing resources and services, including assistance after disasters; and because of their status, prevents them from voicing their needs and participating in decision-making processes. This social process of exclusion is based on:
  - Age
  - Gender
  - Occupation
  - Ethnicity
  - Religion

  Often, a combination of these social divisions magnifies people's vulnerability. Children and the elderly or widowed women belonging to a minority ethnic group of the poor class tends to be more vulnerable to hazards.

- **Attitudinal and motivational vulnerability:** Existence of fatalistic myths and religious beliefs influence people's vulnerability to disaster risks. If people believe that disasters are 'acts of God' and if they have low confidence in their ability to affect change or have 'lost heart' and feel defeated by events they cannot control, these people are often harder hit by disasters than those who have the strength to survive and a sense of confidence to bring the changes they desire.

Vulnerability refers to the way a hazard or disaster will affect human life and property. Vulnerability to a given hazard depends on:

- Proximity to a possible hazardous event
- Population density in the area proximal to the event
- Scientific understanding of the hazard
- Public education and awareness of the hazard
- Existence or non-existence of early-warning systems and lines of communication
- Availability and readiness of emergency infrastructure

- Construction styles and building codes
- Cultural factors that influence public response to warnings

In general, less developed countries are more vulnerable to natural hazards than are industrialized countries because of lack of understanding, education, infrastructure, building codes, etc. Poverty also plays a role - since poverty leads to poor building structure, increased population density, and lack of communication and infrastructure.

Human intervention in natural processes can also increase vulnerability by:

- Development and habitation of lands susceptible to hazards, For example, building on floodplains subject to floods, sea cliffs subject to landslides, coastlines subject to storm surges and floods.
- Increasing the severity or frequency of a natural disaster. For example: overgrazing or deforestation leading to more severe erosion (floods, landslides), mining groundwater leading to subsidence, construction of roads on unstable slopes leading to landslides, or even contributing to global warming, leading to more severe storms.
- Affluence can also play a role, since affluence often controls where habitation takes place, for example along coastlines.

Vulnerability can be quantified as the degree of loss to a given element at risk (or set of elements) resulting from a given hazard at a given severity level. **Vulnerability assessment** is the process of estimating the susceptibility of the 'elements at risk' to various hazards and analyzing the causes behind their vulnerability. The assessment takes into account the physical, geographical, economic, social, political and psychological factors, which make some people or assets more vulnerable to the dangers of a given hazard while others are relatively protected. For example, the location of vulnerable assets (buildings, critical facilities, and infrastructure) have been mapped and the vulnerability of buildings to landslides and floods in Sierra Leone have been assessed and mapped per district.

Capacity, the reverse of vulnerability, is a combination of all the strengths and resources available within communities, organisations and individuals that can reduce the level of risk, or the effects of a hazard. **Capacity assessment** is the process of determining the resources, assets, skills, knowledge and social relations that communities, organisations and individuals have themselves or have access to (e.g. support from national-level agencies and NGOs) to prevent, mitigate, prepare, respond to and recover from disasters. Risk combines the expected losses from all levels of hazard severity, also taking into account their occurrence probability and the ability of a community to cope with the hazard.

Vulnerability and capacity assessments required the Project Team to go into local communities to study the social, economic, cultural, political and environmental conditions, and also engage with the local communities and stakeholders in one way or another. This took on a number of different forms, from a quick information gathering process to more detailed courses of action, including: questionnaire surveys, interviews, focus group discussions, mapping historical timelines, direct observations, and analysis of secondary sources e.g. reports, newspaper articles, websites.

A low-income country like Sierra Leone shows high economic vulnerability to disasters and economic damage from natural disasters is linked intimately with development, poverty and economic growth. Damages to assets, public infrastructure and long-term productivity as a result of disasters can set back development and erode gains in poverty alleviation. Without building economic resilience to natural disasters, the gains in development, poverty alleviation and human security promoted by sustainable development agenda will be repeatedly eroded. This is particularly concerning when we consider that climate change is expected to increase the severity of climate hazards over the coming decades in Sierra Leone.

Disasters can happen when people who are vulnerable simply do not know how to get out of harm's way or what protective measures to take. There may be a lack of awareness about measures that can be taken to build safe houses. Some people may not know about evacuation routes and procedures whereas others may not know where to turn for assistance in times of acute distress. In Sierra Leone, disasters generally affect rich as well as poor communities, but they have a particularly severe impact on poor or low-income communities, which experience disproportionately higher mortality and suffer higher levels of economic loss in relation to the size of their incomes.

Often, it is the weaker groups in society that suffer worst from disasters, principally the poor, the very young and the very old, women, the disabled, migrants and displaced people and people marginalised and other socio-economic or cultural characteristics. Those who are already at an economic or social disadvantage because of one or more of these characteristics tend to be more likely to suffer during disasters. Vulnerability is not just about poverty, but poverty is a fundamental factor. Disasters' impact on society is uneven and unequal: poor and socially marginalised households tend to be much more vulnerable to losses than wealthier households; they are pushed deeper into poverty as a result; and they find it more difficult to recover.

3.5.2 Vulnerability Assessment

Vulnerability to disasters is a function of human action and behaviour. It describes the degree to which a socio-economic system or physical assets are either susceptible or resilient to the impact of hazards. It is determined by a combination of several factors, including awareness of hazards, the condition of human settlements and infrastructure, public policy and administration, the wealth of a given society and organized abilities in all fields of disaster and risk management.

Lack of awareness among the public and decision-makers about factors and human activities that contribute to environmental degradation and disaster vulnerability are aggravating these trends. There is a close correlation between the trends of increased demographic pressure, escalated environmental degradation, increased human vulnerability and the intensity of the impact of hazards. For example, floods are aggravated or even caused by deforestation, which causes erosion and clogs rivers, and other factors. Poverty and hazard vulnerability are integrally linked and mutually reinforcing.

The accelerated, and often uncontrolled, urban growth of cities in Sierra Leone has contributed to the ecological transformation of their immediate surroundings (pressure on scarce land, deforestation, etc.). In addition, the lack of appropriate drainage systems and increase in the volume and speed of rainfall runoff make most cities more vulnerable to flash floods. Recent catastrophic floods and landslides in the Western Area highlight other key deficiencies and trends in the approach to disaster risk reduction, such as a poor understanding by decision makers of landslide related risk, as well as the tendency of some builders, to use the cheapest designs and construction materials to increase short-term economic returns on their investment.

The degree of severity and nature of impact of a disaster depend on a range of factors. These include the type of hazard, the size of the economy and its economic structure, and the sectors affected by the disaster. Looking at hazard types, we see that droughts do not damage buildings or physical structures but their lengthy duration creates other problems: for example, agricultural households may be forced into considerable debt following the loss of crops & livestock. In contrast, sudden-onset disasters such as floods or landslides have a direct impact on infrastructure and productive facilities and resources, as well as on social resources and infrastructure, especially housing.

Some sectors of the Sierra Leonean economy are more vulnerable to hazards than others. Most obviously, the agricultural sector is potentially vulnerable, implying that communities which rely heavily on agriculture may be particularly threatened by hazards. However, even here, the types of crops cultivated and techniques for growing them play a role in determining the scale of vulnerability.

3.6 Disaster Risk Assessment

Disaster risk is the combination of hazard and vulnerability. Risk is the probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions. A community is said to be 'at risk' when it is exposed to hazards and is likely to be adversely affected by the impact of those hazards when they occur. People (their lives and health), household and community structures, facilities and services (houses, access roads, bridges, schools, hospitals, etc.), livelihood and economic activities (jobs, equipment, etc.) are described as 'elements at risk'.

Elements at risk can be classified as tangible or intangible, depending on whether they can be quantified. Tangible elements are physical elements such as people, buildings, equipment and infrastructure, as well as economic elements such as income and savings. Intangible elements are social elements such as social ties, cultural heritage and psychological well-being.

For the purpose of this study, risk is represented as follows:

Risk = Hazard X Vulnerability (Exposure)/Capacity

From the equation, it is clear that protection against risk can be achieved – by reducing or modifying the nature and behavior of the hazard, by reducing vulnerability and exposure, and/or by increasing capacity.

Different people have different perceptions of risk depending on their values, culture, experience, age, profession, and other social and economic factors. These perceived risks may be different from 'real' risks that are measured scientifically. For example, a community who has not experienced severe flooding may deny that it can happen, even when they are presented with results of a risk assessment showing evidence that severe flooding can occur. People's perception of risk is important because it is one of the key factors determining their susceptibility to participate in disaster risk reduction activities. For example, living near a chemical processing plant may pose certain risks but may also bring the benefit of employment for the nearby population. To those who choose to live near the plant, the benefits may outweigh the risks of a chemical accident.

Perceptions are shaped by a number of factors based on:

- Personal experience
- Rate of occurrence and nature of past disaster events
- Availability of disaster-related information
- Socio-economic status

Each person will determine a unique level of acceptable risk based on these and other factors. It is this very personal and individual perception of risk that needs to be examined, discussed and understood in order to build a culture of safety. Unfortunately, this was not feasible for this study. Knowing different people's perception of risks is critical to the successful implementation of disaster risk reduction projects and programmes, including public awareness campaigns. Perceptions can change, and when they do, the level of acceptable risk may also change. Some people may become less 'risk tolerant' while others may be willing to tolerate a higher level of risk to sustain activities necessary for immediate survival. These changes may depend on experience, education or even misinformation.

3.6.1 Disaster Risk Reduction

Disaster risk reduction is increasingly being recognized as a vital strategy in disaster risk management, by building or strengthening capacity of an individual, household, organisation or community to adjust to threats, to avoid or mitigate harm, and to recover quickly from disaster events.

Human capacities include (see Table 3-2):

- Physical and material resources, e.g. cash, food, land, properties, tools;
- Social and organisational capacities, e.g. access to social networks, leadership, various skills, experiences and knowledge; and
- Attitudinal and motivational capacities, e.g. beliefs, compassion, confidence, creativity

In most disasters, people suffer their greatest losses in the physical and material realm. However, even when everything physical is destroyed, people still have their skills, experiences and knowledge; they have family and social networks. They have leaders and systems for making decisions. They also have local, collective 'wisdom' reflected in their cultural practices that help them reduce or cope with disaster risks. People also have positive attitudes and strong motivations such as the will to survive and willingness to help each other. People's social/organisational capacities and attitudinal/ motivational capacities are important capacities and form the basis for development just as much as the material resources that people have.

Table 3-2: Summary of the different vulnerabilities and capacities in a locality

Human Capacities	Vulnerabilities	Capacities
Physical/material	• Proximity and exposure to specific hazard (living in hazard prone areas). • Poverty – few options, no financial savings, few assets. • Limited resources, technology, skills or employment.	• Money, assets, land, jobs, savings. • Insurance • Good health • Protected location • Skills and expertise
Social/Organisational	• Marginalisation- people excluded due to politics, religion, ethnicity or social customs and norms. • Organisation – limited community or legal structures. • Discrimination – lack of support, reduced access to resources and services.	• Community support, Leadership, institutions. • Political structures, adequate management. • Community cohesiveness
Motivational/ attitudinal	• Perception of risk – deny the threat, unaware and misconception of threat. • Attitude – no confidence in their abilities, view themselves as dependent. • Power – no influence in the community.	• People with confidence, dignity and independence. • Ability to influence their environment. • Hold a strong belief system. • Aware of how disasters affect them.

3.6.2 Risk Assessment

Risk assessment answers the fundamental question: “What would happen if a hazard event occurred in an area?” Risk assessment was used to determine the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability that could pose a potential threat, or harm, to people, property, livelihoods and the environment. Results from the risk assessment conducted in this study should enable action and form the foundation for planning and implementing disaster risk reduction measures by the ONS-DMD and other stakeholders. The risk assessment is based on a review of both the technical features of some specific natural hazards (such as their location, intensity, frequency and probability), and the analysis of the dimensions of vulnerability and exposure (physical, social, economic and environmental), while taking particular account of the coping capabilities pertinent to the risk scenarios.

Five essential steps were undertaken in the risk assessment process:

1. **Hazard Identification** – includes identifying the hazards from which an area is at risk.
2. **Hazard Assessment** – includes estimating the likelihood of experiencing the hazards at a location or in a region, and studying the characteristics, frequency and potential severity of the hazards.
3. **Vulnerability, Exposure and Capacity Assessment** – includes determining who or what are exposed to which hazards, where and why; and the resources, assets, skills, knowledge and social relations available to reduce the impact of those hazards, and cope with them.
4. **Risk Estimation** – includes combining all of the above steps to analyze the identified risks and the extent of their impact.
5. **Risk Evaluation** – includes examining how important the risks are to different groups of people, and prioritizing them for action.

Risk Assessment involves not only the assessment of hazards from a scientific point of view, but also the socio-economic impacts of a hazard event. Risk is a statement of probability that an event will cause X amount of damage, or a statement of the economic impact in monetary terms that an event will cause. Risk assessment aids decision makers and scientists to compare and evaluate potential hazards, set priorities on what kinds of mitigation are possible, and set priorities on where to focus resources and further study. The selection of methodology was dependent on the availability of reliable data. The study conducted statistical analyses of a wide range of past hazard events and geological, climatic and meteorological data to determine probable losses on an annual basis. Sometimes, additional scientific investigation were needed to substantiate anecdotal or incomplete data.

3.6.3 Risk Estimation

Risk estimation brings together the results from the hazard identification and assessment, vulnerability and capacity assessments to provide an overview of the risk faced by a community or entity that will help in decision-making and planning risk reduction measures in Sierra Leone. Following the analysis of results, risk statements or scenarios were prepared for key development sectors (education, environment, health, housing, transportation, etc.), regions and/ or vulnerable groups. Visual risk maps are also produced.

Table 3-3: Hazard and vulnerability are scaled according to the severity

Hazard	Value		Vulnerability	Value
Very High	5		Very High	5
High	4		High	4
Moderate	3		Moderate	3
Low	2		Low	2
Very Low	1		Very Low	1

Risk are classified into different classes according to the combined results of hazard and vulnerability based on the equation:

Risk = Hazard x Vulnerability

Hazard	Value
Very High	21 to 25
High	16 to 20
Moderate	11 to 15
Low	6 to 10
Very Low	1 to 5

To consider the dimension of ‘capacity’, the following equation is used:

Risk = (Hazard x Vulnerability)/Capacity

The table below shows sample results of the risk estimation by location within a district.

Location	Exposure to Hazard	Vulnerability	Capacity	Risk
A	3	4	3	4
B	2	5	4	2.5
C	5	2	2	5
D	3	4	5	2.4
E	1	3	3	1

According to the information on the sample table above, location C shows the highest risk location.

3.6.4 Risk Evaluation

The purpose of risk evaluation is to help identify and prioritize risk reduction measures. At this stage, communities and local authorities can jointly agree on criteria to rank the risks. They can decide what levels of risk are acceptable for which no actions need to be taken.

The other risks could be ranked as very high, high, medium, low or very low priority. An acceptable level of risk varies among individuals, depending on their experience, exposure, understanding, beliefs and other factors. An acceptable level of risk can change over time. A risk assessment and other pertinent information can change people’s perception of risk.

Risk evaluation involves balancing perceived risks against potential benefits, and scientific judgments against beliefs systems. Local participatory risk assessment processes could provide vulnerable groups with insights into the risk they perceived that should be taken into consideration when defining acceptable levels of risk.

Risks are ranked according to:

- Their significance
- The existence and feasibility of risk reduction solutions
- The cost-effectiveness of potential risk reduction solutions
- The availability of funds

The broad strategies for dealing with different risks are also identified. At this stage, the cost-benefit analysis of various risk reduction options can be undertaken in a separate project.

Table 3-4: Risk evaluation criteria

Hazard	Descriptor	Description
Very Low	Rare	The event is conceivable, but only under exceptional circumstances
Low	Unlikely	The event might occur under very adverse circumstances
Moderate	Possible	The event could occur under adverse conditions
High	Likely	The event will probably occur under adverse conditions
Very High	Almost certain	The event is expected to occur

3.6.5 Conclusion

Risk assessment is the foundation upon which a local disaster risk reduction plan is developed. With the results from this study, various stakeholders should be able to identify the areas that are susceptible to each of the nine major natural hazards, where the highest losses would occur, how the lives and quality of life in their communities might be affected in the aftermath of a disaster. These identified risk areas and estimated impacts will be the information necessary to support future disaster risk reduction decisions. This Report was presented at a Stakeholders Validation Workshop for them to refer to on various occasions. Feedback from stakeholders allowed information to be reviewed and validated. It will inform stakeholders and facilitate their wider involvement in the risk reduction process as part of the national risk assessment.

4 NATURAL HAZARD ASSESSMENT AND MAPPING

4.1 Landslide Hazard Assessment and Mapping

Slope failures are becoming more widespread, and have over the years caused more human, socio-economic, and environmental losses than any other geologic hazard in Sierra Leone. Landslides, mudslide, and rockfall (hereafter landslides) is a general term covering a wide variety of mass movements and processes involving down slope transport of soil and rock material in mass under the influence of gravitational forces. Although this is a part of the Earth's denudation process and thus considered as a natural phenomenon; slopes which stood stable for centuries are now frequented by landslides, and hence socio-economic losses due to its impact are growing. This is mainly due to the expansion of human activities into more vulnerable hill slopes under the pressure of rising population and associated demands for land and infrastructure facilities.

Sierra Leone's relief is characterized by hilly and mountainous regions in the Western Area and towards the northeast of the country, with an average elevation between 500 and 750 m. The 14 August 2017 landslides, especially at the Mount Sugar Loaf, that hit the Western Area are considered the most devastating disaster after the EVD crisis. The Mount Sugar Loaf landslides were triggered by heavy rainfall overnight on 14 August 2017; where a portion of the north-facing slope in the Mount Sugar Loaf overlooking the densely populated Regent community failed, burring dozens of houses within its immediate vicinity and damaging or destroying many more along the path of the mudflow into the Atlantic Ocean (see Figure 4-1).

Landslides have affected different areas of Sierra Leone in the past, leading to loss of lives, injuries, damage to property and leaving many homeless and without a livelihood. However, little research or literature exists about landslide hazards in Sierra Leone to date. In addition, there are significant data gaps on historical landslide events. No systematic recording of disasters exists in the country to date. International centres of data collection such as CRED EM-DAT, DesInventar and Relief Web are the only sources of disaster data. Most often the recorded events are not well georeferenced and the inventory is challenging.

From DesInventar data, approximately 250 people were affected by landslides between 2009 and 2016 - 57 death, 50 injured, and about 20 houses were damaged or destroyed (see Table 4-1).

From the entire available inventory of landslide disaster events in Sierra Leone, the most impacted region is the Western Area with 89 percent of the total fatality recorded, followed by the Northern Province with 11 percent of the total events. Western Area Urban and Western Area Rural experienced more deaths than others, with Bombali, and Port Loko being the only other Districts to have experienced landslide disaster events in recent time (see Table 4-1).

During the last decades, it is noted that the most vulnerable category of Sierra Leone is composed of households who are located in sloppy areas of the Western Area and the Northern part of the provinces. These people stay often in houses of areas classified as "high risk zones". Most of the area and are characterized by a very fragile settlement and modest income.

Freetown Peninsula, which is most affected by landslide disasters is composed predominantly of gabbroic rock. It forms steep high hills with a relatively flat coastal plain consisting of thick laterite soil overlying weathered hard-pan laterite and gabbro rock. Due to high rainfalls (especially between July and September), the hills of the Freetown Peninsula are covered with widespread thick residual laterite soil and surface boulders overlying the massive gabbro rocks. The laterite surface layers of the peninsula have proved competent in supporting buildings on the slopes, which in Freetown vary from the steep high hills (30 per cent slope) to the coastal plain (5 percent slope).

However, the uncontrollable construction, deforestation and stone mining activities on the hillsides leave the surface open and exposed to landslides, with heavy rainfall acting as the main trigger. Additionally, large boulders, which are difficult to remove, are left hanging above the buildings**.** These roll off from time to time causing the destruction of homes and the deaths of their occupants.

Table 4-1: Historical landslide events

District	Date	Location	Deaths	Injured	Houses Damaged/Destroyed	Victims	Affected	Source
WAR[13]	11/08/1945	Charlotte Village, near Barthurst	13 (or 15)		7			A[14]
WAU[15]	13/08/2009	Kissy Brook, Freetown	5	10	2		15	B[16]
WAU	19/08/2009	Ft Cold Storage, Dwarzark			1			B
WAU	18/08/2010	Yandama Farm, Off Blackhall Road	2	1	2			B
WAU	08/09/2010	Owen Street, Off Mountain Cut	13	4	2			B
WAU	08/03/2011	Kissy Brook, Freetown	1					B
WAU	08/03/2011	Moeba, Freetown	2	1	1			B
WAU	05/2008	New England	1					C[17]
WAU	19/05/2009	New England	2					C
WAU	07/05/2012	New England, Smart Lane, Freetown	2	4	1			B
WAU	07/06/2012	Congo Town, Freetown	5		3		73	B
WAU	07/06/2012	Yadama Kamanda Farm, off Blackhall Road	1		2			B
PL[18]	20/04/2013	Mabenku	4	15		19	38	B
WAU	08/05/2013	York St, off Guard Street, Freetown	1	5	4		26	B
WAU	08/08/2013	King Jimmy (Peters Brook) Wallace Johnson, Street	6		1			B
WAU	08/09/2013	King Jimmy Bridge	6	7	1	15		B
WAU	18/09/2013	Pa Demba Road	2	3		5		B
BOM[19]	31/03/2014	Makeni	2					B
WAU	04/05/2014	Ascension Town	5			5		B
WAU	14/08/2017	Matome, Regent	500				50,000	D

[13] Western Area Rural district
[14] Awoko Newspaper http://awoko.org/2008/10/03/charlotte-has-history/
[15] Western Area Rural district
[16] DesInventar
[17] BBC News (http://news.bbc.co.uk/2/hi/africa/8057383.stm)
[18] Port Loko district
[19] Bombali district

Landslides are common on the steep slopes mainly due to poor knowledge of technical construction and drainage methods when constructing buildings and roads on the hill slopes. A major recorded landslide occurred in Charlotte Village in Freetown in the 1950s. The landslide, which was attributed to heavy rains that acted on denuded land, displaced the entire village and claimed many lives and properties. Rock falls recently claimed the lives of people at Susan's Bay, Wallace Johnson Street (King Jimmy Bridge), Kissy Brook, New England Ville, Cline Town, Hill Cot Road, Leicester, and Falcon Bridge (see Figure 4-1).

Figure 4-1: Landslide disaster events in Sierra Leone

Landslide (Rockall) that left 5 dead and 10 injured in Kissy Brook

(Photo Credit: Peter Ford - Y Care International)

Landslide that left 6 dead and led to the collapse of the King Jimmy Bridge

(Photo Credit: unknown Source)

Landslide that left 4 dead in Oloshoro Community

(Photo Credit: Awoko Newspaper)

Landslide disaster in Kissy Brook (2009)

(Photo Credit: Nazareth House Apostolate)

The Slope in the Sugar Loaf Mountain that failed leading to the most devastating landslide disaster in Sierra Leone

(Photo Credit: INTEGEMS)

Rescue workers search to save victims beneath the debris where their homes once stood

(Photo Credit: INTEGEMS)

Figure 4-2: Historic landslide disasters in Sierra Leone

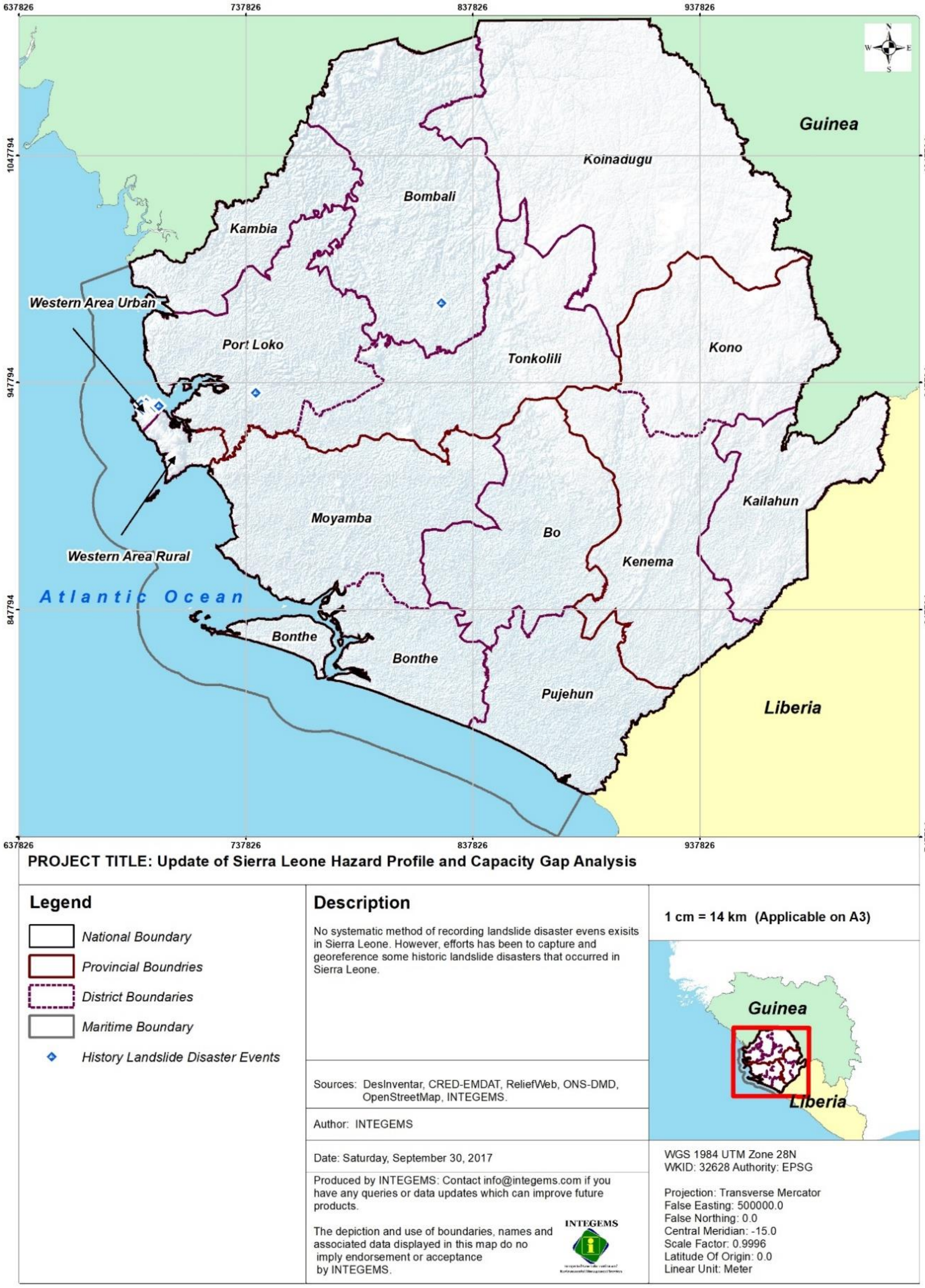
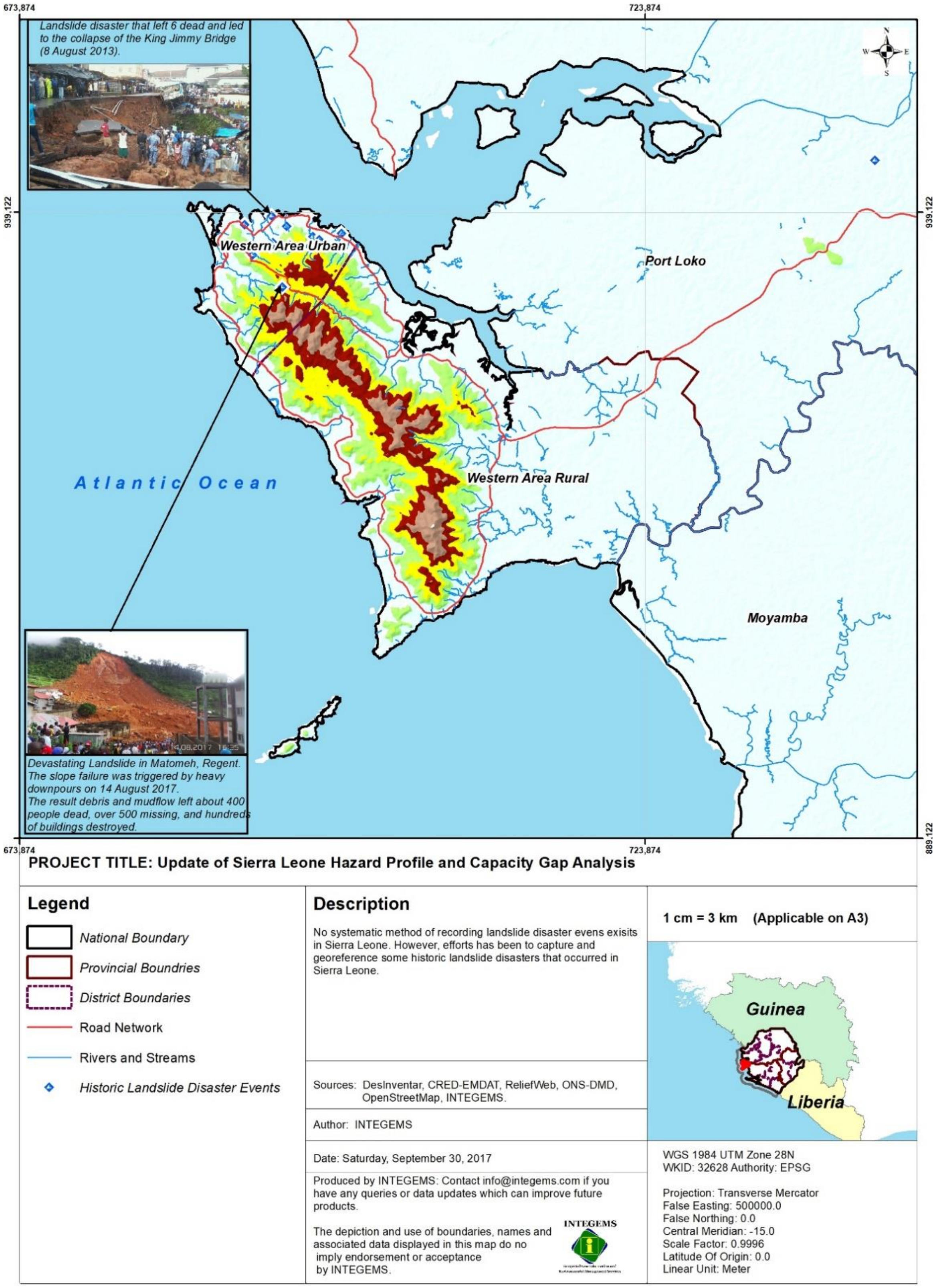


Figure 4-3: Areas with the highest frequency of landslide occurrences



4.1.1 Map Content

The landslide hazard risk map (see Figure 4-11) which has been developed shows the spatial distribution of rainfall-induced landslide risk classes for the entire country. National, Provincial and District boundaries are presented on the map as overlay layers for more detailed comprehension of the spatial distribution.

4.1.2 Application of Maps in Disaster Risk Management

The landslide hazard risk map could serve as the basis for sustainable physical settlement planning that will help in the reduction of the impact of landslides on the population, housing, livelihood, agricultural productivity, and critical infrastructure (road network, health infrastructure, education infrastructure, etc.). The results of this study can also be used as a baseline for future quantitative research that can be done at small scale targeting areas with high risk. The map could also inform land use planning. The map will help relevant stakeholders across different sectors in identifying sites for structural and non-structural mitigation projects.

4.1.3 Methodology

Landslide hazard, defined as the annual probability of occurrence of a potentially destructive landslide event, was estimated by an appropriate combination of the triggering factors (mainly extreme precipitation) and risk factors (slope, lithology, land cover, distance to roads, and soil type). The methodology is presented in Figure 4-4.

There are four different approaches to the assessment of landslide hazard: landslide inventory-based probabilistic, heuristic, statistical and deterministic. Landslide risk assessment methods are classified into three groups, as qualitative (probability and losses based on quality or characteristic terms), semi-quantitative (indicative probability, qualitative terms) and quantitative (probability and losses are both numerical). The heuristic approach is considered to be useful for obtaining qualitative landslide hazard maps for large areas in a relatively short time. It does not require the collection of lots of data.

Given time limitations and scarce data, it was decided to use a semi-quantitative slope susceptibility index approach by adopting a Spatial Multi-Criteria Evaluation (SMCE) method. The slope susceptibility index should use indicator maps collected from reliable secondary sources (Boerboom, et al., 2009). The semi-quantitative index approach is considered useful in the following two situations: 1) as an initial screening process to identify landslide hazards and 2) when the possibility of obtaining numerical data is limited. Semi-quantitative approaches consider explicitly a number of factors influencing the slope stability. For this study, the following six factors were used:

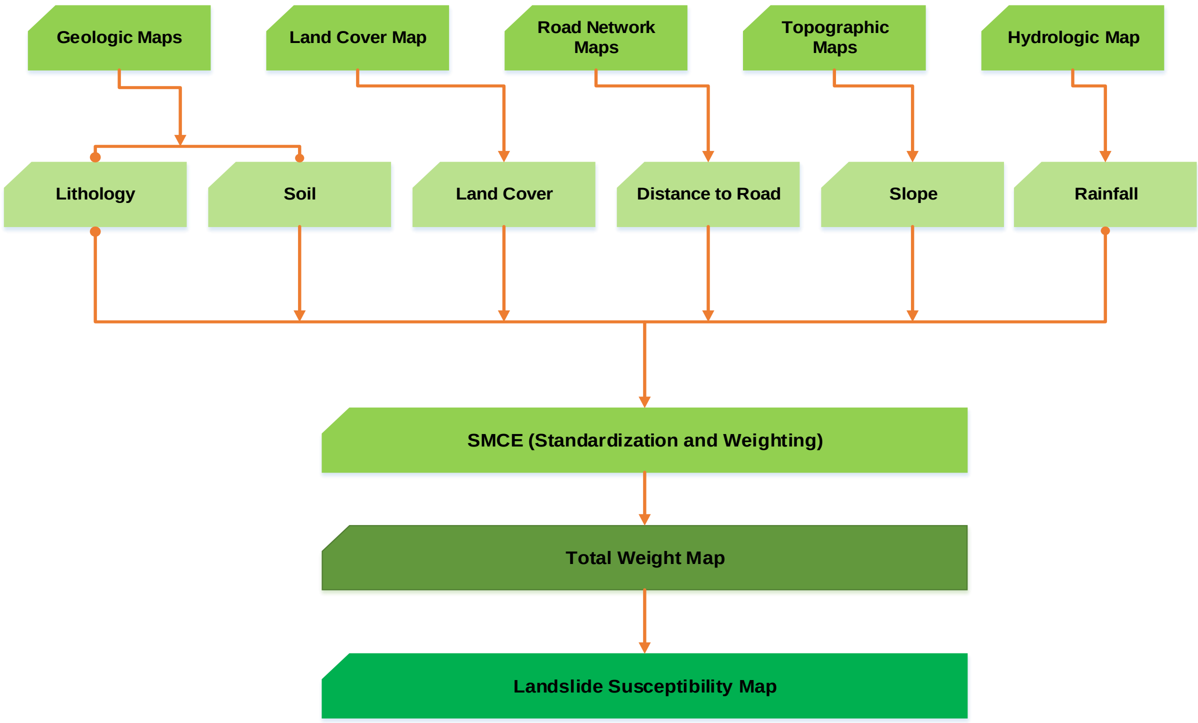
- Slope
- Lithology
- Rainfall
- Land Cover
- Soil Type
- Distance to Roads.

A range of scores and settings for each factor are used to assess the extent to which that factor is favourable or unfavourable to the occurrence of slope instability.

The slope susceptibility index method started with the selection of indicator maps, the way the criteria are going to be structured and the selection of standardisation and weighting methods following the example of Abella and Westen (Abella & Westen, 2007). To implement the model, the SMCE module was used. SMCE application assists and guides users in doing multi-criteria evaluation in a spatial manner. The input is a set of maps that are the spatial representation of the criteria. They are grouped, standardized and weighted in a criteria tree. The output is one or more composite index map, which indicates the realisation of the model implemented. The theoretical background for the multicriteria evaluation is based on the analytical hierarchical process (AHP) developed by Saaty (Saaty, 2008). The AHP has been extensively applied to decision-making problems, and only recently, some research has been carried out to apply AHP to slope susceptibility mapping.

To make spatial multi-criteria analysis possible, the input layers need to be standardized from their original values to the value range of 0–1. Different standardisations were provided in the SMCE module. For standardizing value maps, a set of equations can be used to convert the actual map values to a range between 0 and 1. The class maps use an associated table for standardisation where a column must be filled with values between 0 and 1. In the section of Indicator Analysis, a detailed description of the indicator maps and their standardisation is given. The next step is to determine the weight of each indicator - whether it influences the overall objective or not. The influence of a given indicator can be evaluated through its weight when compared to other indicators.

Figure 4-4: A Contextual framework for landslide hazard risk mapping



4.1.3.1 Scoring and Weighting Process

A score between 0 and 5 is assigned to each factor. After classification of the selected factors, each factor is assigned a weight according to its level of potential influence to cause slope failures. Through experts' judgement and depending on observed physical characteristics of landslide sites, the levels of influence by individual factors were determined. Table 4-2 below details the weights assigned to each of the factors. It is assumed that once a landslide occurs, factors will contribute at different levels according to their nature. A score of 1 is considered as a landslide event and each factor contributes to the score ranging between 0.1 and 1. A weight of 1 in a single factor, therefore means that is the only factor contributing to the event. Otherwise, a weight of 0 is given in case of the absence of influence of a factor to the event. The landslide risk maps generated considering the combined scores of all factors used in the assessment. Meanwhile a combination of GIS tools were used to compute the SMCE.

Table 4-2: Assigned weights to factors

Factor	Weight
Soil type	0.1
Slope	0.4
Lithology	0.13
Rainfall	0.2
Land cover	0.1
Distance in roads	0.07

4.1.3.2 Field Survey in Selected Landslide-prone Areas

The main objective of the field survey was to identify landslide-prone areas based on historical records and testimonies from stakeholders at the consultative workshops held in each of the provincial headquarters. The field visits allowed stakeholders to identify, pinpoint the locations where landslides occurred, take the geographic coordinates, the period of occurrence, and to evaluate different characteristics that might have led to instability. Simple observation and experts' opinions helped to visualize the extent of landslides, to know the type of historical landslides and to identify the possible and potential triggers. A physical landslides 'Hazard Mapping Field Survey' was conducted in the 2 districts that are most affected by landslides (Western Area Urban and Western Area Rural Districts). For the remaining districts, the survey was conducted during the stakeholder consultative workshops in the provincial headquarters. Relevant evidence of past landslide events were used to validate the landslide risk map.

4.1.4 Data Availability from Sources

Different data were collected on the six factors (i.e. lithology, soil type, rainfall, slope, land cover and distance to roads). These are compiled in datasets which are demonstrated in Table 4-3 . The following sections discuss the selected factors and the classification of contents.

Table 4-3: Data required for landslide risk mapping and their sources

Data Type	Source
Administrative Boundaries	OpenStreetMap
Lithology	HydroNova, MWR, NMA, INTEGEMS
Digital Elevation Model (30 m resolution)	ASTER GDEM, SRTM
Slope	ASTER GDEM, INTEGEMS
Soil	FAO
Land Cover	FAO, USGS
Road Network	OpenStreetMap
Rainfall (Annual Average)	MWR

4.1.4.1 Slope

As reported by Goretti (2010) relief is a principal factor in the determination of the intensity and character of landslides. It has both direct and indirect influences. Direct influences encompass slope, steepness, river valley morphology, and thalweg gradients. The most important relief characteristic is the steepness, which affects the mechanism as well as the intensity of the landslides. The greater the height, steepness and convexity of slopes, the greater the volumes of landslides. The stability of the slope against sliding is defined by the relationship between the shear forces and the resistance to shear. The main force responsible for mass wasting is gravity. Gravity is the force that acts everywhere on the earth's surface, pulling everything in a direction toward the centre of the earth. On a flat surface, the force of gravity acts downward and so long as the material remains on the flat surface it will not move under the force of gravity. On a slope, the force of gravity can be resolved into two components, one acting perpendicular to the slope and another acting tangential to the slope.

The perpendicular component of gravity helps to hold the object in place on the slope. The tangential component of gravity causes a shear stress parallel to the slope that pulls the object in the down-slope direction parallel to the slope. On a steeper slope, the shear stress or tangential component of gravity increases and the perpendicular component of gravity decreases. The forces resisting movement downslope are grouped under the term shear strength which includes frictional resistance and cohesion among the particles that make up the object. When the shear stress becomes greater than the shear strength then the slope fails. For most of the studies on landslides, the orientation of the slope or aspect is taken into account. However, the slope aspect does not cause large differences in soil temperature in the tropics because of the low latitude (Knapen, et al., 2006). Accordingly, the aspect was not taken into account in the analysis of Sierra Leone landslides. In this study, slope has been extracted from the 30 meter resolution Digital Elevation Model and is expressed in degrees. The classification (or score) ranges from 1 to 5, where 5 means very high susceptible area and 1 very low susceptible. Figure 4-5 shows the slope angle of all areas in Sierra Leone.

Table 4-4: Slope classification by angle

Slope (Degrees)	Score
0-3	1
4 - 7	2
8 - 18	3
19 - 25	4
26 - 55	5
>55	1

4.1.4.2 Geology and Lithology

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 the 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 northwestern South America. The geology divided into two major tectono-stratigraphic 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 Ma 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 Soyonia 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 gabbro complex and associated minor sills and dykes.

The lithology map of Sierra Leone (see Figure 4-7) depicts the distribution of geologic units classified as mainly type of rock composition and texture. To map the lithology, the Geology of Sierra Leone (see Figure 4-6) was used as a starting point, with the 28 geological units interpreted as nine lithological units (Fileccia, 2017). Geological structures and morphology general show a good degree of correlation, particularly for the younger intrusions and linear elements. The Lithology of Sierra Leone map can yield valuable insights into how landslide is largely controlled by the lithological properties of the land.

Table 4-5: Standardized scores for the lithological classes

Lithology Type	Score
Recent sedimentary unconsolidated deposits (beach sand, clay, silt)	1
Dolerite dykes or sills, Bintumani, Soyonia	
Hard sedimentary rocks, more of less metamorphosed (low to medium grade), shale, argillite, siltstone, amphibolite. Sayonia Scarp, Rokel river, Marampa schist	2
Various lithologies of the Greenstone belt (metasediments, lava, schist, gneiss, amphibolite) Sula Mountain	
Intrusive basic hard rocks, thick ferrallitic cover (anorthosite, metagabbro, gneiss, migmatite, mylotite). Kasila	
Effusive mainly basic rocks (meta-andesite, lavas). Kasewa Hills	4
Intrusive mainly acid rocks (granitoid rocks) thin ferrallitic soil cover	
Highly fractured intrusive basic rocks (gabbro, anorthosite). Freetown Complex	5
Weathered deposits of banded iron formations over metasediments	

Figure 4-5: Slope classification map for Sierra Leone

Figure 4-6: Geological map of Sierra Leone

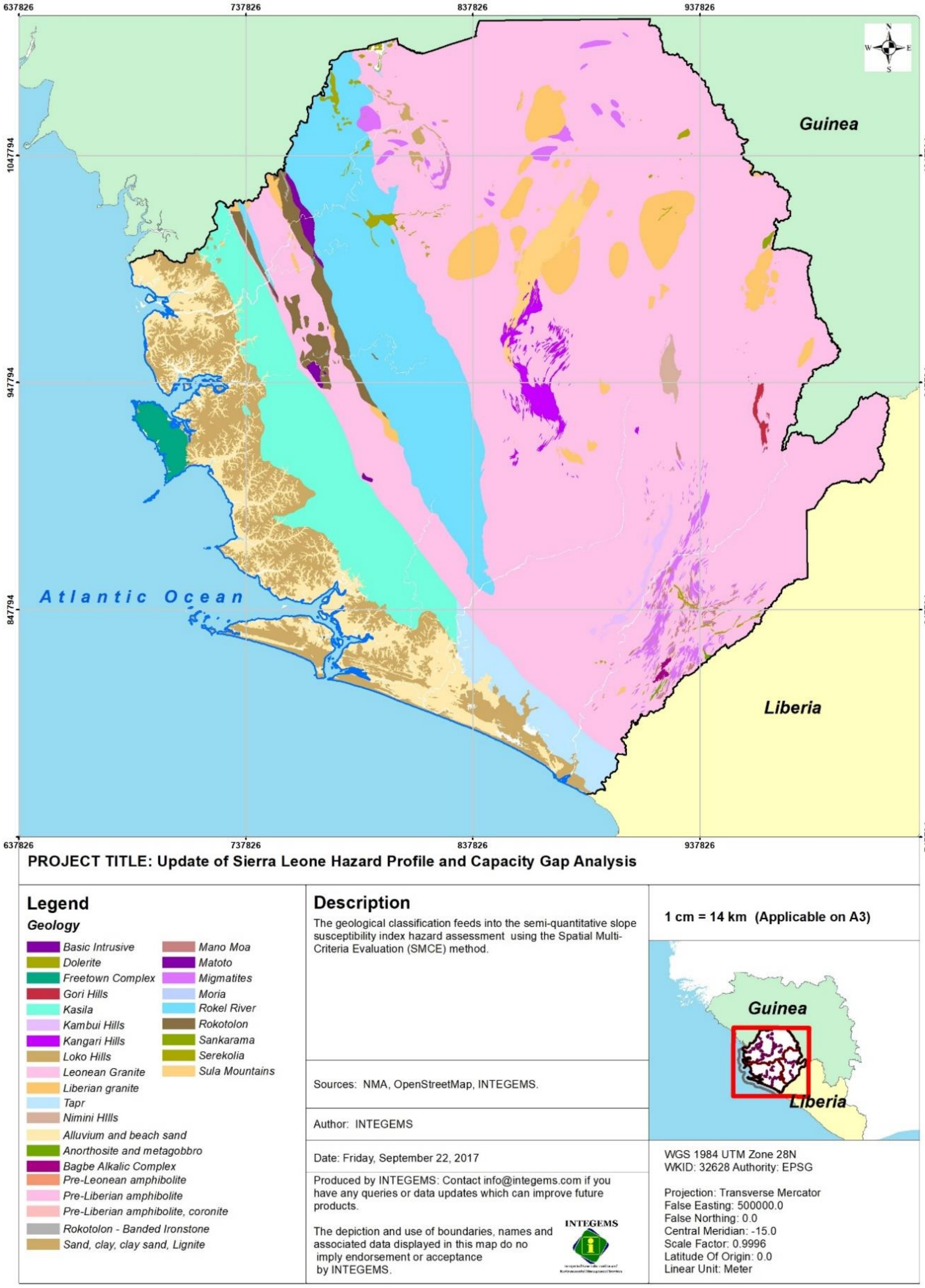


Figure 4-7: Lithological map of Sierra Leone

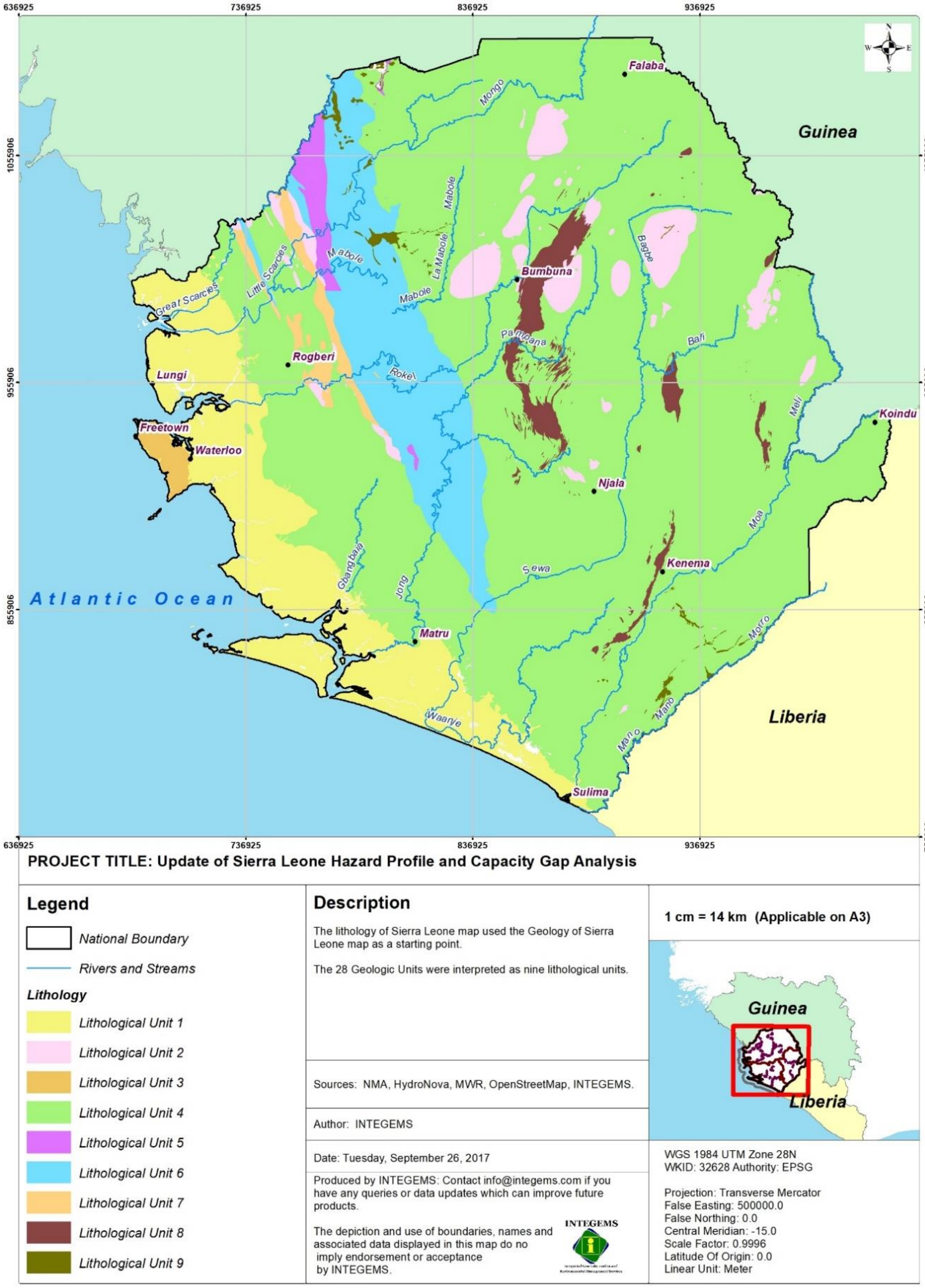


Table 4-6: Lithological units as depicted in Figure 4-7 above

Lithological Units	Description
Lithological Unit 1	Recent sedimentary unconsolidated deposits (beach sand, clay, silt)
Lithological Unit 2	Intrusive mainly acid rocks (granitoid rocks) thin ferrallitic soil cover
Lithological Unit 3	Highly fractured intrusive basic rocks (gabbro, anorthosite). Freetown Complex
Lithological Unit 4	Intrusive basic hard rocks, thick ferrallitic cover (anorthosite, metagabbro, gneiss, migmatite, mylotite). Kasila
Lithological Unit 5	Effusive mainly basic rocks (meta-andesite, lavas). Kasewa Hills
Lithological Unit 6	Hard sedimentary rocks, more of less metamorphosed (low to medium grade), shale, argillite, siltstone, amphibolite. Sayonia Scarp, Rokel river, Marampa schist
Lithological Unit 7	Weathered deposits of banded iron formations over metasediments
Lithological Unit 8	Various lithologies of the Greenstone belt (metasediments, lava, schist, gneiss, amphibolite) Sula Mountain
Lithological Unit 9	Dolerite dykes or sills, Bintumani, Soyonia

4.1.4.3 Soil Type

The role of soil in mass movement is also decisive. Soil plays a dual role - it is a by-product of the landslide process and at the same time, it is an important causal factor. The most important properties in soil stability are those that influence the rate of water movement in the soils and the capacity of the soil to hold water (Sidele, et al., 1985). Regolith and slope transport processes control accumulated soil depth, which in turn controls the volume of material available on the slope to contribute to landslides (BGS, 2017). The pattern of land use change in Sierra Leone follows human colonisation; first, forest is cut forming grassland, followed by inhabitation of grassland forming built-up areas (Mansaray, 2013). Sierra Leone has soils of variable thickness, with up to several metres present on some colluvial slopes, fans and alluvial tracts in valleys. The capacity of the soil to retain water contributes to rock alteration and gives place to instability of land. The soil categories were grouped into five classes of soil type as shown in Figure 4-8 and Table 4-7.

Table 4-7: Standardized scores for the soil type classification

Soil Type	Score
Stony and gravelly ferralitic soils over weathered granitic basement or colluvial gravel on low to moderate relief hills	1
Stony and gravelly ferralitic soils with shallow soils on moderate to high relief hills formed from predominantly acid rocks	
Gravelly ferralitic and plinthic hydromorphic soils on inland terraces, depressions and floodplains	2
Very gravelly ferralitic soils over colluvial gravel on western interior plains	
Gravelly ferralitic soils over weathered granitic basement or colluvial gravel on southern interior and plateau plains	
Gravelly nodular ferralitic soils over weathered granitic basement on northern interior and plateau plains	
Very gravelly ferralitic soils with shallow soils on moderate to high relief hills formed from basic and ultrabasic rocks	
Hydromorphic clays and gravel free ferralitic soils on coastal floodplains	3
Gravel free ferralitic soils on coastal terraces	
Weakly developed muds and hydromorphic clays along coastal river estuaries	4
Undeveloped to weakly developed sand on coastal beach plains	
Shallow soils on plateau mountains and lateritic hills and terraces	5

Figure 4-8: Soils type and spatial distribution in Sierra Leone

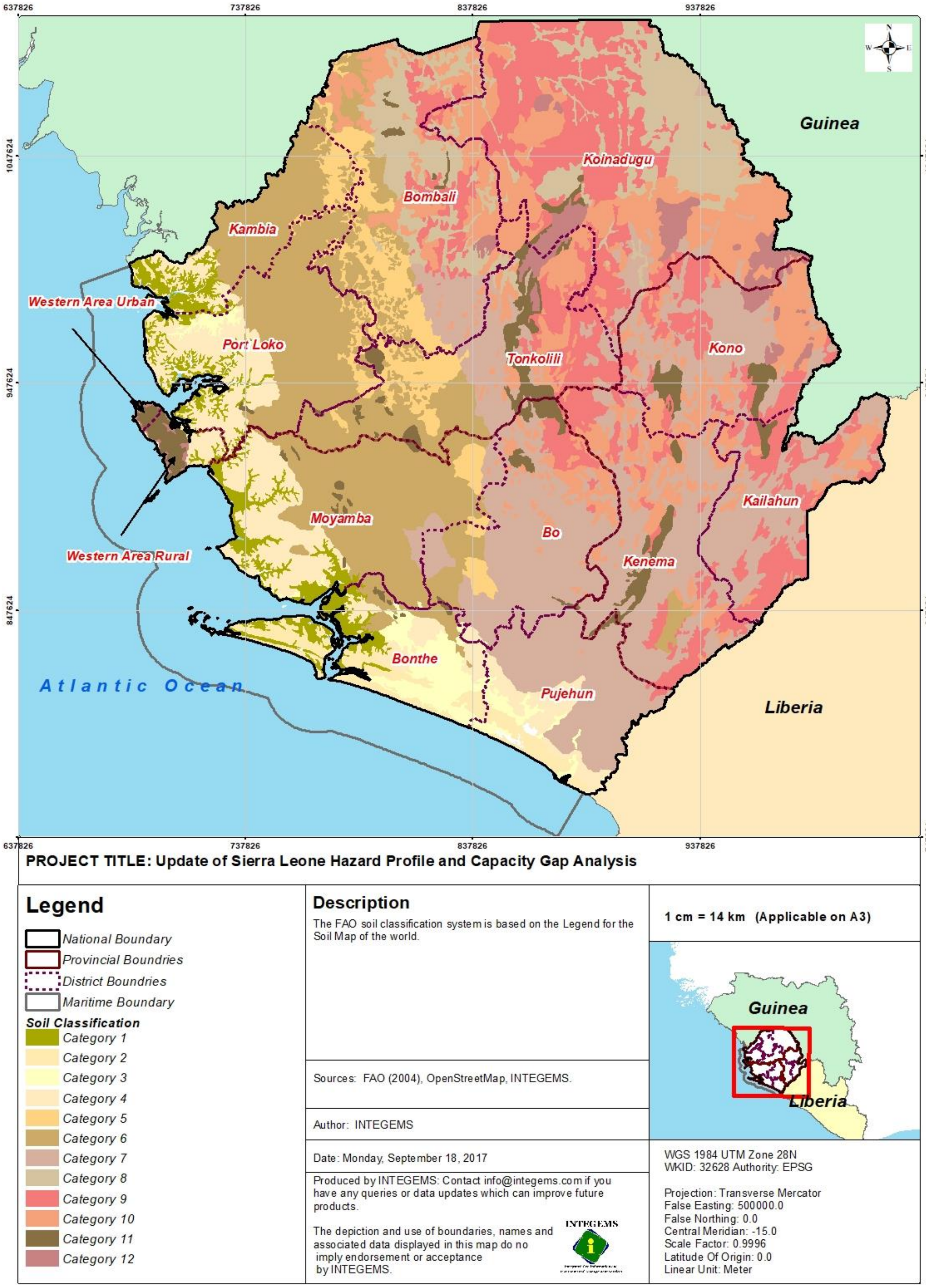


Table 4-8: Soil type classification as depicted on map above

Category	Description
Category 1	Weakly developed muds and hydromorphic clays along coastal river estuaries
Category 2	Undeveloped to weakly developed sand on coastal beach plains
Category 3	Hydromorphic clays and gravel free ferralitic soils on coastal floodplains
Category 4	Gravel free ferralitic soils on coastal terraces
Category 5	Gravelly ferralitic and plinthic hydromorphic soils on inland terraces, depressions and floodplains
Category 6	Very gravelly ferralitic soils over colluvial gravel on western interior plains
Category 7	Gravelly ferralitic soils over weathered granitic basement or colluvial gravel on southern interior and plateau plains
Category 8	Gravelly nodular ferralitic soils over weathered granitic basement on northern interior and plateau plains
Category 9	Stony and gravelly ferralitic soils over weathered granitic basement or colluvial gravel on low to moderate relief hills
Category 10	Stony and gravelly ferralitic soils with shallow soils on moderate to high relief hills formed from predominantly acid rocks
Category 11	Very gravelly ferralitic soils with shallow soils on moderate to high relief hills formed from basic and ultrabasic rocks
Category 12	Shallow soils on plateau mountains and lateritic hills and terraces

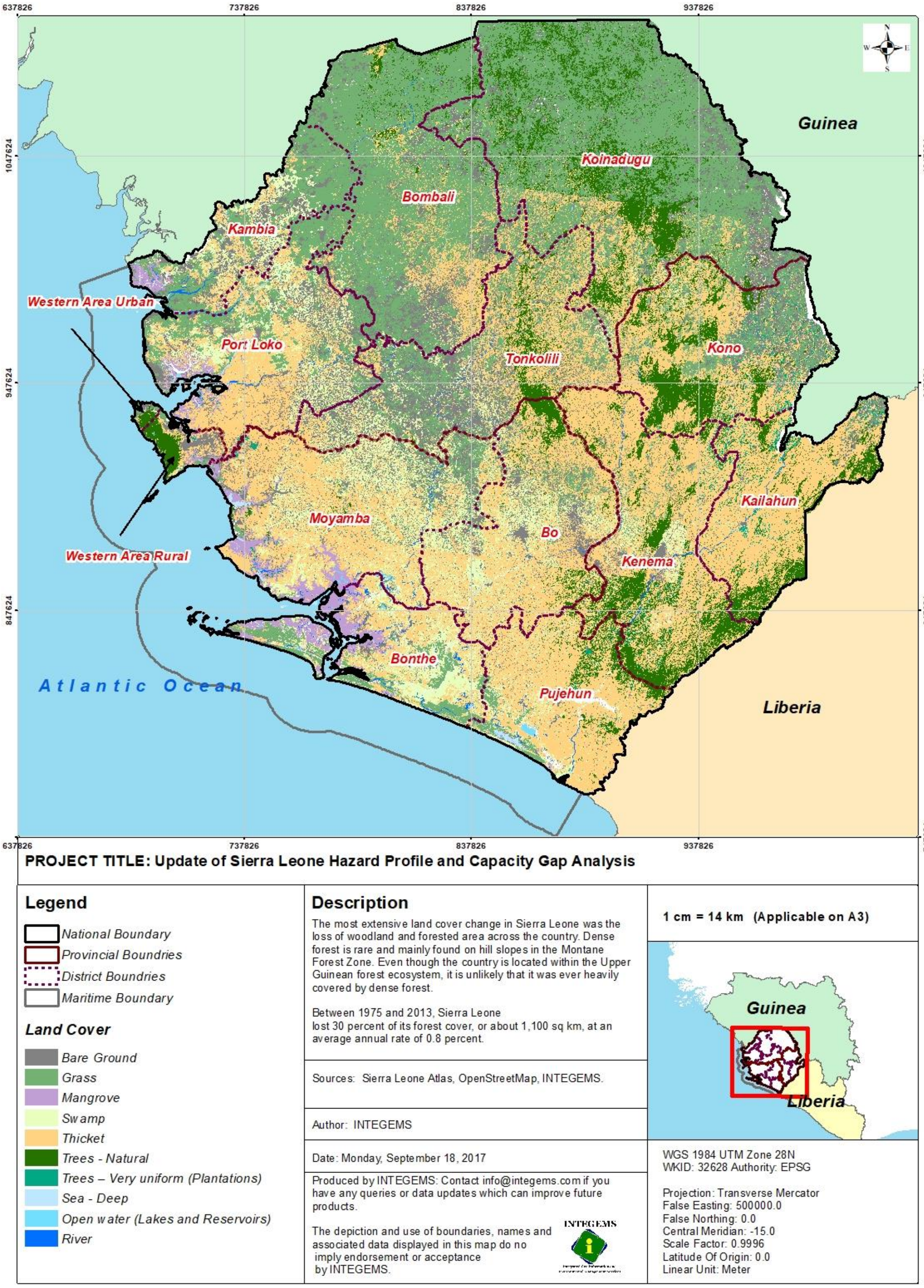
4.1.4.4 Land Cover

The more an area is permanently covered, the less it is susceptible to landslide. Several research studies emphasize on the importance of vegetation cover or land use characteristics on the stability of slopes, and they consider vegetation cover to assess the conditioning factors of landslides. For the slope susceptibility, the land cover map was used to show the relationship between land use factor and landslide occurrence. Five main types of vegetation were identified and were classified according to their potential influence. Table 4-9 and Figure 4-9 below show the different classes of land cover in Sierra Leone.

Table 4-9: Land cover classification and standardized scores

Land Cover	Score
Swamps/ Mangrove	1
Forest	2
Thicket	3
Grassland	4
Bare Ground	5

Figure 4-9: Land cover map of Sierra Leone



4.1.4.5 Rainfall

Rainfall is considered as a major trigger of landslides, which acts as an external stimulus that activates the movement of slopes. Rainfall data were classified as follows:

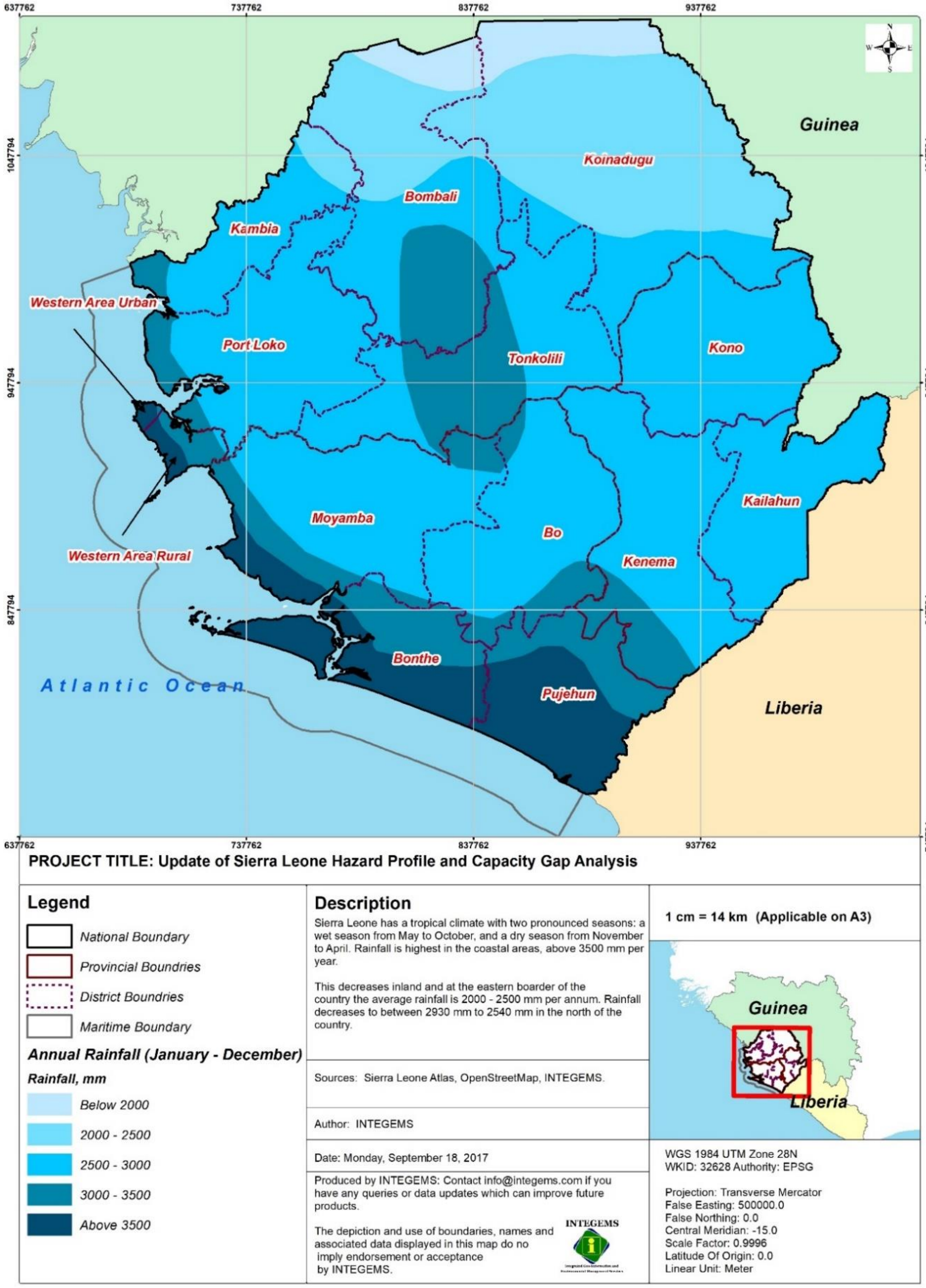
Table 4-10: Rainfall classification and standardized scores

Rainfall, mm/year	Score
< 2000	1
2000 – 2500	2
2500 – 3000	3
3000 – 3500	4
> 3500	5

4.1.4.6 Distance to Roads

Among human activities that can lead to landslides, the distance to road was taken into account. A road segment may constitute a barrier or a corridor for water flow, a break in slope gradient or, in any case, may induce instability and slope failure mechanisms. The distance from roads is computed as the minimum distance between each of the cells and the nearest road represented in vector format. Buffer areas were created along the path of the road in the identified landslide location to determine the effect of the road on the stability.

Figure 4-10: Annual rainfall distribution in Sierra Leone



4.1.5 How to Read the Map

The landslide hazard risk map (Figure 4-11) shows the spatial distribution of risk zones. Colours from green to red indicate the risk classes from very low to very high. The table below illustrates the colours that are used to indicate the different risk zones from the qualitative assessment of landslide hazard.

Table 4-11: Landslide risk colour scheme

Hazard	Descriptor	Description
Very Low	Rare	The event is conceivable, but only under exceptional circumstances
Low	Unlikely	The event might occur under very adverse circumstances
Moderate	Possible	The event could occur under adverse conditions
High	Likely	The event will probably occur under adverse conditions
Very High	Almost certain	The event is expected to occur

4.1.6 Analysis of Hazard Assessment

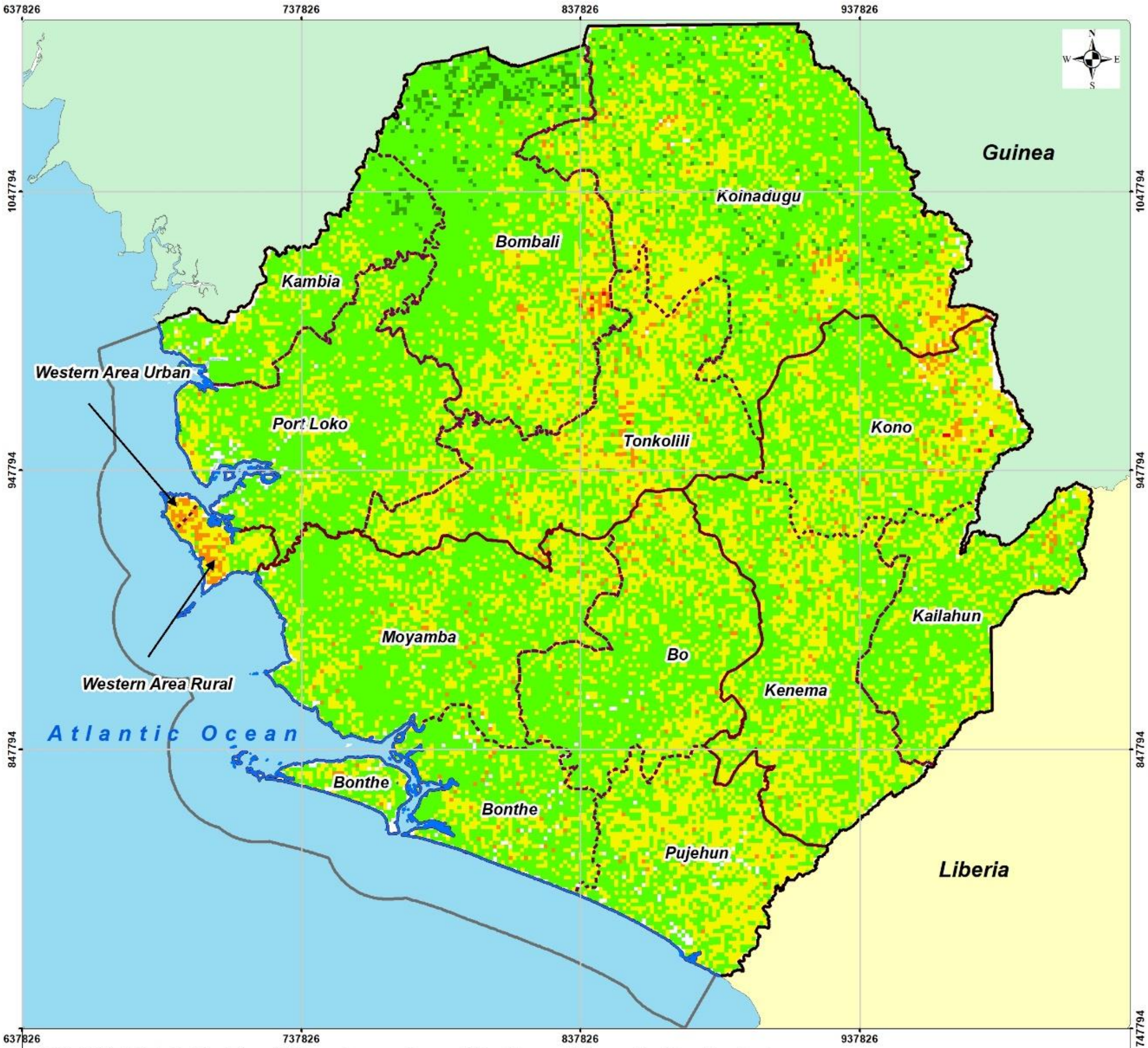
Landslides are characterized by their spatial and temporal occurrence and by their intensity. Intensity can be defined by the volume of the displaced material (in link with landslide depth) and by the velocity of the movement. The intensity a possible slope movement is difficult to foresee as it depends on the magnitude of the triggering event and the environmental conditions (e.g. height of water table) at the onset of the event.

The impacts of a landslide increase significantly with the velocity and the travel (or run-out) distance. The slow and progressive movements do not generally present risk for the human lives, except in the case of crises and potential fluidisation of the landslide mass, but have large impacts on the infrastructures (buildings, roads, etc.). Populations are more vulnerable to sudden, rapid and intermittent landslides (such as mudflows, debris flows and debris avalanches) but the victims still remain rare. Impacts of landslide events are diverse according to the type of movement.

The Sierra Leone landslide hazard risk map (Figure 4-11) shows the spatial distribution of the risk classes for the entire country. The Western Areas (Urban and Rural) are more prone to landslide while the southern and south-western lowlands are of low risk. Due to its hilly topography, Sierra Leone shows moderate risk to landslide. A large part of the country is located in low to medium landslide risk zones. Only 5.2 % of the country is prone to high and very high landslide risk. These high-risk zones are localized in the Western Area. The different risk classes per district are shown in Table 4-12. This was further validated by the results of the field surveys and historical records.

Western Area Urban and Rural Districts have the highest percentage of area exposed to high landslide risk (36.3% and 19%, respectively) and account for the highest number of historic landslide events and the highest number of landslide related fatality and property loss.

Figure 4-11: Landslide hazard risk map of Sierra Leone



PROJECT TITLE: Update of Sierra Leone Hazard Profile and Capacity Gap Analysis

Legend

- National Boundary
- Provincial Boundries
- District Boundries
- Maritime Boundary
- Coastline

Landslide Susceptibility

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

Description

The semi-quantitative slope susceptibility hazard assessment mapping is a general appraisal of the likely of a given area to experiemce a landslide.

Landslide hazard was assessed at a national scale using a semi-quantitative susceptibility index approach by adopting a Spatial Multi-Critera Evaluation (SMCE) method..

The approach considered explicitly seven factors influencing slope stability, namely; slope, lithology, rainfall, land cover, soil type, and distance to roads.

Sources: OpenStreetMap, INTEGEMS, HydroNova, NMA, ASTER GDEM, FAO.

Author: INTEGEMS

Date: Saturday, September 23, 2017

Produced by INTEGEMS: Contact info@integems.com if you have any queries or data updates which can improve future products.

The depiction and use of boundaries, names and associated data displayed in this map do no imply endorsement or acceptance by INTEGEMS.

1 cm = 14 km (Applicable on A3)

WGS 1984 UTM Zone 28N
WKID: 32628 Authority: EPSG

Projection: Transverse Mercator
False Easting: 500000.0
False Northing: 0.0
Central Meridian: -15.0
Scale Factor: 0.9996
Latitude Of Origin: 0.0
Linear Unit: Meter

Table 4-12: Percentage of area exposed to different classes of landslide risk

District	Percentage of Area Exposed to Landslide, %					Area of District, km^2
	Very Low	Low	Moderate	High	Very High	
Kailahun	0	69.2	29.5	1.3	0	4,174
Kenema	0	56.4	42.1	1.5	0	6,182
Kono	0.2	54.3	42.5	2.8	0.2	5,446
Bombali	5.2	66.0	27.4	1.6	0.1	8,211
Kambia	6.9	78.5	14.6	0	0	3,021
Koinadugu	3.5	59.9	34.8	1.8	0	12,415
Port Loko	0	76.6	23.3	0.1	0	5,953
Tonkolili	0.03	47.1	49.7	3.2	0	6,391
Bo	0	65.9	32.6	1.5	0	5,508
Bonthe	0	76.1	22.4	1.5	0	3,558
Moyamba	0	73.6	25.3	1.1	0	6,909
Pujehun	0	47.9	51.3	0.8	0	4,219
Western Area Rural	0	32.5	48.5	19.0	0	590
Western Area Urban	0	16.0	45.7	36.3	0	102
National	**1.13**	**58.57**	**34.98**	**5.18**	**0.02**	**72,679**

4.1.7 Special Remarks

The objective of the study was to assess landslide risk at a nationwide scale. However, there were some issues with data availability, accuracy and detail. The data available did not allow the application of deterministic landslide hazard assessment methods, which are required to derive quantitative landslide hazard maps. Furthermore, the application of statistical or probabilistic methods is not possible because of the lack of a sufficiently complete national landslide inventory. The lack of landslide inventory dataset made the weighting of factors dependent on experts' judgement.

4.1.8 Recommendations

It has been proven that landslides' frequency and extent can be estimated by the use of six factors - lithology, soil type, rainfall, slope, land cover and distance to roads. However, despite these factors landslides remain difficult to predict. It is therefore recommended to conduct a quantitative research on landslides in areas identified as highly susceptible to landslide hazard. This Landslide Hazard Assessment revealed that areas with higher likelihood of hazard are mostly located in the Western Area. It is therefore recommended that local authorities and communities in this region give particular attention to land use and land planning rules including improving settlement regulations in order to keep people and settlements away from landslide-prone areas. In so doing, it directly contributes to reduction of soil erosion and vegetative cover removal and thereby help in the stabilisation of the slopes.

Though there is a significant number of landslide events every year, very less number of events are reported because of resource constraints. Therefore, it is recommended that a national system for collecting and recording landslide data is to develop (Landslide Inventory).

4.2 Flood Hazard Assessment and Mapping

Floods are the most destructive form of natural hazards in both local and global contexts. This is true in terms of both loss of life and property damage. It is also the most prevalent form of natural hazard. No country in the world, except the aridest, can be thought of as entirely free from flooding. In certain regions flooding is more prevalent than in others.

In Sierra Leone, floods are the most common natural hazard that has caused significant negative impacts in different locations and at different scales. Floods cause loss of life. Depending on the type of flood, the losses can be numerous or few. Even when a flood does not cause loss of life, economic damage is almost always present. Economic damage happens irrespective of the nature and the magnitude of the flood. It can be direct damage, such as destruction of property or loss of cultivation, or indirect or intangible damage such as the spread of disease or disruption of social life.

Floods in Sierra Leone can be classified in several different ways. Following is one of the more common and useful ways of classifying floods, based on the source and the nature of flooding.

- Riverine floods
- Flash floods
- Lacustrine floods

It must be stated here that the classes given above are not mutually exclusive: sometimes it may be possible to include a flood into more than one of the above classes. However, in a majority of cases, this classification will be clear-cut. The prevalence of flood hazard in Sierra Leone is mainly due to torrential rainfalls, the country's proximity to the Atlantic Coast and the numerous river/stream network running from the north-eastern highlands to the southwest of the country into the Atlantic Ocean.

Flooding in Sierra Leone generally occurs every year between July and September, when the downpours across the country are heaviest. During this time, surface water runoffs from the catchments converge into the natural and artificial drainage systems in excess causing them to overflow their banks and inundate surrounding areas. Most of the floods are transient with the water receding, sometimes less than an hour after the rains. However, flood waters have been noticed to take up to a week or more before receding. Flooding along the coastal area is not uncommon. Notable areas include the Sewa and Waanje Rivers and the coastal beaches of the Western Area Peninsular.

Areas which have been affected by annual seasonal flooding include: Kroo and Susan's Bays (See Figure 4-14 and Table 4-15); Newton catchments areas; Lumley areas; Torma Bum and Gbondapi in the Pujehun district and New London in Bo City[20]. Flood hazards affect people and activities located in flood prone areas across the country. The effects of flood hazards have worsened with the recent increase in population accompanied with the scarcity of land that has caused people to settle in marginal land and flood prone areas.

Table 4-13: Flood hazard profile

Parameters	**Scale**				
	1	2	3	4	5
Frequency	*Very Rarely*	*Rarely*	*Sometimes*	*Often*	*Frequently*
Magnitude	*Trivial*	*Small*	*Moderate*	*Large*	*Very Large*
Duration	*Very Short*	*Short*	*Average*	*Long*	*Very Long*
Areal Extent	*Limited*	*Very Sparsely*	*Sparsely*	*Densely*	*Widespread*
Spatial Predictability	*Highly Predictable*	*Predictable*	*Likely*	*Randomly*	*Very Randomly*
Speed of onset	*Very Slow*	*Slow*	*Moderate*	*Fast*	*Very Fast*
Importance	*Not Important*	*Somewhat Important*	*Moderately*	*Important*	*Very Important*
Spatial Dispersion	*Very Concentrated*	*Concentrated Moderately*	*Moderately*	*Diffused*	*Widely Diffused*

[20] National Disaster Management Preparedness and Response Plan (ONS-DMD)

Table 4-14: Distribution of reported flood events by district

District	Number of Events
Bo	13
Bombali	1
Bonthe	0
Kailahun	2
Kambia	0
Kenema	7
Koinadugu	0
Kono	1
Moyamba	1
Port Loko	4
Pujehun	5
Tonkolili	0
Western Area Rural	1
Western Area Urban	29
National	**64**

Figure 4-12: Number of reported flood events (DesInventar 2009-2017)

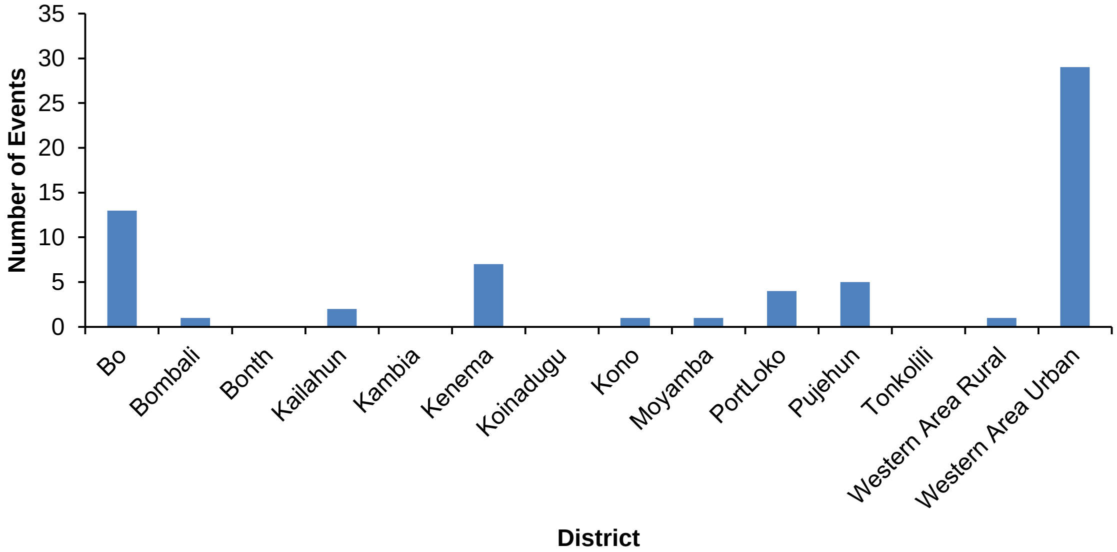


Figure 4-13: Historic flood disasters in Sierra Leone

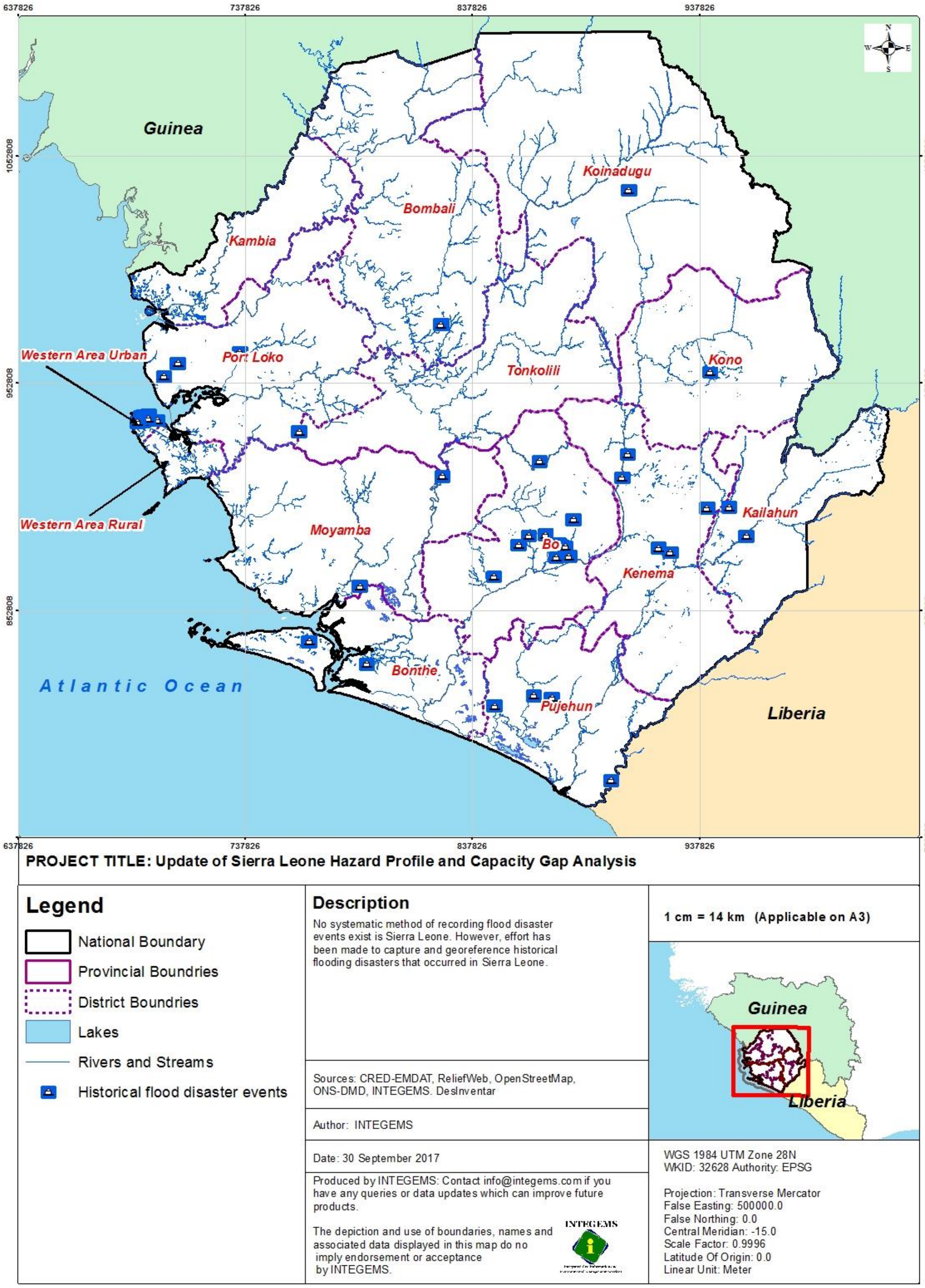


Figure 4-14: Flood prone areas in Freetown

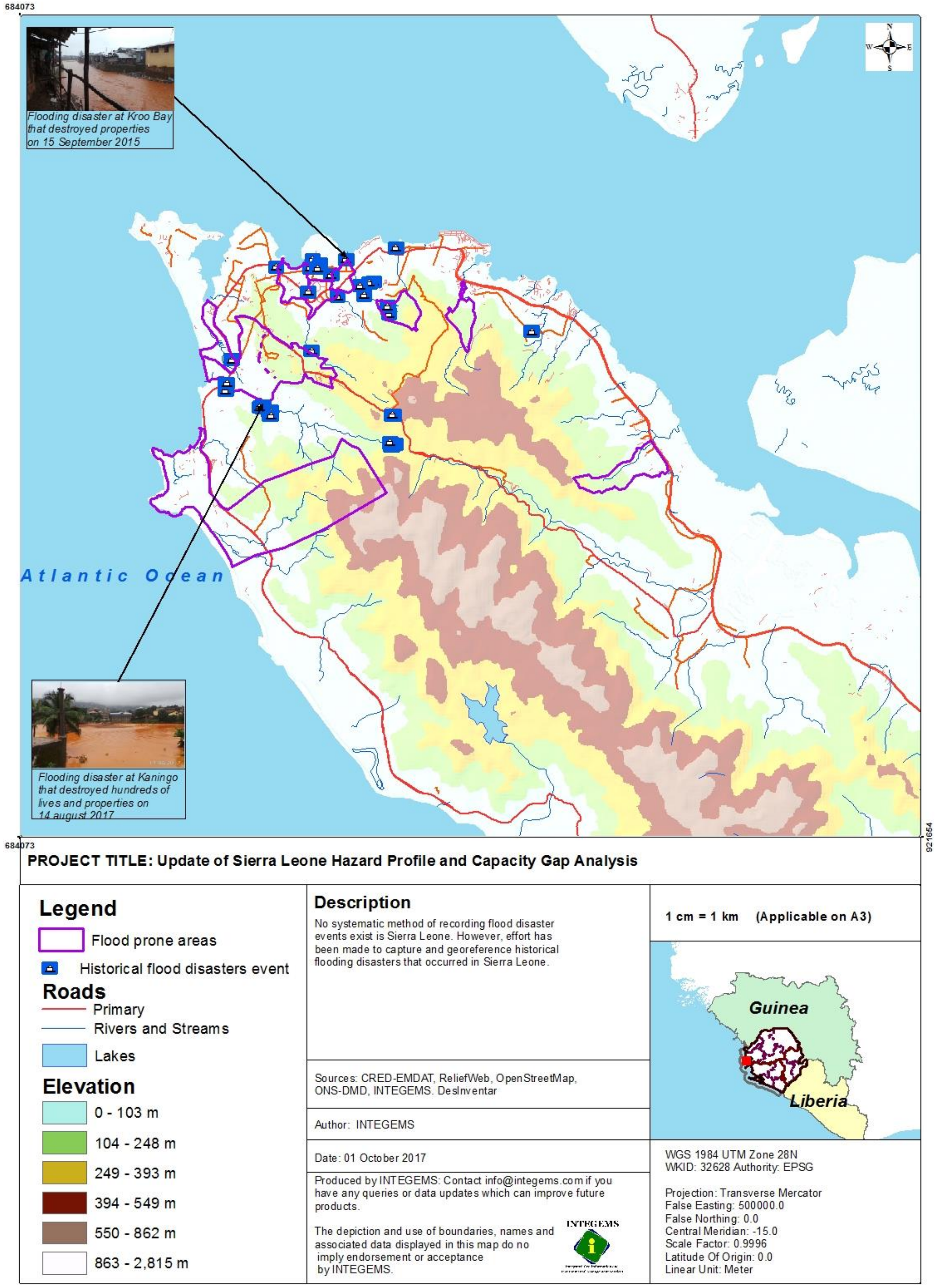


Table 4-15: Historical flood events

District	Chiefdom	Date	Location	Deaths	Affected	Houses Destroyed	Houses Damaged
WAU		13/08/2009	Kroo Bay				
WAU		19/08/2009	Jesus is Lord Ministry, Tower Hill, Ft				
WAU		19/08/2009	Malama, Lumley, Ft	1			
WAU		19/08/2009	Sorie Town Community	2			
WAU		19/08/2009	St. Edwards Primary sch, Forte St.				
WAU		21/08/2009	Aberdeen community, peninsular				
WAU		29/08/2009	Crab town				
WAU		29/08/2009	Old Railway Line Ft				
PUJ[21]		29/08/2009		1		40	
PUJ		09/09/2009	Gbondapi				
KAI[22]		18/09/2009	Daru town			35	
WAU		21/09/2009	Samba Gutter, Ft	1			
WAU	West I	08/10/2009	Kroo Bay				
WAU		08/10/2009	Susans Bay Ft				
PL	Kaffu Bullom	08/10/2009					
BOM		09/10/2009	Makeni Magburaka Highway				
PL	Lokomasama	10/10/2009					
BO	Kakua	24/07/2010	Brima town		300	35	
BO	Kakua	23/08/2010	Gendema		210	10	
KEN[23]		30/07/2011	Nyandeyama and Kpetewoma		437	100	
WAU		08/10/2011	Crab town,Kanigo, Kamayama,Kondi farm	4	250	18	

[21] Pujehun district

[22] Kailahun district

[23] Kenema district

District	Chiefdom	Date	Location	Deaths	Affected	Houses Destroyed	Houses Damaged
KEN		08/07/2012	Kojon village				
MOY[24]	Kori	15/07/2012	Gbehehun, Waiama, Vaama, Njala Kapoima				
PUJ		30/08/2012	Bondapi				
BON		30/08/2012	Bonthe				
WAU		30/08/2012	Hill Cut Road, Freetown	1			
WAU		30/08/2012	Tengbeh Town			1	
Bo	Kakua	08/01/2013			98	7	
KAI		09/01/2013	Lalehun Kovoma		70	5	
WAU		09/01/2013		1			
BO	Kakua	09/03/2013				3	
PL	Marampa	28/05/2013			300	18	
WAU		16/07/2013		1			
WAU		28/07/2013	Old Railway Line Brookfields, Freetown	2		1	
KEN		29/07/2013		2		2	
WAU		29/07/2013		2			
WAU		08/08/2013		1			
WAU		17/08/2013			120	7	
KEN		18/08/2013		1		2	
BON		19/08/2013	Bonthe	1		2	
WAU		20/08/2013				8	
WAU		20/08/2013			123	11	
WAU		20/08/2013					
WAR		22/08/2013	Western Area Urban Peninsular		300		
WAU		29/08/2013				5	

[24] Moyamba district

District	Chiefdom	Date	Location	Deaths	Affected	Houses Destroyed	Houses Damaged
WAU	Kaffu Bullom	14/11/2013		2			
WAU		27/12/2013					
WAU		10/01/2014		2			
WAU		27/04/2014		2			
KON	Tankoro	29/04/2014	Koidu Market		100		
PUJ		17/09/2014		1			
PUJ		05/09/2015	Pujehun		272	16	
BO	Kakua	05/09/2015	Kpan		290		33
BO	Kakua	05/09/2015	Farlu		56		3
BO	Kakua	05/09/2015	Kegbai		124		15
BO	Kakua	05/09/2015	Mbaoma-Lugbu		48		5
BO	Bagbwe	05/09/2015	Njala Gendema		832		62
BO	Bagbwe	05/09/2015	Benduma		492		30
BO	Bagbwe	05/09/2015	Gbonjema		589		33
BO	Baoma	05/09/2015	Gerihun		114		13
BO	Baoma	05/09/2015	Njama		85		10
WAU		16/09/2015	Mainly informal coastal communities	8		123	57
KEN	Simbaru	17/09/2015	Gerihun			150	490
BON		17/09/2015	Bonthe				
PL		17/09/2015			206		
	Sorogbema	12/09/2016	Jendema Customs Integrated Building				1
KEN	Nongowa	24/06/2017	Largo Jasawabu		443	43	
KEN	Lower Bambara	24/06/2017	Meima		244	60	

4.2.1 Map Content

Flood hazard risk maps (see Figure 4-16 - Figure 4-21) have been developed for 10 river basins and estuaries in Sierra Leone and eight (8) major rivers – the Great Scarcies, Little Scarcies, Rokel – Seli, Jong, Moa, Mano, Sewa, and Wanjei (see Figure 4-15). The flood hazard maps show areas at risk of inundation in the different basins and estuaries for a 10 year return period scenario. In common terms, the bigger the return period, the worst is the flood scenario. The flood hazard mapping has been developed at national level. Hence, the maps are not expected to depict any finer detail.

4.2.2 Application of Hazard Maps in Disaster Risk Management

The purpose of developing the hazard maps includes:

- To provide help and support to policymakers, decision makers and planners for future developing master plans and safe development. The authority can take actions to reduce the impacts on various economic sectors like agriculture, housing, tourism, industry, etc.
- To help national, district and local authorities to understand the severity of flood hazards in the country and develop necessary mitigation and preparedness plans.
- To help international and national relief agencies and humanitarian organisations to prioritize hazard disaster preparedness and mitigation interventions.
- To assist stakeholders in the agriculture in changing crop pattern and implementing other non-structural measures for reducing negative impacts on agriculture.

4.2.3 Software and Data for Flood Hazard Assessment

The flood hazard assessment was undertaken with well-established, sophisticated GIS and hydrologic modelling tools. The software packages used for flood hazard assessment include a combination of ESRI's[25] ArcGIS Desktop Archydro Hydrological Analysis Tool, Spatial Analyst, and 3D Analyst Tool, with HEC-GeoHMS[26], HEC-GeoRAS[27] extensions. The Geospatial Hydrologic Modelling Extension (HEC-GeoHMS) is a geospatial hydrology toolkit which uses ArcGIS Desktop and the Spatial Analyst extension to develop a number of hydrologic modelling inputs for the Hydrologic Engineering Centre's Hydrologic Modelling System (HEC-HMS).

Extensive flood hazard mapping is a data-intensive modelling process. Detailed hydrological, meteorological, demographic and geomorphological data are required to produce optimum results and models. It is also imperative to understand the scale of the flood hazard assessment. Quality data are required for site specific flood studies. The application of software and hydrologic modelling systems require the availability of the set of data specified in Table 4-16. However, after an extensive literature review, and consultations, most of these datasets have not been located either from public domain or from the project's implementing partners. Therefore, the current flood hazard maps have been developed based on data available with focal departments and established authentic sources.

Table 4-16: Data requirements and sources

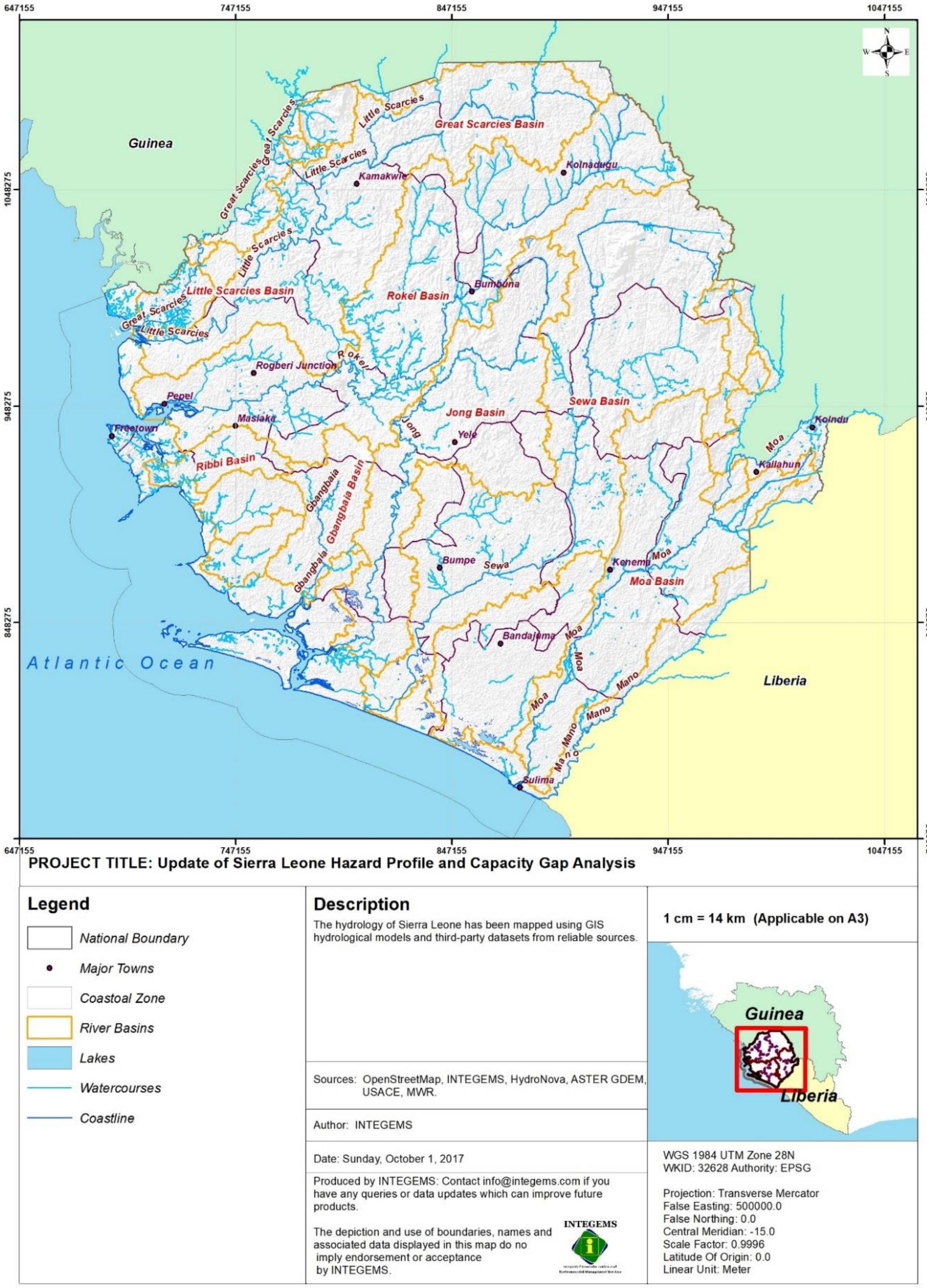
Data	Source
Rainfall	Ministry of Water Resources
Elevation	ASTER GDEM
Land Use/ Land Cover	FAO, USGS
River network and Catchments	OpenStreetMap, INTEGEMS
Historical Flooding Data	DesInventar, Relief Web, Red Cross Society, ONS-DMD, CRED EM-DAT, INTEGEMS

[25] Environmental Systems Research Institute's, Inc. (ESRI); (https://www.esri.com/en-us/home,accessed 7 August 2017)

[26] United States Army Corps of Engineers (USACE) Hydrologic Engineering Center's Geospatial Hydrologic Modelling Extension (http://www.hec.usace.army.mil/software/hec-geohms/, accessed 22 September 2017).

[27] United States Army Corps of Engineers (USACE) HEC-GeoRAS (http://www.hec.usace.army.mil/software/hec-georas/, accessed 22 September 2017)

Figure 4-15: Hydrological map of Sierra Leone



4.2.4 Methodology for Flood Hazard Mapping

The methodology for flood hazard mapping has been developed based on secondary available data from various sources (see Table 4-16). The methodology largely used software ArcGIS ArcHydro Hydrological analysis tools, to extract rivers and stream basins and USACE's HEC-GeoHMS for stream and basin profile characterisation, as stated above. The creation of river basin and river profile has been validated using OpenStreetMap river basin. The following are the steps used in the development of flood inundation maps. - Extraction and profiling of river and basin from ASTER Global Digital Elevation Model (GDEM) using HEC-GeoHMS - Creation of river centre line, bank line, cross section in GIS platform by using HEC-GeoRAS.

Analysing digital terrain data, HEC-GeoHMS transforms the drainage paths and watershed boundaries into a hydrologic data structure that represents the drainage network. The program allows users to visualize spatial information, document watershed characteristics, perform spatial analysis, and delineate sub-basins and streams.

HEC-GeoRAS is a set of procedures, tools, and utilities for processing geospatial data in ArcGIS using a graphical user interface (GUI). The interface allows the preparation of geometric data for import into HEC-RAS and processes simulation results exported from HEC-RAS. To create the import file, the user must have an existing digital terrain model (DTM) of the river system in the ArcGIS TIN format. The user creates a series of line themes pertinent to developing geometric data for HEC-RAS. The themes created are the Stream Centreline, Flow Path Centrelines (optional), Main Channel Banks (optional), and Cross Section Cut Lines referred to as the RAS Themes.

Given limitations in data availability, it was decided to assess flood hazards from the basins and stream from the hydrological analysis using a qualitative flood risk index approach by adopting a Spatial Multi-Criteria Evaluation (SMCE) method. The qualitative approaches consider explicitly a number of factors influencing the flood risk. For this study, the following factors were used:

- Proximity to streams and Coast
- Rainfall
- Land Use/ Land Cover
- Elevation

A range of scores and settings for each factor were used to assess the extent to which that factor is favourable or unfavourable to the occurrence of flood inundation. To make spatial multi-criteria analysis possible, the input layers need to be standardized from their original values to the value range of 1–5. The extent to which each indicator influences or not the overall objective was set (weighting). The influence of a given indicator can be evaluated through its weight when compared to other indicators (see Table 4-17).

Table 4-17: Factors and weighting

Factor	Weight
Proximity to stream and coastline	0.6
Elevation	0.2
Rainfall	0.25
Land Use/ Land Cover	0.05

4.2.5 How to Read the Map

The flood hazard maps (Figure 4-16 - Figure 4-21) show the spatial distribution of flood inundation areas. Colours blue indicate the areas at risk of flood inundation.

Each river flood hazard map shows the following:

- National, provincial, and district boundaries
- River basins
- Flood inundation rivers
- Major roads

Figure 4-16: Flood hazard risk map of Sierra Leone

Figure 4-17: Flood hazard risk map - Western Area

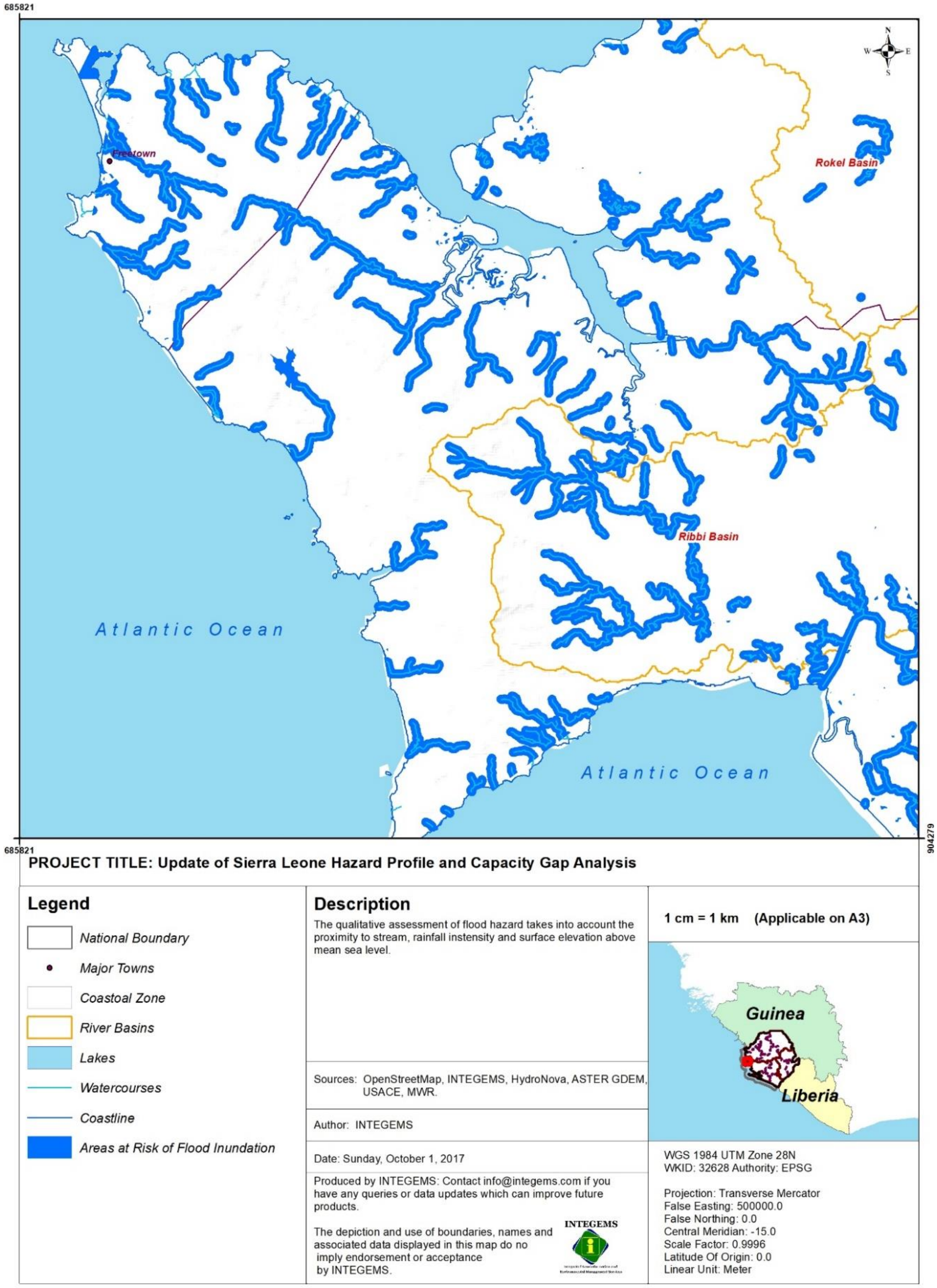


Figure 4-18: Flood hazard risk map - Scarcies River Estuaries

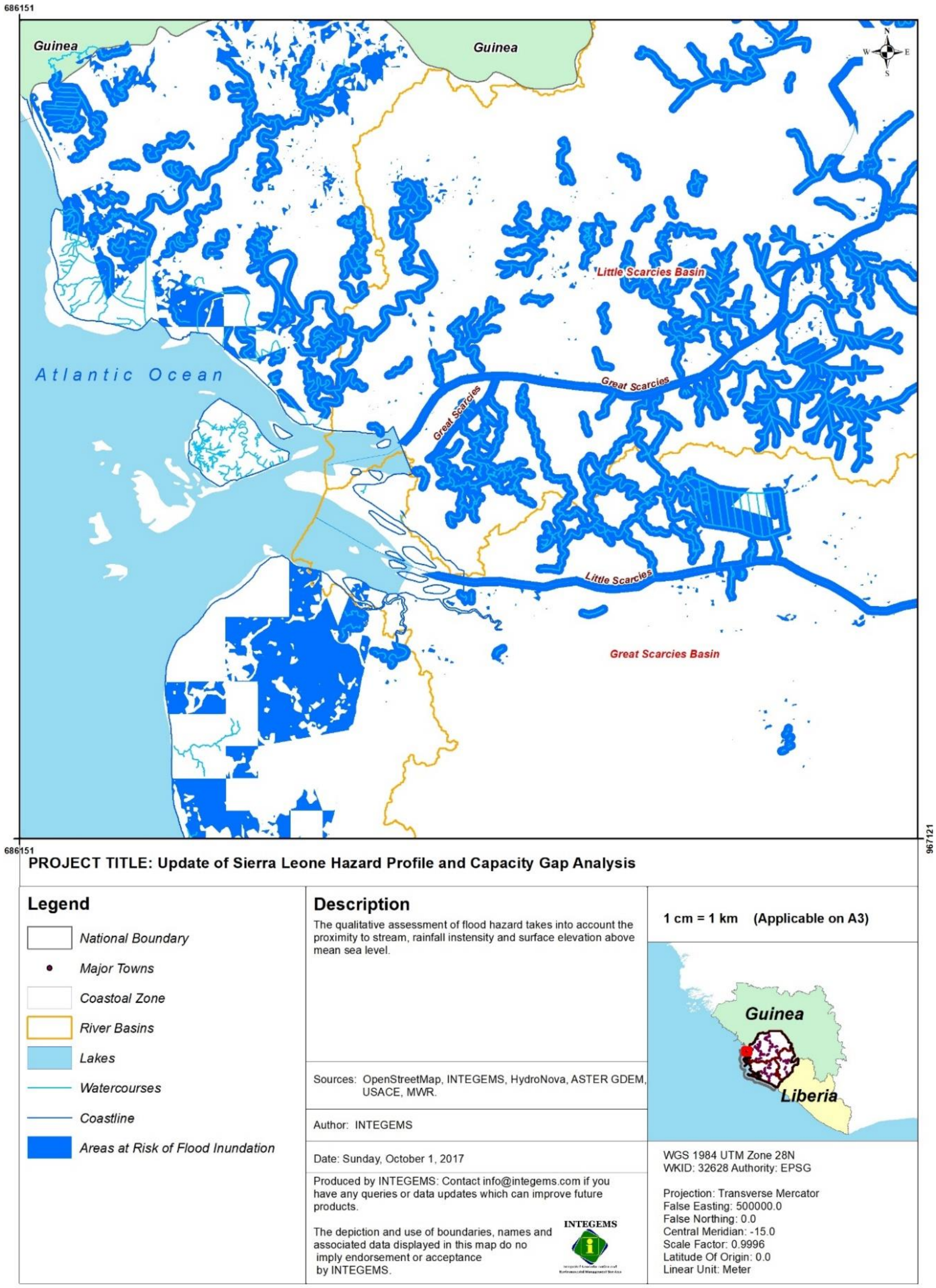


Figure 4-19: Flood hazard risk map -Ribbi and Gbangbaia Basin

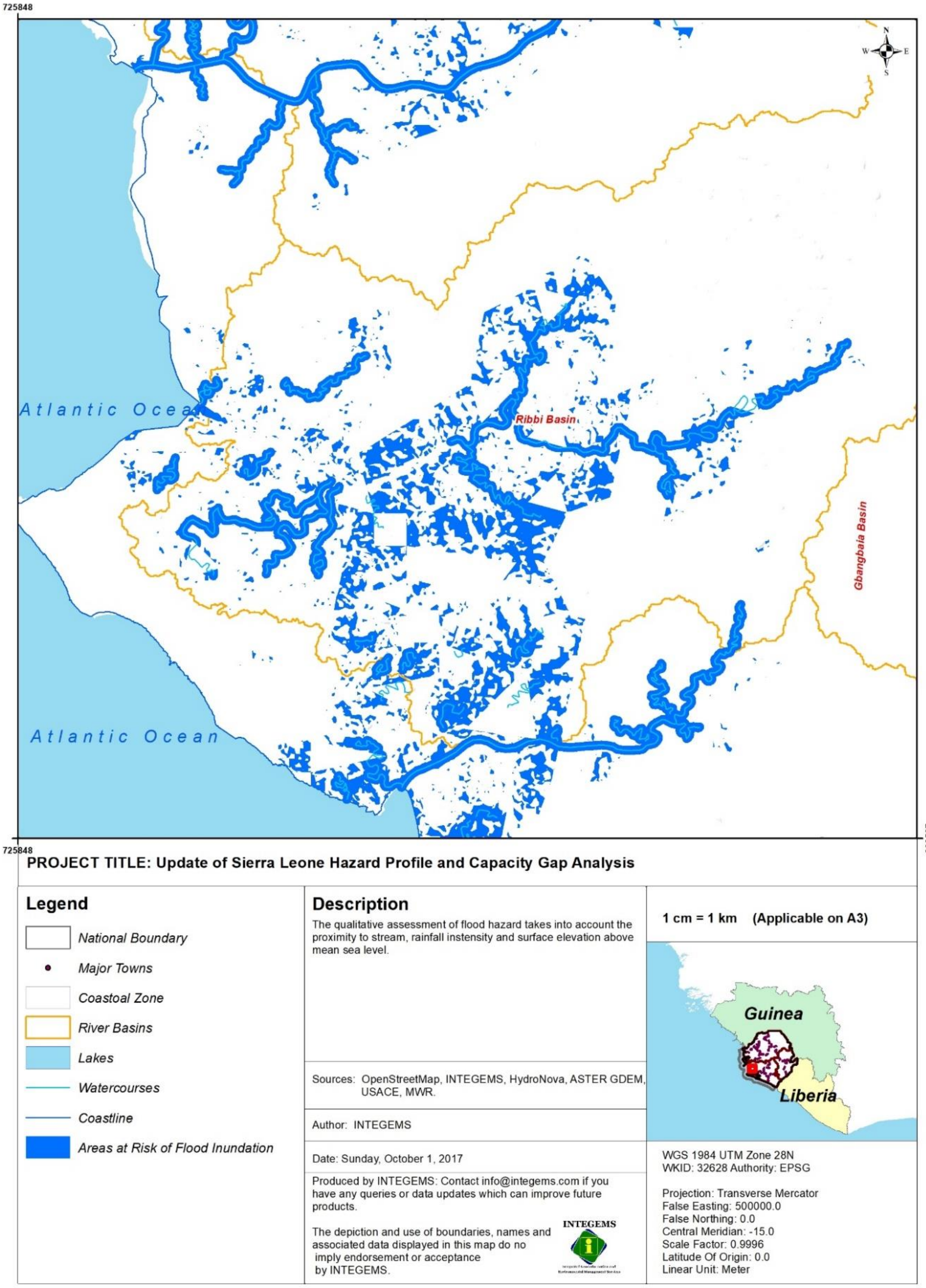


Figure 4-20: Flood hazard risk map - Shebro River Estuary

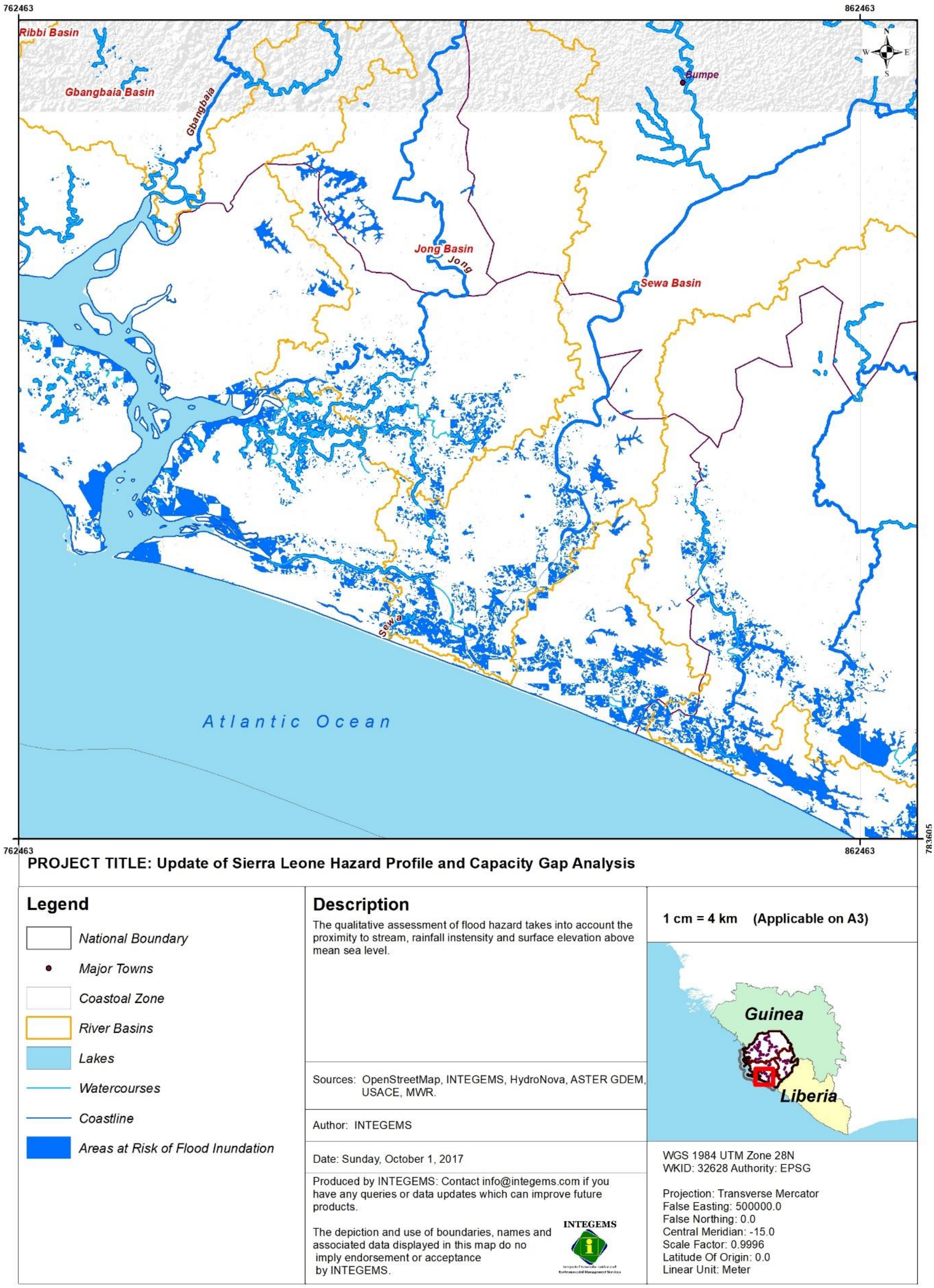
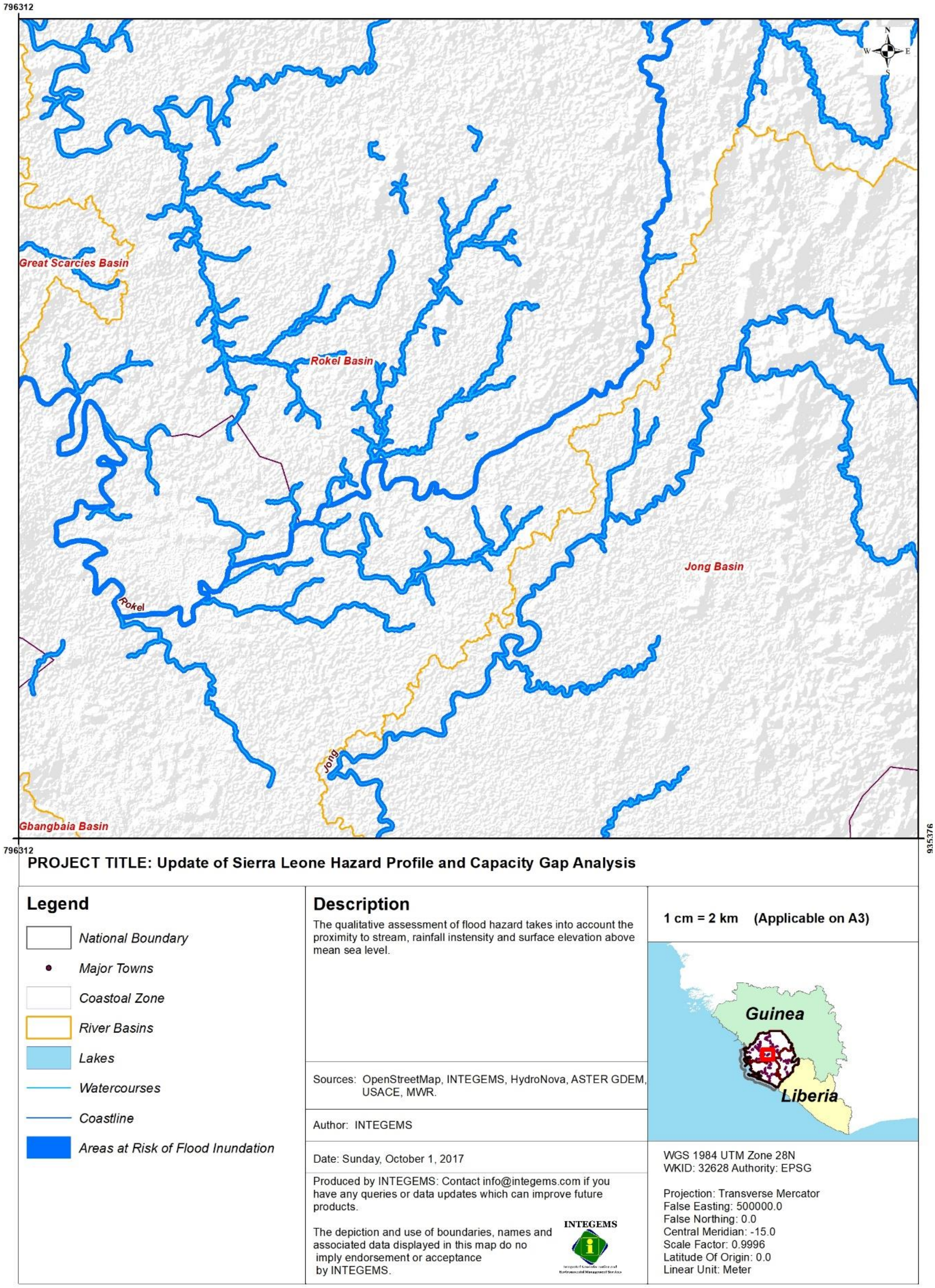


Figure 4-21: Flood hazard map - Rokel River Basin



4.2.6 Analysis of Hazard Assessment

The flood hazard risk maps (Figure 4-16 - Figure 4-21) show areas of inundation in the river basins. The maps for a 10-year return period were overlaid on district maps. The result is providing an area of flood water covered in respective districts. For analysis purpose, the flood water area covered in various districts were worked out for all the 10 major river basins and estuaries.

Based on the topology of Sierra Leone - higher elevations are found in the northeast, and along the Western Area Peninsula of the country with an average elevation of about 800m above sea level. The Northwest and Southern parts of the country which have a lower elevation of less than 100m above sea level are mostly prone to riverine flooding during the wet season when torrential rain cause rivers and streams to over flow their banks. The coastal areas (i.e. districts that are in the south-west of the country - Moyamba, Bonthe, Bo, Pujehun) will be largely affected by 10 year return period flood. The return period is proportional to flood coverage area. As the return period is increasing from 10 through 25 to 100 years, the coverage areas for flood are expected to increase in proportion.

4.2.7 Recommendations

- The flood hazard assessment does not give information on some intensity parameters of flood events such as duration and speed. Therefore, it is recommended that the future studies remove various assumptions as introduced in this research. In addition, the calibration and validation can be done by taking into account discharge, flood depth and duration in different locations of floodplains. Note that, the extent of information currently can only be provided using a participatory approach which is sometimes uncertain and inaccurate. It is recommended that relevant monitoring systems (i.e. hydrometric stations) can be put in floodplains that are reported to be affected by flooding.
- The flood hazard maps have been developed at national level scale using secondary data. The hydrological and hydro-meteorological data for flood hazard assessment are scarce and requires efforts to collect and compile for precise flood hazard mapping. The current flood hazard maps show a broader picture of areas under flood inundation. However, it is imperative to carry out site specific flood hazard mapping for local level planning.
- A detailed localized assessment is needed to help policy makers, planners, decision makers and related actors to better plan and implement an effective flood management system. The detailed local assessment can be done by removing assumptions introduced by this research. High temporal rainfall and river discharge datasets are highly needed for sustainable flood management.

4.3 Drought Hazard Assessment and Mapping

Over the last three decades, few areas in the north and eastern part of the country have experienced either a short or long dry period even within the wet season. A typical case of drought-like conditions was experienced in Kono in 2010 lead to a massive crop failure. The northern and eastern regions of the country experience dry spell while, the southern and western regions are mostly affected by floods, both of these events affect the agricultural production.

The study on drought in time and space is most essential. It is important to study the probability of having a consecutive dry period during the growing season of a crop. The present study on drought in Sierra Leone is the first attempt to analyze drought by using standardized precipitation and soil moisture indices. The probability for having a drought varies from the western part of the country to the Northern. Note that, in general the chance for having drought are below 50% across the country and zero in the west in both rainy and dry seasons. Normally, the northern part of the country records more rainfall anomalies than the western part. Koinadugu and Bombali districts receive the lowest precipitation while higher precipitations are recorded in western parts of the country especially in Freetown.

Drought is a slow-onset hazard since it is a creeping phenomenon. It typically unfolds on a timescale of months to years. This makes drought difficult to determine its onset and end. The impact of drought goes beyond the spatial area directly affected by the shortfall of precipitation and varies in space and time. This is because the shortfall of precipitation has both direct and indirect impacts.

All droughts originate from a deficiency of precipitation. In contrast to aridity, which is a permanent feature of regional climate, drought is a temporal aberration, relative to some long-term average condition of balance between precipitation and evapotranspiration in a particular area, a condition often perceived as "normal". The drought hazard is a function of rainfall, evapotranspiration and moisture. The rainfall amounts and distribution, soil water reserves and evaporation losses combine to cause crop loss. Rainfall is below normal expectation (average) in a number of areas for an extended period especially in the (extreme) north notably, Kabala. Drought-like conditions prevails in such areas at the peak of the dry season between January and March. During these periods the water table becomes very low and moisture deficit can be experienced in the first 100 – 120 cm.

It is evident that there is an apparent surface and ground water shortage. This affects crops considerably, resulting to supplementary irrigation especially in the uplands. The rainfall distribution across the country is not homogeneous. The spatial and temporal patterns of rainfall are influenced by the morphology and topography of a given region. The average rainfall in western area is above the national average. Meanwhile rainfall in the northern and eastern part of the country is below the national average. Elevation is one of the main factors that influences rainfall distribution.

In addition to precipitation, a number of other factors play a significant role in the occurrence of drought. These are evaporation (affected by temperature and wind), soil types and their ability to store water, the depth and presence of ground water supplies and vegetation. Taking this into account three types of droughts are commonly noted: meteorological, agricultural, and hydrological.

Meteorological drought is defined by a precipitation deficiency over a pre-determined period of time, while agricultural drought is defined more commonly by the lack of availability of soil water to support crop and forage growth. Hydrological drought is defined by deficiencies in surface and subsurface water supplies relative to average conditions (UNISDR. 2009). There are clearly strong relationships between the three types of drought especially during prolonged periods of rainfall deficiency, although with leads and lags in terms of their respective onsets and departures.

4.3.1 Map Content

The drought hazard risk map (see Figure 4-24) modelled in this study shows the probability of an area to be affected by a drought or a complete crop failure as explained in the methodology. The map has been developed based on Standard Precipitation Index (SPI). The SPI has been developed on the data collected from uniformly distributed 38 meteorological stations across the country for the period of 1941 to 1960 (Gregory, 1965) and 2007 to 2013, provided by the Ministry of Water Resources.

The risk map has been developed based on the probability of occurrence of droughts with class of severity such as very low, low, moderate to severe.

4.3.2 Data Availability from Sources

Reliable supporting documents, maps, appropriate models and methods for drought assessment were collected from different sources. Based on data quality, quantity and their spatial distribution 14 out of the 38 meteorological stations were selected as representative stations covering the entire country. The necessary climatic data required for computing the indices, i.e., monthly total rainfall and monthly mean temperature were collected from the Ministry of Water Resources and Meteorological Agency for the period of 1941-1960 and 2007-2013. Some of the sources for data is as below:

- Salone Water Security[28]
- Ministry of Water Resources
- Statistics Sierra Leone[29]
- Hydrology of Sierra Leone, Hydro Nova Final Report August 2017
- CIDMEWS-SL[30]

[28] https://www.salonewatersecurity.com/rainfall (Rainfall Monitoring Stations and Records; accessed 28 September 2017)

[29] https://www.statistics.sl/wp-content/uploads/2017/01/final-results_-2015_population_and_housing_census.pdf (Accessed 29/8/2017)

- National Climatic Data Center, 2006. Climate of 2006, U.S. Standardized Precipitation Index.
- World Meteorological Organisation, 2005. Meteoworld (weather. Climate. Water), WMO, August 2005.

4.3.3 Methodology

The methodology adopted for this study is utilizing the Standard Precipitation Index (SPI) to analyze the susceptibility of Sierra Leone to drought conditions.

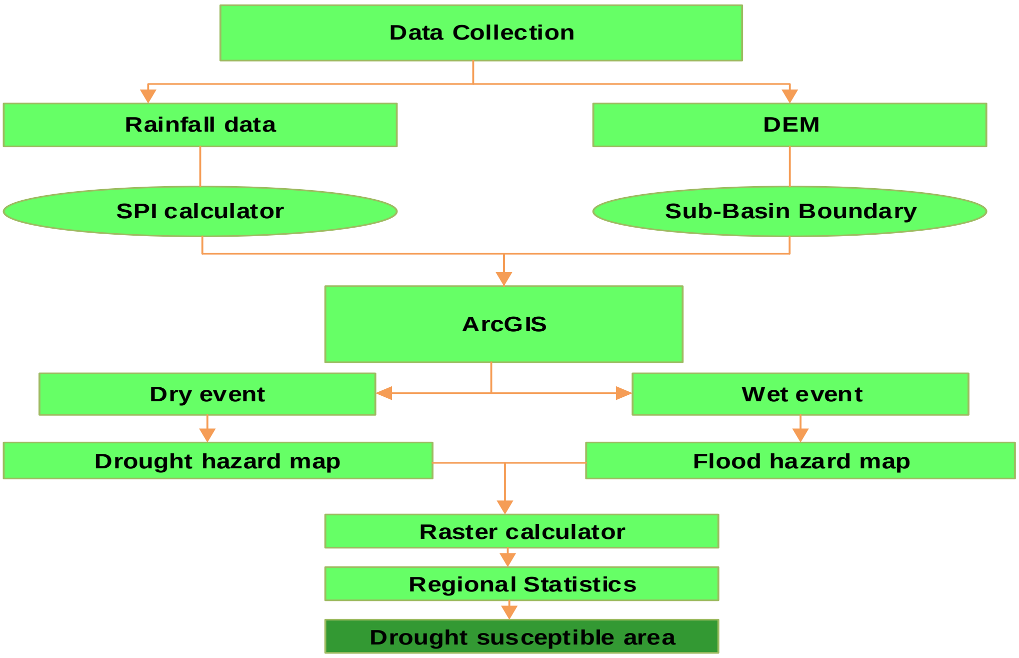
SPI is used to quantify the precipitation deficit for multiple time scales and investigate the temporal and spatial variation of drought and its severity. The SPI is a tool developed by McKee et al., 1993 for the purpose of defining and monitoring local droughts. SPI is value added information related to cumulative effects of a prolonged and abnormal moisture deficiency based on statistical computation. It is based on equi-probability transformation of aggregated monthly precipitation into a standard normal variable. It has advantages of statistical consistency and the ability to describe both short-term and long-term drought impacts through the different time scales of precipitation anomalies. The SPI calculation is based on two assumptions first is the variability of precipitation is much higher than that of other variables, such as temperature, potential evapotranspiration (PET) and the other variables are stationary. SPI having some limitations also that it relies on one input that is precipitation.

Table 4-18: Standardized Precipitation Index (SPI)

SPI Value	Class
> 2	Extremely Wet (EW)
1.5 to 1.99	Very Wet (SW)
1.0 to 1.49	Moderately Wet (MW)
-0.99 to +0.99	Near Normal (NN)
-1.0 to -1.49	Moderately Dry (MD)
-1.5 to -1.99	Very Dry (SD)
< -2.0	Extremely Dry (ED)

The flowchart in Figure 4-22 shows the process of drought hazard assessment.

Figure 4-22: Methodological framework for drought hazard risk mapping



The drought susceptibility mapping for this study begins with delineation of Digital Elevation Model (DEM) of Sierra Leone which serves as the base template. Time series of drought indices is used as input in ArcGIS to depict the spatial variation of drought event in the country. SPI is computed by equi-probability transformation of aggregated monthly precipitation gamma distribution into a corresponding standard normal quantile as the SPI. The SPI represents a z-score, or the number of standard deviation above or below that on event is from the mean. This computed SPI value fed into ArcGIS software with its location and interpolating with the help of spatial analyst tool. The obtained thematic maps are then reclassified according to the event in two classes by assigning the negative value to weight 1 as drought event and positive value to weight 0 as normal condition to obtain drought hazard map.

The obtained drought map is depicted in Figure 4-24. To measure the natural anomaly risk, hazard index is computed which focuses on the probability of crop failure combined with the degree of rainfall variability. Low drought hazard index indicates relatively low chances of crop failure, and High indicates an increased probability of crop failure, due mainly to rainfall variability.

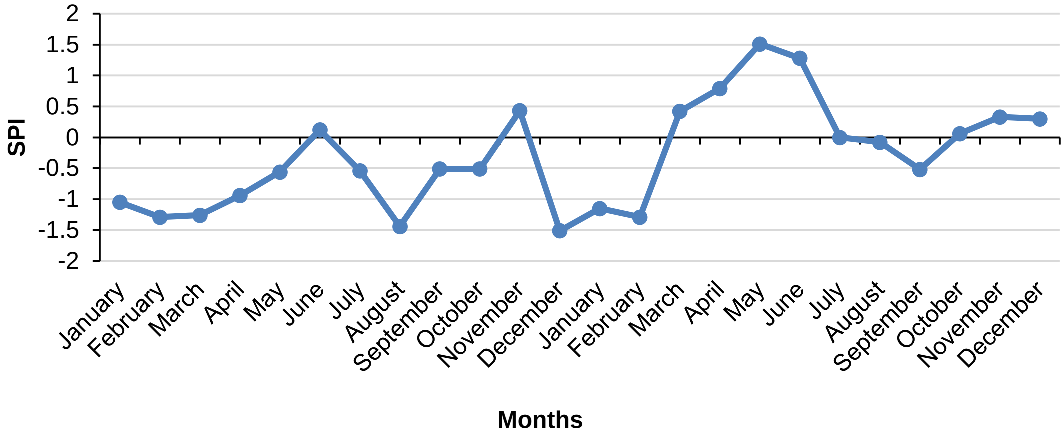
Table 4-19 shows rainfall statistics of 38 meteorological stations for the period of 1941 to 1960 (Source: Ministry of Water Resources).

Monthly SPI provides a lot of useful information about the drought. Time series plot of SPI (Figure 4-23) shows the onset of drought, and its duration. Further, it provides information on drought intensity. Therefore SPI is a very good index for monitoring the drought. For example Figure 4-23 is the time series plot of 3-monthly SPI for Bo from 2009 to 2010. It shows that the 2010 dry spell started from December, reached its highest intensity and lasted for almost three months.

Table 4-19: Monthly rainfall (1941-1960), mm

Station	J	F	M	A	M	J	J	A	S	O	N	D
Bonthe	17	25	17	112	267	572	881	754	615	351	178	66
Rokupr	6	14	15	64	175	376	630	747	460	358	152	25
Daru	12	33	107	147	251	284	284	368	409	333	206	64
Freetown	11	11	21	56	165	356	892	836	592	274	132	48
Makeni	9	9	43	99	224	386	488	615	566	432	196	28
Yengema	11	28	102	150	218	318	312	394	427	307	180	48
Batkanu	7	5	30	74	201	371	445	457	411	389	175	23
Bonthe	14	24	76	130	239	338	485	566	495	373	188	53
Cline Town	12	12	14	56	178	335	851	792	615	287	147	43
Hangha	13	28	114	160	231	274	340	505	488	330	193	46
Hill Station	20	12	15	61	221	533	1290	1189	851	373	163	64
Kailahun	17	38	94	185	264	338	315	427	450	376	183	48
Kambia	4	4	21	61	198	345	625	711	462	330	140	25
Kissy	6	8	20	58	188	361	810	876	630	310	152	46
Marampa	6	6	36	84	198	287	432	549	442	396	206	30
Newton	10	12	20	66	206	368	732	798	528	356	147	51
Njala	14	17	79	127	236	338	445	508	417	351	183	48
Pepel	5	3	20	69	185	284	589	632	447	302	137	33
Mabang	14	9	36	94	221	351	597	645	478	351	178	43
Congo Valley	11	14	20	69	216	483	1361	1417	942	414	183	64
Regent	18	11	16	69	226	485	1361	1336	917	371	152	48
Sembehun	5	15	43	117	231	361	610	589	538	320	173	46
No 2 River	8	11	12	51	201	663	1694	1488	925	333	150	43
Bauya	7	17	30	71	229	310	503	668	475	307	170	46
Mabonto	14	18	58	122	224	338	526	823	569	457	191	38
Port Loko	4	10	28	84	183	351	546	663	399	368	157	36
Kenema	19	33	97	147	221	323	378	546	429	310	168	46
Pendembu	14	30	107	168	251	287	325	406	406	343	160	53
Myamba	4	11	28	81	196	333	447	554	381	290	150	36
Bunumbu	10	48	114	196	216	330	323	373	427	343	178	41
Sulima	31	25	61	104	429	820	902	688	762	386	191	76
Lungi	13	6	30	66	224	368	749	810	559	312	160	43
Sumbaria	8	25	89	127	264	318	376	414	447	414	208	36
Kabala	16	13	58	102	191	305	338	391	414	348	117	28
Musaia	11	14	46	79	188	269	305	323	353	318	130	15
Pujehun	23	25	64	145	226	424	767	686	643	351	188	51
Tower Hill	20	11	21	58	203	424	914	772	643	315	150	58
Sumbuya	20	41	61	94	193	368	500	493	536	340	201	56

Figure 4-23: Time series plot of 3-monthly SPI for Bo from 2009 to 2010



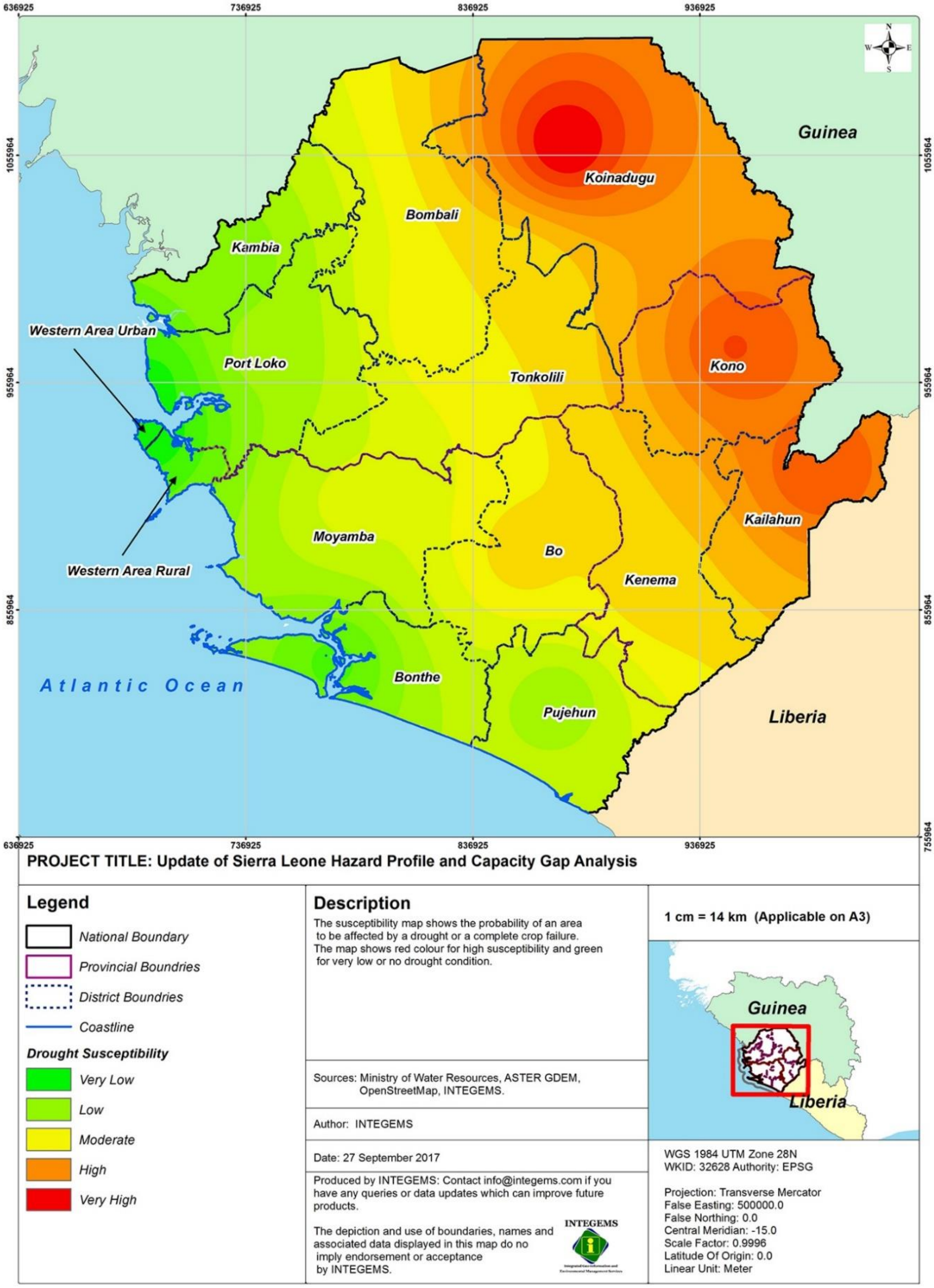
4.3.4 How to Read this Map

The drought risk map (see Figure 4-24) has been prepared based on the probability of occurrence of droughts (very low, low, and moderate to extreme) in 14 selected meteorological stations. The climatological drought susceptibility map in the dry season shows in terms of classification from low to high drought susceptible areas. In empirical manner, drought low susceptible and high drought susceptible areas have been categorized as areas having 15% to 20% and more than 20% probabilities respectively, based on the analysis of probability of occurrence of drought at various stations. The hazard severity map shows red colour for high susceptibility and green for the no drought condition.

Table 4-20: Drought hazard risk

Hazard	Descriptor	Description
Very Low	Rare	The event is conceivable, but only under exceptional circumstances
Low	Unlikely	The event might occur under very adverse circumstances
Moderate	Possible	The event could occur under adverse conditions
High	Likely	The event will probably occur under adverse conditions
Very High	Almost certain	The event is expected to occur

Figure 4-24: Drought susceptibility map for dry season



4.3.5 Special Remark

The drought assessment has been carried out using one of the most practiced indices called Standard Precipitation Index (SPI). The index has been developed based on rainfall data collected from uniformly distributed meteorological stations.

The present study was conducted to prepare the drought hazard map considering it broadly as a hydro-meteorological hazard using time series of rainfall and evapotranspiration data only. Therefore a detailed study considering other factors contributing to drought is needed in order to produce a series of maps with finer resolution to identify the drought hazard to use in future systematic planning.

4.3.6 Conclusion and Discussion

Based on SPI criteria, the following conclusions on drought years can be drawn from the study. The districts of Kono, Koinadugu and Bombali are highly susceptible to drought conditions compared to other districts in the dry seasons. Note that all districts of the southern, eastern province and western area are very low in drought susceptibility. Kabala in the Koinadugu district is the most exposed to high probability of being affected by droughts, where 80% its total area are in high drought risk classes.

The probability for having a drought varies from 0% in the Western part of the country to 26% in the North. Note that, in general the chance for having drought are below 50% across the region and zero in the west in the dry season. Normally, the northern and eastern part of Sierra Leone records more rainfall anomalies than the western part. Koinadugu and Bombali Districts receive the lowest precipitation while higher precipitations are recorded in mountainous part of the country, especially in the Western Area. The drought risk map shows a high correlation between rain distribution and crop performance across the country in both the dry and rainy seasons. During the dry season, the area with low rainfall are those with less crop performance. The dry season receives less of precipitation which leads to a poor crop performance as the rainfall is not well distributed across the season.

Base on the present study, it is recommended that emphasis should be given for installation of monitoring equipment to measure water holding capacity and wilting point (soil properties) of different type of soils of Sierra Leone to calculate Soil Moisture Index directly which also play a key role in drought modelling. Study on wet and dry spells should be also be carried out to monitor agricultural drought. As climate change and climate variability impacts keep worsening, droughts could cause much suffering on communities destroying crops, animals and livelihoods, especially in the northern province of the country. Thus long-term monitoring of climate is highly recommended. Finally, it is recommended to conduct detail study on soil types and their ability to store water, the depth and presence of ground water supplies. All these factors play important roles in the occurrence of drought.

4.4 Coastal Erosion Hazard Assessment and Mapping

4.4.1 Background

Coastal regions of Sierra Leone are greatly influenced by the Country's location along the Atlantic Ocean, where complex land-ocean systems and interactive elements have dynamic relationships that determines the behaviours of the coastal nature. The coastal region extends along the Atlantic for about 400 km. The coastal zone and the Exclusive Economic Zone (EEZ) of Sierra Leone covers an area of about 160,000 km^2 from Kiragba in the north to Mano in the south. The sheltered coast is dominated by extensive mangrove systems 230 km and mudflats. It is a flat, low-lying, and frequently flooded plain that is between 8 and 40 km wide and is composed mainly of sands and clays. Its numerous creeks and estuaries contain mangrove swamps. Sandbars, generally separated by silting lagoons, sometimes form the actual coast.

Coastal erosion is a loss or displacement of land along the coastline resulting from beach-ocean interaction coupled with human activity. In its natural state, the coastal system is in dynamic equilibrium. Coastal forms and shapes are governed by the natural phenomena, which correlate the ocean systems as well as vigorous sediment supplies from land, particularly in the form of river alluvial. Sand and sediment are moved from one location to another, driven primarily by the wind, waves, long shore currents, tides, runoff of surface waters, or groundwater seepage. However, the sand and sediment do not leave the system altogether (unless human activities, such as dredging, permanently remove them from a particular location).

Coastal erosion is a powerful damaging socio-natural hazard that Sierra Leone is facing, mainly due to inadequate human activities along the coast. Resulting from illegal land reclamation and sand mining along the coast, coastal erosion is seriously threatening lives and livelihood of coastal communities. Northern, Southern, Eastern Regions and the Western Area are all vulnerable to coastal erosion, but sea level rise and coastal erosion are mostly affecting and visible along several coastal lowland areas such as Lakka Beach, Conakridee, Krim area, Shenge, Plantain Island, Katta and Bunce Island, Adonkia, Mahera Beach in Lungi area, Bullom shores, Moa Wharf, and Man of War Bay, causing physical alteration of coastline and destruction of infrastructures.

For example, at Conakridee the sea has moved about 100 meters inland over the last 15 years burying several houses under the sea (see Figure 4-27); and at Shenge, the coastline has moved over 50 meters inland in 10 years threatening several public buildings, including a secondary school and road network. In addition to loss of properties and beaches, coastal erosion and sea level rise's consequences include population displacements, coastal flooding and saline intrusion which threaten coastal aquifers, fresh water resources and agricultural water resources, undermining subsistence of local communities. Coastal erosion poses many challenges to coastal communities when property is lost or damaged by this dynamic process. Beach erosion control and restoration are thus leading concerns in coastal communities.

4.4.2 Coastal Hydrodynamics

The ocean systems are featured with frequencies and seasons of hydrodynamics, varying from seconds, to hours, to months to years. Hence, the temporal variability of coastal dynamics is mainly governed by the temporal distribution of the coastal hydrodynamics. The Sierra Leone continental shelf is located in a unique position on the West African coast where it comes under the influence of the Guinea Current, southern off-spins of the Canary Current, the Equatorial Counter Current and the coastal drift occurring in the shallower waters. The resultant effect of these forces is crucial to the ecology of the shelf by creating a vacuum in the northern parts of the shelf and generating some amount of upwelling so necessary for primary production.

Currents are dynamic features of coastal waters of Sierra Leone and affect the coastal zone in a number of ways. The surface currents are significantly influenced by the Southeast and Northeast trade winds. During the spring (March Equinox to June Solstice) in the Northern Hemisphere when the Southeast Trade Winds noticeably weaken, the Northeast Trade Winds are fully developed. During this period the Canary Current intensifies bringing cool water to the coast of Sierra Leone. This current generally flows in a south-easterly direction at the surface in the near-shelf regions.

4.4.3 Coastal Sediment Balance

The shoreline stability is determined by the sediment budget of the coastal area. Positive net sediment balance always results in stable accreting beaches, and negative net sediment balance results in erosion. The sediment budget is balanced with sediment supplies and losses in natural and anthropogenic means. In Sierra Leone almost all the coastal areas are fed by river supplies. The supplied sediment is distributed, and coastal shapes are formed by the local hydrodynamics. Since the hydrodynamics in the coastal areas are with variable frequencies and intensities, sediment balance at the extreme dynamic conditions establishes the coastal stability. The shoreline instabilities create momentous impacts on physical, social-economic and environmental features in the coastal zone.

Long shore drift current is the main mechanism by which sediments are transported along the Sierra Leone coast. The sediment transport takes place mainly within 1–10 m water depth. Three main longshore drift current directions can be recognized along the Sierra Leone coastline. These currents flow in a north-eastern direction causing erosion of the northern coastline around Yelliboya Island and Konakridee. Similar south easterly flowing currents in the south carry sediments from the Freetown Peninsula beaches and along the entire southern coastline of Sierra Leone. Tidal currents also influence the sediment transport dynamics particularly those of very fine sand and mud mainly at the entrances of bays and estuaries. Examples of least impacted coastal areas are found around the Scarcies River. Examples of places most disturbed by humans causing sediment mobilisation (mining, coastal development, sand mining, deforestation, etc.) are found mainly in the north and south of Sierra Leone.

4.4.4 Coastal Geography and Units

Coastal areas are characterized by geomorphologic features and are differentiated to local units. The natural coastal unit boundaries are generally featured with rocky outcrops, or river or lagoon outlets. However, there are few instances, where the unit boundaries are defined by human actions such as Ports & Harbours projected to sea. Even though the coastal units are physically enclosed, some of the long-term coastal processes are continued along the shores. The higher the degree of continuity exists within the subunits, where the major units are subset to minor units by minor features. The forms and shapes of the units are derived from the driving forces. Such as energies and directions of waves, temporal variations of sediment budgets and geographical characteristics of units.

4.4.5 Significance of Coastal Regions

As a poor developing country, coastal regions play a very vital role in Sierra Leone's economy. Fisheries, coastal tourism and mining have become the dominant economic activities widely spread along the coastal belt, but the tourism activities are more clustered into the favourable areas. It is estimated that approximately 1.5 million of Sierra Leone's 7.01 million population is settled on coastal lands, indicating significance of the coastal area. The coastal population is not uniformly distributed. In the north, around the Scarcies River and Lungi areas, the population is around 80,000 whilst in the Freetown Peninsula areas, it is about 1,250,000. In the south around Shenge, the population is close to 9,000 inhabitants and is around 8,000 in the Bonthe Sherbro area. Only 150 km of the coastline is significantly developed or urbanized and this includes Freetown (the Capital City). The inhabitants, in particular who live in rural areas, have social, cultural and livelihood values specifically linked to the coastal features and resources.

As the coastal population continues to grow, these resources correspondingly experience an increasing stress. However, the degree of coastal resources exploitation is to a large extent influenced by the population of the entire country in general and by the coastal population in particular. With an annual growth rate of about 2.5%, it is important that a sound policy for the national exploitation of the coastal resources be pursued with the parallel development of the appropriate institutional framework. The major goals of the GoSL in the coastal sector are the mitigation of the coastal erosion vulnerabilities, enhance the status of the coastal environment and biodiversity, creating opportunities with added values for coastal resources, promoting & facilitating coast specific investments and improving the livelihood of the local people in coastal areas.

4.4.6 Causative Factors, Coastal Erosion and Accretion

The erosion and accretion are resultant of natural coastal processes, which take place over the time scale. The coastal erosions are generally varied from catastrophic events to chronic events. Erosions due to the regular waves of tropical storms are much likely to cause the chronic (long-term) hazard. There are catastrophic (short-term) erosion incidents, which are due to the storm surges and sand mining. Macro-scale events are also active with climate change impacts that may significantly alter sea levels and also cause coastal land subsidence.

Human-induced erosions occur due to the extraction of sand and mineral resources from the coastal areas and improperly cited maritime structures. The erosion can become worse whenever the ill-planned countermeasures are applied. If the entire sediment unit is not considered in the solution, the erosion will transfer to the adjacent shores.

Coastal areas are accreted in places, where adequate sand supplies exist with accretion supported hydrodynamic conditions. Coastal areas with natural or artificial geomorphologic conditions, which provide enough shelter, breaking the high wave energies, are favourable for accretions. Even though the accretion provides land for the country, it would create erosion in the down-shore due to insufficient sand supplies for the alongshore transport. Rapid accretions will definitely result in erosion in the down-shore. In stabilizing the shorelines, coastal structures are constructed accumulating sediment within the scheme to the required level. But, generally, the schemes are nourished with important sand at the initial stage to overcome the down-shore erosion.

4.4.6.1 Severity

Coastal erosion can be gradual or occur rapidly—as it does during storms, for instance. During storms, erosion can be severe, and during the most intense storms, entire beaches may be lost while other portions of the shoreline may become unstable and collapse into the waterways. Long-term erosion is difficult to measure since it can vary significantly from year to year. In addition, along much of the coast changes may be too small to accurately measure with the techniques presently available. Human activities, such as dredging and beach nourishment projects, also make it difficult to determine how much beach is being lost through natural processes.

Geologists measure erosion as a rate of either linear retreat (meter of shoreline recession per year) or volumetric loss (cubic meter of eroded sediment per linear meter of shoreline frontage per year). According to Johnson (2006), coastal erosion along the Sierra Leone coastline has attained rates of some 4-6 metres per year at some locations; e.g., Konakridee, Lumley, Lakka, Hamilton etc.

4.4.6.2 Probability

Long-term shoreline change is a continuous process and therefore 100% certain for the locations below. The probability of rapid erosion events will vary based on a number of factors, including the recurrence intervals for coastal storms and anthropogenic activities. Erosion rates vary significantly depending on location. Sierra Leone's shore is exposed to the effects of coastal erosion and wave action from the Atlantic Ocean. Some of the highest erosion rates have been observed near stabilized inlets and hardened structures, which disrupt the natural movement of sand. Because so many factors are involved in coastal erosion—including seasonal fluctuations and human activity—sand movement will not be consistent year after year in the same location, or between nearby locations.

The following areas have been identified as being vulnerable to coastal erosion:

- Lakka Beach
- Conakridee
- Krim Area
- Shenge
- Plantain Island
- Katta Island
- Bunce Island
- Adonkia
- Mahera Beach in Lungi Area
- Bullom Shores
- Moa Wharf
- Man of War Bay

4.4.7 Scope of the Study

The Coastal Erosion Hazard Assessment has investigated the spatial and temporal distributions of the erosion hazards and disasters along Sierra Leone's entire coast. Erosion caused by storms were not taken into consideration for the assessment. Considering the uncertainties of the sediment dynamics, the Assessment was based on logical approach and expert judgement; hence, the results are largely qualitative rather than quantitative. The degree of coastal erosion is ranked into three categories, as outlined below.

Table 4-21: Coastal erosion hazard risk colour scheme

Hazard	Descriptor	Description
Very Low	Rare	The event is conceivable under exceptional circumstances
Low	Unlikely	The event might under very adverse conditions
Medium	Possible	The event could occur under adverse conditions
High	Likely	The event will probably occur under adverse conditions
Very High	Almost Certain	The event is expected to occur

The coastal erosion hazard levels determined are on reference scale and not the absolute.

4.4.8 Methodology for Coastal Erosion

In the absence of a developed state-of-art model far erosion hazard assessment, tailored methodology has been developed with the fuzzy logical and expert judgment approach. There are high end tools that could be used in the Assessment, but due to lack of long-term data collected for the past period, the alternative approach was adopted.

4.4.8.1 Coastal Sediment Cells

In Sierra Leone, the majority of coastal sediments are fed by the rivers. The command shores of each river are clearly identified by long-term observations. With the existence of coastal geophysical characters such as rocky headlands and river outlets, etc., the shorelines were featured into sediment cells, where the seasonal sediment stability is reasonably autonomous. However, it does not mean that the inter cells sediment movements are discontinued. The long-term sediment stabilities are uncertain too. Considering the degree of inter cells sediment movement array, sediment cells are categorized into major and minor cells.

The identifications of the cells were done by the frozen geographic characters along the shoreline. The major cell boundaries have been identified by the frozen visible projections on 1: 1,000,000 maps, and the minor cell on 1: 100,000 maps. The assessments were made locally on the sediment approach.

4.4.8.2 Driver Analysis

There are many factors to be considered in the coastal erosion hazard assessment. Hydrodynamic features such as waves, tides and currents; geomorphologic features such as bathymetry, shore alignments, beach profiles, etc.; anthropogenic stresses such as near- shore marine structures, sand mining, maintenance dredging of navigation channels, etc., are some of the factors for erosion. However, for avoiding the complexity of the erosion assessment model, only three drivers of wave incident namely: the angle, sediment balance and shoreline geometry were considered.

4.4.8.2.1 Wave Incident Angle

The shorelines are aligned to diverse directions depending on the locality. The directions were measured as the bearing of the shoreline, .i.e., the angle of the shoreline to the true north. In nature, the wave directions are also varied in 360°. The wave incident angle is defined as the angle between the wave direction and shore normal at the shore. For both wind and swell waves, the predominant wave directions were identified for each wave zones. Varying with the cell geometry, the bearing of the shore and then the wave incident angles were determined.

4.4.8.2.2 Sediment Balance

As detailed in the background, the sediment balance is a critical driver for coastal erosion. The sediment balance was assessed in short- and long-term. The short-term sediment balances depend on the seasonal dynamics, and the long-term balances are due to the trends of sediment sources and losses. Since the majority of the sediments are supplied by rivers, the long-term sediment trends depend on the upstream catchment activities. Hence, the major sediment trends in the coastal cells are directly or indirectly human induced. Further, the onshore sediment movements are naturally governed by the hydrodynamics of the area, but the near-shore manned developments alter the natural coastal processes and patterns offering the long-term sediment balance. Hence, in order to consider the long-term sediment trends, any natural and most of the anthropogenic factors were included.

Trends of onshore sediment volumes were analyzed using satellite images and aerial photographs captured in 1970, 1990, 2010 and 2017. Since the seasonal wave climates remain in the similar patterns, resulting unchanged mean slopes of the shores, it was reasonably assumed that the beach volumes are more or less proportionate to the beach areas.

4.4.8.2.3 Shoreline Geometry

The shoreline geometry of sediment cells are characterized by the local hydrodynamics, geomorphology and sediment budget. The fixed boundaries of the sediment cell were used to determine the alongshore length of the cell, while the offset shape is governed by the hydrodynamics and sediment balance. In the coastal erosion assessment, the shape was simply analysed considering only the length of the cell.

4.4.8.3 Coping Capacity

Very little coast protection schemes have been implemented for the control of coastal erosion in Sierra Leone. Of those implemented, virtually all of the schemes are of hard structures, which stand for longer lifespan. These coastal defence structures have reduced the risk of the erosion hazard in those areas by increasing the coping capacities. Hence the distribution of coast protection structures was considered in the erosion hazard assessment. The coverage of cells by structures is varied and very sparse. Some cells are covered while majority are not covered at all. The degrees of cell coverage by the structures were used in the assessment.

4.4.8.4 Significance of Drivers

The three drivers, considered in the coastal erosion hazard assessment have differentiated significances on the coastal erosion, due to the integrity and temporal & spatial resolutions of data, uncertainties and assumptions made, etc. In the evaluation of those factors, with experts' judgments, driver weightings were assigned for normalizing the different significances. In determining the comparative significances of sediment cells, the cumulative normalized significances of drivers were evaluated.

Since the coping capacities reduce the risk of erosion, the cumulative normalized significances were divided by the degree of coping capacities in each cell. The degree of hazard, on Sierra Leone’s coastal reference scale, were then determined.

4.4.8.5 Verification of the Results

In validation of the model, the results were verified by following three indicators. The verifications were done with the degrees of individual drivers and also with the cumulative normalized significances.

4.4.8.5.1 Degree of past erosion incidents

In the absence of erosion incident inventory, indirect mode of the indicator was used in determining the erosion incidents. Because the coast protections were done as a post action against erosion, each and every structure represented an erosion incident that occurred in the past.

4.4.8.5.2 Length averaged annual rate of erosion or accretion

The change of the coastlines considered as the coastal erosion. In most of the cases, the erosions are controlled at the inception by means of temporary measures followed by permanent solutions. However, it can be observed that there are coastline changes for the past period.

4.4.8.5.3 Rate of length averaged normalized percentage of sediment loss or gain

Even though the coastal erosion is commonly known as coastline erosion, theoretically the beach erosion is considered as the setting up of erosion. It is measured by means of the permanent loss of sediment from the system. All the above indicative measures were applied in coastal sediment cell approach.

4.4.9 Coastal Erosion Hazard Assessment and Mapping

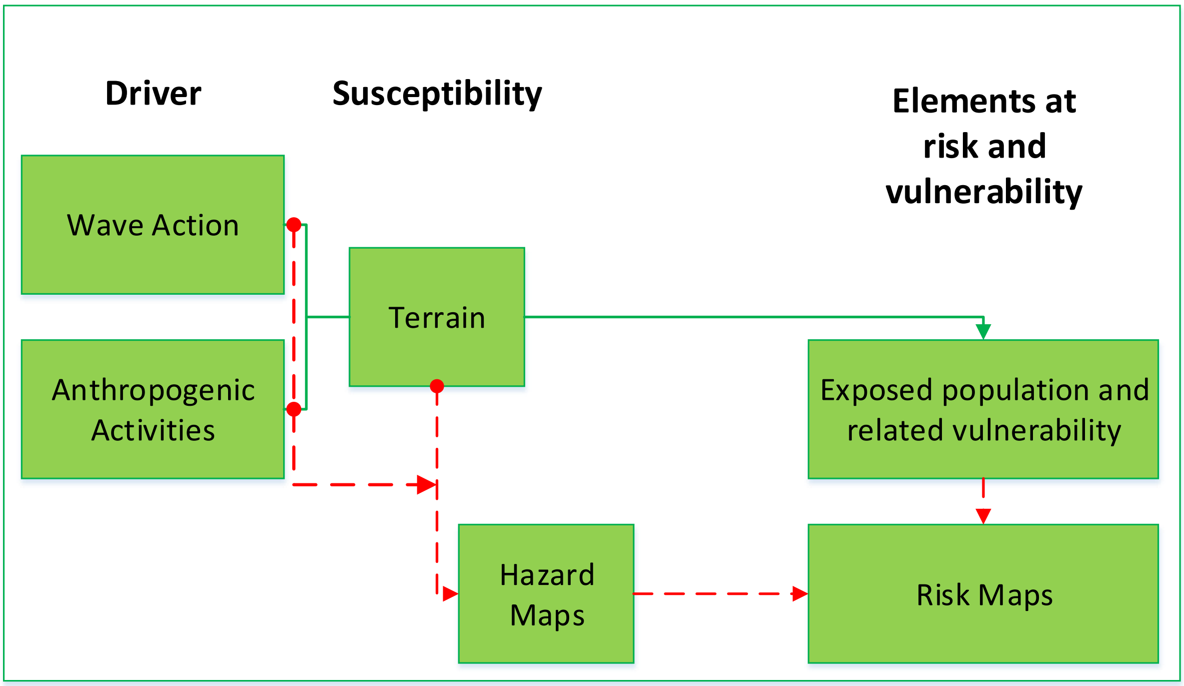
The coastal erosion is one of the major hazards prevailing in Sierra Leone, mainly due to the human induced acceleration. Many erosion hotspots are in the Western Peninsula, Yawri Bay and Sierra River Estuary in the western, north-western and south-western coastal regions, respectively, but few cases are on the south-western coasts. As a result, a large number of public and private properties are annually damaged or under threat. Fishing, tourism, mining and critical services have been disrupted. In addition large number of residents and communities are affected or displaced.

The coastal erosion assessment is based on erosive driver analysis approach. The degree of drivers was categorised into four ranks. The ranks were assigned as per the severity and highest as assigned to the most severe category. The final ranks are High, Medium and Low and no erosion. Through the current assessment, erosive forces prevailing on the shoreline were assessed. Degrees of erosive forces indicate the susceptibility to the erosion, meaning that if the corrective measures are not applied, there will be erosion incidents as per the severity of rank.

For the graphical presentation of the degree of coastal erosion hazard, map layers were prepared with geographical references. The degree of hazard are shown with differentiated colour scheme as linear features. Since the hazard assessments are coupled to multi-hazard profile, the uniformity of the layers have been maintained.

The layers were overlaid with the topographic maps of Sierra Leone at various scales. Coastal erosion was assessed by combining the driving factors (primarily wave action and human activities) and susceptibility factors (terrain/geomorphology/- cove, sandy, rocky and vegetated). The schematics of this approach are is illustrated in Figure 4-25. The assessment encompassed an analysis of the variation in likelihood of coastal erosion occurring along Sierra Leone's entire coastline.

Figure 4-25: Schematic approach for coastal erosion hazard and risk evaluation



The entire coastline was divided into cells and each cells coastline nature was studied was done by reviewing the nature of the whole coastline, and dividing into section lengths (cells). Due to the scarcity of coastal erosion data sets, expert judgment was exercised to determine the effects of the coastal erosion drivers and geomorphology on the coastline of each cell. The drivers were given a value Ranging from 0 to 1 (0 – infrequent: 1 – prevailing) based on their prevalence in the area and susceptibility took into consideration the vulnerability of the area (0 – resilient: 1 vulnerable) to the effects of the drivers. In the table below the drivers and susceptibility, factors of coastal erosion have been assigned weights.

Table 4-22: Weighting of coastal erosion factors

Factor	Weight
Wave action	0.23
Sand mining	0.27
Vegetation	0.12
Cove	0.14
Rocky headland	0.02
Sandy Beach	0.22

Each factor was then multiplied against its weight to obtain its weighted score. The Weighted Coastal erosion scores were then re-classified into a scale of 1 – 5. 1 being Very low coastal erosion hazard and 5 being very high coastal erosion hazard.

4.4.10 How to Read this Map

The coastal erosion hazard maps (Figure 4-26 - Figure 4-29) shows the spatial distribution of coastal erosion zones. Colours from green to red indicate the hazard ranking classes from very low to very high. The figure below illustrates the colours that are used to indicate the different risk zones.

Hazard	Descriptor	Description
Very Low	Rare	The event is conceivable, but only under exceptional circumstances
Low	Unlikely	The event might occur under very adverse circumstances
Moderate	Possible	The event could occur under adverse conditions
High	Likely	The event will probably occur under adverse conditions
Very High	Almost certain	The event is expected to occur

Figure 4-26: Coastal erosion hazard risk map of Sierra Leone

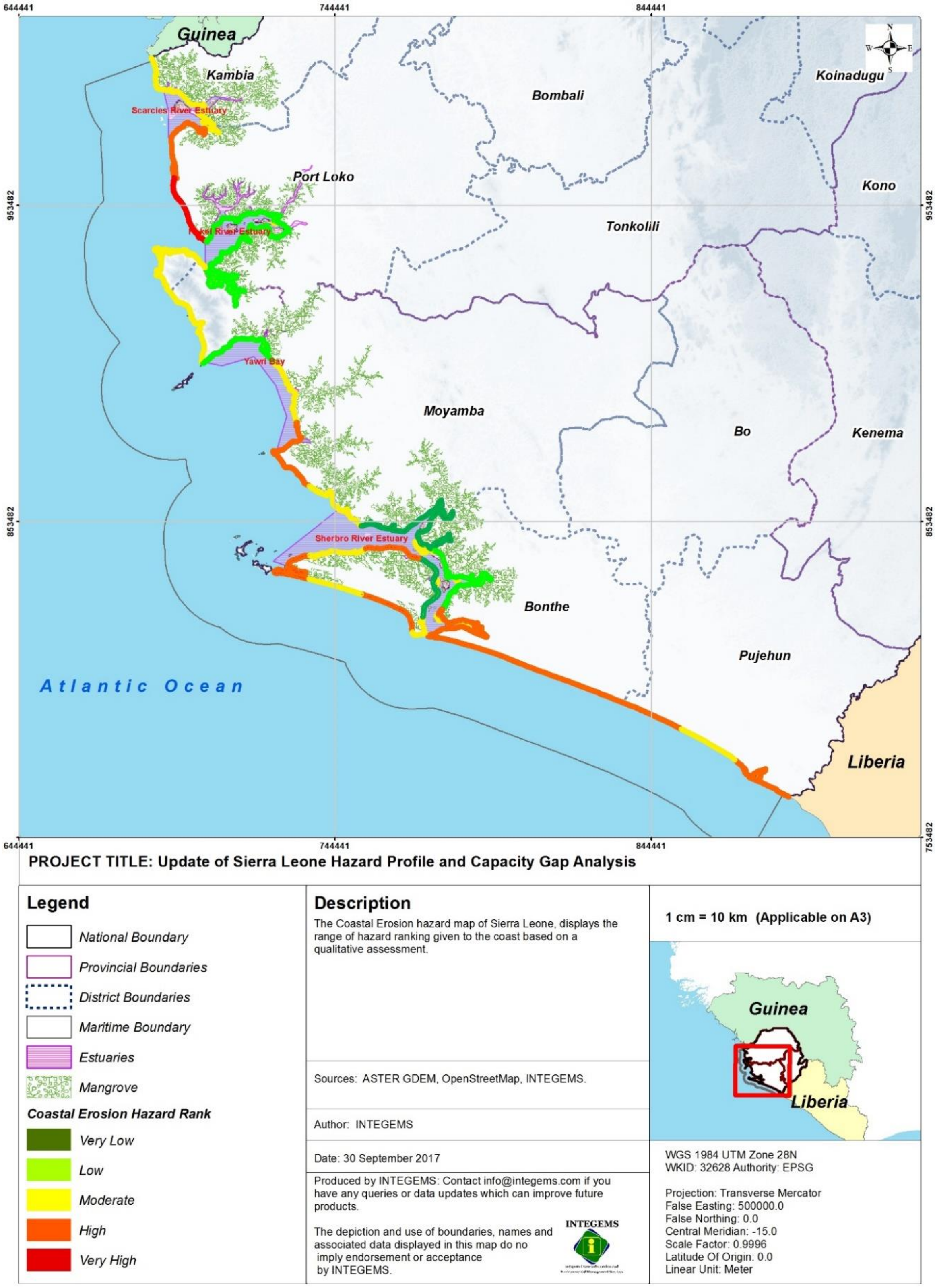


Figure 4-27: Coastal erosion hazard map of Sierra Leone (Konakridee axis)

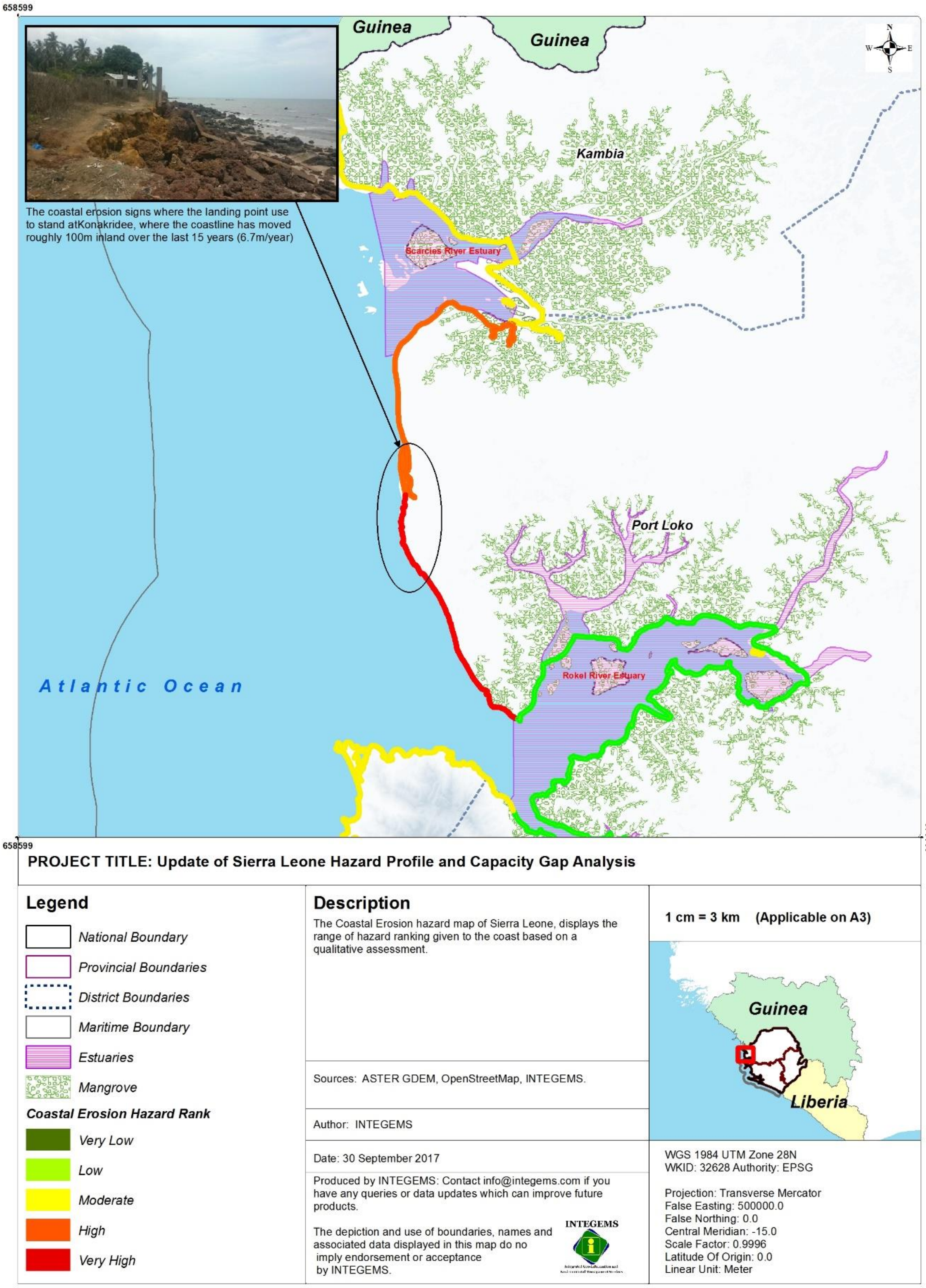
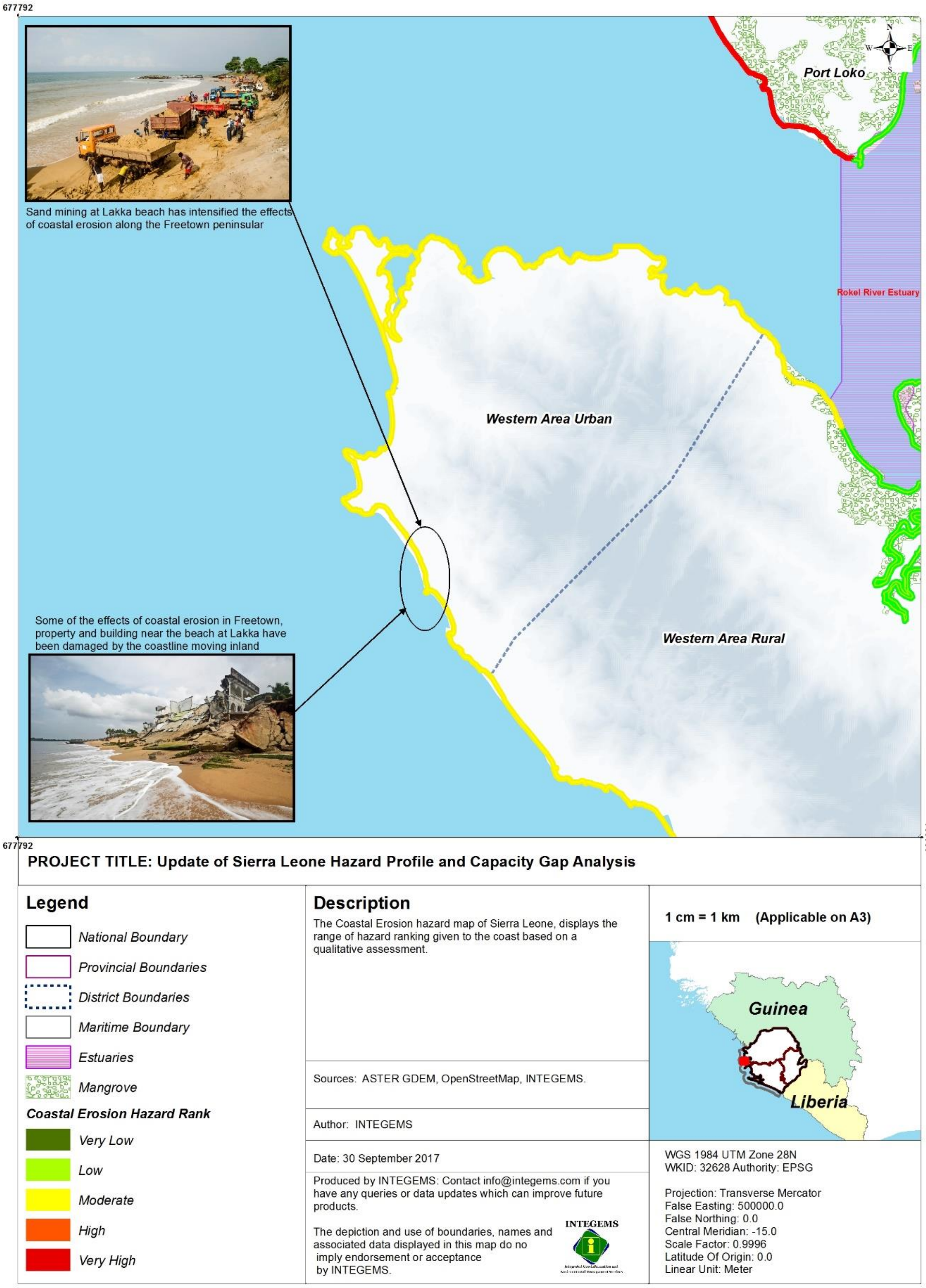


Figure 4-28: Coastal erosion hazard map of Sierra Leone (Lakka beach axis)



4.4.11 Analysis of Coastal Erosion Assessment

Wave action and terrain are the primary controlling factors for coastal erosion, sand mining may be localised but propagates the effects of coastal erosion regionally. Large areas of medium to high coastal erosion hazard have been identified (71%) along Sierra Leones coast is mainly due to expansive beaches along which vegetation and out crops are sparse. Excessive illegal mining also contributed to the propagation coastal erosion. Inter-tidal areas and coastlines along estuary and river mouths were also zones where coastal erosion were high. Areas of low and very low coastal erosion were primarily found along mangrove swamps and Sheltered coves protected by their alignment to the coast where the terrain/ geomorphology provided some resistance to the effects of wave action. It was also observed that these areas lacked extensive beaches. Table 4-23 breaks down the coastal erosion hazard of coastal district by length and erosion rating.

Figure 4-29: Coastal erosion and its effects in Sierra Leone

Uncontrolled sand mining propagates the effects of coastal erosion

(Photo Credit: Tommy Trenchard - IRIN)

A building at Laka Beach in Freetown destroyed by coastal erosion

(Photo Credit: Tommy Trenchard - IRIN)

Coastal sand mining at Goderich

(Photo Credit: Awoko Newspaper)

A landing port at Konakridee now destroyed by coastal erosion

(Photo Credit: Dr. T C Ferreira)

Table 4-23: Coastal erosion hazard ranking of districts[31]

District / Area	Coast Length (km)	Very Low		Low		Moderate		High		Very High	
		Distance (km)	Percentage of Coastline	Distance (km)	Percentage of Coastline	Distance (km)	Percentage of Coastline	Distance (km)	Percentage of Coastline	Distance (km)	Percentage of Coastline
Pujehun	77.92	0	0	0	0	19.79	25	58.13	75	-	0
Bonthe	401.69	71.70	18	59.88	15	75.16	19	194.95	49	-	0
Moyamba	155.78	46.02	30	18.83	12	54.48	35	36.45	23	-	0
Western Area	204.74	-	0	108.84	53	95.90	47	-	0	-	0
Port Loko	194.30	-	0	110.29	57	11.89	6	46.65	24	25.47	13
Kambia	39.93	-	0	-	0	39.93	100	-	0	-	0

[31] Only districts located along Sierra Leones coast were included the table as a result Bombali, Koinadugu, Tonkolili, Kono, Bo, Kenema and Kailahun were excluded

4.4.12 Conclusion and Recommendation

With the accelerated development in the coastal areas, the socio-economic activities should be secured from coastal erosion. Knowing the vulnerabilities for coastal erosion, appropriate remedial measures can be adopted for the safety of the coastal areas. The coastal erosion hazard assessment can be used for many applications of erosion hazard management through adaptation to mitigation. The assessment can be used as the base for preparing the coastal erosion risk profile. The coastal cells are very specific natural units which behave with both intra and inter dynamic relationships. Alternation of any element of the system within the cell would impact on the entire system within the cell, and with extended impacts to the adjacent cells too. Hence all activities should be done on the coastal cell approach. The degree of erosion hazard in cells would be then much appropriate.

The maps can be further improved by adopting quantitative figure into the model rather than qualitative inputs. Increasing the reliability of wave data, calibrations can be done for the existing wave data accessing the available measurements around the country. However it is strongly recommended to establish a wave data measurement network along the coast of the country appropriately.

The sediment balances can be estimated as a much accurate figure through site investigations and also using frequent aerial and space observations. Since the cell boundaries are fixed with geological features, the cell shapes are mainly governed by the sediment balance and local hydrodynamics. Even the hydrodynamics are with known seasonal cycles, the cell stabilities are purely tailored by the sediment balance. Hence the assessments of sediment balances should be continually monitored. The coastal erosion hazard profile shall be used by policy makers, developers, administrators and coastal engineers for varying purposes. The setback system in the coastal zone shall be updated with the degree of erosion hazard.

4.4.13 Limitation

There are few issues on the accuracy of the assessment. It is a fact that the beach sediment volumes are seasonally varied. Since aerial and satellite images are used for extracting the shorelines, there might be a seasonal effect if the images are captured in different seasons. But as per the capturing dates of the images used in the assessment, all datasets were captured within November to February. Hence, the seasonal effects of the images are resolved.

Even when the images are captured within the same season; there might be error due to apparent erosion visible on the images by the tidal water level variations. Since the assessment was done largely on qualitative approaches, such errors can be accommodated.

4.5 Sea Level Rise Hazard Assessment and Mapping

There are two main reasons for sea-level rise namely: thermal expansion of ocean waters as they warm; and increase in the ocean mass, principally from land-based sources of ice (glaciers and ice caps, and the ice sheets of Greenland and Antarctica). Global warming from increasing greenhouse gas concentrations is also a significant driver of both contributions to sea-level rise (John et al 2007).

Global warming may cause a sea level rise, which will have a great impact on the long-term coastal morphology and an increased flooding risk. The IPCC Fifth Assessment Report on climate change models projects global sea level to rise. However, they do not account for rapid changes in the behaviour of ice sheets and glaciers as melting occurs (ice dynamics) and thus likely underestimate future sea-level rise.

Sea level projected increase due to climate change a rise of 0.2m – 0.5m is expected by the year 2100 and could change to 1– 2m under the same emission scenario[32]. Sea level is neither constant nor uniform everywhere, but changes continually as a result of interacting processes that operate on timescales ranging from hours (e.g., tides) to millions of years (e.g., tectonics). On local scales, sea level is also affected by vertical land motions and local climate and oceanographic changes. Along the coast of Sierra Leone sea level is influenced by changes in global mean sea level as well as by regional

[32] http://www.sl.undp.org/content/dam/sierraleone/docs/focusareadocs/undp_sle_analysisclimatechangeDM.pdf (Accessed on 21 August 2017)

changes in ocean circulation, climate patterns, and uplift or subsidence along the coast. The relative importance of these factors in any given area determines whether the local sea level will rise or fall and how fast it will change.

The effect of sea level rise induced by climate change is visible in coastal areas such as Yeliboya and Kortimor in the north, and in Shenge and Plantain Island in the south of the country. There are also visible signs of severe coastal erosion around Adonkia, Mahera Beach in the Lungi area, Conakridee and Eureka which resulted to the physical alteration of coastline and destruction of structures as well as displacement of people in coastal communities. The effect is that most of the livelihoods of the people are threatened. In Shenge, Moyamba District, it has been recorded that the sea has eaten into the land by about 100 m. At Lakka beach, the sea has eaten into the land by 41 m. This is considered as one factor for the collapse of guest complex structures by sea erosion.

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, livelihood security, water resources and major economic sectors such as fishing, tourism 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.

Sierra Leone has developed many adaptation projects to address adverse effects of climate change based on existing coping mechanisms and practices such as develop and enact appropriate policies and regulations relevant to the development of coastal communities, urban growth planning, and critical coastal ecosystems preservation.

4.5.1 Map Content

The sea level rise susceptibility maps (see Figure 4-30 - Figure 4-34) which has been developed shows the spatial distribution of the potential for sea level inundation in the coastal areas of Sierra Leone. National, Provincial and District boundaries are presented on the map as overlay layers for more detailed comprehension of the spatial distribution.

4.5.2 Application of Maps with Respect to Disaster Risk Management

- Sea-level rise hazard maps are useful for policy makers, decision makers and planners as they can serve as basis to complement, developed master plans (rural and urban communities) for safe development.
- The maps can be useful in planning and implementing measures for the sustainability of different economic sectors such as agriculture, housing, tourism and production.
- The sea level rise maps will help local authorities in sea level rise hazard prone areas to undertake necessary measures to cope with the hazard accordingly and develop preparedness plans.
- The sea level rise maps can help decision-makers, economic operators and other occupants to determine the areas that may potentially be impacted.
- They can then adapt their activities, and or safeguard their equipment, houses, facilities and tools against the potential hazard.
- The hazard maps will allow the government including humanitarian organisations to also prioritize preparedness.

4.5.3 Data Requirements and Availability

The primary local datasets needed to accurately map and assess the impacts of sea level rise include but not limited to: topographic/bathymetric, LiDAR and DEM imageries. High resolution LiDAR topographic data are not available to cover the entire coastal area of the country. Hence, the ASTER GDEM datasets were used in areas where higher resolution topographic data are not available.

4.5.4 Methodology and Scope of the Assessment

The potential for sea level inundation events is assessed qualitatively based largely on expert judgement. This was carried out in accordance with global best practices, by comparing the elevation of low-lying areas around the coastline with the potential effects of increase in sea level. A range of GIS analysis tools were used to map areas which are at risk of sea level rise inundation for different scenarios.

4.5.5 How to Read this Map

The sea level rise hazard map (see Figure 4-34 - Figure 4-30) present areas which have been assessed to be prone to sea level inundation at varying degrees. Colour codes from green to red indicate the susceptibility classes from very low to very high. The figure below illustrates and explains the classification scheme used in this sea level rise hazard assessment.

Table 4-24: Sea level hazard susceptibility

Hazard	Inundation elevation	Descriptor	Description
Very Low	5 – 8m amsl	Rare	The event is conceivable, but only under exceptional circumstances
Low	4 – 5m amsl	Unlikely	The event might occur under very adverse circumstances
Moderate	3 – 4m amsl	Possible	The event could occur under adverse conditions
High	2 – 3m amsl	Likely	The event will probably occur under adverse conditions
Very High	< 2m amsl	Almost certain	The event is expected to occur

Figure 4-30: Sea level rise hazard risk map of Sierra Leone

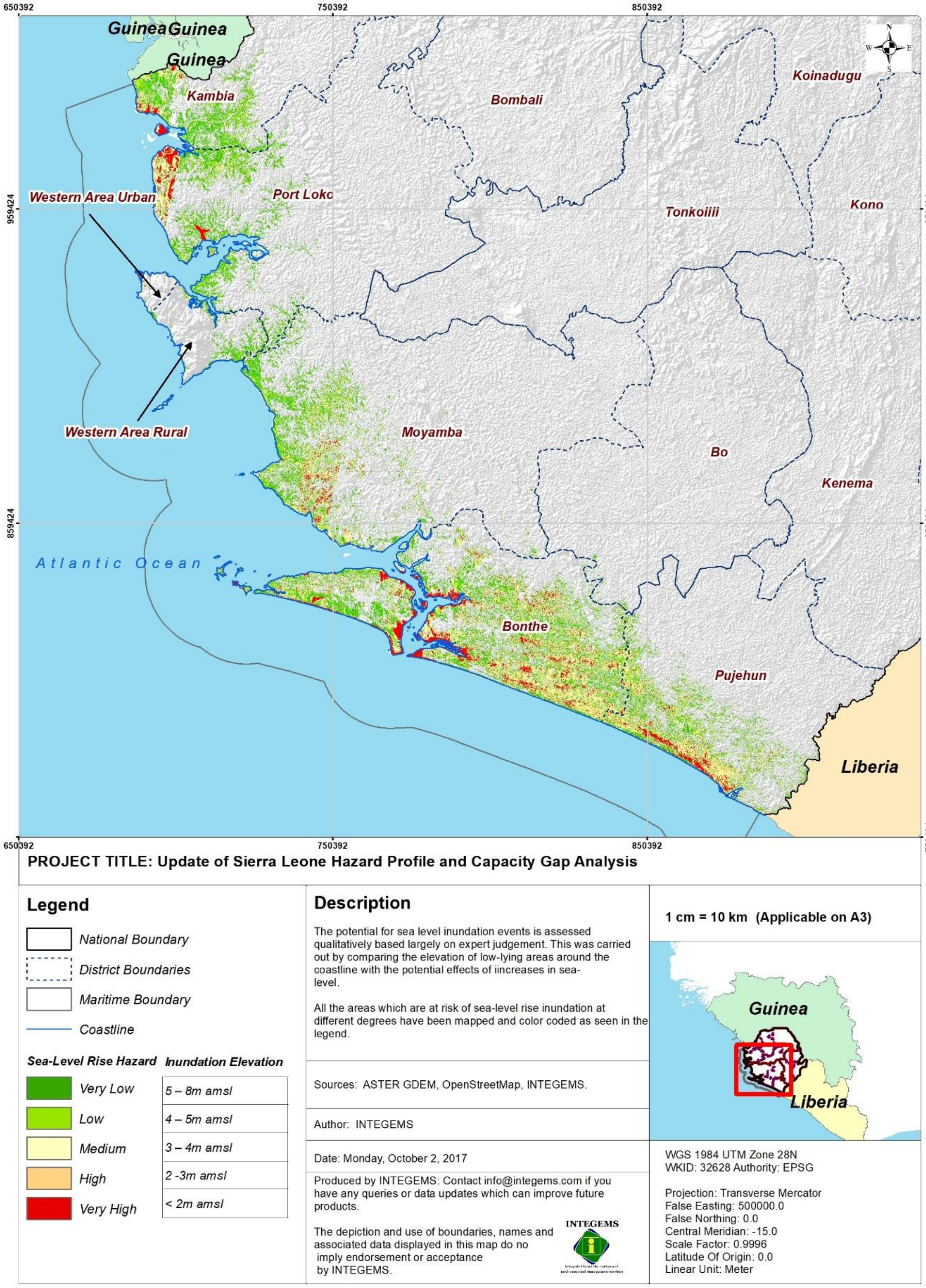


Figure 4-31: Sea level rise hazard risk map - Scarcies and Sierra Leone River Estuaries

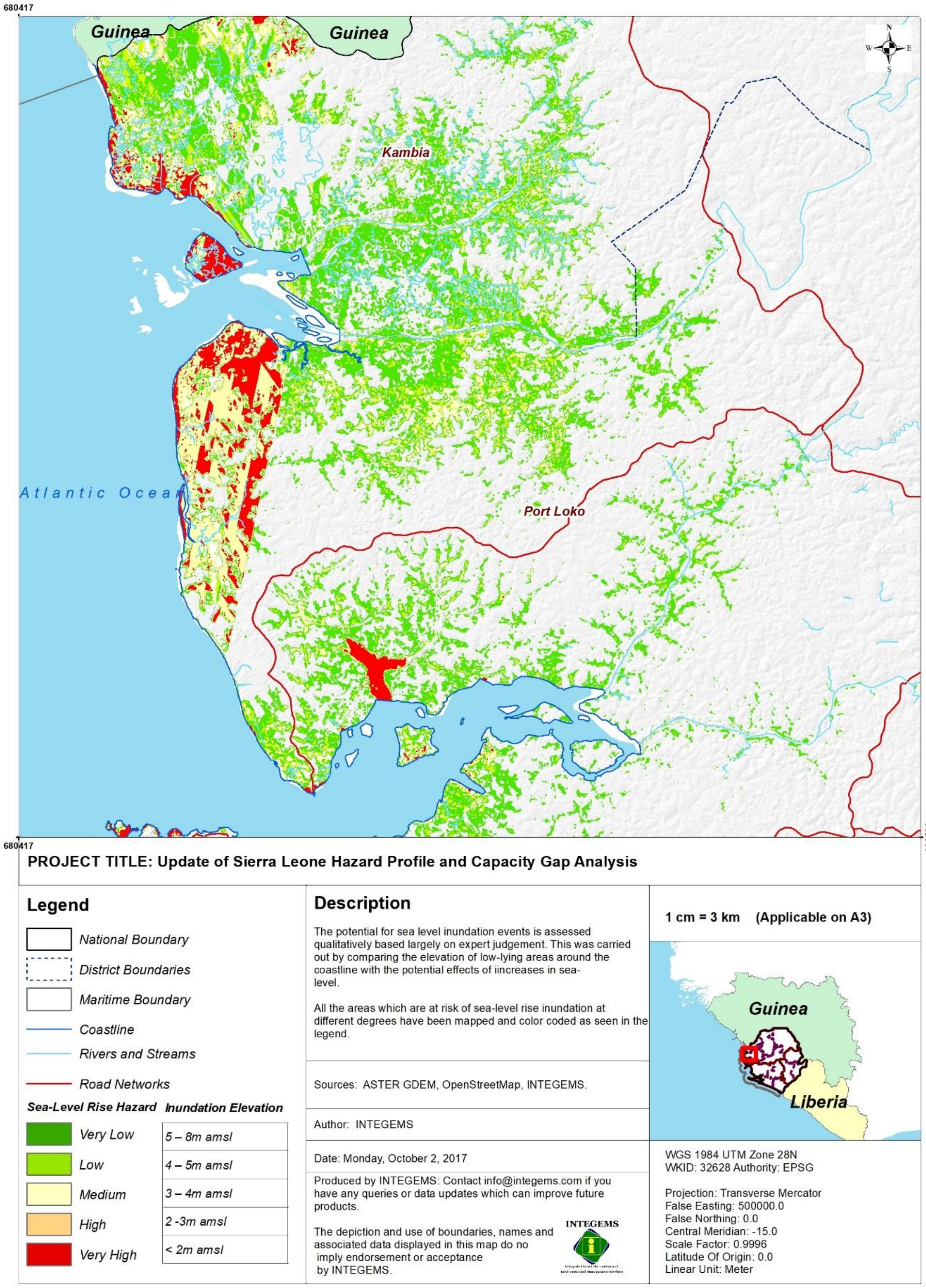


Figure 4-32: Sea level rise hazard risk -Western Area Urban

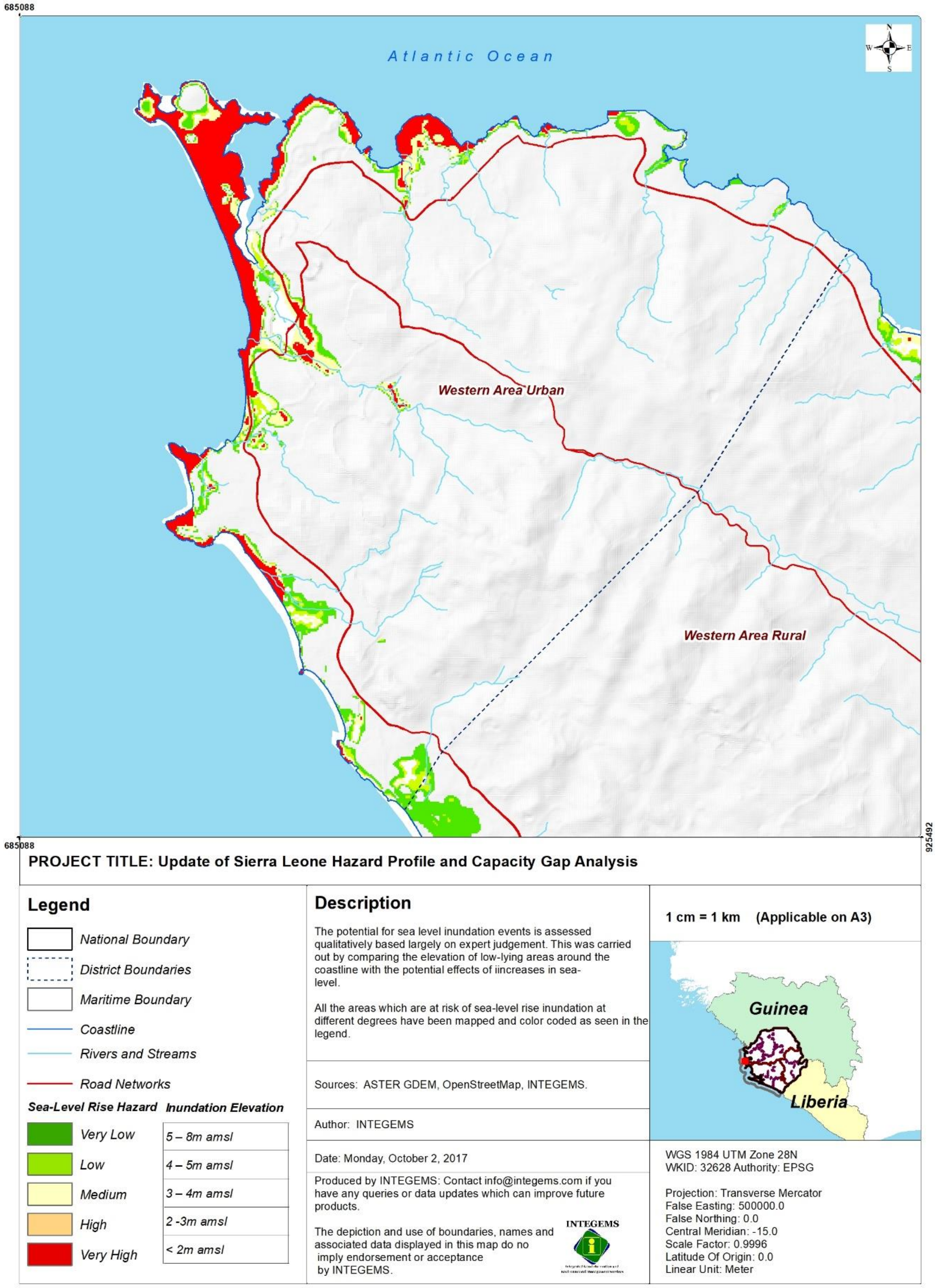


Figure 4-33: Sea level rise hazard map – Shebro River Estuary

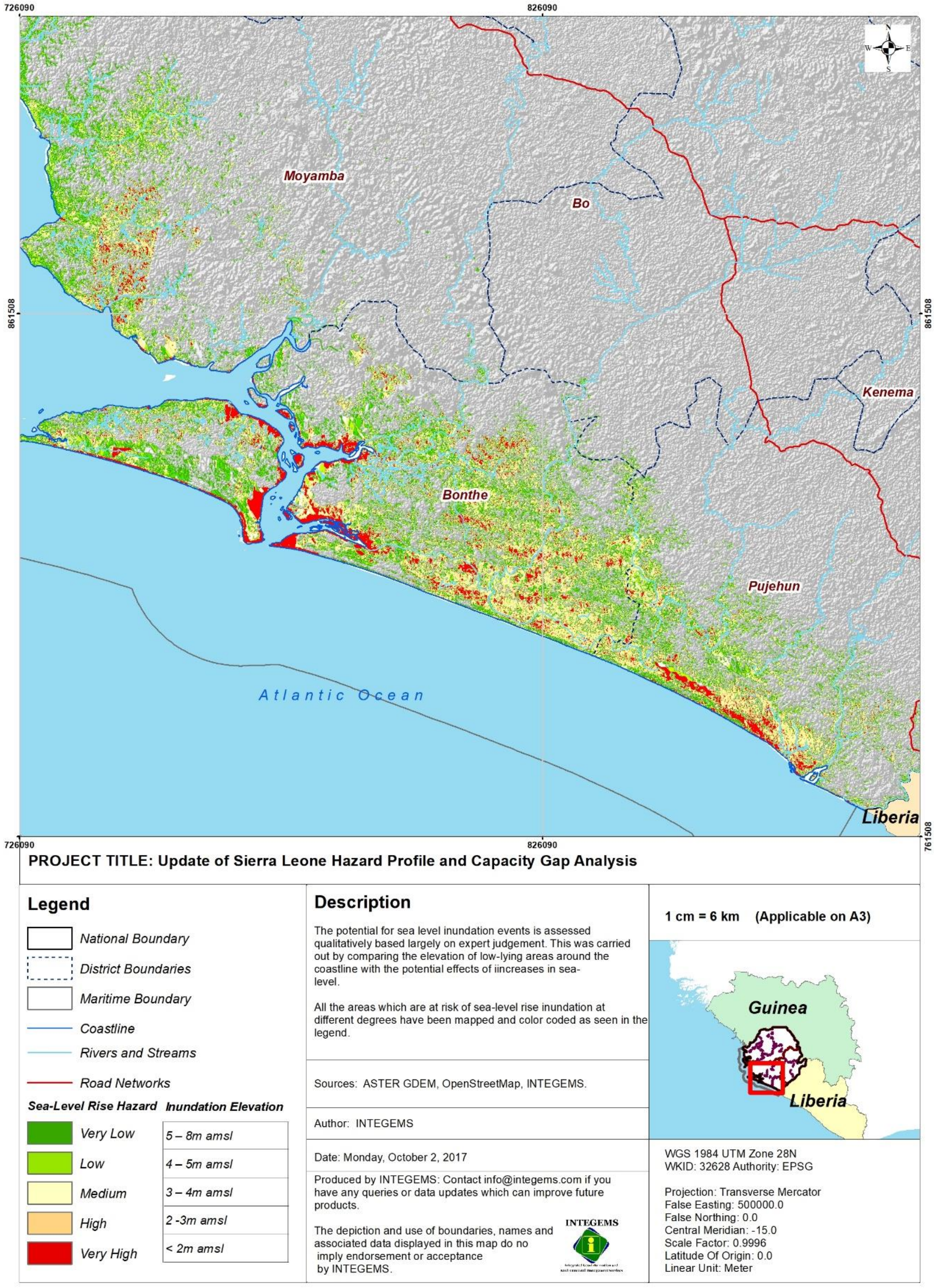
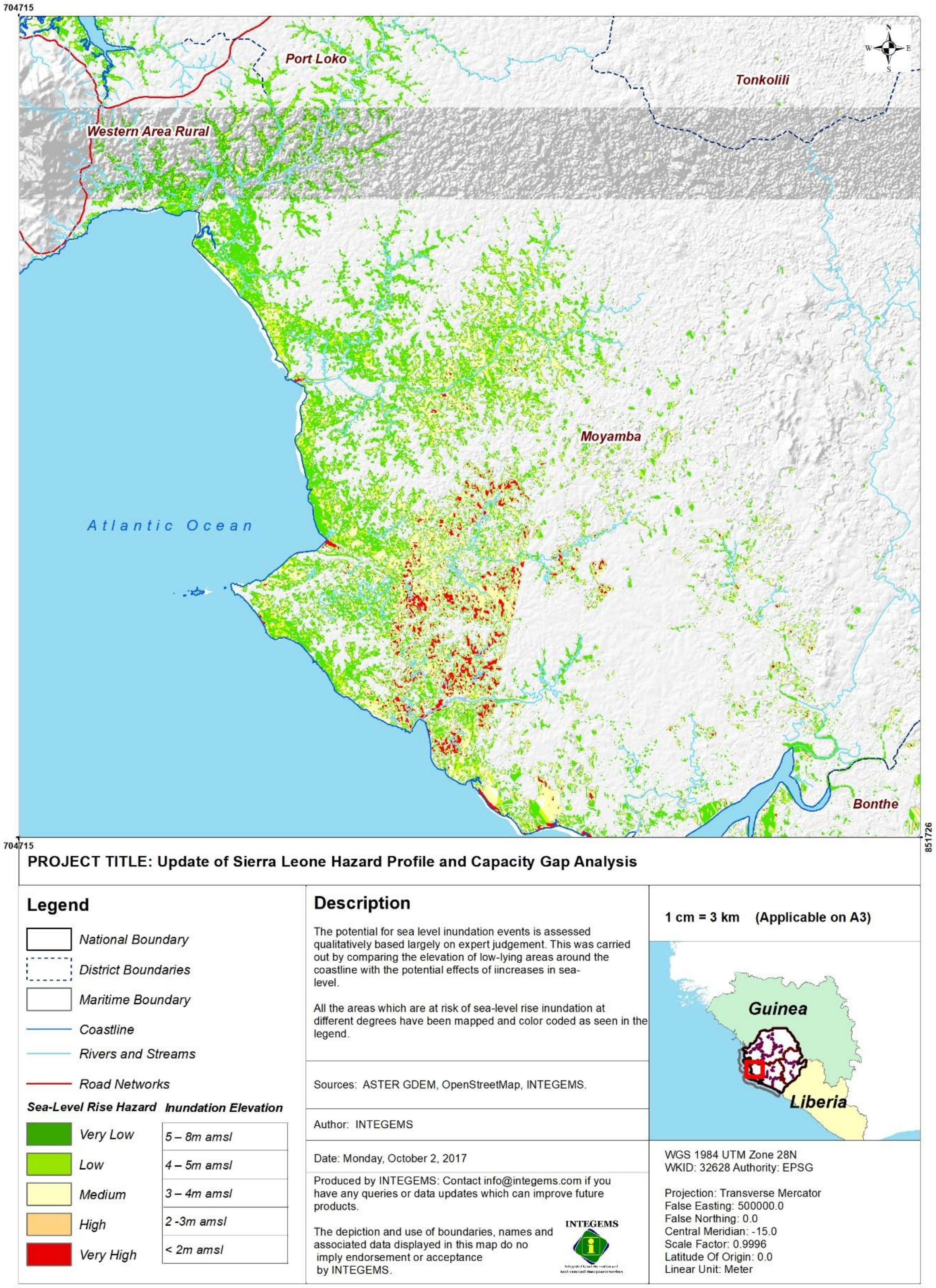


Figure 4-34: Sea level rise hazard risk map – Yawri Bay



4.5.6 Limitations

The sea level rise hazard risk assessment and mapping relied on secondary data and expert judgement to qualitatively identify and assess areas with varying risk of inundation due to an increase in sea level. Data unavailability prevented the application of deterministic sea level raise hazard assessment methods, which are required to derive quantitative maps. The assessment was carried out at a national scale. Hence, no finer details is expected to be derived from the maps.

Sea level rise inventory in Sierra Leone has never been prepared. Only a hand full of research has been done by the EPA-SL on the impact of climate change on sea level rise and mapping of marine protected areas by the Ministry of Fisheries and Marine Resources (MFMR). Therefore, this assessment applied another rating system of projections as suggested by experts for sea level rise hazard which is a more simple approach.

4.5.7 Conclusion

Sea level rise hazard profile development used the worst case scenario of maximum level of sea rise of about 1-2m in 100 years.

The potential impacts of sea level rise in coastal areas within the next 25 to 100 year period was studied. The sea level rise maps covering the entire coastal belt indicating the inundation areas in 2100 were prepared. It is important to note that sea level rise predictions used only one type of elevation data, namely the ASTER GDEM that are of a coarser resolution (30m).

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 destruction of infrastructure.

The assessment revealed that areas within the closest proximity to the coast of the country bear the greatest risk of inundation for a sea level increment between 1 – 2 m. specifically, communities within coastal plains around the Scarcies River Estuary, the Shebro River Estuary (Bonthe and Pujehun) are within the high risk zone.

4.6 Epidemics Hazard Assessment

An epidemic refers to the occurrence of more cases of a disease than would normally be expected in a community or region during a given time period. Epidemics are commonly thought to involve outbreaks of acute infectious disease. Disease and epidemics occur as a result of the interaction of three factors: agents, hosts and environment[33]. Agents cause the disease, hosts are susceptible to it and environmental conditions permit host exposure to the agent. An understanding of the interaction between agent, host and environment is crucial for the selection of the best approach to prevent or control the continuing spread of an epidemic. Sierra Leone faces risks from several epidemic-prone diseases, including cholera, Ebola virus disease, Lassa fever, monkey pox, meningitis, rabies, yellow fever, HIV, malaria and typhoid.

Epidemics are the deadliest hazards in Sierra Leone during the last 30 years, responsible of 83% of the total number of death due to disaster. From 1980 to 2017, epidemics (including EVD) killed an estimated 5,100 people and affected about 28,500 people. The Ebola Virus Disease (EVD) outbreak in 2014-15 caused devastation across all spheres of life in Sierra Leone: health, economic, social, and cultural. The outbreak highlighted the weaknesses in the capacity to prevent, detect, and respond to disease outbreaks in Sierra Leone, and spurred the Ministry of Health and Sanitation (MoHS) and its partners to push forwards with an ambitious plan to strengthen its capacities in this area.

Malaria and cholera are also amongst the important killer diseases in the country. Many other diseases require constant surveillance and response, including Lassa fever, Yellow Fever, HIV and – as the outbreak in 2016 showed – measles. In order to ensure this area received the political and financial resources necessary to prevent future outbreaks of infectious diseases, it was made one of the key results areas of the President's Recovery Priorities for health: to prevent, detect, and respond to epidemics and ensure zero EVD cases. The table below illustrates data from the annual epidemiological report, then provide an overview of key activities in the area of ensuring health security and emergencies.

In general inadequate access to sanitation and clean water, environment insalubrities and pollution, and inadequate household hygiene are their main causes in both urban and rural areas, where the majority of the population lives without access to pipe borne water. Floods are an important factor increasing the number of people exposed to waterborne diseases including cholera, but dry spells also because water resources become scarcer and competition for water increases, polluted water is then often used for drinking and bathing, spreading infectious diseases such as typhoid and cholera and gastroenteritis, mainly among urban poor. The socio-economic burden of disease is very high in Sierra Leone, particularly for the common communicable and epidemic-prone disease. It plays an important role in the poverty cycle because it slows economic growth and human development by depleting the workforce and productivity country-wide

Major outbreaks such as cholera in 2012 and Ebola virus disease in 2014-15 have demonstrated the need to strengthen the health system's capacity as required under the International Health Regulations (IHR). Since the Ebola outbreak, major efforts have been made to strengthen the country's preparedness and response capacities.

[33] Developing A National Risk Profile Of Lao PDR, Part 1: Hazard Assessment,2010

Table 4-25: Summary of priority diseases, conditions, and events

Disease	Number of Cases	Number of Deaths	Case Fertility Rate, %
Malaria cases	2,732,006	N/A	N/A
Malaria tested	2,699,157	N/A	N/A
Malaria positive	1,622,948	2,512	0.2
Severe pneumonia	88,568	469	0.5
Suspected typhoid fever	75,097	317	0.4
Severe malnutrition	26,652	174	0.7
Diarrhoea with severe dehydration	26,152	106	0.4
Suspected measles	8,133	31	0.4
Bloody diarrhoea	6,824	41	0.6
Animal bites	2,132	27	1.3
Adverse events following immunisation	125	0	0
AVHF	79	25	31.6
Suspected meningococcal meningitis	68	10	14.7
Acute flaccid paralysis	57	0	0
Suspected yellow fever	51	1	2
Neonatal tetanus	36	13	36.1
Acute jaundice syndrome	26	2	7.7
Suspected cholera	1	0	0
Maternal death	0	618	

Sources: Government of Sierra Leone Ministry of Health and Sanitation, Annual Health Sector Performance Report 2016

4.6.1 EVD Crisis

The Ebola virus epidemic in Sierra Leone occurred in 2014, along with the neighbouring countries of Guinea and Liberia. It was identified as Ebola virus disease and spread to Sierra Leone by May 2014. The disease is thought to have originated when a child in a bat-hunting family contracted the disease in Guinea in December 2013. Consumption of African bush meat, including rats, bats, and monkeys, is commonplace in Sierra Leone and West Africa in general. At the time it was discovered, it was thought that Ebola virus is not endemic to Sierra Leone or to the West Africa region. However, some samples taken for Lassa fever testing turned out to be Ebola virus disease when re-tested for Ebola in 2014, showing that Ebola had been in Sierra Leone as early as 2006.

Bats are known to be carriers of at least 90 different viruses that can make transition to a human host. However, the virus has different symptoms in humans. It takes one to ten viruses to infect a human but there can be millions in a drop of blood from someone very sick from the disease. Transmission is believed to be by contact with the blood and body fluids of those infected with the virus, as well as by handling raw bush meat such as bats and monkeys, which are important sources of protein in West Africa. Infectious body fluids include blood, sweat, breast milk, saliva, tears, faeces, urine, vomit, and diarrhoea.

The main start of the outbreak in Sierra Leone was linked with a tribal healer. She had treated an infected person and died on 26 May 2014, in which estimates showed as many as 365 died from Ebola disease after contracting the disease at the funeral. The virus took two years three month (May 2014 to March 2016) in Sierra Leone. The movement of people were restricted in certain district known as hot spot which include Kenema, Kailahun, Bombali, Port Loko, Kono, Moyamba, Tonkolili and Kissy Freetown during the Ebola period. These places were declared hot spot because, they produce 100 cases daily. Official statistics showed that approximately 10,074 confirmed cases were recorded, and a total of 3,029 lives were lost by the deadly virus, including the lives of 221 health workers across the country (see Figure 4-35 and Figure 4-36).

Figure 4-35: Ebola Virus Disease (EVD) cases by District

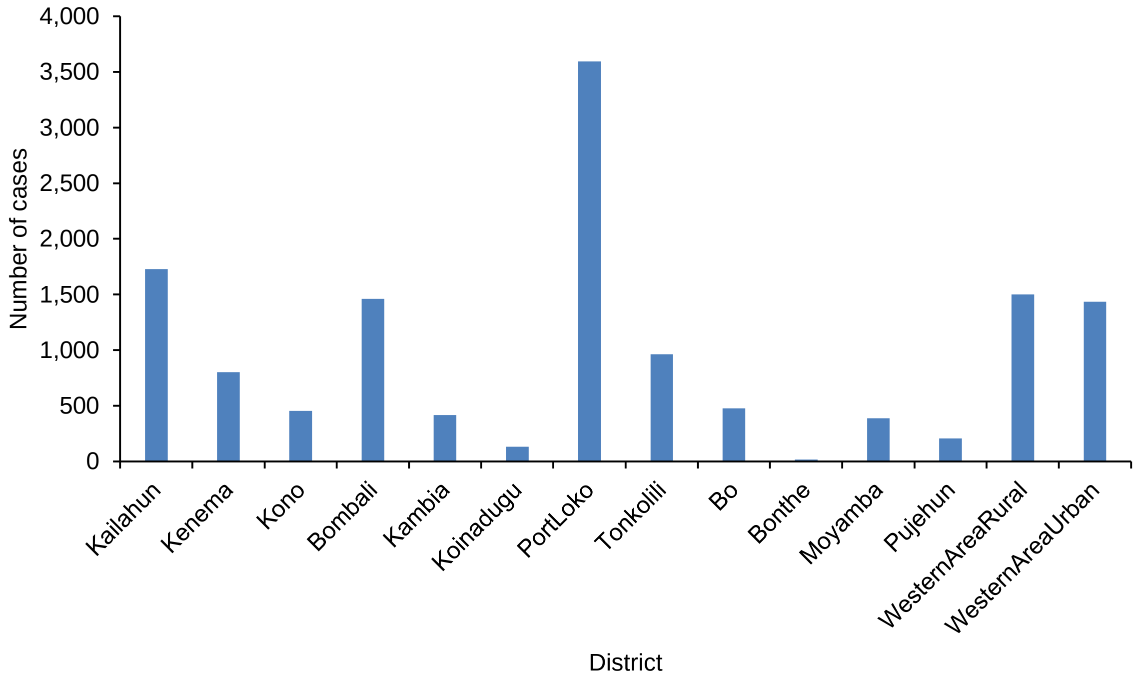
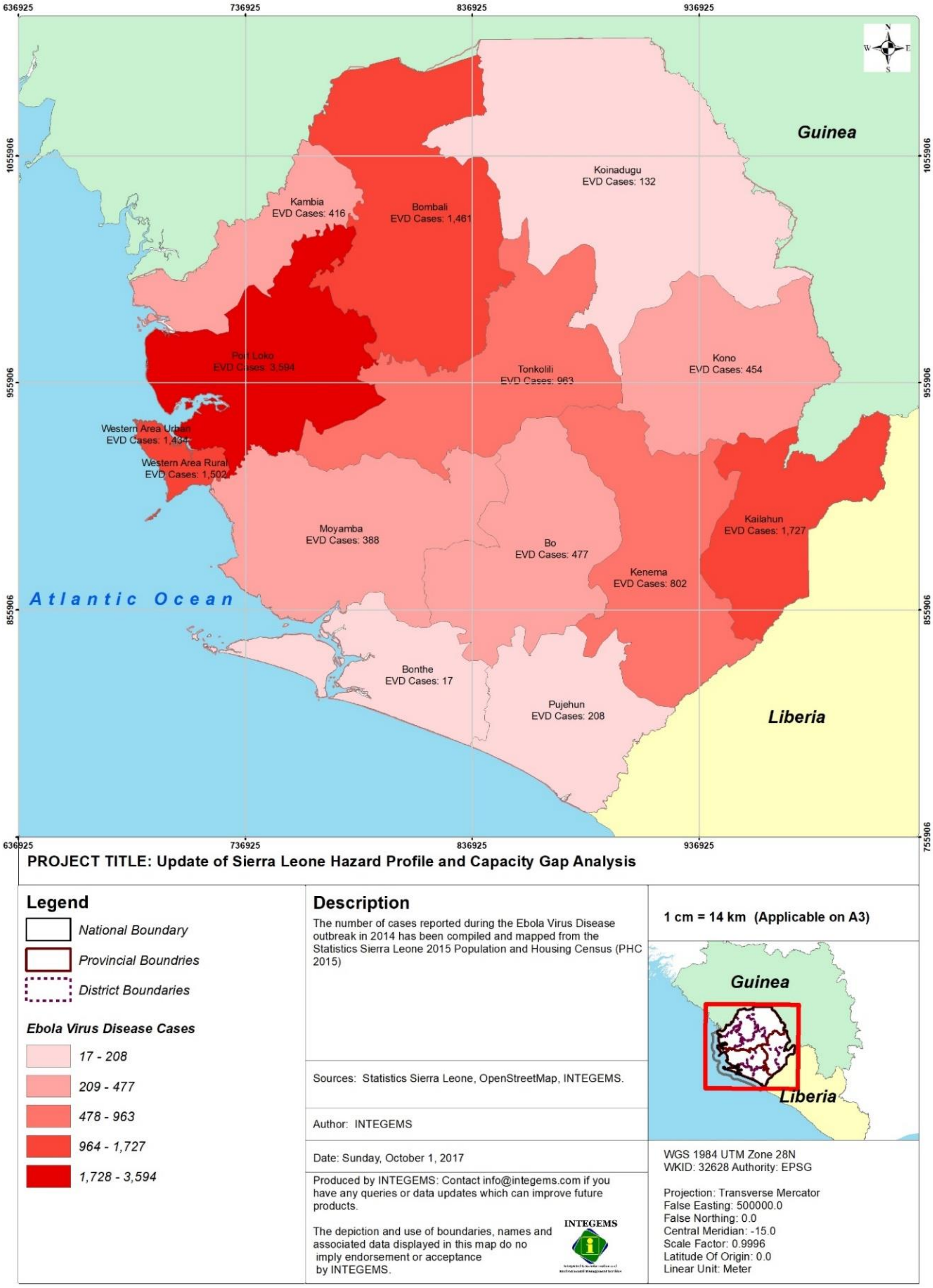


Figure 4-36: Ebola Virus Disease (EVD) cases by District



4.7 Storm Surge Hazard Assessment

Storm surge refers to 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 (IPCC AR4 2007). The storms produce strong winds that push the water into shore, which can lead to flooding. This makes storm surges very dangerous for coastal regions. It's an abnormal rise of water generated by a storm, over and above the predicted astronomical tide.

Scientific evidence indicates that increased surface temperature will intensify cyclone activity and heighten storm surges and these surges will, in turn, create more damaging flood conditions in the coastal zones and adjoining low-lying areas in Sierra Leone. The destructive impact are generally greater when storm surges are accompanied by strong winds and large onshore waves.

4.7.1 Causative Factors

Storm surge is caused primarily by high winds pushing on the ocean's surface and it is a surface phenomenon. It makes unusual rise in water level, due to piling up of sea water higher than the ordinary sea level caused by forces generated from a sever storm's wind, wave and low atmospheric pressure at the centre of the weather system. It is extremely dangerous because they are capable of flooding large coastal areas. The height of the storm surge depends on cyclone dynamics such as the wind speed, the translation speed, the angle of attack at landfall, the pressure drop and also on coastal and shelf morphological factors such as bathymetry and the shape of the coastline. Furthermore, the severity and the extent of onshore inundation depend primarily upon the surge height and the prevailing tide as well as the elevation, the slope and surface roughness of the terrain.

4.7.2 Scope of the Study

The scope of this study is to evaluate and map the distribution of the tropical storm-induced storm surge hazard inclusive of the probable extent of onshore inundation for the entire coastline of Sierra Leone. Information gathered from the present assessment would provide the basis for disaster risk mitigation policy planning and decision making with regard to storm surge hazard for Sierra Leone.

The hazard assessment which is based on a qualitative and statistical analysis of the past storm surge events in the Scarcies River Estuary, Sierra Leone River Estuary, Yawri Bay and Sherbro River Estuary of Sierra Leone. Given the considerable uncertainty on the probable storm tracks including the landfall location, the storm surge analysis were carried out using historical datasets to determine areas prone to storm surges.

4.7.3 Hazard Profile

The storm surge hazard assessment is useful for short-term and long-term planning to prevent the impacts of storm surges on people living in coastal regions. The assessment will help locate the potential sensitive and storm surge prone areas in Sierra Leone.

4.7.4 Limitations

The storm surge hazard assessment has been based on the best available data for estimating the relative vulnerability of various coastal areas in Sierra Leone to increased storm surge. However, several gaps in the data limit the storm surge hazard assessment. First, the absence of a national or regional database on shoreline protection denied the assessment the opportunity to incorporate the effects of man-made protection measures, if any. Secondly, the absence of reliable and spatially disintegrated data on socio-economic and environmental variables greatly limited the assessment. Furthermore, the assessment did not estimate the impacts of planned adaptation measures and coastal-zone management practices (e.g., land-use planning, regulations, relocation).

4.8 Tropical Storm Hazard Assessment

4.8.1 Background

A tropical storm is a type of storm system that develops in tropical environments. A tropical region is considered as a region between the Tropic of Cancer (23^0 North) and the Tropic of the Capricorn (23^0 South) of the Earth. The weather characterized in this region is called tropical weather and tropical storms are one of the most important tropical weather systems and among the most devastating of all natural hazards. Tropical storms are capable of producing very strong winds, particularly near its centre, torrential rainfall and associated storm surge. Tropical storms can also be very destructive, often causing severe and widespread damage to coastal communities, infrastructure and ecosystems.

Sierra Leone's climate is tropical; although it could be classified as a tropical monsoon climate, it could also be describe as a climate that is transitional between a continually wet tropical rainforest climate and a Tropical Savanna climate. There are two seasons determining the agricultural cycle: the rainy season from May to November, and a dry season from December to May, which includes Harmattan, when cool, dry winds blow in off the Sahara Desert and the night-time temperature can be as low as 18°C. The average temperature is 28 °C and varies from 28 °C to 41 °C during the year. Average rainfall is highest at the coast, 3,000–5,000 mm per year; moving inland this decreases and at the eastern border of the country, the average rainfall is 2,000-2,500 mm

The occurrences of tropical storms in Sierra Leone are prevailent event during the rainy season. Records show that the most devastating tropical storm with wind speed of over 120 km per hour blew over Freetown on June 21, 1976, and in September 2000 that resulted in the removal of the roofs of more than 150 houses and disruption to both electricity and communication. Trees were shaved off their leaves, whilst large number of trees fell within and outside forests. Even the bird perching on trees were not speared. Over 50 vultures perished at the Cotton Tree in central Freetown and in the provinces, however, since that storm, no other storm of similar nature in terms of intensity, expanse and causality have been recorded.

Tropical storms are characterized by extremely low pressure systems, high speed and swirling winds. In order for a storm to be classified as a "tropical storm", a specific set of circumstances must exist and the wind speed must be between 39 and 73 miles per hour. Lower or higher wind speeds would be another classification (lower: tropical depression, higher: hurricane). Storms whose wind speed do not reach these higher limits but have wind speeds reaching 60 km/hr are usually called tropical storms. Tropical Storms start within 8º and 15º north and south of the Equator where surface sea temperatures reach 27ºC. The air above the warm sea is heated and rises. This causes low pressure. As the air rises it cools then condenses, forming clouds. They also need to be between 5 and 20° north or south of the Equator.

Tropical storms cause major disruptions to economic life and require effect-control and mitigation strategies. They blow off the roofs of houses, destroy farms, fell trees across roads, damages and interference to radio communications and damages to electrical installations (power lines, telephone transmission lines, transformer stations, individual/electrical appliances).

4.8.2 Causative Factors

A major contributing factor for the formation of tropical storm is the sea- surface temperature. Higher loads of solar radiation over the region during the period feeds sensible heat required to maintain the ocean temperature at over 26-27°C which is a critical requirement for the formation of tropical storms. Sensible heat maintains the vertical coupling between the lower and upper tropospheric flow pattern in the storm. The Cumulus convection acts as prime mechanism for vertical coupling. The absence of sensible heat leads to the degeneration of cyclone.

Numerous studies have shown that Sea Surface Temperatures (SST) below 26°C do not contribute sufficient thermal buoyancy to sustain cumulonimbus convection. Tropical storm are influenced, greatly by the underlying ocean surface over which they form and travel. As long as a tropical storm remains over warm water, the energy is limitless. Warm and highly humid equatorial and maritime tropical air spirals inward towards the centre of the low pressure to replace the heated and rapidly ascending air. Ascending air releases heat into the atmosphere, cools and are condensed into cloud. Since tropical storms are warm-core systems, air from the core rises and cold air sinks which converts heat energy to potential energy and, thereafter, potential energy to kinetic energy. When this warm and wet air rises, it condenses to form towering clouds, heavy rainfall. The reason is that the Earth's rotation sets up an apparent force (called the Coriolis force) that pulls the winds to the right in the Northern Hemisphere (and to the left in the Southern Hemisphere).The opposite (a deflection to the left and a clockwise rotation) will occur south of the Equator.

Satellite information is very important for tracking and determining intensity trends of tropical storms. Windstorms occur annually during the rainy season causing loss of property (housing destruction, house roofs removal), agricultural loss (crop falling and breaking), environmental loss (trees falling within and outside forests), and even loss of life.

4.8.3 Methodology

The tropical storm hazard assessment was performed considering entire Sierra Leone as the study area. The methodology section consists of availability of data, and a brief description of the domain considered as the study area and the model used in preparation of hazard profile maps of Sierra Leone. Because of lack of reliable and up-to-date data, qualitative assessment using historic data was used for the tropical storm hazard assessment.

4.8.3.1 Tropical Storm Hazard Analysis

In 30 years (1980-2010), windstorms with associated thunderstorms and lightning, affected 3,334 people and killed 24 people. Windstorms, often associated with tropical storms, occur annually during the rainy season causing loss of property (housing destruction, house roofs removal), agricultural loss (crop falling and breaking), environmental loss (trees falling within and outside forests), and even loss of life. The most devastating event was recorded in 1976 with wind speed of over 120 km per hour blowing over Freetown resulting mainly in the removal of the roofs of more than 150 houses, disruption to both electricity and communication, trees falling. Generally accompanying windstorms and heavy rains, thunders and lightning do not occur regularly. Potentially disastrous thunder and lightning normally occur at the start April/May and end September/October of the rainy season, causing human and animal deaths. The whole country is exposed and vulnerable but more specifically open areas and areas with tall trees such as palm trees. Past events occurred mainly in Rogbane Forest Reserve in Port Loko, Bonthe District, Bo District, and in Koinadugu District[34].

4.8.4 Limitations

The main limitation of the tropical storm assessment has been the data availability. In Sierra Leone tropical storm cannot occur regularly, but when they occur the intensity is high. To accurately model the tropical storm hazard, it requires a long period recorded data and have enough meteorological stations. To make the interpolation approach possible, the model needed spatially distributed data covering the whole territory as well. The possibility was to retain all weather stations with at least three years of data. Hence, the geo-statistical interpolation of existing stations' values was impossible to estimate the hazard in some districts affected by strong wind hazards in the past.

4.8.5 Recommendations

Daily monitoring of tropical storm information is highly recommended. In addition, there is a need of a networking system of monitoring and observation to minimize the rate of tropical storm disasters in Sierra Leone. Storm hazard assessment should also be carried out at the local scale/level in the locations where strong tropical storm are most likely to occur. This can result in a more detailed hazard mapping of tropical Storm-prone areas that can address some of the gaps identified in this report. The Tropical storm hazard maps must be updated after at least two years when the data of different meteorological stations will be available. It will allow mapping of the hazard with more accuracy. But to facilitate this task, an organized data collection and treatment system must be established by the SLMA.

[34] Government of Sierra Leone, Ministry of Transport and Aviation. (2007, December). Sierra Leone National Adaptation Programme of Action (NAPA) – Final Report "– "Office of National Security. (2004). National Hazard Assessment Profile".

4.9 Lightning and Thunder Hazard Assessment

4.9.1 Background

Lightening is an unpredictable disaster and a channel of ionized air carrying electrical current between two differing areas of charge. The polarity of lightning discharge can affect the way it propagates and branches in space and time, but in the end, it's all an electrostatic discharge - a 'spark' in its fundamental sense. The characteristics of locations with frequent lightning incidents should be surveyed, studied and understood thoroughly before concluding the reasons for damages caused by lightning in those locations. Not all lightning strikes the ground but, when it does, that energy can be devastating.

Fires, injuries or loss of life, damage and destruction of property, and the significant downtime and outage-related revenue losses due to equipment damage make lightning a serious threat. While the direct effects of a lightning strike are obvious, the secondary effects can be just as devastating. This is especially true for electrical power lines and facilities with sensitive electronic equipment. As far as the industries are concerned, one of the most significant loses that lightning may cause is the downtime.

Sierra Leone is more vulnerable to lightning than countries in higher latitudes, due to more convective activities triggered by direct incidence of solar energy to the Earth surface. Lightning activity over Sierra Leone is comparatively high during months of April, May, September and October. During these periods convective clouds develop over most parts of the country (mostly during the afternoon or evening) producing thunderstorms. Thunderstorms are often associated with hazards such as lightning. Nationally, dozens of people are affected by lightning and thunderstorms leading to injuries, property damages, and in some cases – death.

Classical examples of lightning and thunderstorm incidences recorded in Sierra Leone include:

- Thunderstorm disaster in 2004 at Torma Bum (Bonthe District) that claimed the lives of three adults.
- Thunderstorm in 2004 in Bo District that killed an adult and some animals. Several others were hospitalised, as a result of shock from the discharge.
- The 1988 lightning and thunderstorm incidence that led death in Rogbane Forest Reserve in Port Loko.

Unfortunately, lightning injuries and deaths in Sierra Leone are most times inaccurately reported. This could be attributed to the fact that lightning most often strikes individuals and not large groups of people, making it spatially very disperse and mostly uncounted for.

This lightning and thunder hazard assessment aims to identify vulnerable areas for lightning activities and reasons for the vulnerability to introduce mitigatory options in order to minimize the damages.

4.9.2 Causative Factors of Lightning & Thunder

Lightning activities are higher at the start and the end of rainy season, during which, the Inter Tropical Convergence Zone (ITCZ) – the zone where the northern and southern hemisphere winds meet, is over the Sierra Leonean territory. Therefore, more convection occurs subsequently leading to more lightning activities.

Lightning may be categorized mainly into two types:

- Ground Flash - Discharge between a cloud and the Earth
- Cloud Flash - Discharge within a cloud or between clouds

In a ground flash, the electrical discharge usually occurs between the negative charge of the cloud and the induced positive charge on the ground or structures on the ground. A ground flash is completed through a number of steps and strokes. A complete lightning discharge is called a lightning flash. A lightning flash usually comprises of a number of individual discharges which are called strokes. Characteristics of individual steps are different from stroke to stroke. The polarity of the prevailing cloud charge defines the polarity of the lightning current. The discharge of a positive cloud to Earth is called a positive flash while the discharge of a negative clouds is termed a negative flash.

The sky is filled with electric charge. In a calm sky, the positive (+) and negative (-) charges are evenly spaced throughout the atmosphere. Therefore, a calm sky has a neutral charge. Inside a thunderstorm, the electric charge is spread out differently.

The direct effects of a lightning strike are physical destruction caused by the strike and subsequent fires. When a direct strike hits a facility where flammable materials are present, the flammables may be exposed to the lightning bolt itself, the stroke channel, or the heating effect of the lightning strike. Lightning current reaches a peak value of about 30,000 Amperes on average but currents in the range of 200,000 Amperes are also reported. The lightning current heats its path to a temperature of about 30,000^{0}C. The enormous current involved with lightning flash may destroy entire power and communication networks in buildings.

4.9.2.1 Thunder and Thunderstorms

Thunder is the acoustic wave resulted by the sudden expansion of the air within and around the path of a lightning flash. A thunderstorm is a series of sudden electrical discharges resulting from atmospheric conditions. These discharges result in sudden flashes of light and trembling sound waves, commonly known as thunder and lightning. Thunder is not hazardous as lightning but it may result in property damage and injuries to hearing system of human and animal when it happens at close locations. The damage depends on the intensity of the vibration wave.

Thunderstorms develop when the atmosphere is unstable - this is when warm air exists underneath much colder air. As the warm air rises it cools and condenses forming small droplets of water. If there is enough instability in the air, the updraft of warm air is rapid and the water vapor will quickly form a cumulonimbus cloud. Typically, these cumulonimbus clouds can form in under an hour. As the warm air continues to rise, the water droplets combine to create larger droplets which freeze to form ice crystals. As result of circulating air in the clouds, water freezes on the surface of the droplet or crystal. Eventually the droplets become too heavy to be supported by the up draughts of air and they fall as hail.

4.9.3 Impacts of Lightning and Thunder

There are several records of impacts relating to lightning and thunder storm.

4.9.3.1 Impacts on Human Casualties

Sierra Leone has experienced multiple reported lightning and thunder incidences over the past years - affecting human lives, disturbing human settlements and damaging properties. Lightning ignites fires that may bring an entire building or a house down to ashes. Therefore, the development of a lightning and thunder hazard profile for the country is imperative to prevent damages and save lives.

4.9.3.2 Secondary Impacts

The secondary effects of a direct or nearby strike include the bound charge, electromagnetic pulse, and Earth currents. The bound charge is the most common. The electrostatic and electromagnetic pulses induce high voltage transients onto any conductors within their sphere of influence. These transients will cause arcing between wires, pipes and Earth. Again, arcs in the ‘right’ place initiate both fires and explosions. The secondary effects are not always easily identified as to cause or mechanism. This mode of interruption of the lightning current cause less damages than a direct strike, yet service are subjected to lightning strikes much more frequently than buildings themselves.

4.9.3.3 Impacts on Power and Communication Lines

Power line voltage fluctuations and interruptions are the greatest source of destructive and disruptive phenomena that electrical and electronic equipment experience in day-to-day operations. Power and communication lines get affected by secondary effect of lightning. A direct strike to the power line at the service entrance can cause significant damage inside unprotected or improperly facilities. Most of these events can be eliminated through the correct use of relatively inexpensive protection equipment.

4.9.4 Methodology for Lightning Hazard mapping

Sierra Leone is now equipped with a lightning detection system. Earth Networks, under a contract with the UNDP, in late 2016 installed a baseline network of integrated compact automatic weather stations

(AWS)[35] and lightning sensors on mobile communications towers in eight secured locations across Sierra Leone. These eight installed and sufficiently sophisticated AWS now play the central role in the Sierra Leone Meteorological Agency (SLMA) observing network.

Dangerous Thunderstorm Alerts (DTAs) by Earth Networks provide advanced notification of the increased threat of severe weather moving into an identified area. A DTA alert is issued when there is a high frequency of lightning detected by the Earth Networks Total Lightning Network™ (ENTLN) indicating the increased potential for: lightning strikes, heavy rain rates, high winds and hail activity. The alert is updated every 15 minutes until the dangerous weather activity is no longer a threat and the alert expires. The advanced technology used within ENTLN enables the detection of both in-cloud and cloud-to ground lightning (otherwise known as total lightning). High rates of total lightning activity serve as precursory indicators of the potential for severe weather activity.

Earth Networks issues a DTAs when the lightning detection rate exceeds high levels. These alerts are available through a data API that will return the alert information in CAP format. The alert CAP feed includes a polygon encompassing the area at risk, direction and speed of the severe lightning activity, cities in the route of the storm and current observations from weather stations near or in the affected area. A ready to use weather bulletin text is also provided within the CAP feed.

The scope of the lightning and thunder hazard assessment consists of the preparation of lightning hazard maps to plan mitigation activities in potential hazard areas. The main parts concerned of the study are;

- Lightning phenomena in Sierra Leone based on monthly behavior using thunder day data collected from the ENTLN and the eight AWS.
- Lightning phenomena in Sierra Leone based on yearly behavior using thunder day data collected from the ENTLN and the eight AWS.
- Mapping of lightning hazard areas in Sierra Leone for 12 months using ArcGIS software. Point data constructed with latitude and longitudinal pairs were ingested into GIS.
- Develop composite annual map of lightning hazard areas in Sierra Leone.

4.9.5 Recommendations

The following are recommended to improve the quality of lightning hazard assessment in Sierra Leone.

- Establish lightning flash counter network and lightning detection system in Sierra Leone at least with four lightning sensors.
- Conduct lightning studies to collect lightning data (thunder day) with more locations in the country.
- Leverage the Earth Networks DTAs that provide advanced notification of the increased threat of severe weather moving into an identified area. Undertake studies to analyze weekly lightning data to generate high resolution lightning calendar and maps.
- Conduct countrywide survey to collect past lightning incidents in the country and together with past media reports, vulnerability maps can be developed.
- Study soil structure of the lightning prone areas.
- Investigate the increasing (or decreasing) tendency of lightning activity over the country.
- Use available satellite data to study the vertical profile of the thunder clouds.

[35] These AWS have been installed and maintained by Earth Networks through an approach being promoted in the UNDP's Programme on CIRDA, which exploits the capabilities of the latest generation of smart, integrated, all-in-one (AIO) AWS, supplemented where necessary by even more powerful stand-alone data loggers, to provide sustainable observing networks for the 11 sub-Saharan African countries partnered with the support programme.

5 MAN-MADE HAZARDS

Man-made hazards are events that are caused by humans and occur in or close to human settlements. The events leading up to a man-made hazard may be the result of deliberate or negligent human actions, but their impact can be equally as devastating as natural hazards. Although mitigation planning in Sierra Leone traditionally focused on planning for natural hazards, recent events such as the 14 August 2017 landslide and flood/mudflow disaster and recent scores of man-made fire incidents and accidents in urban areas of Sierra Leone are reinforcing the need to incorporate man-made hazards into all aspects of disaster management planning in Sierra Leone to reduce communities' exposure and vulnerability to future man-made hazards and disasters.

There is close link between natural and man-made hazards and disasters. For example, the changes in land use associated with urban development affect flooding in many ways. Removing vegetation and soil, grading the land surface, and constructing drainage networks increase runoff to streams from rainfall. As a result, the peak discharge, volume, and frequency of floods increase in nearby streams. Changes to stream channels during urban development can limit their capacity to convey floodwaters. Roads and buildings constructed in flood-prone areas are exposed to increased flood hazards, including inundation and erosion, as new development continues.

5.1 Deforestation and Land Degradation

5.1.1 Background

Sierra Leone's predominant natural vegetation is the western extremity of the Upper Guinean Forest formation that hosts rich indigenous flora and fauna, important endemic species, and internationally rare and threatened species. Sierra Leone was once a well-forested country, but the closed forest cover has been reduced from about 70% of the total land area in about seven decades period to approximately 38% forest cover (FAO, 2010). Much of that forest cover has been converted to agricultural lands, savannas and other secondary vegetation.

Decreases in forest cover are the result of multiple factors including clearing for agriculture, logging (both legal and illegal), mining, construction, fuel wood, and charcoal production. Along the coastal areas, mangrove forests cover approximately 286,000 hectares but these forests are also threatened by the unregulated use of wood for construction and fuel wood. A large proportion of the country's land surface (over 50%) is now occupied by farm bush and forest regrowth at various stages of succession. The changes in forest cover have been under a dynamic state characterised by clearing, cultivation and regeneration. This cycle, which is basically a cultivation-fallowing ecological succession, is the most common agricultural practice in the country.

The majority of forest land is found on community-owned land in the provinces, which amounts to 2.43 million ha. Only 395 000 ha of forestland is under public ownership (FAO, 2010) with protected areas covering approximately 4% of the total land area. So far, there are three National Parks - the Outamba Kilimi National Park (OKNP), the Gola Rainforest National Park (GRNP), and most recently the Western Area Peninsula National Park. The Loma Mountains has been proposed and is currently awaiting final approval by the Parliament.

The Forest Reserve is under the management control of the Forestry Division and comprises forty-eight forest reserves and conservation areas totalling 284,591 ha, with an additional 636,360 ha proposed. Community forests located on community land but leased to the Forestry Division for management total 11,800 ha. Information from the 2003 Biodiversity Strategic Action Plan identifies approximately 300,000 hectares of mainly mangrove forest within the wetland and marine ecosystem protected areas.

Because of its closeness to the capital city, the Western Area Peninsula Forest Reserve (WAPFR) received high premium and hence, became the first forest area in the Sierra Leone to receive protection, declared in1916 under the British Colony. Protection of terrestrial landmarks in Sierra Leone, which covers WAPFR, also incorporating the wider Goderich community, comes under the jurisdiction of the Conservation and Wildlife section of the Division of the Ministry of Agriculture, Forestry and Food Security (MAFFS). Both the Forest Acts 1988 and the Wildlife Conservation Acts 1972 forms the guiding principles responsible for the protection of forests and biodiversity in relation to wildlife in Sierra Leone but has so far proved inadequately in addressing existing issues relating to forest management in the country. This is due to lack of capacity of the division to provide full protection and monitoring of its terrestrial forest reserve and hence making it vulnerable to abuse by intruders and particularly, to existing biodiversity.

Lately, the establishment of the EPA-SL and most the National Protected Areas Authority (NPAA) have taken vital steps towards the protection of biodiversity and forests in the country. These institutions are established under special jurisdictions 'Environment Agency Protection Acts 2008 and the 'National Protection Area Authority and Conservation Trust Fund Acts 2012) to ensure full protection of the environment, which also encompass terrestrial boundaries and biodiversity.

5.1.2 Spatial and Temporal Distribution of Land Cover and Land Use

About 2,754,000 ha (38.5%) of the country is forested. Between 1990 and 2000, the country lost an average of 19,300 hectares of forest per year. Between 2000 and 2005, the rate of forest change increased by 7.3% to 0.68% per annum so that in total between 1990 and 2005, Sierra Leone lost 9.5% of its forest cover (about 290,000 ha).

Major surviving wildlife species are within forest reserves (see Table 5-1 and Figure 5-1). The most prominent is the Gola Forest Reserves which is the only substantial tract of primary moist lowland forest remaining in Sierra Leone, together covering 748 km^2. These reserves still have a full complement of rain forest tree species and are comparable to primary forests in Liberia, Cote d'Ivoire and even Nigeria.

Table 5-1: Summary of Established Reserves by Ecosystem

Ecosystem Type	Number of Reserves	Total Land Area, ha	Categories Represented
Montane	2	43,720	National Park, Game Reserve
Rainforest	27	124,789	Forest Reserve, National Park, Game Reserve, Game Sanctuary
Savanna	3	113,500	National Park, Game Reserve, Game Sanctuary
Wetland	13	350,677	Strict Nature Reserve, Game Sanctuary, Game reserve, National Park, Important Bird Area
Marine	1	300,000	Inshore Exclusion Zone (IEZ)

In an effort to maintain these surviving habitats, the country has endorsed and signed several international conventions and protocols including: Convention on Biological Diversity (CBD), United Nations Framework Convention on Climate Change (UNFCC), United Nations Convention to Combat Desertification/Land Degradation (UNCCD), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Convention on Wetlands of International Importance (the Ramsar Convention), The Cartagena Protocol on Biodiversity, United Nations Convention on the Law of the Sea (UNCLOS), Basel Convention, Vienna Convention and Montreal Protocol, and the Stockholm Convention on Persistent Organic Pollutants. These conventions and protocols are at different stages of implementation, but implementation is generally slow as many have not been ratified or harmonized with the national laws, policies and programmes in Sierra Leone. As a result the country trails far behind in the implementation of the provisions of these conventions.

Figure 5-1: National Park and Protected Areas in Sierra Leone

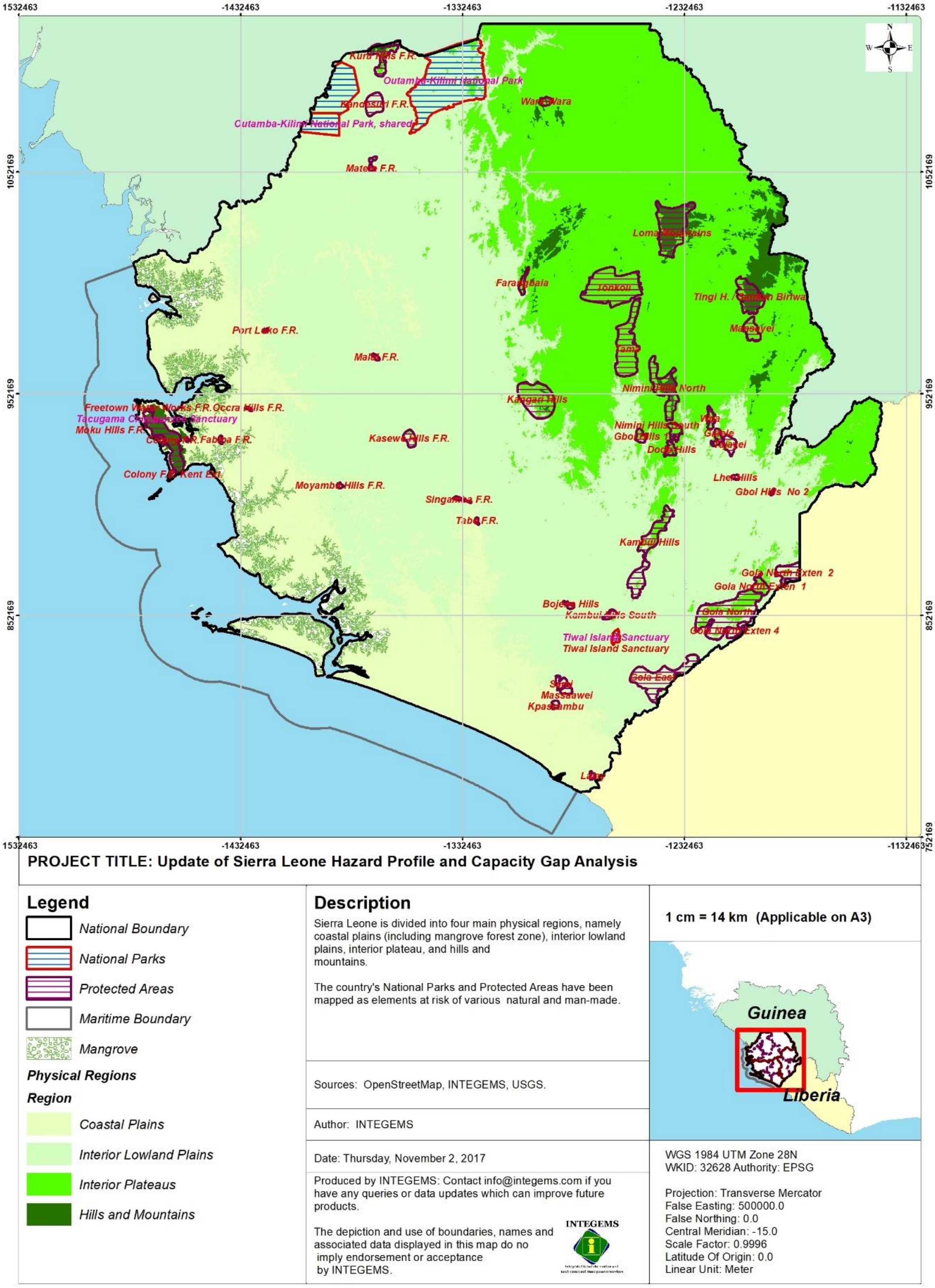


Table 5-2: Designated Reserves and Corresponding Areas in Sierra Leone

Reserve	Area (Ha)	Reserve	Area (Ha)
Gola	77,044	Nimini	15,557
Tonkoli	47,656	Freetown Peninsula (Western Area Peninsula Forest)	14,089
Loma	33,200	Sanka Biriwa	11,885
Kambui	21,213	Kangari Hills	8,573
Dodo Hills	21,185	Kuru Hills	7,001
Tama	17,094	Kasewe	2,333

Only two areas, Outamba Kilimi National Park (OKNP) and Tiwai Wildlife Sanctuary (TWS), have been elevated to the status of national park and wildlife sanctuary, and both fulfil the IUCN classification system. Several protected areas have been proposed as national parks or game reserves. All of the major ecosystem types are represented within the protected area system of Sierra Leone.

Currently, Sierra Leone has 11 protected areas with moist forest formations (closed moist and semi-deciduous) within their boundaries. Three of these protected areas have entirely moist evergreen forest and they include two strict nature reserves (Gola North and Gola East) and a proposed national park (Western Peninsula Area forest reserve). Kangari Hills in central Sierra Leone is made up of semi-deciduous forest. Other protected areas with some moist forests within their boundaries include Lake Sonfon, Loma Mountains, Dodo Forests, Yawri Bay, and Tingi Hills. Protected areas with both moist and semi-deciduous forests have an estimated land area of just over 33,900 ha.

The wetland ecosystem also occupies the largest land area in Sierra Leone, with numerous "proposed" protected areas. The marine ecosystem has a limited protected area within 3-4 miles offshore, known as Inshore Exclusion Zone (IEZ), where industrial fishing vessels are prohibited from fishing. These areas are protected for the artisan fleets.

There is a vast increase in percentage of tree cover loss from 2013 – 2016 (see Table 5-3 to Table 5-12 and Figure 5-2 to Figure 5-11) as a result of urbanisation and timber logging[36].

Table 5-3: Tree cover by percent canopy cover (2000)

Provinces	Area, hectares						
	>10%	>15%	>20%	>25%	>30%	>50%	>75%
Eastern province	1,566,122	1,558,959	1,510,658	1,500,753	1,457,222	1,280,872	166,812
Northern province	3,552,151	3,484,591	2,866,737	2,781,735	2,434,927	1,014,674	41,492
Southern province	1,956,457	1,919,306	1,757,924	1,742,137	1,680,631	1,267,176	30,856
Western area	62,996	59,499	49,923	48,877	45,098	26,565	3,421
National	**7,137,726**	**7,022,355**	**6,185,242**	**6,073,503**	**5,617,878**	**3,589,287**	**242,582**

[36] Due to variation in research methodology and/or date of content, tree cover, loss and gain cannot be compared against each other. Accordingly, "net" loss cannot be calculated by subtracting tree cover gain from tree cover loss, and current (or post-2000) tree cover extent cannot be determined by subtracting annual tree cover loss from year 2000 tree cover extent.

Please also note that "tree cover" does not equate to common definitions of "forest." "Tree cover" refers to the biophysical presence of trees, which may be a part of natural forests or tree plantations. Thus, loss of tree cover may occur for many reasons, including deforestation, fire, and logging within the course of sustainable forestry operations. Similarly, tree cover gain may indicate the growth of trees within natural or managed forests.

Figure 5-2: Tree cover by percent canopy cover (2000)

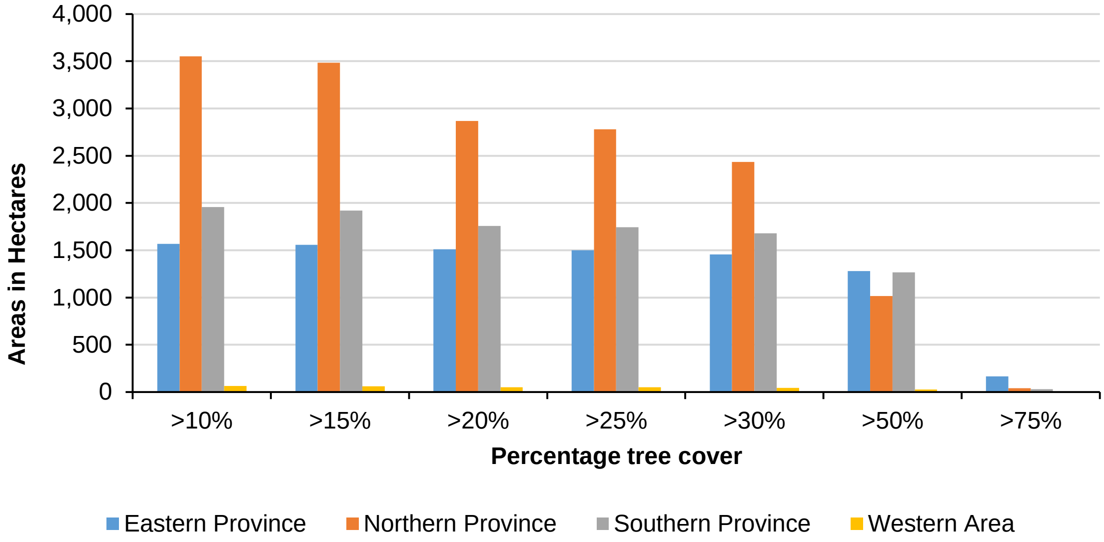


Table 5-4: Tree cover gain (>50% canopy cover) (2001-2012)

Provinces	Tree cover gain
Eastern Province	15,893
Northern Province	10,189
Southern Province	19,026
Western Area	25
National	**45,132**

Source: http://www.globalforestwatch.org/

Figure 5-3: Tree cover gain (>50% canopy cover) (2001-2012)

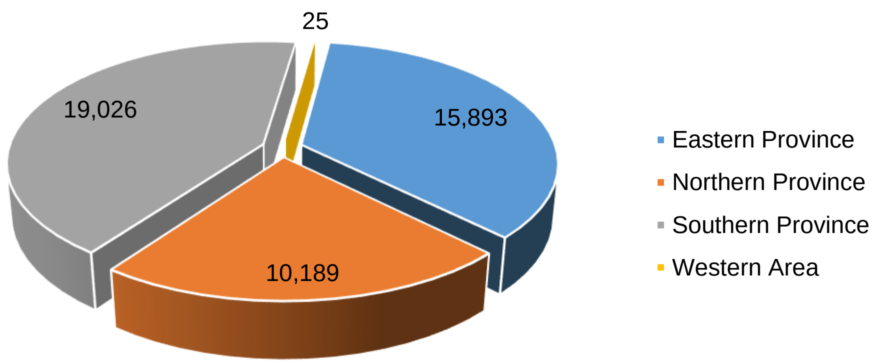


Table 5-5: Tree cover loss by (>10% canopy cover)

Year	Eastern	Northern	Southern	Western
2001	5,885	6,039	7,133	41
2002	4,382	2,148	9,114	37
2003	3,250	2,190	3,916	50
2004	1,805	1,210	899	195
2005	3,960	1,568	1,521	163
2006	11,172	7,249	10,461	481
2007	12,527	5,075	4,357	156
2008	13,540	4,602	2,923	96
2009	11,601	5,859	12,638	957
2010	4,724	1,783	2,316	102
2011	8,515	15,105	11,231	156
2012	7,012	4,245	5,312	286
2013	50,677	57,134	67,053	508
2014	36,629	63,347	66,465	500
2015	53,945	95,250	88,624	801
2016	42,328	75,527	63,251	754
Total	**271,950**	**348,329**	**357,212**	**5,284**

Source: http://www.globalforestwatch.org/

Figure 5-4: Tree cover loss by (>10% canopy cover)

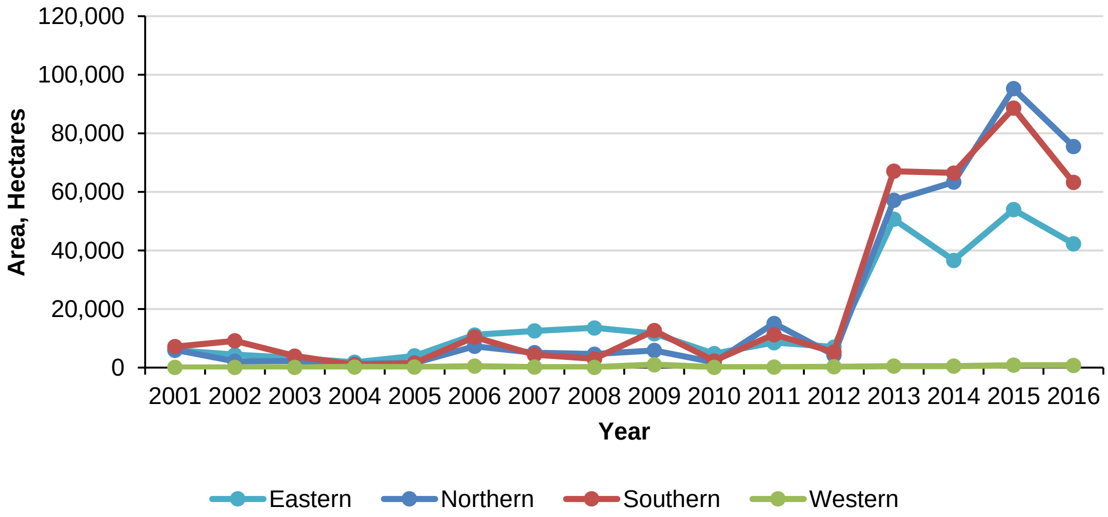


Table 5-6: Tree cover loss by (>15% canopy cover)

Year	Eastern Province	Northern Province	Southern Province	Western Area
2001	5,882	6,035	7,131	38
2002	4,374	2,144	9,104	36
2003	3,247	2,181	3,912	49
2004	1,803	1,209	899	194
2005	3,957	1,564	1,518	162
2006	11,164	7,235	10,450	479
2007	12,525	5,073	4,355	156
2008	13,539	4,594	2,921	95
2009	11,600	5,835	12,632	956
2010	4,723	1,779	2,312	101
2011	8,512	15,086	11,226	155
2012	7,011	4,237	5,308	284
2013	50,654	57,084	66,992	506
2014	36,612	63,300	66,424	498
2015	53,926	95,218	88,586	801
2016	42,314	75,508	63,222	754
Total	**271,842**	**348,083**	**356,992**	**5,264**

Source: http://www.globalforestwatch.org/

Figure 5-5: Tree cover loss by (>15% canopy cover)

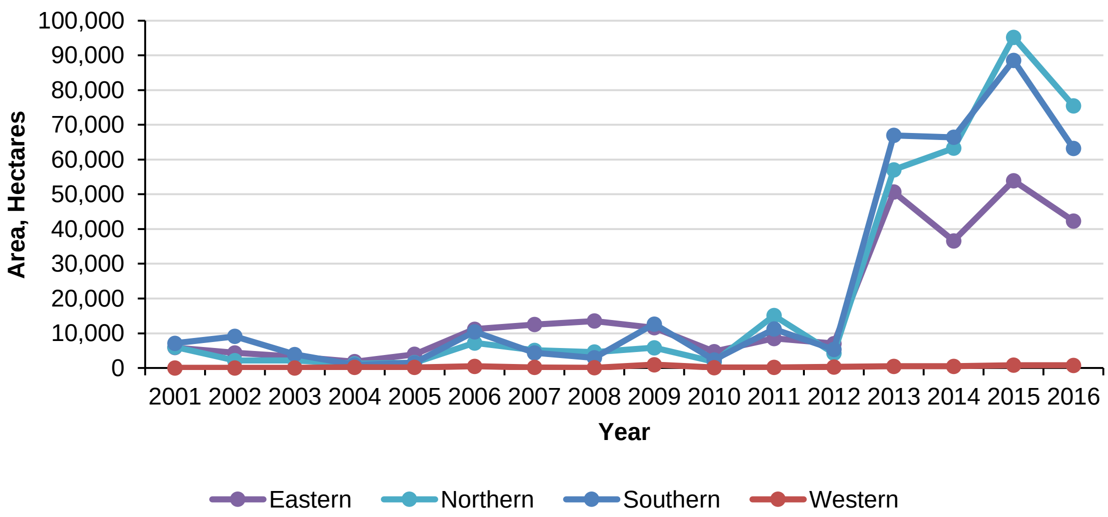


Table 5-7: Tree cover loss by (>20% canopy cover)

Year	Eastern	Northern	Southern	Western
2001	5,835	5,942	7,117	34
2002	4,296	2,101	9,084	33
2003	3,228	2,119	3,898	44
2004	1,794	1,198	897	189
2005	3,942	1,480	1,500	157
2006	11,080	7,090	10,395	450
2007	12,505	5,035	4,345	154
2008	13,531	4,541	2,913	92
2009	11,593	5,722	12,596	941
2010	4,714	1,750	2,302	97
2011	8,486	14,745	11,185	152
2012	7,002	4,122	5,291	269
2013	50,521	55,800	66,708	478
2014	36,522	61,706	66,182	475
2015	53,867	94,138	88,357	790
2016	42,273	74,783	62,995	747
Total	**271,189**	**342,272**	**355,766**	**5,102**

Source: http://www.globalforestwatch.org/

Figure 5-6: Tree cover loss by (>20% canopy cover)

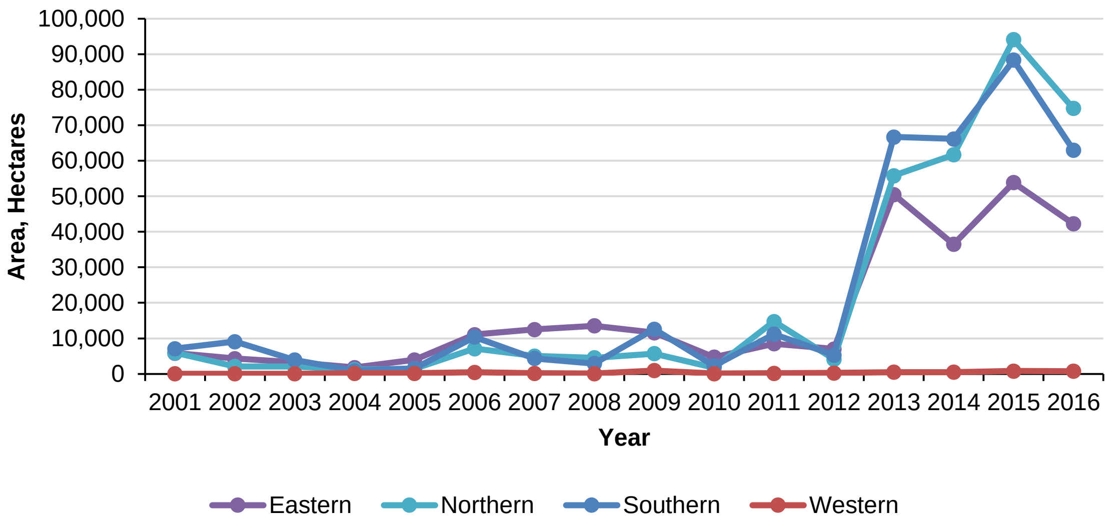


Table 5-8: Tree cover loss by (>25% canopy cover)

Year	Eastern	Northern	Southern	Western
2001	5,826	5,906	7,111	32
2002	4,284	2,086	9,078	33
2003	3,222	2,096	3,894	43
2004	1,792	1,192	896	188
2005	3,936	1,457	1,496	155
2006	11,061	7,045	10,380	440
2007	12,499	5,020	4,342	153
2008	13,528	4,521	2,911	92
2009	11,591	5,687	12,585	936

Year	Eastern	Northern	Southern	Western
2010	4,711	1,743	2,300	96
2011	8,480	14,652	11,174	150
2012	7,000	4,091	5,287	265
2013	50,484	55,453	66,649	474
2014	36,500	61,358	66,119	472
2015	53,853	93,710	88,285	787
2016	42,262	74,495	62,936	744
Total	**271,029**	**340,512**	**355,442**	**5,061**

Source: http://www.globalforestwatch.org/, accessed 31 October 2017.

Figure 5-7: Tree cover loss by (>25% canopy cover)

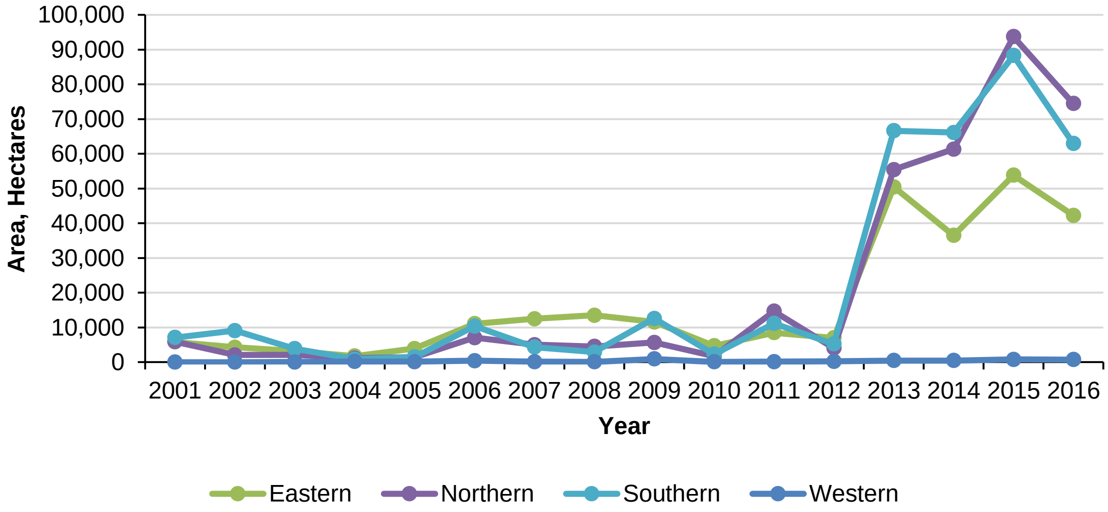


Table 5-9: Tree cover loss by (>30% canopy cover)

Year	Eastern	Northern	Southern	Western
2001	5,774	5,717	7,075	30
2002	4,236	1,997	9,046	31
2003	3,193	1,990	3,878	38
2004	1,785	1,165	891	178
2005	3,912	1,336	1,476	149
2006	10,986	6,837	10,298	405
2007	12,477	4,925	4,327	150
2008	13,517	4,420	2,900	87
2009	11,582	5,509	12,546	910
2010	4,700	1,702	2,288	93
2011	8,456	14,209	11,119	145
2012	6,989	3,858	5,260	249
2013	50,305	53,324	66,214	435
2014	36,357	59,088	65,626	443
2015	53,760	90,617	87,630	754
2016	42,184	72,342	62,432	729
Total	**270,212**	**329,036**	**353,005**	**4,827**

Figure 5-8: Tree cover loss by (>30% canopy cover)

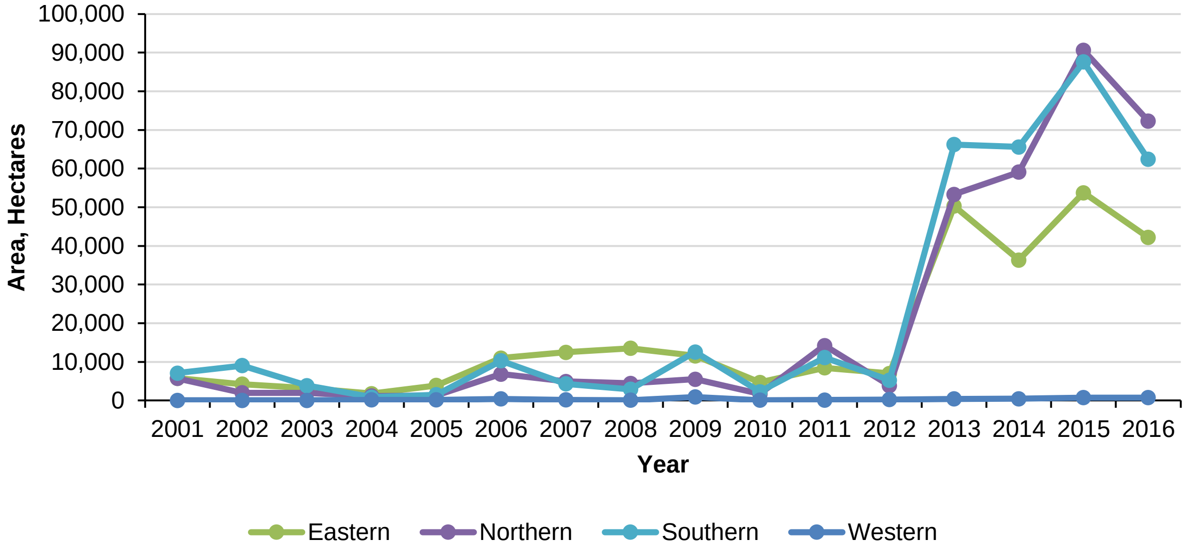


Table 5-10: Tree cover loss by (>50% canopy cover)

Year	Eastern	Northern	Southern	Western
2001	5,472	4,536	6,553	22
2002	4,007	1,338	8,363	19
2003	3,030	1,388	3,587	17
2004	1,723	845	829	94
2005	3,719	722	1,279	92
2006	10,553	4,750	9,128	184
2007	12,128	3,587	3,982	69
2008	13,310	3,260	2,617	45
2009	11,448	3,784	11,957	480
2010	4,602	1,159	2,175	56
2011	8,229	10,442	10,057	102
2012	6,761	1,925	4,640	138
2013	47,498	29,695	54,144	166
2014	33,750	31,560	52,434	187
2015	50,602	48,117	71,234	355
2016	39,831	40,872	49,096	487
Total	**256,663**	**187,980**	**292,075**	**2,514**

Source: http://www.globalforestwatch.org/, accessed 31 October 2017.

Figure 5-9: Tree cover loss by (>50% canopy cover)

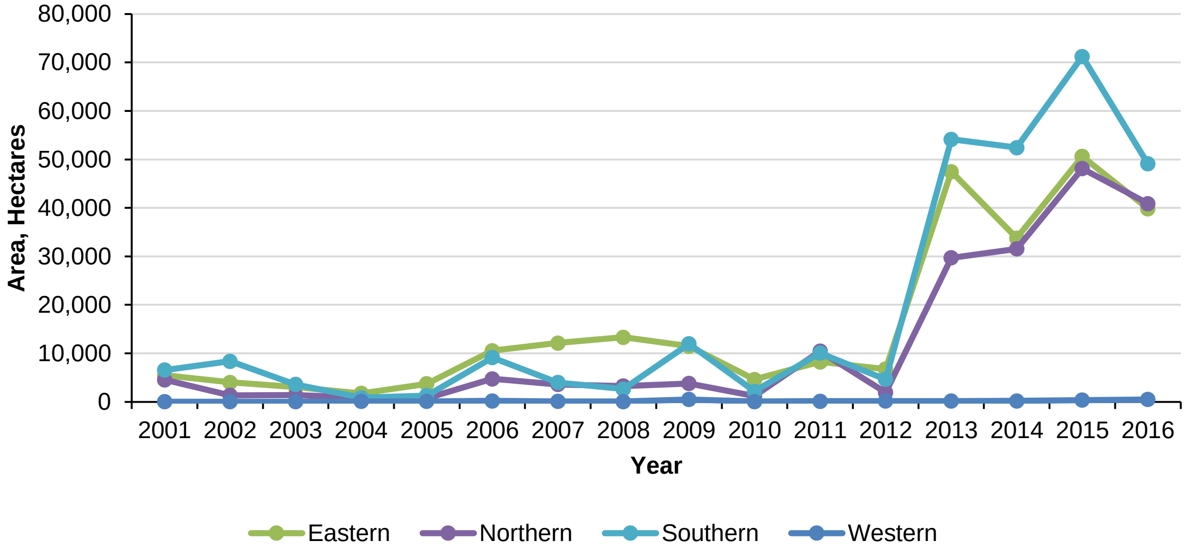


Table 5-11: Tree cover loss by (>75% canopy cover)

Year	Eastern	Northern	Southern	Western
2001	2,882	1,527	1,341	3
2002	1,349	344	1,150	2
2003	1,302	524	558	1
2004	530	254	120	5
2005	1,187	129	181	12
2006	3,968	1,485	1,392	16
2007	3,877	1,090	576	4
2008	4,397	972	453	2
2009	4,185	936	1,505	18
2010	1,476	172	250	3
2011	2,533	3,378	880	5
2012	748	73	75	11
2013	2,308	429	281	1
2014	1,169	341	167	1
2015	2,043	456	392	4
2016	1,824	495	313	13
Total	**35,777**	**12,604**	**9,632**	**98**

Source: http://www.globalforestwatch.org/, accessed 31 October 2017.

Figure 5-10: Tree cover loss by (>75% canopy cover)

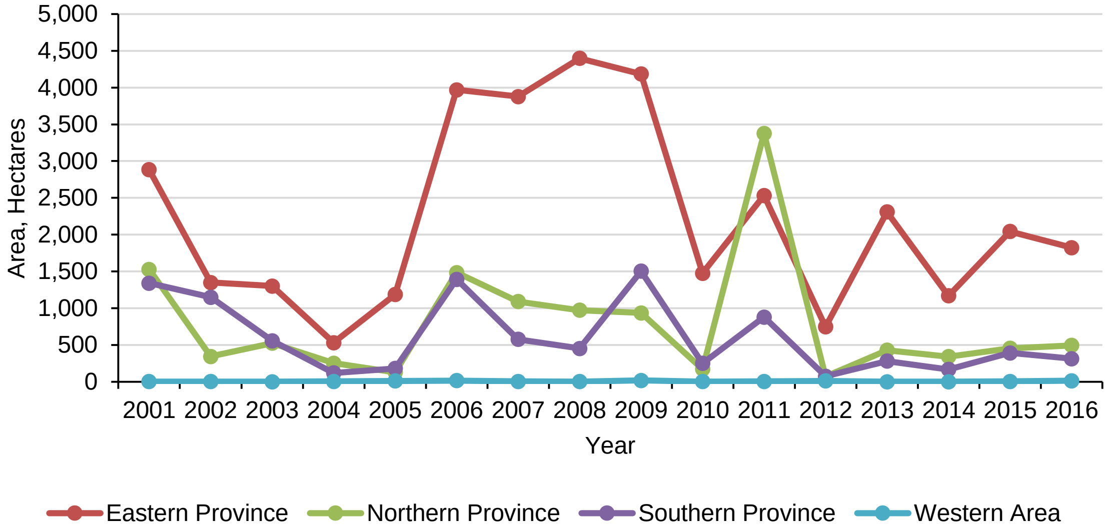
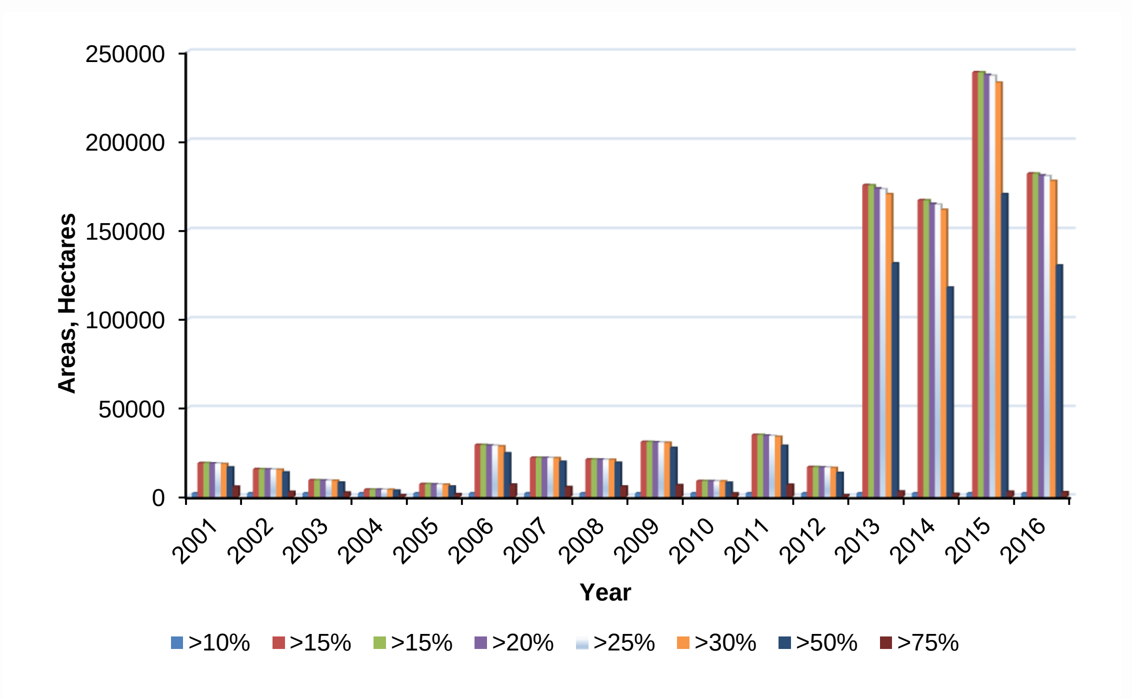


Table 5-12: National tree cover loss by percentage canopy cover

Year	>10%	>15%	>20%	>25%	>30%	>50%	>75%
2001	19,098	19,087	18,928	18,876	18,596	16,583	5,753
2002	15,680	15,658	15,515	15,481	15,310	13,728	2,844
2003	9,406	9,389	9,289	9,255	9,099	8,022	2,384
2004	4,108	4,104	4,078	4,068	4,020	3,491	909
2005	7,212	7,201	7,080	7,044	6,872	5,812	1,508
2006	29,363	29,327	29,015	28,926	28,526	24,614	6,861
2007	22,116	22,108	22,039	22,014	21,878	19,766	5,548
2008	21,160	21,150	21,078	21,052	20,925	19,232	5,823
2009	31,055	31,023	30,851	30,799	30,546	27,669	6,643
2010	8,926	8,915	8,863	8,850	8,782	7,992	1,900
2011	35,007	34,979	34,568	34,457	33,929	28,830	6,796
2012	16,855	16,839	16,683	16,643	16,356	13,464	906
2013	175,371	175,237	173,508	173,060	170,278	131,503	3,019
2014	166,940	166,834	164,885	164,449	161,513	117,931	1,678
2015	238,620	238,531	237,153	236,635	232,761	170,307	2,894
2016	181,859	181,798	180,799	180,437	177,687	130,287	2,644
Total	**982,776**	**982,182**	**974,330**	**972,044**	**957,080**	**739,231**	**58,111**

Source: http://www.globalforestwatch.org/, accessed 31 October 2017.

Figure 5-11: National tree cover loss by percentage canopy cover



5.1.3 Causes/Drivers of Deforestation and Land Degradation

Deforestation refers to the cutting, clearing, and removal of rainforest or related ecosystems into less bio-diverse ecosystems such as urbanisation, mining, construction, farming, or plantations, etc. Land degradation is a composite term; it has no single readily-identifiable feature, but instead describes how one or more of the land resources (soil, water, vegetation, rocks, air, climate, relief) has changed for the worse. A landslide is often viewed as an example of land degradation in action – it changes the features of the land, causes destruction of houses, and disrupts activities. In the longer term, however, the area of a landslide may regain its productivity. Land degradation is caused by multiple forces, including extreme weather conditions particularly drought, and human activities that pollute or degrade the quality of soils and land utility negatively affecting food production, livelihoods, and the production and provision of other ecosystem goods and services.

About 38% of Sierra Leone's remaining land covered by forest is decreasing, principally as a result of anthropogenic activities which can all be attributed to poverty as the underlying cause of much of the forest degradation and deforestation. The main drivers of deforestation in Sierra Leone are:

5.1.3.1 Urbanisation

The degradation of habitats through urbanisation has impacted strongly on the depletion of agricultural biodiversity in Sierra Leone. Studies indicate that 85 % of the species on the IUCN Red List is threatened by habitat loss while clearing land for development and agricultural expansion have dramatically accelerated habitat loss. The Sierra Leone civil war (1991-2002) led to large numbers of people migrating from rural areas where there was violence, to the relatively safe cities (especially Freetown). These people were mainly subsistence farmers who occupied the forested area around the city to provide them with a living. Consequently, the clearing of trees for housing and farmland, as well as the chopping of wood to sell and earn living has put increasing strain on the forests near the most densely populated area of the country. This has increased flood risk during the rainy season and endangered many local wildlife species such as the chimpanzees.

Forests have been degraded or altered by urbanisation (development of tourism, deforestation, mining and aquaculture). Fragmentation of large areas of habitat into smaller patches makes it difficult for isolated species to maintain large enough breeding populations to ensure their survival. It also diminishes the quality of the remaining habitats. Urbanisation generally increases the size and frequency of floods and may expose communities to increasing flood hazards. Especially in the Western Area of Sierra Leone, urbanisation is responsible for the loss of vegetation and soils, particularly in the Western Area Peninsula Forest Reserve (WAPFR). The vegetation holds down the soil, and contributes to its protection from heavy rains. The soils are very important because they act as a sponge, and absorb most of the water when it rains. When trees are cut down and roads built, they make it easier for the rains to erode the soils. And when the soils disappear, rainwater simply rushes to the lowest point in the topography, where it accumulates and causes flooding.

5.1.3.2 Mining and Quarrying

Illegal quarrying/stone mining and mineral mining all take place within the Forest Reserve, and often without the knowledge, permission or oversight of the Forestry Division. These activities are often destructive and undermine sustainable forest management objectives. Management and oversight of these activities need to be better coordinated, monitored and overseen by the Forestry Division. Construction of roads to mining sites through the forests leads to division of habitation of animals, birds and other species. Once the roads are put to use, they pose a barrier for free movement of wildlife. Although, a small portion of forest land would have been used by felling trees, the division of habitation would be strongly felt by wildlife leading to imbalance. Further, such construction of roads to access mining facilities provides easy access to logging and encourages uncontrolled activity of timber production.

5.1.3.3 Agriculture Slash and Burn Farming

A major driver of deforestation comes from agriculture slash and burn is used in both commercial and subsistence farming practices throughout Sierra Leone. It refers to the cutting down of trees and bushes including grasses and burning them. Most farmers in Sierra Leone practice farming by claiming forest land to grow crops by cutting and setting the forest areas fire claiming that the forest land is fertile due to forest's flora and fauna. This way large tracts of forest land is deforested for cultivation. Unfortunately, most of these farmers do not realize that the land itself is responsible for its fertility rather than the forest mass. Repeated slash and burn is detrimental to all living ecosystems on the land and minimizes the opportunities for the indigenous wild plant/crop species rehabilitation and survival. Grass lands are needed for cattle feeding and developing the cattle growing industry, especially in the Northern Region of the country. In order to raise the cattle cheaply, some herdsmen follow the deforestation route as it is and cheap allowing local industry to meet the demand for cheaper animal products.

5.1.3.4 Fire Wood and Charcoal Production

Less privileged Sierra Leoneans, because of poverty and poor economic conditions, are forced to use forest as a principle source of fire wood. They tend to deforest for fuel wood production leading to large tracts of forest land becoming barren. In combination with logging and pole extraction, wood-fuel production is now a leading cause of habitat degradation in various ecosystems, including closed forest, woodlands and mangroves. The rate of wood, charcoal and log production is so high nowadays that the rate of habitat recovery is hardly keeping pace with the rate of depletion. Charcoal production and trade is also a source of income, especially for rural people. As a result, there is always a tendency to extend wood resource extraction into pristine areas and reserves. The recent introduction of the power-saw into wood processing for logs and charcoal is a very potent factor that has accelerated the destruction and degradation. Although logging can sometimes be selective, the increasing demand for building poles and logs is causing indiscriminate extraction. Forest tree species have been the main target of logging companies and private loggers. The extraction of species like *Pterocarpus mildbraedii* and *Lophira lanceolatais* have devastated woodland habitats in northern Sierra Leone, including the Outamba-Kilimi National Park.

5.1.3.5 Timber Production

Forests in Sierra Leone is greatly threatened as a result of the high demand placed on forest timber resource as one of the main source of bio-energy; this account for 80-90% of the country's population, both rural and urban and over 70% of energy consumption in the country (Blinker, 2006). High pressure placed on high demand for forest resources like wood has intensified deforestation rate and the existence of forest biological diversity in the country as a whole. Wood products from the forest have traditionally ranked as an income earner, while fuelwood, bush meat, medicinal plants and other nontimber products have continued to contribute significantly to the welfare of most Sierra Leoneans. The timber is used as important construction material which destroys ecological balance.

5.1.4 Types of Land Degradation

Types of land degradation include:

- **Soil erosion by water:** The removal of soil particles by the action of water. Usually seen as sheet erosion (a more or less uniform removal of a thin layer of topsoil), rill erosion (small channels in the field) or gully erosion (large channels, similar to incised rivers). One important feature of soil erosion by water is the selective removal of the finer and more fertile fraction of the soil.
- **Soil erosion by wind:** The removal of soil particles by wind action. Usually this is sheet erosion, where soil is removed in thin layers, but sometimes the effect of the wind can carve out hollows and other features. Wind erosion most easily occurs with fine to medium size sand particles.
- **Soil fertility decline:** The degradation of soil physical, biological and chemical properties. Erosion leads to reduced soil productivity, as do:

  a) Reduction in soil organic matter, with associated decline in soil biological activity;

  b) Degradation of soil physical properties as a result of reduced organic matter (structure, aeration and water-holding capacity may be affected);

  c) Changes in soil nutrient content leading to deficiencies, or toxic levels, of nutrients essential for healthy plant growth;

  d) Build-up of toxic substances – e.g. pollution, incorrect application of fertilisers.

- **Waterlogging:** Caused by a rise in groundwater close to the soil surface or inadequate drainage of surface water, often resulting from poor irrigation management. As a result of waterlogging, water saturates the root zone leading to oxygen deficiency.
- **Increase in salts:** This could either be salinisation, an increase in salt in the soil water solution, or sodication, an increase of sodium cations (Na+) on the soil particles. Salinisation often occurs in conjunction with poor irrigation management. Mostly, sodication tends to occur naturally. Areas where the water table fluctuates may be prone to sodication.
- **Sedimentation or 'soil burial':** This may occur through flooding, where fertile soil is buried under less fertile sediments; or wind blows, where sand inundates grazing lands.

In addition to these principal types of soil degradation, other common types of land degradation include:

- **Lowering of the water table:** This usually occurs where extraction of groundwater has exceeded the natural recharge capacity of the water table.
- **Loss of vegetation cover:** Vegetation is important in many ways. It protects the soil from erosion by wind and water and it provides organic material to maintain levels of nutrients essential for healthy plant growth. Plant roots help to maintain soil structure and facilitate water infiltration.
- **Increased stoniness and rock cover of the land:** This would usually be associated with extreme levels of soil erosion causing exhumation of stones and rock.

Although the foregoing list neatly breaks down the components of soil degradation by cause, very often these agents of degradation act together. For example, strong winds often occur at the front of a storm, thus wind erosion and water erosion may result from the same event. Additionally, a soil that has suffered some form of degradation may be more likely to be further degraded than another soil similar in all respects except for the level of degradation. One well-accepted indicator of increased erodibility is the level of soil organic matter. Where the organic matter content of a soil falls below 2% the soil is more prone to erosion, because soil aggregates are less strong and individual particles are more likely to be dislodged. Some environments are naturally more at risk to land degradation than others. Factors such as steep slopes, high intensity rainfall and soil organic matter influence the likelihood of the occurrence of degradation.

Some environments are naturally more at risk to land degradation than others. Factors such as steep slopes, high intensity rainfall and soil organic matter influence the likelihood of the occurrence of degradation. Identification of these factors allows land users to implement techniques that safeguard against loss of productivity. Management practices also exert a significant influence on the susceptibility of a landscape to degradation. Extensive and poorly managed land use systems are more likely to degrade than intensive, intricately-managed plots. Milder forms of land degradation can be reversed by changes in land management techniques, but more serious forms of degradation may be extremely expensive to reverse (such as salinity) or may be, for practical purposes, irreversible. Soil erosion, when serious and prolonged, is effectively irreversible because, in most circumstances, the rate of soil formation is so slow.

In moist, warm climates like Sierra Leone, formation of just a few centimetres of soil may take thousands of years and in cold, dry climates it can take even longer. Soil loss through erosion happens far faster: up to 300 times faster where the ground is bare. Soil erosion is the most widely recognised and most common form of land degradation and, therefore, a major cause of falling productivity. However, since the effects of soil loss vary depending on the underlying soil type, soil loss, by itself, is not an appropriate proxy measure for productivity decline.

5.1.5 Causes of Land Degradation

Although degradation processes do occur without interference by man, these are broadly at a rate which is in balance with the rate of natural rehabilitation. So, for example, water erosion under natural forest corresponds with the subsoil formation rate. Accelerated land degradation is most commonly caused as a result of human intervention in the environment. The effects of this intervention are determined by the natural landscape. The most frequently recognised main causes of land degradation include:

- Deforestation;
- Over-cultivation of cropland;
- Overgrazing of rangeland;
- Waterlogging and salinisation of irrigated land; and
- Pollution and industrial causes.

Within these broad categories a wide variety of individual causes are incorporated. These causes may include the conversion of unsuitable, low potential land to agriculture, the failure to undertake soil conserving measures in areas at risk of degradation and the removal of all crop residues resulting in 'soil mining' (i.e. extraction of nutrients at a rate greater than resupply). They are surrounded by social and economic conditions that encourage land users to overgraze, over-cultivate, deforest or pollute.

It is possible to distinguish between two types of land degrading actions. The first is unsustainable land use. This refers to a system of land use that is wholly inappropriate for a particular environment. It is unsustainable in the sense that, unless corrected, this land use or indeed any other could not be continued into the future. Unsustainability has the implication of being irreversibly degrading.

Secondly, inappropriate land management techniques also cause land degradation, but this degradation may be halted (and possibly reversed) if appropriate management techniques are applied. The effect of a land degrading process differs depending on the inherent characteristics of the land, specifically soil type, slope, vegetation and climate. Thus an activity that, in one place, is not degrading may, in another place, cause land degradation because of different soil characteristics, topography, climatic conditions or other circumstances. So, equally erosive rainstorms occurring above different soil types will result in different rates of soil loss. It follows that the identification of the causes of land degradation must recognise the interactions between different elements in the landscape which affect degradation and also the site-specificity of degradation.

5.1.6 Effects of Deforestation and Land Degradation

There are several effects of deforestation on Sierra Leone's climate and nature.

- **Atmospheric** – For deforestation is the major contributor. Deforestation causes of carbon dioxide in the atmosphere. As the concentration of carbon dioxide increases, a layer forms in the atmosphere that traps sun radiation. This radiation gets converted to heat and causes global warming. In other terms it is known as greenhouse effect. Deforestation also influences trees to release carbon stores.
- **Hydrological** – Water cycle in the nature gets affected by deforestation. Trees pull up ground water with the help of their roots and then release the water vapour into the atmosphere. If trees are reduced, the water vapour content in the atmosphere is reduced and it results in drier climate. It also results in soil erosion which may lead to landslides or floods. Reducing forest cover reduces the capacity of the soil to perspire. It means the absence of trees can influence the quantity of water on the land, in the atmosphere or in the soil. It affects the ecological cycle.
- **Soil** – Forests as such have a very low soil loss rate. It is at approximately two metric tons per square kilometre. Deforestation results in soil erosion because tress can bind the soil together. If trees are removed from steep slopes, it may result in landslides.
- **Biodiversity** – Deforestation results in the decline in biodiversity and many species of living organisms are becoming extinct. Forests support wildlife habitat and the tropical rainforests contribute to 80%of the biodiversity. The removal of trees has led to the degradation of environment and biodiversity.
- **Economic** – Deforestation and its effects can change the living standards of the people. Human societies utilize timber and wood from forests for building houses and cooking fuel. On an average it is estimated that four million people in Sierra Leone depend on wood for cooking and other purposes. Rapid increase in economic growth also has the impact on forests. As population increases, there is demand for new homes and empty spaces. Roads are laid to expand cities and it results in the reduction of forest cover.

5.1.7 Vulnerability - Sensitivity and Resilience

Sensitivity and resilience are measures of the vulnerability of a landscape to degradation. These two factors combine to explain the degree of vulnerability. Sensitivity is the degree to which a land system undergoes change due to natural forces, human intervention or a combination of both. Some places are more likely to be sensitive to change – for example, steep slopes, areas of intense rainfall or highly erodible soils. These places are subject to natural hazards that make them sensitive to change. Human intervention in these systems can result in dramatic alterations.

Sensitivity to change can arise as a result of human intervention – for example, in a natural state, forested hillsides may be difficult to degrade, but once converted to farmland degradation may occur more easily. Resilience is the property that allows a land system to absorb and utilise change, including resistance to a shock. It refers to the ability of a system to return to its pre-altered state following change. The natural resilience of an environment may be enhanced by the diversity of the land management practices adopted by land users. Degraded land is less resilient than un-degraded land. It is less able to recover from further shocks, such as drought, leading to even further degradation.

Where a landscape is susceptible to change (high sensitivity) the risk of degradation is affected by the resilience of that landscape – high resilience lessens the danger of serious degradation, whereas low resilience indicates that changes are not likely to be easily reversible and may even be permanent. Land systems that exhibit high resilience are likely to return to their previous stable state following disruption, whereas systems with low resilience are more likely to be permanently altered by such disruption. Advance recognition of the sensitivity and resilience of a land system should influence land use decisions, thereby reducing the risk of permanent degradation to the system. Similarly, the sensitivity and resilience of specific soil types should also alert assessors to the risk of permanent or temporary soil degradation.

5.2 Fire

Fire is crucial for the development of human society, and it has become an important part of human civilisation. Among different types of hazards, fire constitutes a significant threat to life and property in urban and rural areas. Fire hazards in Sierra Leone are broadly divided into wild/ bushfires and domestic fires. Domestic fires are particularly prevalent in the urban communities, especially in the capital city Freetown, where there is steady increase in the number of lives it has claimed every year due to illegal and unprofessional connections, use of sub-standard building materials, carelessness etc. Wild or bushfires are one of the biggest causes of forest destruction and land degradation in the country particularly in the savanna grassland regions of the Northern Province and the forested areas of Southern and Eastern Provinces. The estimated wildfire prone areas is between 90,000 hectares to 100,000 hectares[37].

5.2.1 Domestic Fire

5.2.1.1 Background

Sierra Leone experiences several domestic fire disaster events on an annual basis, leading to significant injuries, loss of lives and properties. Domestic fires are mostly prevalent in urban centres, especially Freetown, where a spark in one building can prove dangerous to many others. A combination of subpar electrical connections, the use of fire wood and or charcoal in homes as cooking fuel, poor handling of flammable materials such as gasoline, sub-standard building materials, and carelessness from the public, exacerbated by the dense nature of buildings provide the perfect fuel, ignition source for fires and media through which they can propagate and burn down several buildings in one event.

In the early hours of 3 April 2017, a fire broke out at the Susan's Bay Community, in the slums of Freetown. The fire raged through a community densely built with corrugated zinc sheets (Pan-body) and other sub-standard building materials burning down to ash many houses and leaving over 200 people homeless (see Figure 5-12)[38]. In December 2016, a serious fire outbreak at Fort Street, Angola Town in Freetown burned down at least 40 houses leaving over 1,000 residents homeless, and many injured[39].

From DesInventar data, over 11,000 people were affected by fires between 2006 and 2015. A total of 30 people were killed as a result of fire disasters nationwide, with almost half of that number from Western Area Urban alone. Some 1,356 houses were destroyed and 459 houses were damaged by fires nationwide (see Table 5-13). Although the DesInventar database is not an exhaustive list of fire disaster in Sierra Leone, it is however clear that urban centres, especially Western Area Urban, are much more prone to fire disasters.

[37] Karim, A. B., et al. (2004). National Hazard Assessment Profile, Final Draft Report – Office of National Security (ONS), UNDP.

[38] Sierraloaded (2017) (http://sierraloaded.net/3-front-line-fire-fighters-hospitalized-fire-outbreak-at-eastern-freetown/, accessed 11 October 2017)

[39] Sierraloaded (2016) (http://sierraloaded.net/fire-raves-down-fort-street/, accessed 11 October 2017)

Table 5-13: Historic fire disaster events (DesInventar 2006 - 2015)

District	Events		Deaths		Houses Destroyed		Houses Damaged		People Affected	
	Number	%	Number	%	Number	%	Number	%	Number	%
Bo	3	1.2		0.0	3	0.2		0.0		0.0
Bombali	12	5.0	1	3.3	74	5.5	30	6.5	694	6.3
Bonthe	10	4.1	1	3.3	133	9.8	41	8.9	1,521	13.7
Kambia	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Kailahun	3	1.2		0.0	18	1.3	11	2.4	102	0.9
Kenema	7	2.9	2	6.7	51	3.8	51	11.1	400	3.6
Koinadugu	11	4.5	1	3.3	92	6.8	50	10.9	1,283	11.6
Kono	5	2.1	2	6.7		0.0	25	5.4	520	4.7
Moyamba	9	3.7	4	13.3	116	8.6	7	1.5	300	2.7
Port Loko	8	3.3		0.0	95	7.0	21	4.6	885	8.0
Pujehun	12	5.0	1	3.3	166	12.2	32	7.0	2,108	19.0
Tonkolili	12	5.0	4	13.3	183	13.5	68	14.8	1,089	9.8
Western Area Rural	6	2.5		0.0	64	4.7	1	0.2		0.0
Western Area Urban	143	59.1	14	46.7	361	26.6	107	23.3	2047	18.4
Unknown[40]	1	0.4	0	0.0		0.0	15	3.3	150	1.4
National	**242**	**100.0**	**30**	**100.0**	**1,356**	**100.0**	**459**	**100.0**	**11,099**	**100.0**

[40] District not reported, but the event reportedly occurred in the Eastern Province.

Figure 5-12: Fire disaster events in Sierra Leone (Susan's Bay, Freetown) - 3 April 2017

Figure 5-13: Fire disaster events in Freetown, Sierra Leone – 19 February 2016

5.2.2 Wildfire/ Bushfire

5.2.2.1 Background

While Sierra Leone does not experience the devastating wildfires that often rage through countries like South Africa, Australia, and the United States of America, wildfires do occur many times a year in the country. Certain districts of the country face a significant risk from this hazard. Wildfires, also referred to as bushfires, are uncontrolled fires that are ignited in woodland, brush, or grassland (savanna) areas with minimal development.

For wildfires to ignite, grow, and sustain themselves, they require optimal weather conditions, a fuel source, and an ignition source. Optimal weather conditions include lack of precipitation, high temperatures, and low relative humidity (which allow vegetation and brush to burn more easily) and high winds (which cause the fire to spread). During the dry season, dry leaves, brush, and grass accumulate, forming a hazardous source of fuel. A savanna vegetation, comprising grasses and bushes, dominates in the Northern Province of Sierra Leone, significantly contributing to the risk of wildfires. These high fuel loads create a dangerous scenario when weather conditions are favourable.

Once the right combination of fuel and weather is in place, all that is required is an ignition source. Ignition sources may be natural, such as lightning, but are more commonly the result of human activities. Agricultural fires from slash-and-burn practices in rural farming settlements that burn out of control can mostly lead to wildfires. Although wildfires may occur during any time of year, conditions are most conducive for the start of bushfires during the Harmattan period – between the end of November and mid-March, when dry and dusty north-easterly trade winds blow from the Sahara Desert over the West African sub-region into the Gulf of Guinea.

5.2.2.2 Severity, Probability and Location

The severity of wildfires is dependent on weather conditions (precipitation, temperature, humidity, and winds) and the type and amount of fuel available. If favorable weather conditions persist for a significant period, more fuel will accumulate and any fires that are sparked will be more severe. Wildfires can spread in three different patterns, and thus, can be categorized in three levels of intensity. At the lowest level are ground fires, which are sustained by glowing combustion and primarily burn organic matter and leaves in the soil. At the next level are surface fires, which burn leaf litter, fallen branches, and other fuels at ground level. The hottest and most dangerous fires are crown fires, which can reach significant heights and burn the top layer of foliage on trees, known as the canopy or crown. Crown fires are also the most difficult type of wildfire to contain.

Wildfires occur many times a year throughout Sierra Leone, although the frequency and recurrence interval vary depending on the exact location. Based on historic occurrences, it is probable that the country will continue to experience wildfires. Most incidences of bush fires are not reported, because of isolation, remoteness and lack of communication, even though they may result in disasters. Rural communities in Sierra Leone face a greater risk of wildfires than urban areas. Districts in Northern Province (within the savanna grassland belt) are the most vulnerable of all the 14 districts. The areas particularly affected are those between Fadugu and Kurubunla, and the zone stretching from Kambia through Makeni to Yonibana[41]. These areas contain the highest concentration of savanna grasslands in the country, and the grasses become highly flammable during optimal weather conditions. However, forested areas in the Eastern and Southern Provinces have also been known to experience isolated cases of wildfires.

In January 2013, the risk of fire increased as a result of the dry Harmattan wind that blew across Sierra Leone. Several villages in the Northern and Southern Provinces were affected by fire disasters between 2 and 28 January, destroying 279 houses and making 2,257 people from 450 families homeless[42]. The affected communities include Blama Gbani in Bo district, Tiama camp in Moyamba district, Bompilia in

[41] Karim, A. B., et al. (2004). National Hazard Assessment Profile, Final Draft Report – Office of National Security (ONS), UNDP.

[42] Relief Web (2013). Sierra Leone Wildfires (https://reliefweb.int/disaster/fr-2013-000003-sle, accessed 10 August 2017)

Bonthe district and Rogbenk in Port Loko district. In 2003, over 100 houses were burnt and over 600 people rendered homeless in Manjama in the Pujehun District[43].

Fire alerts data covering the three Provinces and Western Area of Sierra Leone has been sourced from Global Forest Watch Fires[44] a World Resources Institute (WRI)[45] initiative which uses NASA Fire Information for Resource Management System (FIRMS) near real time (NRT) active fire data from the MODIS and VIIRS satellites to map fire locations. The sensors on these satellites detect the heat signatures of fires from the infrared spectral band. When a fire is detected, the system indicates the area where the fire occurred with an “alert.” Because each satellite orbits the earth twice per day, these alerts can be provided in near-real time. Fire alerts are posted on the NASA FIRMS website within 3 hours of detection by the satellite.

Between 22 and 29 October 2017 only, a total of 21 MODIS fire alerts were recorded across Sierra Leone, with the Bombali, Tonkolili, and Port Loko (all in the Northern Province) contributing 14 to that number (see Figure 5-14)[46]. From WRI’s Fire Season Progression (see Figure 5-15 to Figure 5-19**Error! eference source not found.Error! Reference source not found.**) compiled from NASA’s MODIS fire alerts data, a total of 1,736,925 fires were detected across the country from 2012 to 2017, with the Northern Province contributing more than half of that number (53.5 percent). The number of fire alerts recorded for Western Area for just 0.23 % of the total, while the Eastern and Southern Provinces registered almost the same number of fire alerts (22.6 % and 23.6 %, respectively). Although such fires are not necessarily immediately hazardous, they can degrade natural resources if people burn an area too frequently, and can also cause air pollution.

On 30 April 2016, NASA's Suomi National Polar-orbiting Partnership (NPP) satellite collected a natural-colour image using the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument. The location, widespread nature, and number of fires seen from the image suggest that these fires were deliberately set to manage land[47]. Farmers often use fire to return nutrients to the soil and to clear the ground of unwanted plants during planting seasons. Actively burning areas are outlined in red (see Figure 5-20) (NASA, 2006).

Table 5-14: Total MODIS fire alerts by Province/Area

Province/Area	Years						Total (2012-2017)	Percentage, %
	2012	2013	2014	2015	2016	2017		
Eastern	82,878	65,720	76,595	87,492	44,851	35,623	393,159	22.6
Northern	177,631	155,723	181,254	162,326	137,606	114,791	929,331	53.5
Southern	73,413	68,875	83,037	93,587	55,114	36,491	410,517	23.6
Western	738	621	837	616	606	500	3,918	0.23
Total	**334,660**	**290,939**	**341,723**	**344,021**	**238,177**	**187,405**	**1,736,925**	**100**

[43] Karim, A. B., et al. (2004). National Hazard Assessment Profile, Final Draft Report – Office of National Security (ONS), UNDP.

[44] Global Forest Watch Fires. (http://fires.globalforestwatch.org/map/#activeLayers=viirsFires%2CactiveFires&activeBasemap=topo&x=-1&y=40&z=3, accessed 30 October 2017)

[45] World Resources Institute (http://www.wri.org/, accessed 31 October 2017)

[46] Global Forest Watch Fires. Fire Report for Sierra Leone (http://fires.globalforestwatch.org/report/index.html#aoitype=GLOBAL&reporttype=globalcountryreport&country=Sierra Leone&aois=Eastern!Northern!Southern!Western&dates=fYear-2017!fMonth-10!fDay-22!tYear-2017!tMonth-10!tDay-29, accessed 30 October 2017)

[47] NASA (2016), Fires Cover Large Portions of West Africa, Fire and Smoke (https://www.nasa.gov/image-feature/goddard/2016/fires-cover-large-portions-of-west-africa, accessed 9 October 2017). NASA image courtesy of Jeff Schmaltz, Rapid Response Team.

Figure 5-14: Greatest number of fire alerts

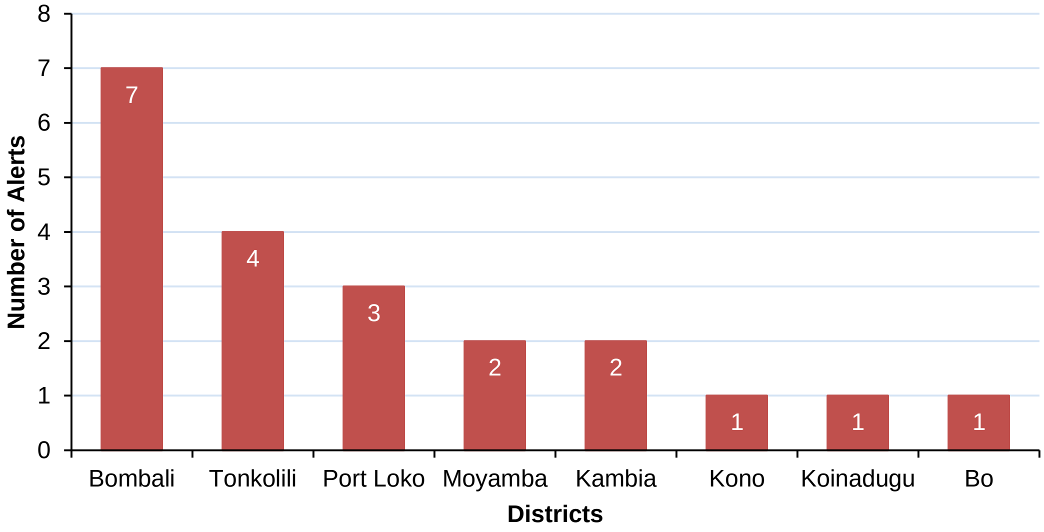


Figure 5-15: Number of MODIS fire alerts by Province/Area

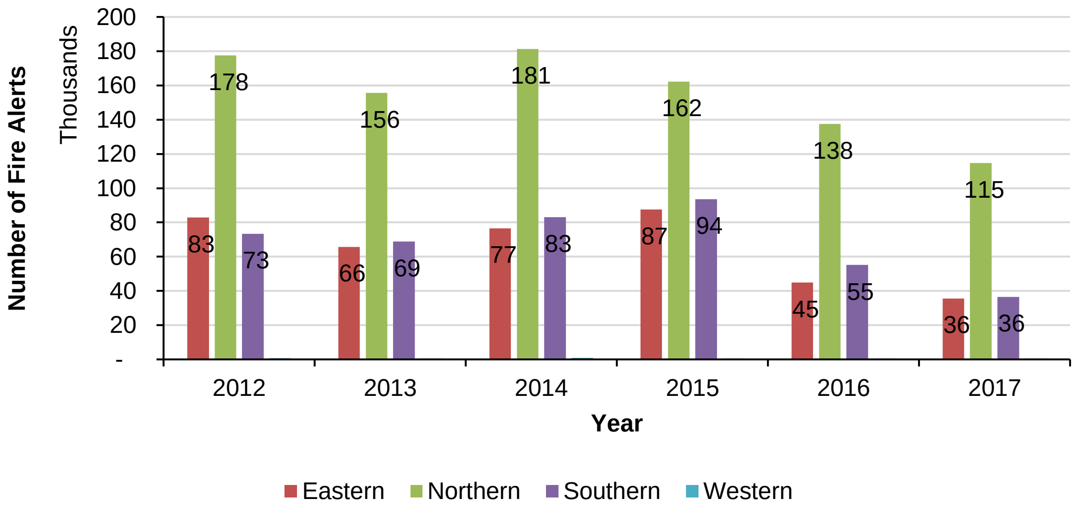


Figure 5-16: Eastern Province fire season progression from MODIS fire alerts

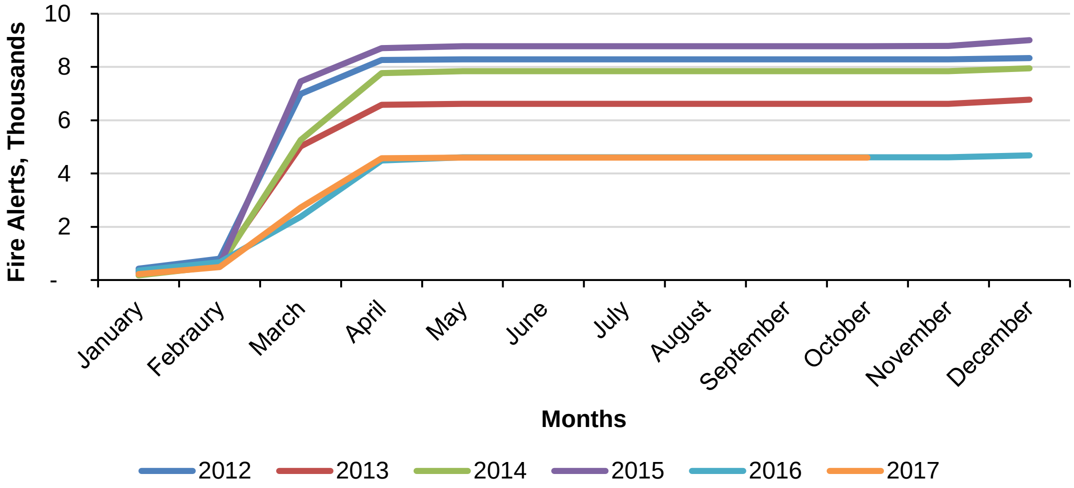


Figure 5-17: Northern Province fire season progression from MODIS fire alerts

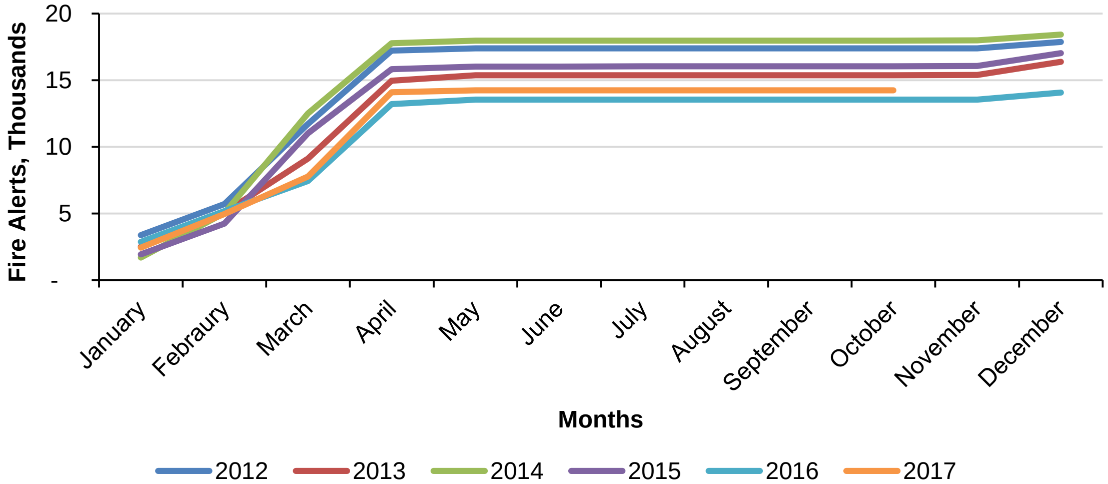


Figure 5-18: Southern Province fire season progression from MODIS fire alerts

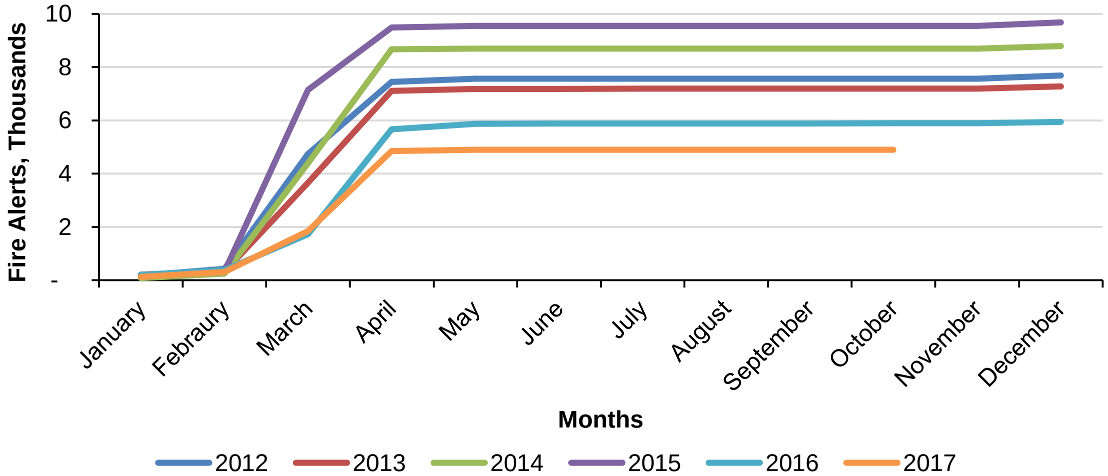


Figure 5-19: Western Area fire season progression from MODIS fire alerts

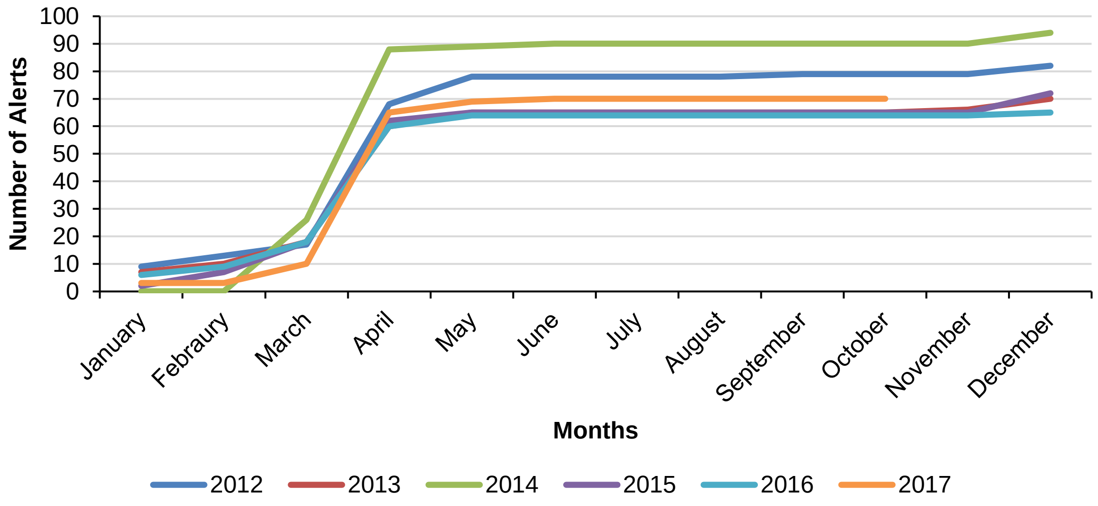
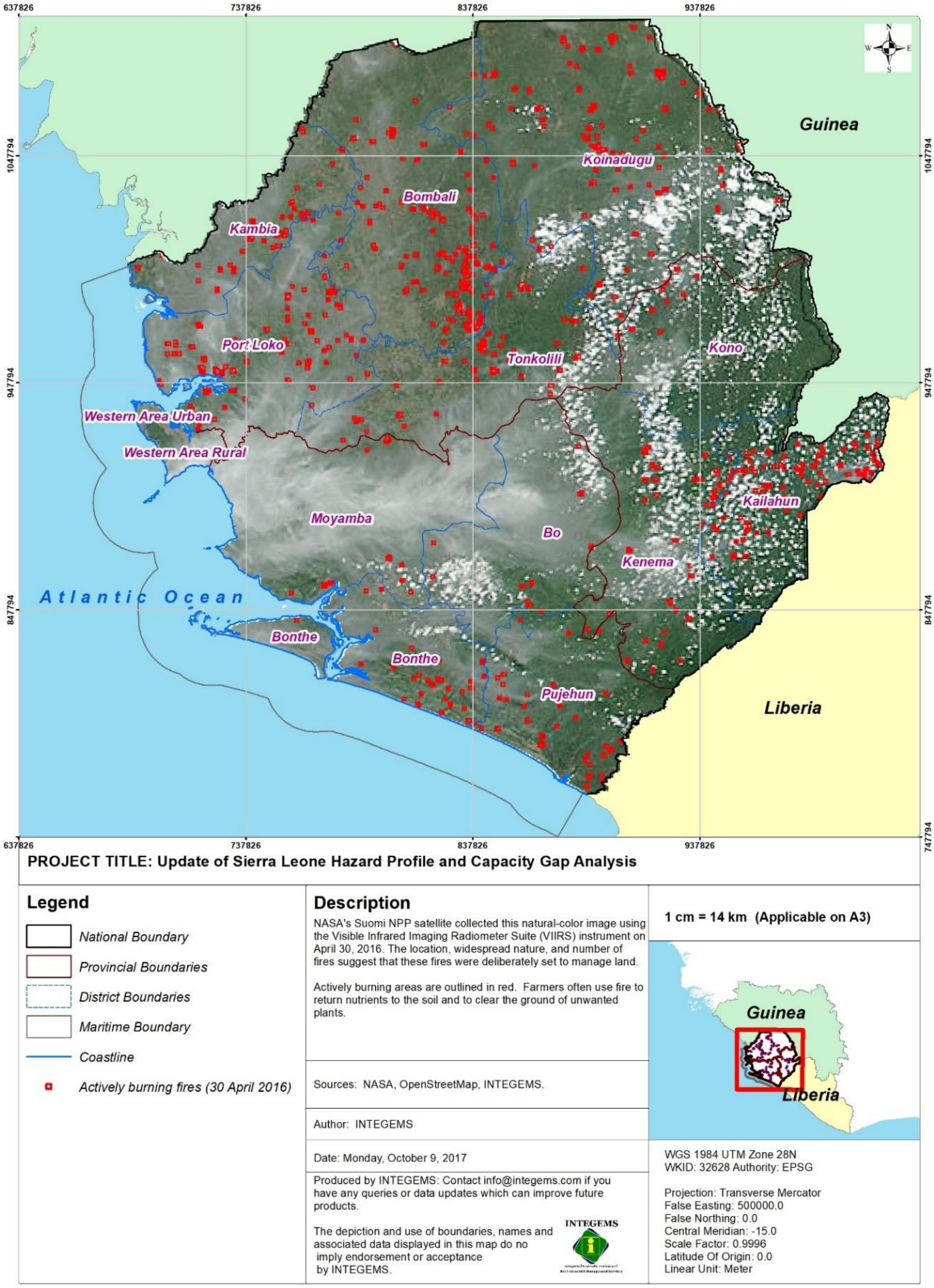


Table 5-15: Fire season progression from MODIS fire alerts by Province

Province/Area	Month	2012	2013	2014	2015	2016	2017
Eastern	January	436	352	176	262	355	225
Eastern	February	808	630	532	554	672	488
Eastern	March	6,991	5,020	5,257	7,459	2,381	2,721
Eastern	April	8,263	6,587	7,772	8,713	4,494	4,574
Eastern	May	8,291	6,619	7,841	8,784	4,607	4,600
Eastern	June	8,292	6,622	7,845	8,784	4,610	4,603
Eastern	July	8,292	6,622	7,845	8,784	4,610	4,603
Eastern	August	8,292	6,622	7,845	8,784	4,610	4,603
Eastern	September	8,292	6,622	7,845	8,784	4,610	4,603
Eastern	October	8,292	6,622	7,845	8,784	4,611	4,603
Eastern	November	8,292	6,624	7,846	8,789	4,611	
Eastern	December	8,337	6,778	7,946	9,011	4,680	
Northern	January	3,372	2,518	1,712	1,935	2,885	2,450
Northern	February	5,720	5,054	5,037	4,244	5,175	4,972
Northern	March	11,718	9,123	12,516	11,032	7,444	7,789
Northern	April	17,209	14,968	17,771	15,823	13,205	14,105
Northern	May	17,388	15,377	17963	16,029	13,539	14,245
Northern	June	17,390	15,378	17,965	16,031	13,547	14,245
Northern	July	17,390	15,378	17,965	16,032	13,547	14,245
Northern	August	17,390	15,378	17,965	16,032	13,547	14,245
Northern	September	17,390	15,378	17,965	16,032	13,549	14,245
Northern	October	17,390	15,380	17,968	16,034	13,551	14,250
Northern	November	17,393	15,403	17,996	16,076	13,555	
Northern	December	17,881	16,388	18,431	17,026	14,062	
Southern	January	178	206	81	149	201	131
Southern	February	429	318	249	320	384	303
Southern	March	4,738	3,662	4,387	7,137	1,721	1,842
Southern	April	7,449	7,110	8,673	9,483	5,670	4,853

Province/Area	Month	2012	2013	2014	2015	2016	2017
Southern	May	7,560	7,181	8,691	9,541	5,870	4,893
Southern	June	7,562	7,184	8,694	9,545	5,885	4,893
Southern	July	7,563	7,187	8,694	9,546	5,887	4,893
Southern	August	7,563	7,187	8,694	9,546	5,887	4,893
Southern	September	7,563	7,187	8,694	9,547	5,887	4,894
Southern	October	7,564	7,189	8,696	9,547	5,888	4,896
Southern	November	7,564	7,192	8,698	9,551	5,891	
Southern	December	7,680	7,272	8,786	9,675	5,943	
Western	January	9	7	0	2	6	3
Western	February	13	10	0	7	9	3
Western	March	17	18	26	18	18	10
Western	April	68	60	88	62	60	65
Western	May	78	65	89	65	64	69
Western	June	78	65	90	65	64	70
Western	July	78	65	90	65	64	70
Western	August	78	65	90	65	64	70
Western	September	79	65	90	65	64	70
Western	October	79	65	90	65	64	70
Western	November	79	66	90	65	64	
Western	December	82	70	94	72	65	

Figure 5-20: Fires in Sierra Leone (April 2016)



5.2.3 Vulnerabilities and Risk Assessment

When fires do threaten populated areas, residents may be at risk, especially those who choose not to evacuate. The situation may be particularly dangerous in the case of fires that spread quickly or unpredictably, which can result in little or no advanced warning or evacuations. Secondary health effects may result from smoke inhalation and poor air quality in the vicinity of fires. Populations that may be particularly vulnerable include children, women, the elderly, residents with pre-existing respiratory conditions, and, in the event of an evacuation, people with mobility impairments.

Domestic and wildfires (when the reach settlements) have the potential to cause significant damage to the built environment. There are many areas in Sierra Leone where the built environment is congested with buildings of sub-standard (easily flammable) materials or directly adjacent to open areas with minimal or no natural buffers. This puts many homes and critical facilities at risk. In addition, fires in densely built environment with little or no access to fire extinguishing capabilities are very difficult to contain. Wildfires on the hand, are often more difficult to contain than normal building fires due to their size, abundant natural fuel sources, and weather conditions. Buildings constructed of thatch roof and other combustible materials in rural communities are particularly at risk. Utilities, transportation, and telecommunications infrastructure are also vulnerable to the effects of fires, which may in turn lead to service disruptions. The two extensive critical inter-city power (the Bumbuna and Dodo Hydroelectric Power) transmission lines in Sierra Leone almost exclusively traverses via bushlands, grasslands, and secondary forests, making them vulnerable to wildfires.

Depending on the type and severity, the impacts of fire on the natural environment may be either positive or negative. For certain ecosystems, fires are a necessary part of the ecological cycle and promote the overall health and longevity of these environments. Benefits of fires include insect pest control, removal of invasive species, addition of nutrients for trees and other types of vegetation, and removal of undergrowth that may prevent the growth of native species. Certain types of vegetation are also dependent on periodic fires for survival. Additionally, burned trees may provide homes for certain species of birds and mammals and a base from which new plants can grow. Although low-intensity fires may be beneficial to the environment, high-intensity fires can be devastating. In addition to burning large stands of trees, these fires cause soil destruction and the removal of debris needed to protect seedlings. In extreme cases, wildfires may destroy entire habitats and threaten numerous species. Since certain ecosystems require periodic low-intensity fires to sustain themselves, a dangerous situation may arise if those types of fires are too infrequent. In these cases, fuel can accumulate to dangerous levels and result in devastating fires. Periodic intentional burning (also known as "prescribed" or "controlled" fires) is a tactic often used to reduce the amount of fuel available for large fires and to promote healthy ecosystem function.

Fires, especially wildfires are a frequent occurrence in certain areas of the country and this will likely continue into the future. Since wildfires are largely dependent on weather conditions, climate change may affect the frequency of wildfires in the future. However, there is still much uncertainty as to what effect climate change will have and how significant it would be. Other factors which may play a role in determining future vulnerability are the rate of future development within fire-prone areas and the presence of buffers between urban infrastructure and wooded or grassland areas.

5.3 Accident

An accident is an unplanned, unforeseen and unexpected event that has a negative impact on all activities of the individual(s) concerned. An accident can result in death, injury, health hazard, and loss of property, damage to environment, loss of production, time and morale, and a negative impact on good of the organisation, society, family or any other persons concerned.

Accidents are a great concern to the public in all 14 Districts of Sierra Leone. Transportation in Sierra Leone occur in three forms, land, marine, and air, all of which (save air) have recorded alarming rate of accident over the past few years. Traffic accidents result in life and financial loss to the society. In Sierra Leone, traffic fatalities are comparable to other leading causes of unnatural death. The need for the analysis of the spatial distribution of traffic accidents, as an aid to select the most appropriate type of accident reduction programme (e.g. site, route and area plans) and assessing the effectiveness of such plans after implementation, is very important.

There is no systemic method of recording accident disasters in Sierra Leone. However, accident (road, maritime, aviation) disasters have been sourced from the DesInventar – a global Disaster Information Management System database that systematically collects, documents and analyses data about losses caused by disasters. Between 2006 and 2015, over 150 accidents were recorded, with over 40% of them occurring in Western Area Urban (Freetown) alone (see Figure 5-21 to Figure 5-23). A total of 418 traffic accident related fatalities were recorded during that time, with a national fatality-to-event ratio of 2.4 (see Table 5-16). There's anecdotal evidence that these figure can be construed as grossly underestimated given that not all accidents are reported and recorded in the country.

Table 5-16: Historic accident disaster in Sierra Leone

District	Number of Events	Deaths	Injured	Affected	Deaths/Events
Bo	4	8	8		2.0
Bombali	3	6	50		2.0
Bonthe	10	5	5	116	0.5
Kailahun	2	23	5		11.5
Kambia	9	176		87	19.6
Kenema	7	26	10		3.7
Koinadugu	4	9	2	36	2.3
Kono	1	21	29		21.0
Moyamba	6	5	5	117	0.8
Port Loko	24	29	38	570	1.2
Pujehun	5	10	16	3	2.0
Tonkolili	3	4	15		1.3
Western Area Rural	20	3	3	389	0.2
Western Area Urban	76	93	70	2,669	1.2
National	**174**	**418**	**256**	**3,987**	**2.4**

Figure 5-21: Historic accidents in Sierra Leone (2006 - 2015)

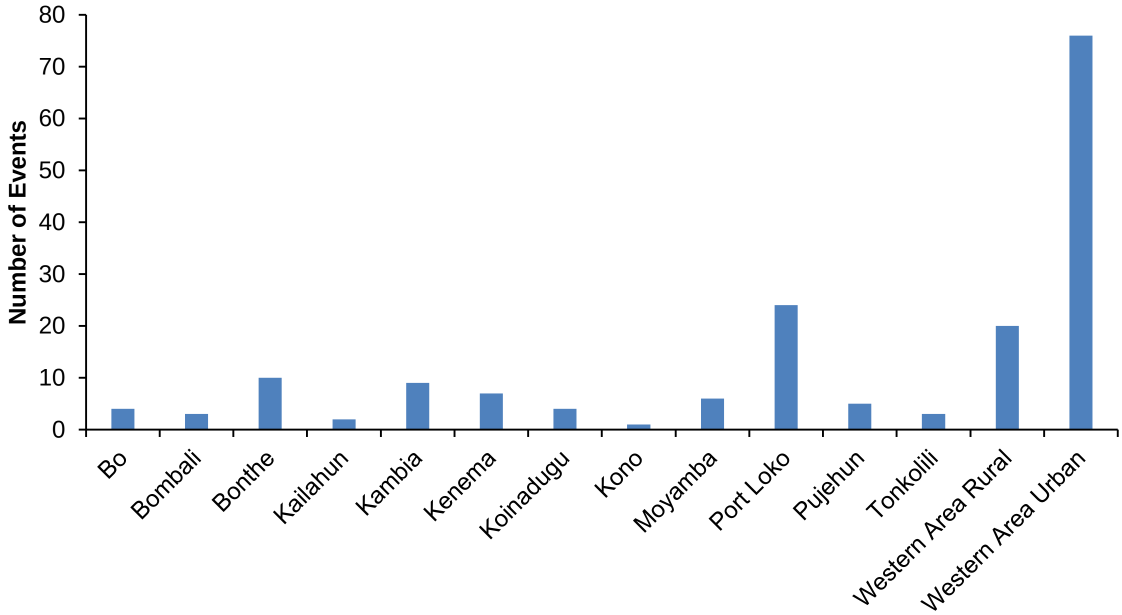


Figure 5-22: Some accidents in Sierra Leone

Remains of a helicopter crashed at Sierra Leone's Lungi International Airport (3 June 2007)

(Photo credit: Sierra Leone's Premier Online News Portal)

A trailer vehicle loaded with a D8 bulldozer got stuck on Gbereh Bridge (29 January 2017)

(Photo credit: Awoko Newspaper)

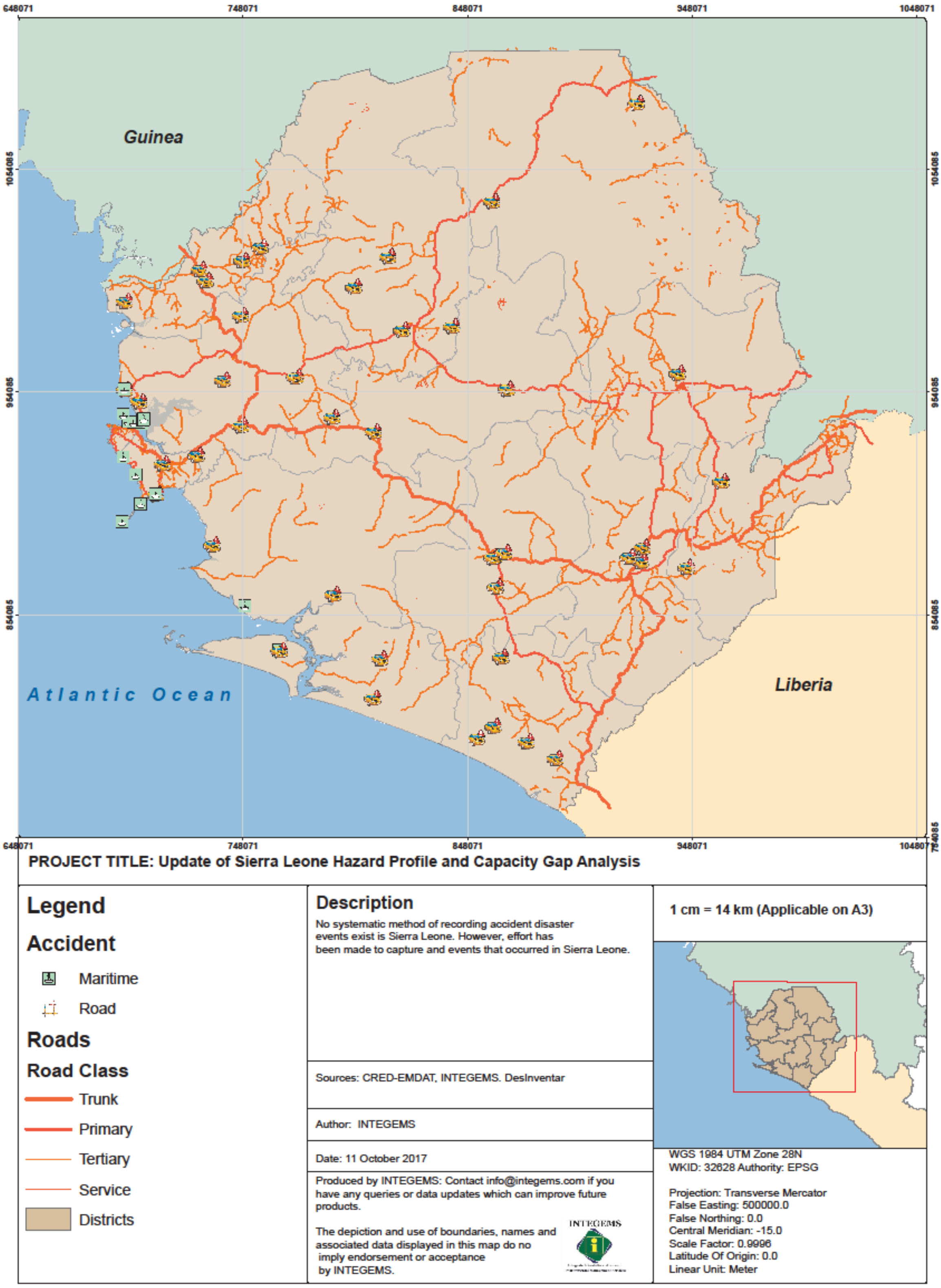
Fatal accident in Sierra Leone (3 August 2013)

(Photo credit: Kemo Cham – Africa Review)

A fatal road accident along the Kenema – Koindu highway

(Photo credit: Naharnet newsdesk)

Figure 5-23: Historic Accidents Events in Sierra Leone



5.3.1 Road Accident

Road transport is the most dominant mode of transportation and represents about 85% of the entire transport system in Sierra Leone. About 95% of the inland transport of passengers and goods are carried out on roads. Road accident is one of the major causes of unnatural deaths and it is undeniably one of the leading causes of death in Sierra Leone. Even though the circumstances or the actual causes for each road accident may vary, the fact remains that quite a good number of people are killed by road accidents every other day. Such accidents can either occur on extremely bad roads or on relatively very good roads.

The Sierra Leone Police (SLP) statistics show that 2,204 road traffic accidents (RTA) were reported during 2009; 165 of these were fatal crashes in which 216 people were killed. Corresponding frequencies for 2008 are 2,501 RTAs, 232 fatal crashes and 322 fatalities; and for 2007 the numbers are 1,574 RTAs, 158 fatal crashes and 182 fatalities[48].

There are several reasons that undermine the safety of people on roads. On the basis of investigation, the social processes and dimensions embedded in road transport regulations and the broad spectrum of circumstances in which road accidents frequently occur play a major role in the casualties faced with road accident. These causes include, but not limited to:

- Over speeding
- Drunk driving (driving while intoxicated)
- Distraction to drivers
- Poor traffic control system
- Mechanical error
- Poor road and bad weather condition

5.3.2 Aviation Accident

Aviation accidents can be of natural, technical or human origin, such as mechanical breakdowns, negligence or terrorist attacks. Usually small aircraft (helicopters, light aeroplanes, gliders) do not cause disasters as such, since the number of victims and the impact of the crash is limited. This is not the case for large aircraft such as transport planes or jet fighters, although there has been no record of accidents involving this type of aircrafts in Sierra Leone.

The only aviation accident which has been recorded in the country over the last decade occurred on 3 June 2007, when members of the Togolese Football Team, including the country's Minister of Sports lost their lives in a commercial helicopter from Aberdeen Heliport that crashed at the Lungi International Airport in Freetown[49].

As economic growth is expected in Sierra Leone, the possibility of a busy air traffic looms. Therefore, it is prudent that some of the causes of aviation accidents be reviewed and prepared for adequately to prevent such occurrences.

Some of the most frequent causes of aviation accidents include:

- Human/Pilot error
- Mechanical error
- Extreme weather
- Air traffic controller error

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[48] SWE ROAD (2011). Review of Road Safety Management Capacity in Sierra Leone, World Bank Group

[49] The Sierra Leone Telegraph (http://www.thesierraleonetelegraph.com/3rd-june-2007-a-very-sad-day-for-football-in-sierra-leone-and-relations-with-the-people-of-togo/, accessed 16 October 2017).

The causes listed above are some of the most common ones, but they are far from the only factors that can contribute to an aviation accident. Given the complexities of air travel and the number of factors that can influence any particular flight, determining the cause of an aviation accident can be challenging. Generally, there is not a single cause for an accident, but a combination of several factors.

5.3.3 Maritime Accident

Sea travelling is a common means of transportation on the islands along the coast of Sierra Leone. These islands normally use wooden ferries, boats or canoe to transport people and goods to nearby islands and inland thereby increasing the risk of maritime accident in the country.

On 8 September 2009, an accident involving a wooden ferry travelling from Shenge village to Tombo occurred off the coast of Sierra Leone. The ferry sank during a storm, with at least 90 people confirmed dead, and over 100 others were listed as "missing". Several of the passengers were children who had been on holiday, though the official passenger manifest did not include them. Sierra Leone's police initially indicated there were only 150 people on the ferry when it sank; however, it has since been determined that there were far more aboard[50].

Severe weather condition, sub-standard ferries and overloading amongst others are the common causes of maritime accident in the country.

5.3.4 Risk and Vulnerability of Accident Disaster

The road safety situation in Sierra Leone is serious and has deteriorated over the last years, mainly due to the growing vehicle population and ineffective implementation of the road safety interventions. Economic growth, including rehabilitation of roads and increased vehicle growth, will increase road safety challenges in the country. Maritime accident is also common along the coast of the country and this increases the risk and vulnerability of lives and properties of people living on the islands that depend on ferries, boats and canoes as their means of transportation.

5.4 Waste Disposal

Waste is an unwanted or any substance which is discarded after primary use, or it is insignificant, defective and of no use. Waste generation and disposal is a very common problem in most third world countries. In Sierra Leone, the problem has been a persistent battle, with successive Governments applying different approaches in a bid to eradicate the scourge. Sustainable management of waste is critical to the health and well-being of residents, the environment, and in revenue and power generation. The negative health effect has become a growing concern especially due to the increase in urbanisation, changes in consumer pattern, and industrialisation which all directly translates to an increase in waste generation.

Poor waste management practices, in particular, widespread dumping of waste in water bodies and uncontrolled dump sites, exacerbates the problems of generally low sanitation levels across the country. Urbanisation is on the rise in Sierra Leone, and this trend is expected to continue in the future. Urban population of Sierra Leone increased from 21.8 % in 1967 to 40.3 % in 2016 growing at an average annual rate of 1.27 %[51]. The inability of infrastructure and land use planning methods (including for waste management) to cope with urban growth is of major concern. This is particularly urgent in slum areas, which constitute a big part of many of the cities and towns in the country. Waste generation is expected to increase significantly as a result of industrialisation, urbanisation and modernisation of agriculture in Sierra Leone. This will further aggravate current capacity constraints in waste management.

The most affected areas are Freetown, Bo, Kenema, and Makeni. Coping with the rapid rise in population and its corresponding demand to manage their waste has posed a major problem to occupants. Poor solid waste management practices in Sierra Leone is a serious problem that likely

[50] https://en.wikipedia.org/wiki/2009_Sierra_Leone_ferry_accident, (Accessed 12 October 2017)

[51] https://knoema.com/atlas/Sierra-Leone/Urban-population (Accessed 20 August 2017)

caused a cholera outbreak in 2012 which led to the deaths of almost 400 people with the capital reporting more than 50 % of the total cases[52].

Improper management of waste is a major concern in the capital city, with only three major landfill sites; Granvill Brook (Bumeh) & Bottom Oku in the east and Kingtom in the west where there is no base or top seal to prevent the flow of leachates to underground water or rivers or the infiltration of water into the waste. At the King Tom dump site, leachate seeps into White Man's Bay where it mixes with discharges of raw sewage effluent from sludge drying ponds on the same site. This results in the spread of contagious and water-borne diseases into soil and water. In Bo city, an estimated population of 200,000, with around 14,000 households generate 25,000-50,000 kg of human (faecal) waste every day[53]. In the absence of appropriate sewerage networks, residents and institutions rely on on-site facilities such as pit toilets and septic tanks. When full, these must be emptied, or new facilities constructed. The service for pit-tank emptying is relatively unregulated, and poses considerable public health risks to workers and the general public.

5.4.1 Sources of Waste

5.4.1.1 Urban or Municipal Waste

The wastes, collected from residential houses, markets, streets and other places mostly in the urban areas and disposed of by municipal bodies are called municipal solid wastes (MSW). In general, the urban solid wastes are called refuse. The Municipal solid wastes are a mixture of paper, plastic, clothes, metals, glass, organic matter etc. generated from households, commercial establishments and markets.

In Freetown and other cities around the country, the proportions of different constituents vary from season to season and place to place depending on the life style, food habits, standard of living and the extent of commercial and industrial activities in the area. Municipal solid waste should be collected locally and the amount collected depends upon the size and consumption of the population. A large portion of waste piles in the city posing health risks to different communities. Some of the factors that impede solid waste collection efficiency in Freetown includes the type of containers used, road conditions, congestion of buildings, traffic conditions, etc. The municipal wastes contents and sources are summarized in the table below.

Table 5-17: Sources of urban/municipal waste

Name	Contents	Source
Garbage	Waste from kitchen, cooking and serving of food, slaughter houses, market refuse etc.	From households, institutions etc.
Rubbish: **a**. Combustible **b**. Non-combustible	**a.** Leaves, grasses, plants, cloths, paper, lather, rubber etc. **b.** Bottles, glass, metals etc.	Households, restaurants, markets etc.
Ashes	Residues from fire, cinders etc.	Fuel burning and cooking by households with fire wood and charcoal.
Street refuse	Leaves, dirt, paper, plastic etc.	From streets
Dead animals	Small animals; cats, dogs, etc. Large animals; cows etc.	
Construction and demolition wastes	Wood, roofing and sheathing scrap, rubble concrete, plaster etc.	buildings
Sludge	Settled solid components of sewage wastes	Sewage treatment plants, septic tanks

The most recognizable impact of municipal waste in Sierra Leone is the pollution associated with the waste practices through uncontrolled landfills, open dumping and partial combustion. Many problems

52 http://www.thisissierraleone.com/sierra-leones-waste-management-challenges/ (Accessed 20 August 2017)

53 http://www.washlearningsl.org/wp-content/uploads/2016/03/Liquid-Waste-Management-Strategy-Bo-City-Final-Draft-February-2016.pdf (Accessed 20 August 2017)

connected to this could threaten the ground water and surface water resources beside the spread of odours, insects, rats, smoke and gases resulting from the decomposition of waste.

There is a need for greater co-ordination in the implementation of waste management plans and programs, and also in the overall management of hazardous and non-hazardous waste. In order to achieve a network of integrated waste management facilities, much more effective national, regional and district co-operation is required.

5.4.1.2 Bio-medical Waste

Bio-medical waste, normally refers to waste produced from health care facilities, such as hospitals, clinics, surgical theatres, veterinary hospitals and labs. They tend to be classified as hazard waste rather than general waste. These wastes are highly infectious and the items in this group include surgical items, pharmaceuticals, bandages, blood, body parts, wound dressing materials, needles and syringes. Pharmacies around the country must properly discard out-dated and unused drugs; testing laboratories dispose of chemical wastes which are hazardous in the environment. Bio-medical waste can become a serious health risk if it is not disposed of in an efficient and reliable manner that is compatible with the latest international regulations.

In Sierra Leone, medical centres, clinics, veterinary practices, hospitals and laboratories rely on incinerators (some locally constructed) to guarantee that their medical waste is effectively destroyed in the correct incinerator to ensure that it cannot pose any health hazard, either through emissions or via the final remains that are recovered following the incineration process.

Disposal of bio-medical waste may pose health risks indirectly through the release of pathogens and toxic pollutants into the environment. Landfills can contaminate drinking-water if they are not properly constructed. Occupational risks exist at disposal facilities that are not well designed, run, or maintained. Incineration of waste has been widely practiced in the country, but inadequate incineration or the incineration of unsuitable materials results in the release of pollutants into the air and of ash residue. Incinerated materials containing chlorine can generate dioxins and furans, which are human carcinogens and have been associated with a range of adverse health effects. Incineration of heavy metals or materials with high metal content (in particular lead, mercury and cadmium) can lead to the spread of toxic metals in the environment.

5.4.1.3 Industrial Waste

The rise in the number of industries manufacturing glass, leather, textile, food, plastic and metal products has significantly contributed to waste production. Take a look at Plastic debris in drainages and waterways around Freetown and other parts in the country seems ubiquitous. Water sachets are one of the largest contributors to Sierra Leone's environmental menace. In Freetown for example there are approximately 118 plastic sachet water companies identified by the Sierra Leone Electricity and Water Regulatory Commission (SLEWRC)[54]. On average a sachet water company produces 20 bundles of sachet water a day, which is equivalent to 400 sachets (20 sachets per bundle). With increasing capacity to meet the very high demand and consumption rate of the sachet water; proper disposition must be in place in order to reduce its effects on the environment which is already widespread in the country.

5.4.1.4 Agricultural Waste

Agricultural waste, which includes both organic and inorganic wastes, is a general term used to describe waste produced on a farm through various farming activities. These activities can include, but not limited to: dairy farming; horticulture; seed growing; livestock breeding; grazing land; market gardens; nursery plots; and even woodlands. Agricultural and food industry residues, refuse and wastes constitute a significant proportion of national agricultural productivity. When discharged to the environment, agricultural wastes can be both beneficial and detrimental to living matter; the pros and cons of waste derived from animal agriculture in today's environment. Given that, agricultural wastes are not restricted to a particular location, but rather are distributed widely, their effect on natural resources such as surface and ground waters, soil and crops, as well as human health, must also be addressed.

[54] http://awoko.org/2017/02/28/sierra-leone-news-environmental-menace-plastic-sachet-debris/ (Accessed 21 August 2017)

5.4.2 Temporal and Spatial Distribution

As it is managed today, solid waste presents severe environmental health risks for residents in Communities close to the dump sites. For instance, residents of King Tom, Ascension Town, Culvert and Congo Town that live in the vicinity of the King Tom and Granville Brook Dump Site suffer from dust, smoke, odours, and fly problems. In 2012, the cholera epidemic in Sierra Leone recorded greater incidences in neighbourhoods closer to the solid-waste dump sites than in other areas. A contributing factor is that a greater number of slums and sub-standard settlements are close to the dump sites. Studies have shown that environmental health risks related to solid waste is very low in communities where people can both afford a better standard of living and practise household solid-waste management.

5.4.3 Risk and Vulnerability

In Sierra Leone, the group at risk from the unregulated disposal of waste include – the population in areas where there is no proper waste disposal method, especially the pre-school children; waste workers (MASADA and FCC); and workers in facilities producing toxic and infectious material. Other high-risk group include population living close to a waste dump and those, whose water supply has become contaminated either due to waste dumping or leakage from landfill sites. Uncollected solid waste also increases risk of injury, and infection.

In particular, the dump sites in Freetown (King Tom, Granville, and Bottom Oku) there is no base or top seal to prevent the flow of leachates to underground water or rivers or the infiltration of water into the waste. At the King Tom dump site, leachate seeps into White Man's Bay where it mixes with discharges of raw sewage effluent from sludge drying ponds on the same site. This results in the spread of contagious and water-borne diseases into soil and water. Recently there has been an increase in metal markets, notably in Freetown, Makeni, Bo, and Kenema. Metal scraps are bought from locals who scavenge dump sites in search of metal scraps and in the process contract infectious diseases. Barefooted children are often seen rummaging waste for recyclable materials.

Leachates and run-offs emanating from the dumping sites infiltrate the soil beneath as well as flow into the nearby streams. They deposit pollutants in the process, especially in the bay, which is a major source of water for domestic purposes for people residing close to the site when tap water is unavailable. At a location at the back of the King Tom Cemetery, close to the King Tom dumpsite, there is an underground spring which, although it only supports water flow during the rainy season, showed high levels of pollutants. The result suggests seepage and infiltration of leachates into subsoil of the dump site and into the groundwater, thus highlighting the high risk of groundwater pollution in the King Tom area. Waste pickers, scavengers, or rag pickers as they are commonly called, constitute that segment of the people involved in the waste trade who make a living by collecting and selling recyclable materials out of municipal solid waste. Though they play a pivotal role in the larger waste management systems they remain most vulnerable in the society. Any effort to categorize them meets with limited success as they represent varied demographic and social characteristic.

Due to the extremely unorganised and scattered nature of the waste collection activities in the country it is difficult to give an accurate estimate of the population (the precise age or the sex profile) involved in waste collection. On the whole, men and women often assisted by their children within the household are engaged in waste collection. Hence the most vulnerable population are those directly involved in the collection of waste and the inhabitants of communities very close to these dump sites.

Figure 5-24: Waste dump sites

Granville Brook (Bumeh) Dump site

(Photo Credit: Resource Magazine)

Deliberate fire set off to burn waste at King Tom Dump site

(Photo Credit: DailyMail.co.uk)

Plastic waste in the middle of the street in Freetown

(Photo Credit: Sierra Leone Telegraph)

Street in Freetown used as a rubbish dump

(Photo Credit: Sierra Leone Telegraph)

Waste at the city centre (Freetown)

(Photo Credit: Sierra Leone Telegraph)

Waste emptied in the Samba Gutter (Freetown)

(Photo Credit: Sierra Leone Telegraph)

5.5 Pollution

5.5.1 Water Pollution

Water pollution in Sierra Leone is the contamination of water bodies such as boreholes, streams, and rivers. It transcends many fields of human activity. Rivers that serve rural communities as sources of drinking water encounter challenges of pollution as a result of agricultural, industrial and domestic activity. The country is inadequately supplied with pipe-borne water. Springs and dugout wells, which are common sources of drinking water, are not well protected. Hence, seepage from surrounding pollutants and toilets are common.

Water pollution (particularly drinking water) is a serious problem in the country. Almost half of the population of Sierra Leone has no access to safe drinking water and only 13% of the population has access to improved non-shared sanitation facilities. Some 74% of urban dwellers have access to safe drinking water while only 46% of rural people use safe water. In the Northern Region, only 30% of residents have access to safe drinking water. According to the Sierra Leone Water Company, on average only 35% of rural residents have access to safe drinking water[55].

Figure 5-25: A man washes his hands during cholera prevention session

In 2012, Sierra Leone experienced the worst cholera outbreak in its history, having over 20,000 cases with 392 deaths[56]. The main cause of the outbreak was as a result of the heavy rainfall and flooding combined with poor hygiene practices, unsafe water sources, and ineffective waste management in the country.

There are several causes of water pollution in Sierra Leone but, the most common is the sewage efflux and surface run-offs into boreholes, streams and rivers. In most parts of the country, boreholes and rivers are the means by which most of the water is supplied for drinking and domestic, agricultural, and industrial use. Since rivers flow through the country from the north-east to south-west, polluting the rivers upstream can affect the people and greatly endanger marine life and the environment downstream. Some of the causes of water pollution in Sierra Leone are highlighted below:

[55] Report of the situation analysis and needs assessment on health and environment for Sierra Leone. Government of Sierra Leone, Ministry of Health and Sanitation.

[56] "GUINEA-SIERRA LEONE: Cholera outbreak easing". *IRIN. Dakar. 24 September 2012. Retrieved 24 September 2012.*

- **Sewage and waste water:** The sewage and waste water that is produced by each household is not chemically treated but is released into streams and rivers mostly in the rainy season, with the potential of carrying harmful bacteria that cause serious health problems. Microorganisms in these rivers and streams are known to be causes of some very deadly diseases.
- **Mining activities:** The process of crushing rocks and extracting mineral resources such as iron ore, rutile, bauxite, gold and other minerals from underground contribute greatly to surface water pollution in the country. These elements when extracted in the raw form contains harmful chemicals and can increase the amount of toxic elements when mixed up with water which may result in health problems. Mining activities in the country emit harmful (to human and the environment) metallic wastes and sulphides from the rocks that runoff into the streams and rivers.
- **Industrial waste oil:** Oil spills from most companies in Sierra Leone pose a huge concern as large amount of waste oil, which does not dissolve enters into streams and rivers, thereby causing problem for local marine life.
- **Burning of fossil fuels:** A great percentage of people in the country rely on subsistence farming for their livelihood. These farming activities involve clearing and burning of the bush/forest. The fossil fuels including charcoal and oil when burnt produce substantial amount of ash in the atmosphere. These particles which contain toxic chemicals when mixed with water vapour result in acid rain; unfortunately most communities rely on rain water for both drinking and domestic purposes.
- **Chemical fertilizers and pesticides:** Chemical fertilizers and pesticides are used by farmers in the country to protect crops from insects and bacteria. They are useful for the plants growth. However, when these chemicals are over use and mixed up with surface water they become harmful for plants and animals. Also, when it rains, the chemicals mix up with rainwater and flow down into streams and rivers which pose serious damages for aquatic animals.
- **Leakage from the landfills**: Landfills like Granville Brook, popularly called 'Bormeh' in east of Freetown, are nothing but huge pile of garbage that produces awful smell and can be seen across the city. When it rains, these landfills leak and pollute the surface and underground water with large variety of contaminants. The waste dumped in these areas are washed away into the rivers when it rains. It gets mixed up with other harmful chemicals and causes various water borne diseases like cholera, diarrhoea, dysentery and typhoid.

5.5.2 Air Pollution

Air pollution occurs when gases, dust particles, fumes (or smoke) or odour are introduced into the atmosphere in a way that makes it harmful to humans, animals and plant. It is a major problem in Sierra Leone that causes illness.

Major sources of air pollution in the cities especially Freetown, Makeni and Bo are vehicular exhaust emissions, industrial activities, road and building industries, all which produce enormous amounts of pollutants in their vicinity. These urban activities generate close to 80% of all carbon dioxide (CO_2) as well as a significant amount of other greenhouse gases (GHG).

In Sierra Leone air pollution is perhaps not as wide varied as in the other countries. Most of the air pollution comes mainly from domestic sources and dust generated from the ground mostly in the dry season both in urban and rural areas. The domestic sources include basically smoke from chimney of kitchens, farm bush burning (bush fire) which could be menace especially in the surrounding rural villages in the Western area and the country’s interior and carbon monoxide and carbon dioxide from automobile exhaust pipes.

Mining also has a great effect on the quality of the air in country. Since these mines need to blast through rock to get to an ore, dust is produced in the process. Air pollution in the form of this dust generated by mining activities, is a serious cause of illnesses, generally in the form of respiratory disease in people and asphyxia of plants and trees. Although workers in the mining companies in Sierra Leone report respiratory problems, many of these effects are felt in areas surrounding open-pit mines. Wind carries debris far from the source, creating a more widespread problem.

Outdoor air pollution is a mix of chemicals, particulate matter, and biological materials that react with each other to form tiny hazardous particles. It contributes to breathing problems, chronic diseases, increased hospitalisation, and premature mortality. The concentration of particulate matter (PM) is a key air quality indicator since it is the most common air pollutant that affects short term and long term health in the country.

Sierra Leone is rated as the 17th most vulnerable countries in terms of air pollution. The causes of air pollution are multiple. Because many households use charcoal or wood as source of fuel for cooking and other related activities, this has led the amount of carbon dioxide produced in the cities to be on the rise. The people that live in Freetown are exposed to indoor and outdoor air pollution that can cause many different health problems (WHO)[57].

Figure 5-26: Preparing charcoal for cooking fuel from bush wood

A study conducted in 2012 by the African Journal of Environmental Science and Technology to monitor the levels of toxic air pollutants in the ambient air of Freetown, Sierra Leone, revealed that the annual average concentrations of total polycyclic aromatic hydrocarbons (PAHs), $PM_{2.5}$ and PM_{10} fractions for the various sites were found to be 37.18 and 6.24 ng/m^3. The average concentration of suspended particulate matter (SPM) was 216.3 count per min (cpm) and the 8-h average concentration of carbon monoxide (CO) was 10 ppm. Higher concentrations of $PM_{2.5}$ and $PM_{2.5}$ to 10 PAHs were found in dry season compared with wet season. The annual carcinogenic potential of PAHs was high in $PM_{2.5}$ fraction while the levels of SPM and CO were high enough to raise concern of health risks. The ambient air quality in Freetown was judged to be poor and in view of human exposure, large portion of urban residents are exposed to high levels of toxic air pollutants which is recognized to be a public health risk (Taylor & Nakai, 2012)[58].

Anything people do that involves burning things (combustion), using household or industrial chemicals (substances that cause chemical reactions and may release toxic gases in the process), or producing large amounts of dust has the potential to cause air pollution. Some of the causes of air pollution in the country are highlighted below:

- **Wood fires:** Many homes in Sierra Leone rely on charcoal and firewood for cooking. It is one of the most commonly visible type of air pollution in homes that cause serious respiratory

[57] http://www.who.int/mediacentre/news/releases/2016/air-pollution-estimates/en/

[58] Monitoring the levels of toxic air pollutants in the ambient air of Freetown, Sierra Leone, https://www.ajol.info/index.php/ajest/article/download/135018/124523

infections. Wood fires cause air pollution by releasing particulate matter into the air. These particles can become lodged in your respiratory system, causing irritation to tissues. The particles can also aggravate existing health conditions such as asthma.

- **Forest fires:** Forest fires release pollutants into the air in the same way as fireplaces burning wood produce pollution. They produce fine smoke particles, which are small enough to be able to get into the lungs and damage the lungs and the heart.
- **Industrial plants and factories:** Plants that produce the goods we all rely on often release small but significant quantities of pollution into the air. Industrial plants that produce cement, synthesize plastic, or make other chemical products are among those that produce harmful air pollution. Most of these plants that pollute release small amounts of pollution continually over a long period of time, though the effects can be cumulative (gradually building up). Sometimes these plants and factories release huge of amounts of air pollution accidentally in a very short space of time.
- **Vehicle Emissions**: Vehicle emissions are another source of fossil fuel emissions and air pollution. The combustion process releases pollutants into the air, such as particles and carbon monoxide, and also releases substances that quickly form into nitrogen oxides and ozone, which are important air pollutants. Most of the commercial transportation, especially the "*Poda Podas"* in Freetown, accounts for a greater percentage of carbon footprint, in the atmosphere.
- **Garbage incineration/burning:** One of the most practiced ways of solid waste disposal in homes in the country is by incineration/burning instead of recycling or landfill. This method of locally managing waste produces significant air pollution in neighbourhoods.

6 LANDSLIDE VULNERABILITY AND RISK ASSESSMENT (VRA)

6.1 Overview

Sierra Leone has witnessed several large-scale landslides, with the most recent occurring on 14 August 2017. These landslides have had a widespread impact both on human life and physical infrastructure. In light of both past and much recent landslide events in Sierra Leone, it is necessary to study the distribution of landslide hazard, vulnerability and risk factors, as well as the exposure of social and physical infrastructure. The approach taken in this project to assess landslide exposure, vulnerability and risk in Sierra Leone is supported by quantitative evidence identifying the exposure and risk of a number of vital elements at risk. The elements at risk studied are population, housing infrastructure, education infrastructure, health infrastructure, energy and power infrastructure, transportation and industry. A scenario has been built upon precedent set by significant landslides in the past. This scenario is analysed in terms of the population, housing infrastructure, education infrastructure, health infrastructure, energy and power infrastructure, transportation and industrial sectors. The landslide risk assessment analysis has been presented in a series of user-friendly charts and graphs. The analysis should be easily understood by policy makers and sectoral development officials.

6.2 Landslide Vulnerability Assessment

Landslide VA aims to identify the physical and social elements at risk. Quantifying the vulnerability of sectoral assets illustrates the proportion of assets that are located in hazard prone areas. This provides understanding about the stock of asset which may be vulnerable to different landslide hazard severity. The assessment provides information to policy makers, decision makers and planners about assets which may need mitigation intervention. Nevertheless it does not characterize the performance of assets on varying hazard intensities. Thus EA aims to initiate the process of the VRA.

The impact profiles of hazards on different assets are distinctive; they vary depending upon the characteristics of the sectoral assets. For example landslide primarily affect physical infrastructure, followed by other secondary sectors. The study aims to estimate primary physical infrastructure including housing, education, health, and transport systems. Apart from these, the population is also considered for landslide impacts. Population is further classified by gender (male and female). There are other sectors which are impacted by landslides however the effects are comparatively low and therefore not considered in this study.

Landslide vulnerability assessment helps to provide information, which could be used to protect population and to improve settlement planning, housing sector, infrastructure, and transportation sector. The landslide exposure assessment is limited to the exposure analysis of the following elements at risk: population, housing, health facilities, schools, roads, and agriculture.

The landslide hazard assessment has developed landslide risk maps, which classifies landslide into five risk classes (very high, high, moderate, low and very low). In this landslide vulnerability assessment only moderate, high and very high risk classes are included in the analysis. The two other classes (low and very low) were not included as landslides are less likely to occur at these levels.

6.3 How to Read and Analyse the Vulnerability Results

A combination of sophisticated GIS tools were used to identify the impacts of landslide on the population, housing sector, education infrastructure, health infrastructure, transportation in each of the 14 Districts in Sierra Leone.

6.3.1 How to Read the Map

The landslide hazard map (Figure 6-1) shows the spatial distribution of risk zones. Colours from green to red indicate the risk classes from very low to very high. The figure below illustrates the colours that are used to indicate the different risk zones from the qualitative assessment of landslide hazard.

Table 6-1: Landslide risk colour scheme

Hazard	Descriptor	Description
Very Low	Rare	The event is conceivable, but only under exceptional circumstances
Low	Unlikely	The event might occur under very adverse circumstances
Moderate	Possible	The event could occur under adverse conditions
High	Likely	The event will probably occur under adverse conditions
Very High	Almost certain	The event is expected to occur

6.3.2 Population

Population data has been sourced from Statistics Sierra Leone's Population and Housing Census (Statistics, 2015) to carry out the landslide population exposure assessment. The data include population classification by gender at district, chiefdom and section levels, making it possible to extract with a high degree of confidence the population exposed to the different landslide risk levels. The datasets, however, are inadequate for population exposure to be carried out by age classes (i.e. working age and dependent age). The ensuing charts show the exposure of population to landslides at three risk levels: very high, high and moderate.

Figure 6-3 presents the population, classified by gender, vulnerable to landslide at moderate susceptibility. Noting the landslide hazard map, the mountainous areas in Western Area and some parts of the Northern and Eastern provinces are landslide prone areas with moderate risk. The vulnerability assessment revealed that about 36% of the total population are vulnerable to landslide at moderate risk. Western Area Rural and Bombali top the list of districts with the highest percentage of total district population exposed to landslide at moderate level (68.3% and 49.7%, respectively).

The ensuing charts and tables present the population, classified by gender, exposed to landslide in high and very high risk zones. The landslide risk map reveals that the slopes of the Western Area Peninsula Mountains are landslide prone with high risk. The VA revealed that about 4.9% of the total population of Sierra Leone are exposed to landslide at high risk, while only 0.25 percent of the population are exposed to landslide at very high risk.

Figure 6-1: Landslide risk map of Sierra Leone

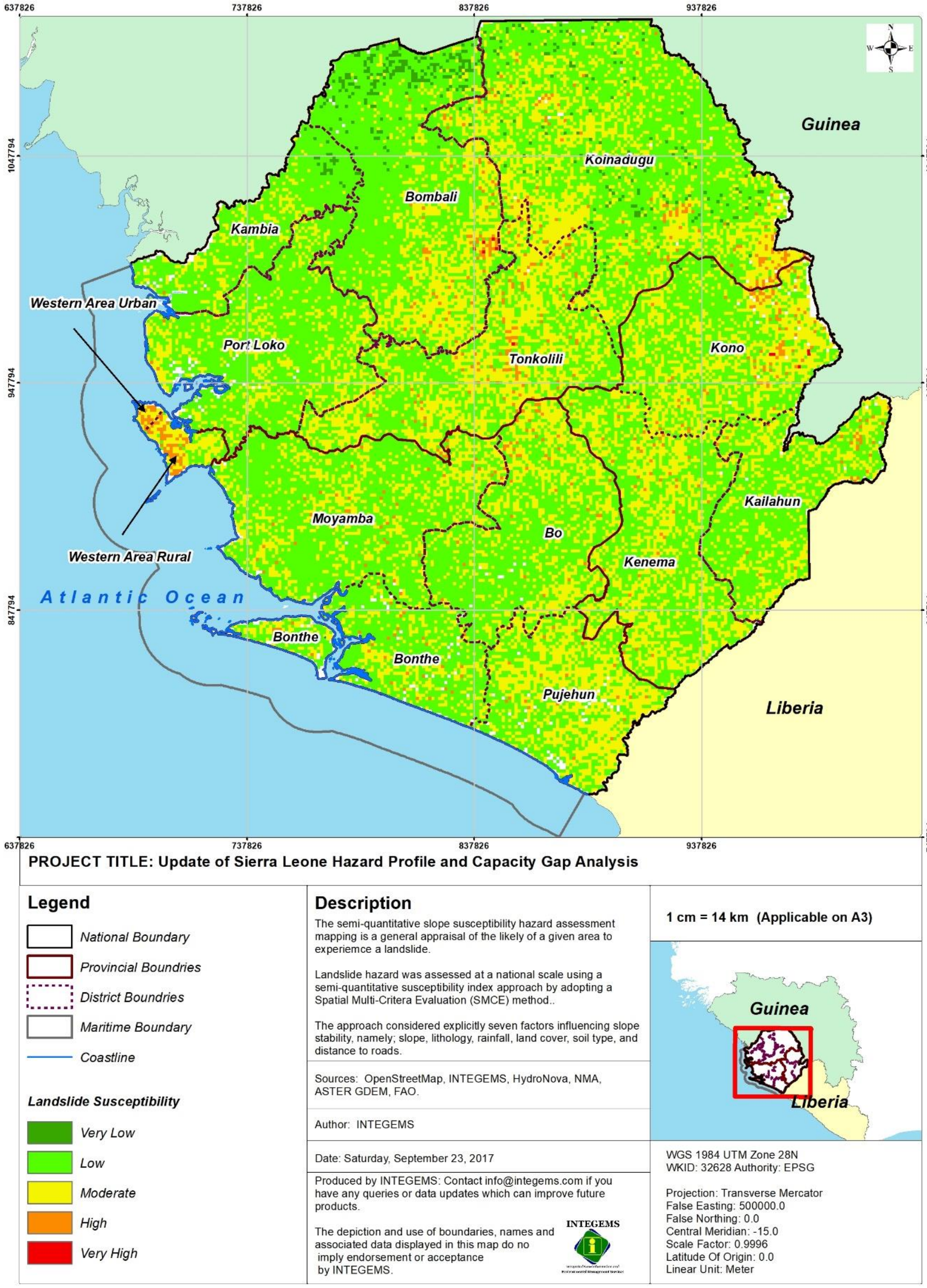
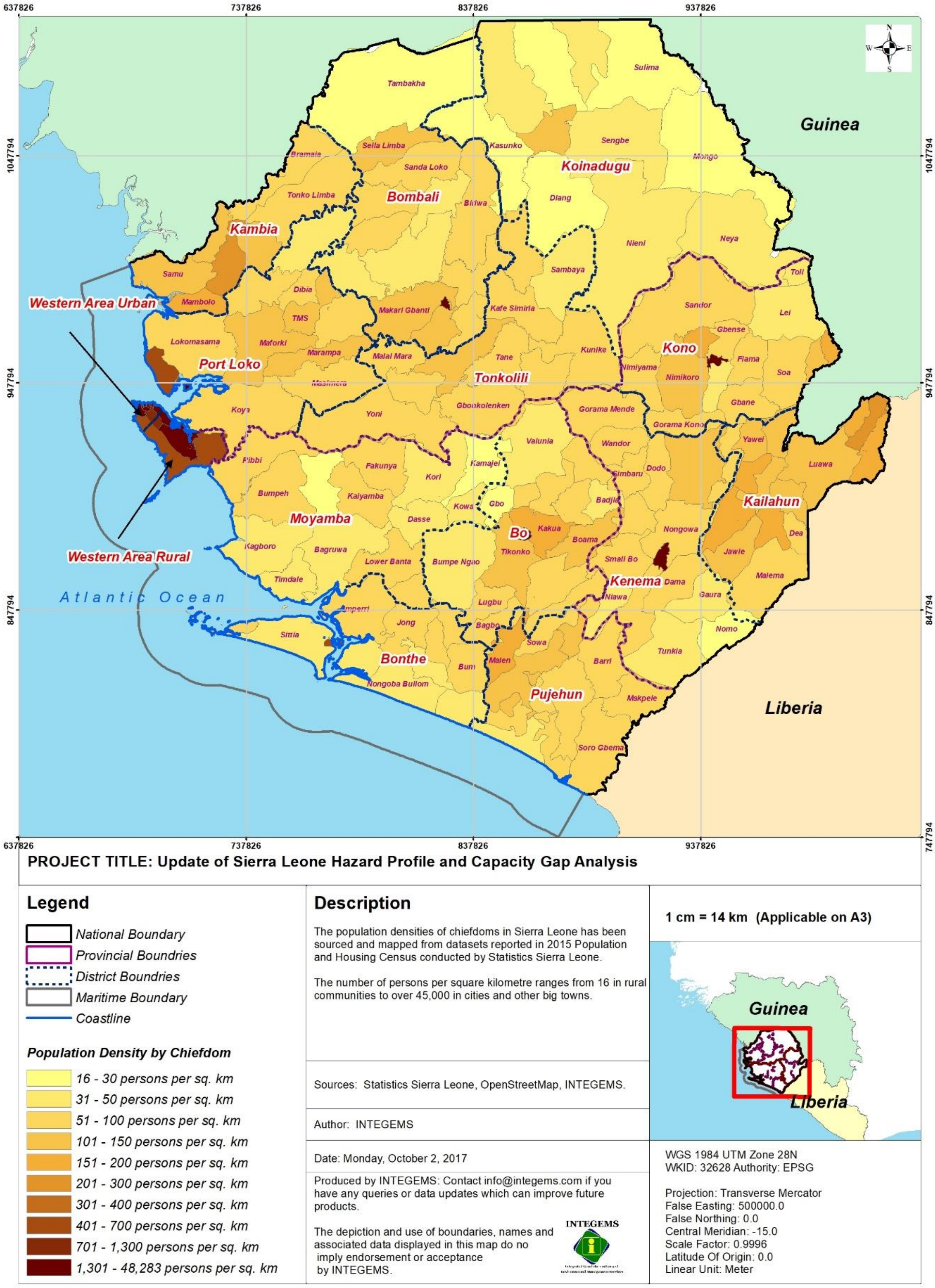


Figure 6-2: Population density at chiefdom level in Sierra Leone



A list of communities exposed to landslide at high susceptibility is presented in Table 6-4.

Table 6-2: Population vulnerable to landslide at moderate risk

District	Male	Female	Total	Percentage of Population	District Population
Bo	57,060	59,325	116,385	20.2	575,478
Bombali	147,578	154,105	301,683	49.7	606,544
Bonthe	19,218	20,250	39,468	19.7	200,781
Kailahun	60,791	61,676	122,467	23.3	526,379
Kambia	27,617	28,942	56,559	16.4	345,474
Kenema	114,908	118,380	233,288	38.3	609,891
Koinadugu	73,205	73,460	146,665	35.8	409,372
Kono	120,196	120,825	241,021	47.6	506,100
Moyamba	39,497	42,918	82,415	25.9	318,588
Port Loko	100,847	107,223	208,070	33.8	615,376
Pujehun	81,339	85,694	167,033	48.2	346,461
Tonkolili	119,469	122,893	242,362	45.6	531,435
Western Area Rural	150,742	152,594	303,336	68.3	444,270
Western Area Urban	151,242	153,039	304,281	28.8	1,055,964
National	**1,263,709**	**1,301,324**	**2,565,033**	**36.2**	**7,092,113**

Figure 6-3: Population vulnerable to landslide at moderate risk

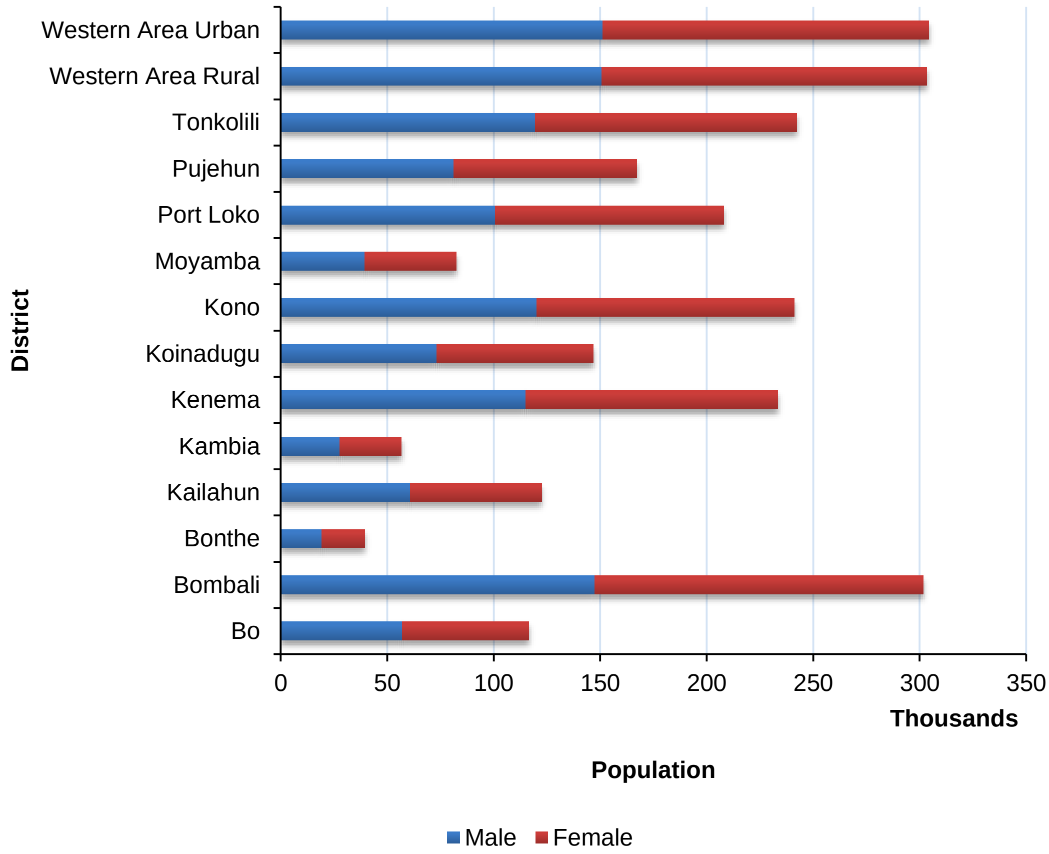


Table 6-3: Population vulnerable to landslide at high risk

District	Male	Female	Total	Percentage of Population	District Population
Bo	1,499	1,587	3,086	0.5	575,478
Bombali	4,115	4,642	8,757	1.4	606,544
Bonthe	538	551	1,089	0.5	200,781
Kailahun	3,405	2,984	6,389	1.2	526,379
Kambia	0	0	0	0	345,474
Kenema	3,120	3,130	6,250	1.0	609,891
Koinadugu	3,289	3,153	6,442	1.6	409,372
Kono	2,276	2,332	4,608	0.9	506,100
Moyamba	1,620	1,784	3,404	1.1	318,588
Port Loko	1,968	2,076	4,044	0.7	615,376
Pujehun	1,436	1,534	2,970	0.9	346,461
Tonkolili	5,464	5,663	11,127	2.1	531,435
Western Area Rural	17,775	16,626	34,401	7.7	444,270
Western Area Urban	129,188	127,222	256,410	24.3	1,055,964
National	**175,693**	**173,284**	**348,977**	**4.9**	**7,092,113**

Figure 6-4: Population vulnerable to landslide at high risk

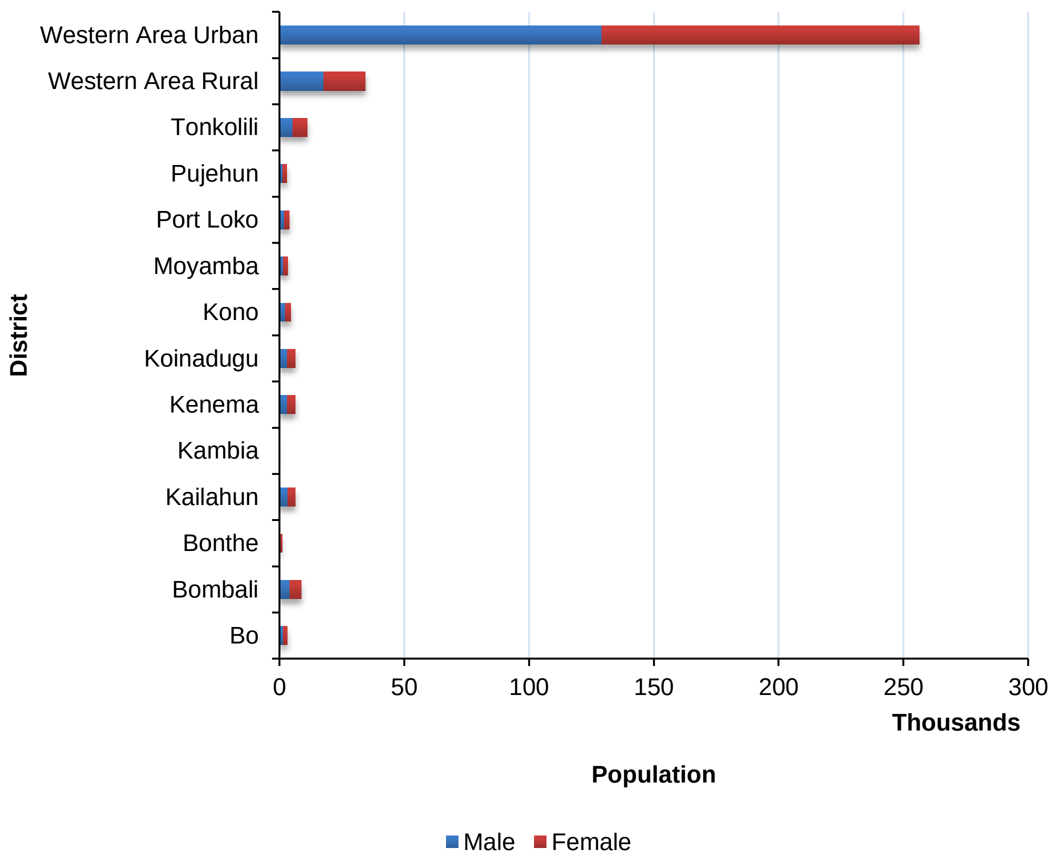


Table 6-4: Communities/sections vulnerable to landslide at high risk

District	Chiefdom	Section/Community
Kailahun	Jawie	Lower Giebu
		Mano
		Upper Giebu
	Kissi Kama	Kama Teng
		Kama Toh
	Kissi Teng	Bumasadu
		Lela
	Kissi Tongi	Bende Bengu
		Lower Pokorli
		Lower Tongi Tingi
		Upper Konio
		Upper Pokorli
		Upper Tongi Tingi
	Luawa	Gbela
		Mano-Sewallu
		Upper Kpombali
	Malema	Bamburu
		Lower Sami
		Pelegbambeima
	Penguia	Nimima
Kenema	Dodo	Bonya
		Bundoryama
		Golama
		Korgay
	Gorama Mende	Famanjo
		Kaklawa
		Kualley
	Kenema City	Gbo Lambayama A-Nyandeyama
		Gbo Lambayama A-Reservation
	Koya	Koya Gbundohun
		Menima
	Lower Bambara	Bonya
		Gboro
		Korjei Buima
		Korjei Ngieya
	Malegohun	Konjo Yematanga
		Lower Torgboma
	Niawa	Kpatawa
		Niawa
	Nongowa	Gbo Lambayama B
		Kagbado Kamboima
		Kona Kpindibu
	Simbaru	Bundoryama

District	Chiefdom	Section/Community
		Fallay
		Fonde
	Small Bo	Gorama
		Kamboma
	Tunkia	Gorahun
	Wandor	Boryongor
		Gbogbeima
		Kemoh
		Niawa
		Songhai
		Tongorwa
Kono	Fiama	Fiama
		Kokar
		Kooma
	Gbane	Gbane Yemao
		Maikandor
	Gbane Kandor	Gbane Kandor
	Gorama Kono	Bunabu
		Kangama
	Lei	Dia
		Kamara
		Kensay
		Koaro
		Lei
		Sangbada
		Tankoro
		Tingi-Kor
		Yawai
	Nimikoro	Bandafafeh
		Gbogboafeh
		Jaiama
		Masayiefeh
	Sandor	Fakongofeh
		Samgbafeh
		Yawatanda
	Soa	Kokongokuma
		Maindu
		Mofinkor
		Tensekor
	Tankoro	Njama
	Toli	Komadu
		Kwidu
Bombali	Biriwa	Bumban
		Kabakeh Balandugu

District	Chiefdom	Section/Community
		Kagbankuna
		Kamabai
		Karassa
		Kayonkro
	Bombali Sebora	Kafala
		Kagbaran Dokom B
		Matotoka
	Gbanti Kamaranka	Kamaranka
		Makapr
		Royeama
		Sakuma
	Gbendembu Ngowahun	Kalangba
		Kania
		Lohindie
		Masongbo
		Sahun
	Magbaimba Ndorwahun	Kagberay
		Makendema
		Mambiama
	Makari Gbanti	Gborbana
		Mabanta
		Magbenteh
		Mangay
		Mankneh Bana
		Masongbo A
		Rosint
		Yainkassa
	Makeni City	Kagbaran Dokom A
	Paki Masabong	Kathanthan
		Masabong Pil
		Masabong Thoron
		Mayagba
		Rosanda
	Safroko Limba	Binkolo
		Kabonka
		Kagbo
		Kasengbeh
		Kayassi
		Mabamba
	Sanda Loko	Laminaya
		Madina
	Tambakha	Dugutha
		Paramount Chief
Kambia	Samu	Kychom
Koinadugu	Dembelia-Sinkunia	Mannah

District	Chiefdom	Section/Community
	Diang	Darakuru
		Gbenekoro
		Kania
		Kondembaia
		Sokurala
	Folosaba Dembelia	Balandugu
		Kamba
		Lagor
		Musaia
	Kasunko	Fangama
		Gbonkobor
		Kakallain
		Kasunko
		Tamiso I
		Tamiso II
	Mongo	Lower Deldugu
	Neya	Kulor
		Lower Neya I
		Lower Saradu
		Neya II
		Nyedu
		Upper Neya I
		Upper Saradu
	Nieni	Barawa
		Kalian
		Nieni
		Wallay
	Sengbe	Bendugu
		Yogomaia
	Sulima	Falaba II
		Fodaia
		Kaliyereh
		Laylay
		Timbako
	Wara Wara Bafodia	Bafodia
		Kakoya
		Kamannikie
		Kambalia
		Semamaia
	Wara Wara Yagala	Zone 1
		Zone 2
		Zone 5
Port Loko	Kaffu Bullom	Foronkoya
		Lungi
		Mayaya

District	Chiefdom	Section/Community
	Lokomasama	Yurika
Tonkolili	Gbonkolenken	Lower Polie
		Mayeppoh
		Petifu Bana
		Petifu Mayawa A
		Upper Polie
	Kafe Simiria	Kabaia
		Kamarugu
		Mabonto
		Makelfa
		Makontande
		Mayaso
	Kalansogoia	Bassaia
		Fuladugu
		Kakallain
		Kamakathie
		Kasokira
		Kemedugu
		Makilla
		Songoni
	Kholifa Mabang	Mabang
		Mamanso
		Marunia Sakie
		Rogbabai
		Rokankarr
	Kholifa Rowala	Lal-Lenken
		Makump
		Mamuntha
		Mayatha
		Mayossoh
	Kunike	Rolal
		Sanda
		Semorkanie
		Thambaya
		Wana
	Kunike Barina	Makong
		Mamurie
		Masaba
		Wonkibor
	Malal Mara	Mabilafu
		Makoba
		Malal
		Manewa
		Rochen
	Sambaya	Borowah

District	Chiefdom	Section/Community
		Buyan
		Dayie
		Sambaya
	Tane	Maboboh Koray
		Makrugbeh
		Mange-bana
		Mapakie
		Mathunkara
		Matotoka
	Yoni	Foindu
		Gaindema
		Macrogba
		Malompor
		Mamaka
		Masengbe
		Petifu
		Yoni
Bo	Badjia	Kpallay
	Bagbo	Tissana
	Bagbwe(Bagbe)	Jongo
		Samawa
	Boama	Mawojeh
	Bumpe Ngao	Bumpe
		Kpetema
		Sahn
	Jaiama Bongor	Lower Kama
		Lower Niawa
		Upper Niawa
	Kakua	Samamie
	Komboya	Kemoh
	Niawa Lenga	Lower Niawa
		Yalenga
	Tikonko	Ngolamajie
		Sendeh
	Valunia	Deilenga
		Kendebu
		Lunia
		Ngovo
		Seilenga
		Vanjelu
		Yarlenga
	Wonde	Upper Kargoi
Bonthe	Bendu-Cha	Yallan-gbokie
	Bum	Fikie
		Gbondubum

District	Chiefdom	Section/Community
		Tamba
		Torma
	Imperri	Babum
		Bigo
		Kahekay
		Moimaligie
	Jong	Basiaka
		Beyinga
		Kumabeh-Kwe
		Landi-Ngere
		Sopan-Cleveland
		Tucker-Nyambe
	Kpanda Kemo	Bewoni
	Kwamebai Krim	Mosenten Sahen II
	Nongoba Bullom	Gbangbassa
		Gbap
		Hahun
		Kessie
		Manyyime
		Salma
		Salon
		Torma Subu
	Sittia	Kamai
		Kwalloh
		Ngepay
		Sahaya
		Sahn-Gbegu
		Sampoh
	Sogbeni	Beyorgboh
	Yawbeko	Baryegbe
		Kataway
		Yorma
Moyamba	Bagruwa	Kawaya
		Mani
		Mokassi
		Sembehun
	Bumpeh	Mamu
		Massah
	Dasse	Bongoya
		Taninahun Gomoh
	Fakunya	Kovella
		Kpangulgo
		Njawa
		Tullu
	Kagboro	Bendu B

District	Chiefdom	Section/Community
		Konolor
		Mambo
		Mokebay
		Mokobo
		Mopaileh
		Thumba A
	Kaiyamba	Angigboya
		Koromboya
		Kpange
		Lungili
		Mosoe
		Waliwahun
	Kamajei	Mogbuama
		Ngoahun
		Tawovehun
		Yeima
	Kongbora	Gondama
		Mobonor
		Mosongla/Lawana
		Taninihun
	Kori	Zone - 1
		Zone - 2
		Zone - 4
		Zone - 6
		Zone - 7
	Lower Banta	Bengelloh
		Gbangbatoke
		Mokotawa
		Ndendemoya
		Njagbahun
	Timdale	Mando
	Upper Banta	Songbo
Pujehun	Barri	Dakona
		Fallay
		Sonjour II
	Galliness Perri	Dakona
		Gendema I
		Joya
		Kortugbu
		Pelegbulor
	Kpaka	Jassende Ngoleima I
	Makpele	Samagbe
		Selimeh
	Malen	Kemoh
	Panga Kabonde	Panga

District	Chiefdom	Section/Community
		Samba
		Setti - Yakanday
	Panga krim	Samba
		Somasa
	Pejeh(Futa peje	Koilenga
		Pejeh East
		Pejeh West
	Soro Gbema	Kiazombo
		Massaquoi II
		Zoker I
		Zoker II
	Sowa	Sabba I
		Upper Geoma
	Yakemu Kpukumu	Bapawa
Western Area Rural	Mountain Rural	Bathurst
		Charlotte
		Gloucester
		Leicester
		Regent
	Waterloo Rural	Deep Eye Water/Devil Hole
		Hastings-Yams Farm
		Jui-Grafton
		Rokel
		Waterloo Benguema
		Waterloo Lumpa
	York Rural	Gbendembu
		Goderich-Adonkia/Milton Margai
		Hamilton
		Kent
		Sattia/Tombo
		York
Western Area Urban	Central I	Albert Academy
		Mountain Regent
		Sorie Town
		Tower Hill
	Central II	Sanders Brook
	East II	Ashobi Corner
		Foulah Town
		Ginger Hall
		Kissy Brook I
		Quarry
	East III	Allen Town I
		Allen Town II
		Congo Water I
		Congo Water II

District	Chiefdom	Section/Community
		Industrial Estate
		Jalloh Terrace
		Kissy Brook II
		Kissy Bye Pass (Dock)
		Kuntolor
		Mamba Ridge I
		Mamba Ridge II
		Mayenkineh
		Robis
		Thunder Hill
	West I	Brookfields
	West II	Brookfields-Congo
		Brookfields-Red Pump
		CongoTown
		George Brook (Dworzak)
		New England-Hannessey Street
		New England-Hill Cot
		Sumaila Town
		Tengbeh Town
	West III	Hill Station
		Juba/Kaningo
		Lumley
		Malama/Kamayama
		Wilberforce

Table 6-5: Population vulnerable to landslide at very high risk level

District	Male	Female	Total	Percentage of Total Population	District Population
Bo	0	0	0	0	575,478
Bombali	3,510	3,677	7,187	1.2	606,544
Bonthe	0	0	0	0	200,781
Kailahun	0	0	0	0	526,379
Kambia	0	0	0	0	345,474
Kenema	0	0	0	0	609,891
Koinadugu	0	0	0	0	409,372
Kono	5,070	5,267	10,337	2.0	506,100
Moyamba	0	0	0	0	318,588
Port Loko	0	0	0	0	615,376
Pujehun	0	0	0	0	346,461
Tonkolili	146	149	295	0.06	531,435
Western Area Rural	0	0	0	0	444,270
Western Area Urban	0	0	0	0	1,055,964
National	**8,438**	**9,093**	**17,819**	**0.25**	**7,092,113**

Figure 6-5: Population vulnerable to landslide at very high risk by gender

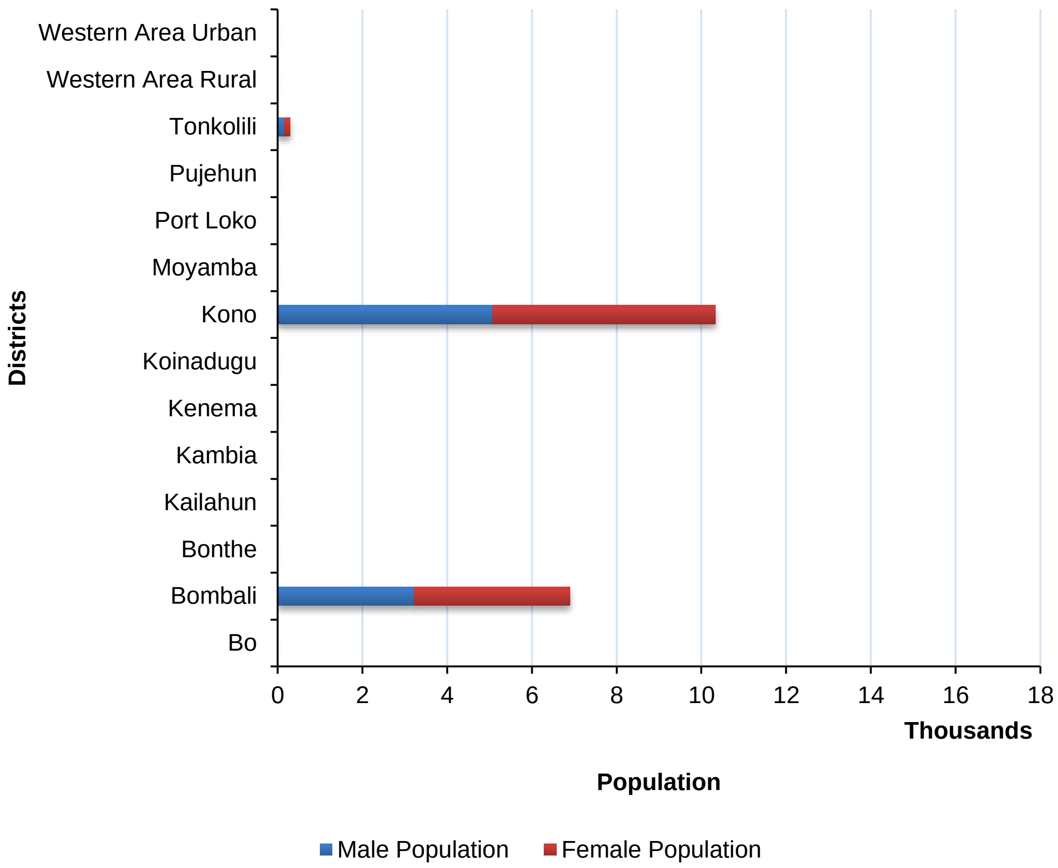


Table 6-6: Sections/communities vulnerable to landslide risk

District	Chiefdom	Section
Bombali	Biriwa	Bumban
		Kamabai
	Safroko Limba	Kasengbeh
Kono	Gbane Kandor	Gbane Kandor
	Soa	Kokongokuma
		Mofinkor
		Tensekor
Tonkolili	Tane	Maboboh Koray

6.3.3 Housing Sector

Housing is another sector, which may be affected by landslides. Ideally, the VA for housing must take into consideration the type of walls of the exposed buildings. In general, the type of wall is important in the occurrence of landslide and determines the resilience of a building. In Sierra Leone, the houses are built with walls made of sun dried sandcrete brick, wattle and mud, cement, stone, corrugated zinc sheets, plastic, timber and burnt clay brick, etc. Most of the houses' walls are made of weak and non-resistant materials such sundried brick, and wattle and mud.

The housing characteristics data captured during the PHC 2015 serves as starting point to acquire a general overview of the building typology at district level. However, the data presents the number of households in each of the 14 districts living in buildings of different wall, floor, and roof material. Although a very vital starting point in determining which districts have much more vulnerable buildings, this data is not spatially referenced (geotagged/georeferenced) to individual buildings making it impossible to identify the buildings exposed to landslide at different risk levels. To circumvent this, buildings datasets for this study have been sourced from OpenStreetMap (OSM, www.openstreetmap.org). A total of about 530,000 buildings have been mapped in the entire country to extract the number of buildings exposed to landslides at moderate, high, and very high risk in the 14 districts.

Figure 6-6 and Table 6-7 present the exposure of housing to landslides at three risk levels: moderate, high, and very high. There are a total of 214,283 buildings exposed to landslide at moderate susceptibility in the 14 districts, 34,248 in high risk areas, and only 12 in very high susceptibility areas (11 in Kono, and 1 in Bombali). The exposure in high risk area is highest for buildings in Western Area Urban (27.3 % of the district's total) followed by Western Area Rural (7.8 % of the district's total), while Kambia and Bo districts have the lowest number of exposed buildings.

Figure 6-6: Buildings exposed to landslide risk

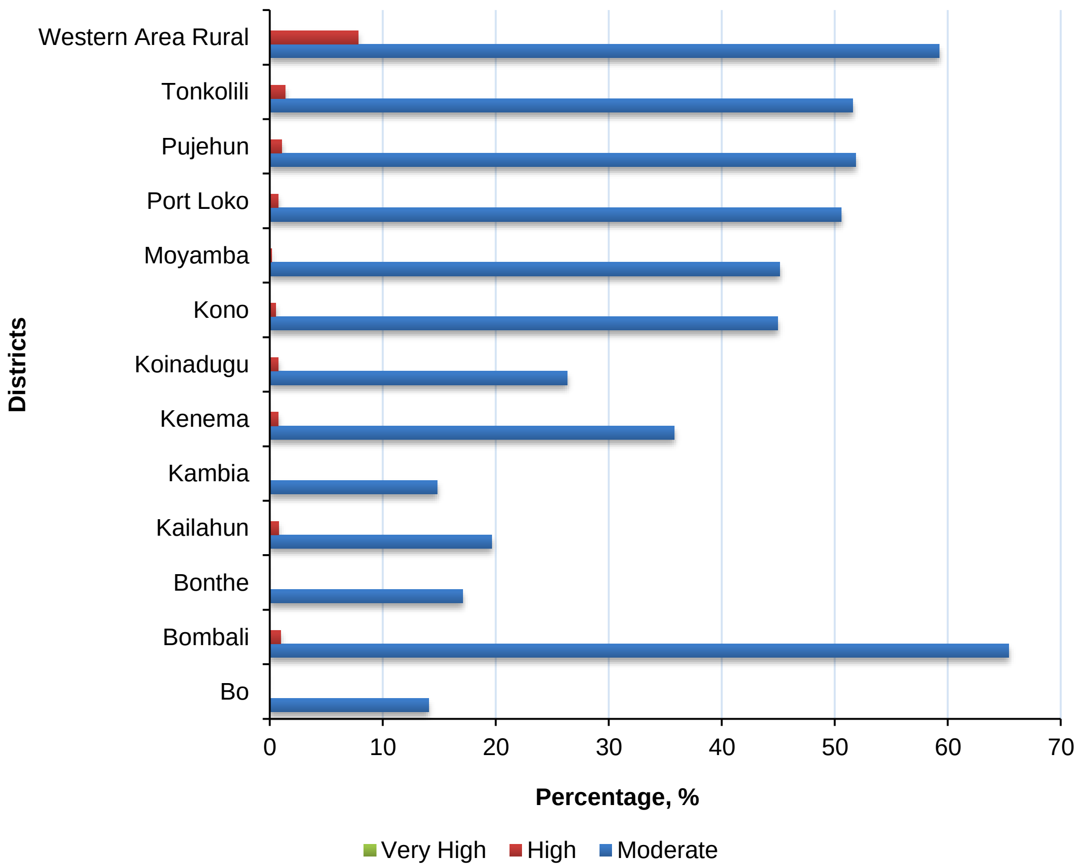


Table 6-7: Buildings exposed to landslide risk

District	Moderate		High		Very High		Total Number of Buildings
	Number	%	Number	%	Number	%	
Bo	5,620	14.1	8	0.02	0	0	39,989
Bombali	21,222	65.4	306	0.9	1	0.003	32,451
Bonthe	610	17.1	1	0.03	0	0	3,570
Kailahun	12,822	19.6	505	0.8	0	0	65,366
Kambia	1,833	14.8	2	0.02	0	0	12,382
Kenema	28,546	35.8	579	0.7	0	0	79,715
Koinadugu	4,677	26.3	136	0.8	0	0	17,772
Kono	24,789	44.9	295	0.5	11	0.02	55,157
Moyamba	3,638	45.1	14	0.17	0	0	8,058
Port Loko	12,184	50.6	174	0.7	0	0	24,088
Pujehun	4,523	51.8	90	1.03	0	0	8,724
Tonkolili	7,919	51.6	212	1.4	0	0	15,355
Western Area Rural	47,115	59.2	6,215	7.8	0	0	79,520
Western Area Urban	38,785	41.2	25,711	27.3	0	0	94,082
National	**214,283**	**38.4**	**34,248**	**3.02**	**12**	**0.0016**	**536,229**

6.3.4 Education Sector

The VA for the education sector analyses the exposure of educational institutions (i.e. schools, colleges/universities, and vocational institutions) to landslides at different risk levels. Specifically, the analysis only refers to the institutions' building or infrastructure.

Academic institution datasets have been sourced from UNICEF. A total of approximately 3,330 academic institutions have been mapped in the entire country to extract the number of institutions exposed to landslides at moderate, high, and very high risk in the 14 districts. The datasets captures only 1 academic institution in Bombali District. Therefore, the exposure (vulnerability) of academic institutions for Bombali was not carried out.

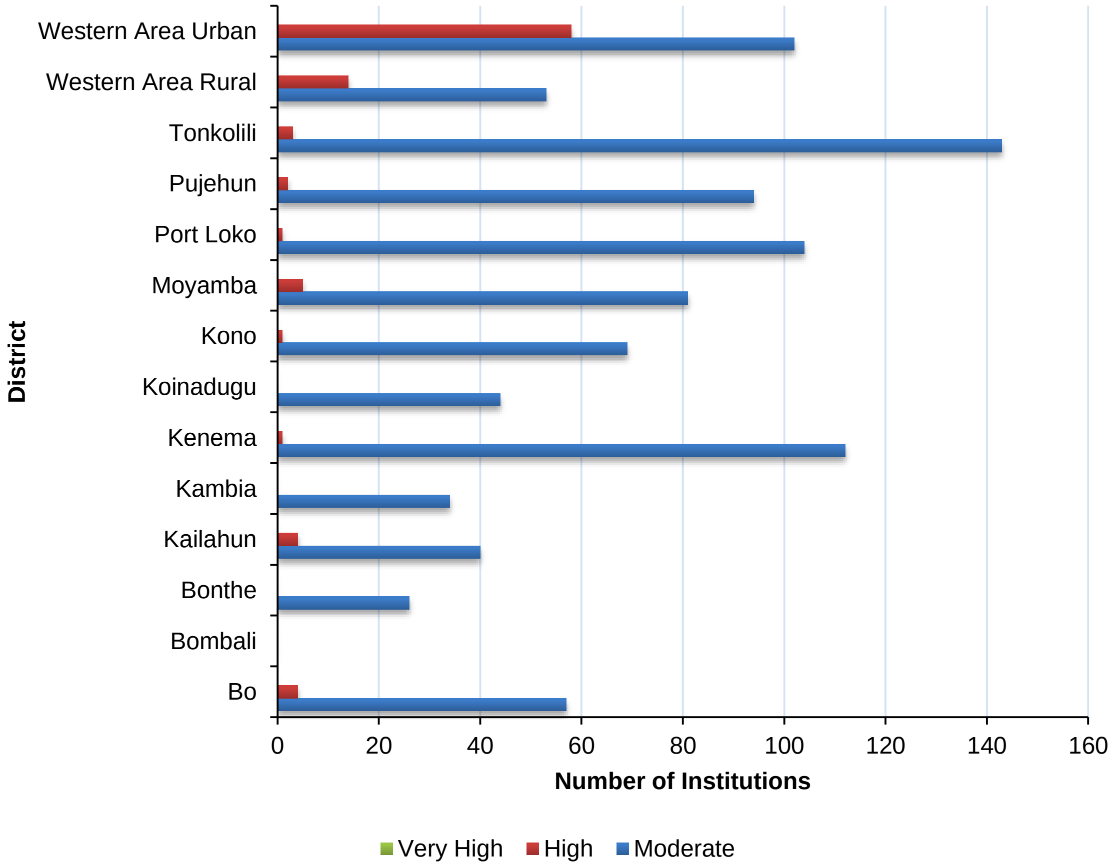
The ensuing table and chart (Figure 6-7 and Table 6-8) show the exposure of academic institutions to landslides at three risk levels: moderate, high, and very high.

A total of 1,052 academic institutions are exposed to landslides at varying risk levels. None of the schools in the database were found be exposed in areas designated as very high landslide risk zones, while 959 fall within areas designated as moderate risk zones. A total of 93 schools from 13 districts were found to be exposed in areas of high landslide risk.

Table 6-8: Academic institutions exposed to landslide risk

District	Moderate	High	Very High
Bo	57	4	0
Bombali	NA	NA	NA
Bonthe	26	0	0
Kailahun	40	4	0
Kambia	34	0	0
Kenema	112	1	0
Koinadugu	44	0	0
Kono	69	1	0
Moyamba	81	5	0
Port Loko	104	1	0
Pujehun	94	2	0
Tonkolili	143	3	0
Western Area Rural	53	14	0
Western Area Urban	102	58	0
National	**959**	**93**	**0**

Figure 6-7: Academic institutions exposed to landslide



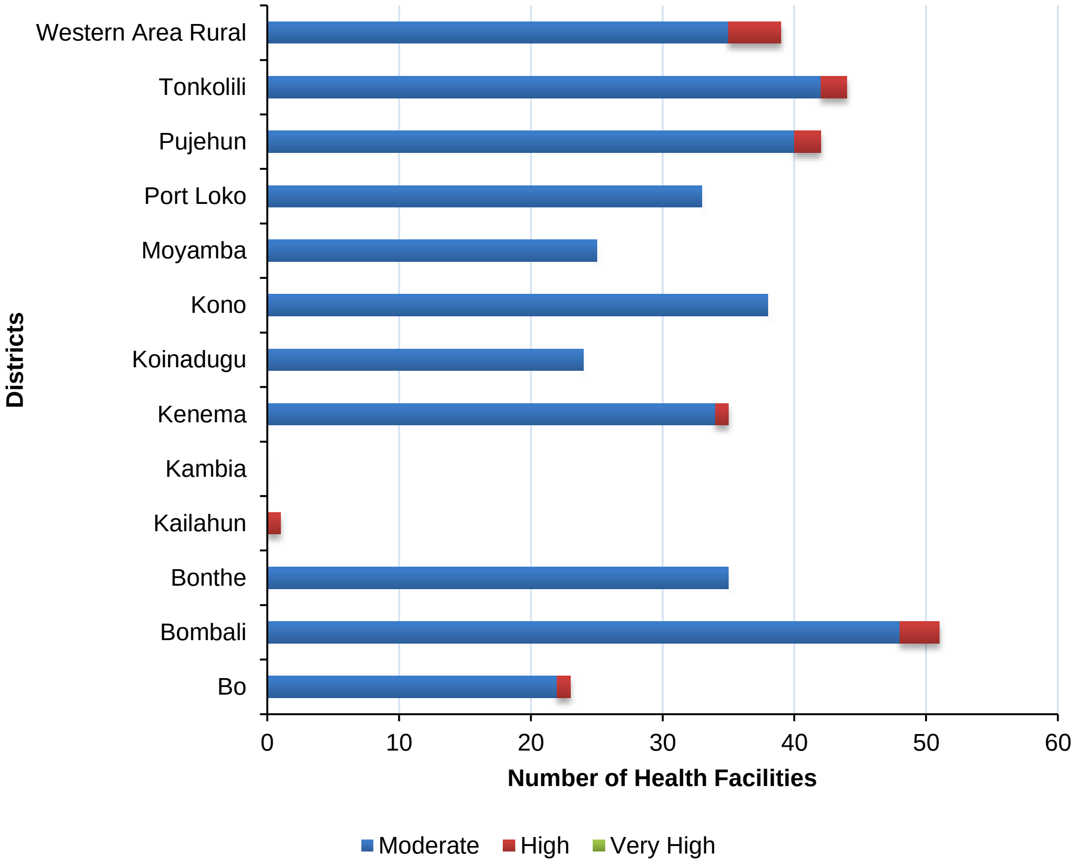
6.3.5 Health Sector

The exposure analysis found no health facility (from the MoHS 2015 Health Facility database) exposed to landslides at very high susceptibility level. Some 30 health facilities were found to be located in areas of high landslides risk, with Western Area Urban and Western Area Rural accounting for over 60% of that number. A total of 431 health facilities were found to be exposed to landslides at moderate risk level, with Kailahun and Kambia being the only districts without a health facility exposed at this level. Details of the number of health facilities exposed to landslide at moderate, high and very high risk levels are given in Figure 6-8.

Table 6-9: Health facilities exposed to landslide at moderate, high, and very high risk

District	Moderate	High	Very High
Bo	22	1	0
Bombali	48	3	0
Bonthe	35	0	0
Kailahun	0	1	0
Kambia	0	0	0
Kenema	34	1	0
Koinadugu	24	0	0
Kono	38	0	0
Port Loko	33	0	0
Pujehun	40	2	0
Tonkolili	42	2	0
Western Area Rural	35	4	0
Western Area Urban	55	16	0
National	**431**	**30**	**0**

Figure 6-8: Health facilities exposed to landslide at moderate, high, and very high risk



6.3.6 Transport Sector

A comprehensive network of roads is an important factor in landslide risk and DRM in general, particularly in hard-to-access areas and in a country like Sierra Leone with a growing transportation network. The spatial distribution of road damage risk is needed to assess the extent of impact on sectors that are dependent on a functioning transport system. District-wide transportation damage risk will also assist the government and stakeholders in allocating rehabilitation and maintenance budgets for transport infrastructure.

The exposure assessment for the transportation sector is limited to analysing the exposure of roads (trunk, primary, secondary, tertiary, and residential) to landslide hazards in high, and very high landslide risk areas. Figure 6-9 and Table 6-10 present the exposure of different classes of roads at the aforementioned risk levels in the 14 districts.

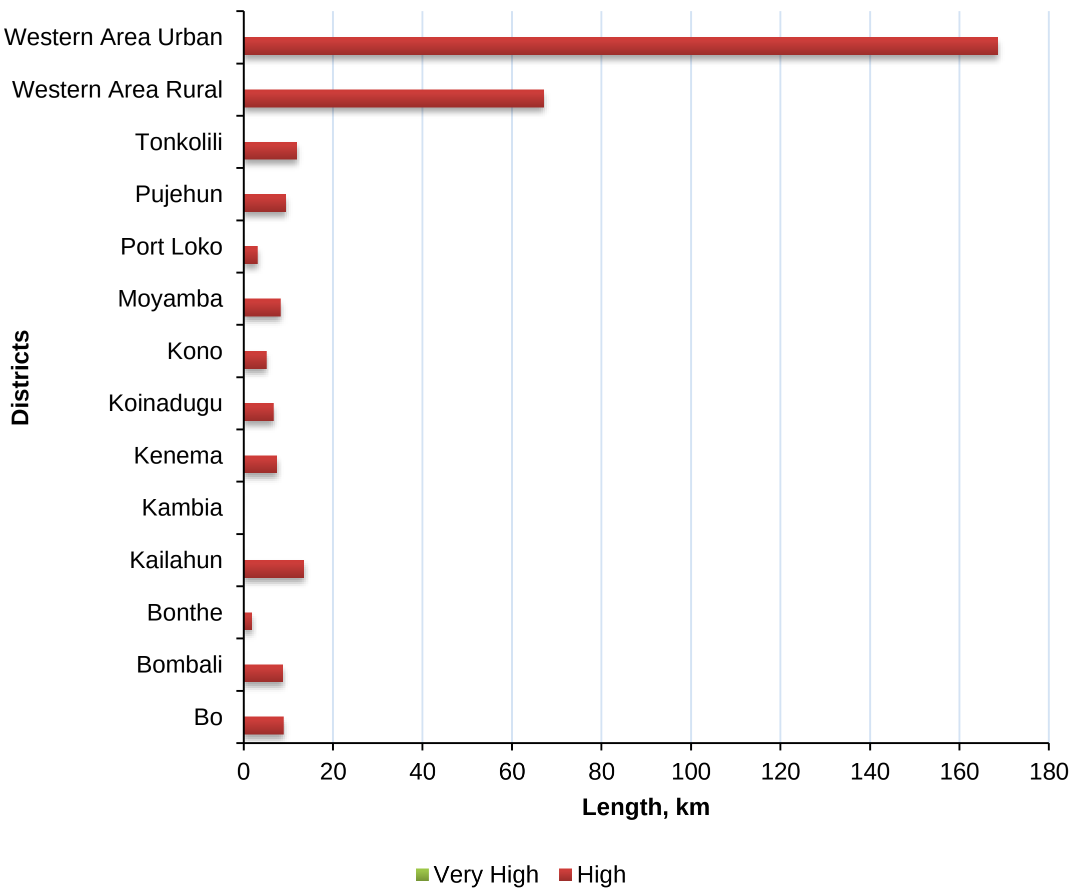
Open Street Map is the primary sources of roads data for the project. The one freight-only railway in Northern Province of Sierra Leone is not considered by this study. Bridges are also not considered by this study.

The road exposure analysis found no roads to be exposed to very high landslide risk, while a total of 320 kilometres of roads are exposed to landslide at the moderate, high and very high risk levels. Western Area Urban District has the highest combine length of roads exposed to landslide at high risk (169 km), while Kambia District has the least combine length of roads (0 km) exposed to landslide at high risk.

Table 6-10: Length of roads exposed to landslide at high risk

District	Length of Road, km					
	Trunk	Primary	Secondary	Tertiary	Residential	Total
Bo	1.1	0.4	0.9	6.3	0.2	8.9
Bombali	0	2	2.6	2.7	1.5	8.8
Bonthe	0	0	1.5	0	0.3	1.8
Kailahun	2.4	1.5	0	7.3	2.3	13.5
Kambia	0	0	0	0	0	0
Kenema	0.7	0	0.3	3	3.5	7.5
Koinadugu	0	2.9	0	1.2	2.6	6.7
Kono	0	2.3	2.1	0.6	0.04	5.04
Moyamba	1.4	0	4.2	1.3	1.3	8.2
Port Loko	0	0	0	0	3	3
Pujehun	2.6	1.8	1.5	3.4	0.2	9.5
Tonkolili	0	0	9.8	1.7	0.4	11.9
Western Area Rural	2	14.3	0.04	3.5	47.2	67
Western Area Urban	1.3	11.7	9.5	13.4	132.7	169
Total	**11.5**	**36.9**	**32.44**	**44.4**	**195.24**	**320**

Figure 6-9: Length of roads exposed to landslide at high and very high risk



7 FLOOD VULNERABILITY AND RISK ASSESSMENT

7.1 Overview

According to data from DesInventar, about 64 flood disaster events were reported between 2009 and 2017. UNDP's Diagnostics Analysis of Climate Change and Disaster Management in Relation to PRSP III reports that floods affected the most important number of people between 1980 to 2010 - representing 90% of people affected by disaster in Sierra Leone. During that period floods affected 221,204 people and killed 145 people (11% of people killed by disaster) (Tarawalli, 2012).

The approach taken in this project to assess flood exposure, vulnerability and risk in Sierra Leone is supported by quantitative evidence identifying the exposure and risk of a number of vital elements at risk. The elements at risk studied are population, housing infrastructure, education infrastructure, and health infrastructure. A scenario has been built upon precedent set by significant floods in the past. This scenario is analysed in terms of the population and housing, education and health infrastructure. The flood risk analysis should be easily understood by policy-makers and sectoral development officials.

7.2 Flood Exposure Assessment

The exposure assessment for floods provides vital information about the elements and assets, which are located in the areas at risk of flood inundation or the flood hazard prone areas. The information generated from the assessment are important and useful to and decision-makers as basis for plans and interventions on preparedness, early warning, response recovery, and mitigation. In Sierra Leone, floods primarily affect population, and physical infrastructure such as buildings. It also affects agricultural productivity. However, for this report, the assessment has been limited to analysing the exposure of population and primary physical assets such housing, health facilities, and schools.

The flood hazard assessment identified and mapped at a national level areas at risk of flood inundation. The impact profiles of hazards on different assets are distinctive; they vary depending upon the characteristics of the sectoral assets. The study aims to estimate the impact on the population (male and female), primary physical infrastructure including housing, health, and education.

7.3 Methodology for Flood Exposure Assessment

The identification of sectors for exposure, vulnerability and risk assessment (EVRA) is based on past impacts. Table 7-1 illustrates what effect a flood will have on the various sectors; for the analysis only primary sectors are considered.

Table 7-1: Elements at risk of flood hazard

Type of Hazard	Primary Affected Sectors	Secondary Affected Sectors	Others
Floods	Agriculture	Industry	Real estate
	Housing	Power	Financial institutions
	Education	Tourism	
	Health	Trade	
	Population		

- **Data Collection:** Data relating to the primary sector is collected from a number of reliable sources. The data is created at the district level and is structured in GIS format.
- **Application of the GIS tools for EA:** The flood hazard assessment and mapping presents the flood hazard maps for river basins and flood plains.
- **Analysis of EA:** The analysis of the EA provides information about the stock of assets in the flood prone areas.

A combination of sophisticated GIS tools have been used to identify the impacts of floods on the population, housing sector, education infrastructure, and health infrastructure in each of the 14 districts in Sierra Leone.

Figure 7-1: Flood Hazard map of Sierra Leone

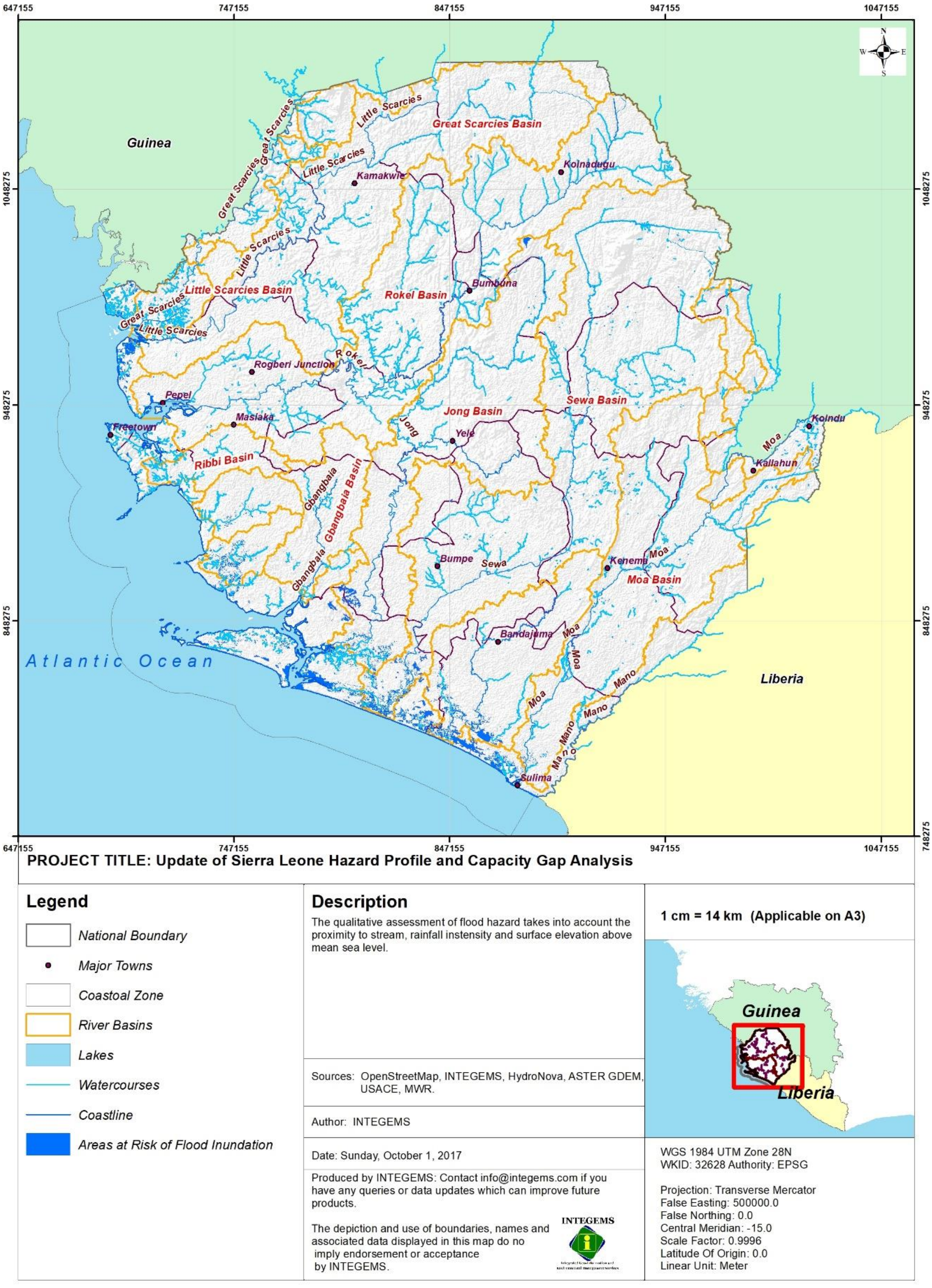
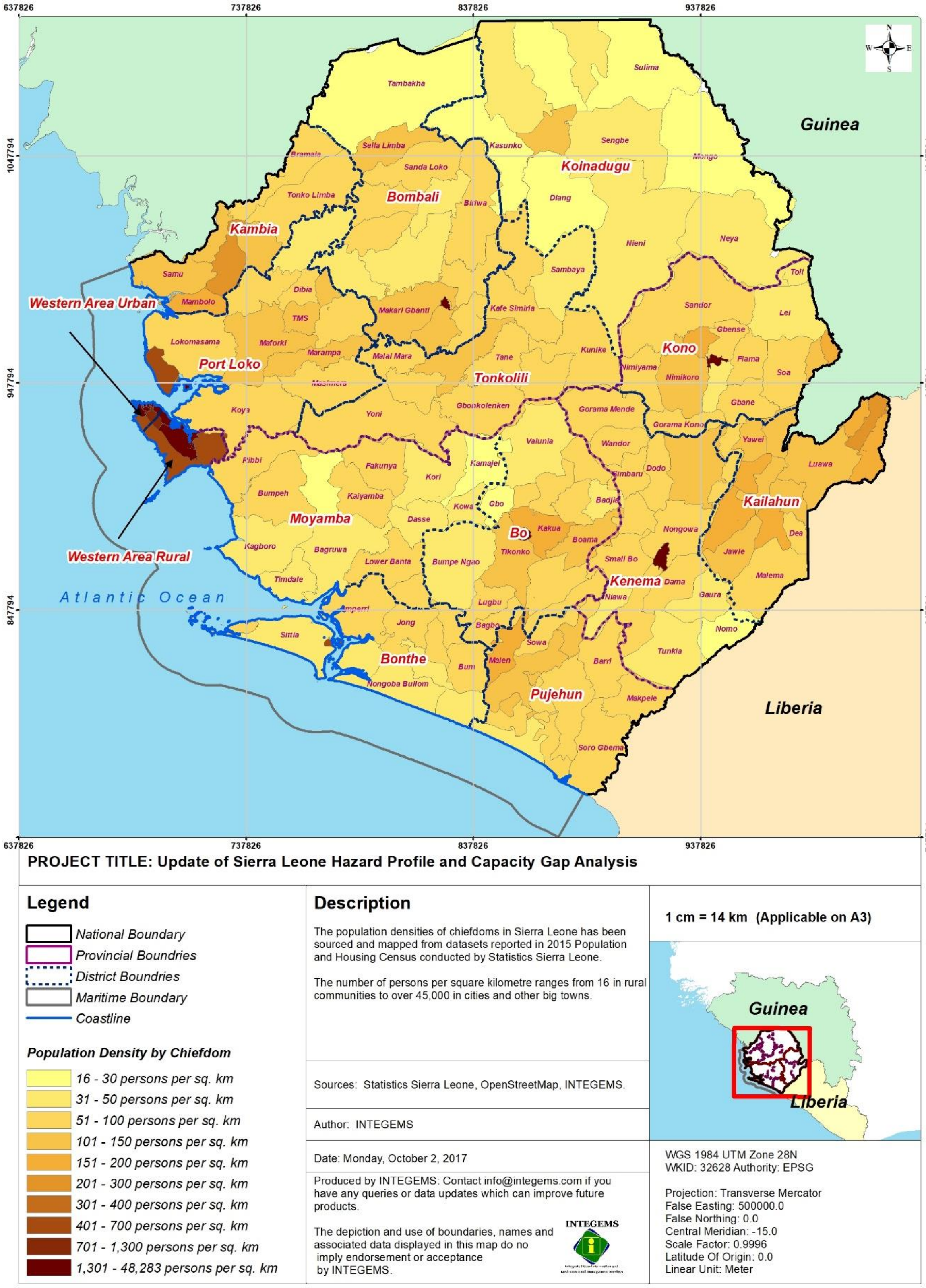


Figure 7-2: Population Density at Chiefdom Level in Sierra Leone



7.3.1 Population

Population data has been sourced from Statistics Sierra Leone's Population and Housing Census (Statistics, 2015) to carry out the flood population exposure assessment. The data include population classification by gender at district, chiefdom and section levels. (Table 14-6 presents a list of communities/sections found to be exposed in flood prone areas.

Table 7-2and Figure 6-3) show the exposure of population to flood in the 14 districts).

The analysis revealed that cities with the largest population densities have more people exposed to flood. The percentage of population exposed to flood ranges from 1.4 percent (Koinadugu district) to 39 percent (Western Area Rural District). At a national scale about the population exposed to flood is slightly about 10 percent of the total population recorded during the PHC 2015. Table 14-6 presents a list of communities/sections found to be exposed in flood prone areas.

Table 7-2: Population exposed to flood

District	Male	Female	Total	Percentage	District Population
Bo	19,641	21,451	41,092	7.1	575,478
Bombali	21,162	21,356	42,518	7.0	606,544
Bonthe	11,538	11,452	22,990	11.5	200,781
Kailahun	12,983	12,856	25,839	4.9	526,379
Kambia	16,849	18,756	35,605	10.3	345,474
Kenema	23,199	23,451	46,650	7.6	609,891
Koinadugu	2,819	2,901	5,720	1.4	409,372
Kono	22,508	22,209	44,717	8.8	506,100
Moyamba	7,149	7,889	15,038	4.7	318,588
Port Loko	15,385	17,000	32,385	5.3	615,376
Pujehun	10,683	11,361	22,044	6.4	346,461
Tonkolili	8,152	8,465	16,617	3.1	531,435
Western Area Rural	60,527	62,748	123,275	27.7	444,270
Western Area Urban	180,470	180,139	360,609	34.1	1,055,964
National	413065	422,034	**835,099**	**10.00**	**7,092,113**

7.3.2 Housing Sector

Housing is the second worst affected sector after agriculture. Flooding leads to damage and loss of household items, and impacts on the functionality of the household. There are several complex losses associated with the impact of flooding on housing.

Building datasets for this project have been sourced from OpenStreetMap (OSM, www.openstreetmap.org). A total of about 530,000 buildings have been mapped in the entire country to extract the number of buildings exposed to landslides at moderate, high, and very high risk in the 14 districts.

There are a total of 84,454 (11 percent of the total OSM) buildings are found to be exposed in flood prone areas in the 14 districts, with about 65 percent of that figure from Western Area Rural (24,556) and Western Area Urban (31,082) districts (see Table 6-7and Figure 6-6) . The exposure analysis revealed that Koinadugu and Tonkolili districts have the lowest percentages of exposed buildings (2.5 and 5 percent of total number of buildings, respectively).

Figure 7-3: Population exposed to flood

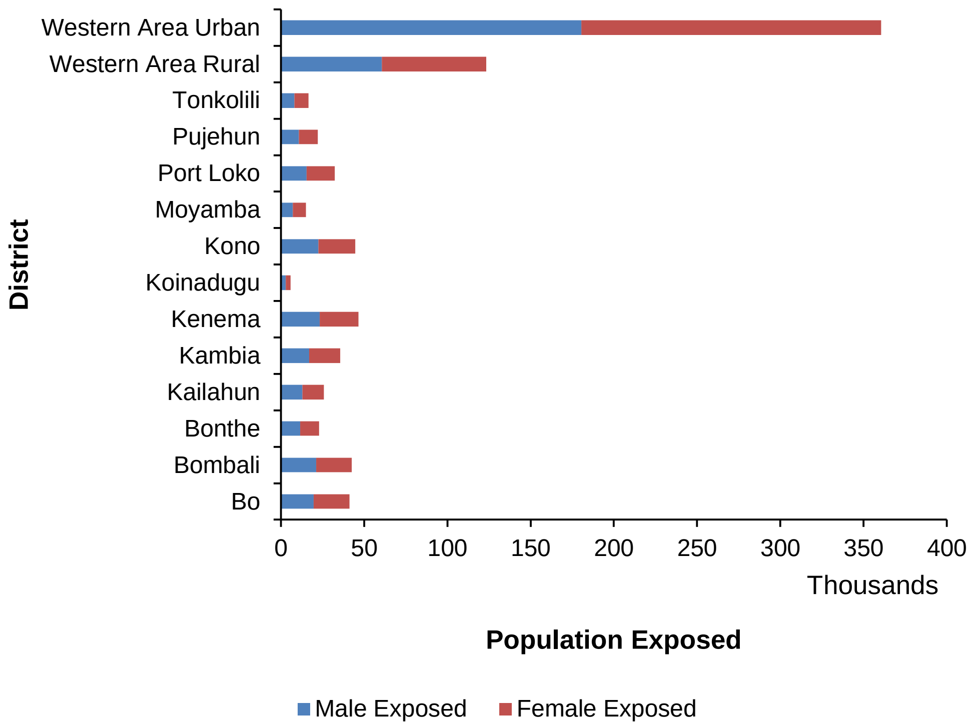


Figure 7-4: Population exposed to flood (as percentage of total)

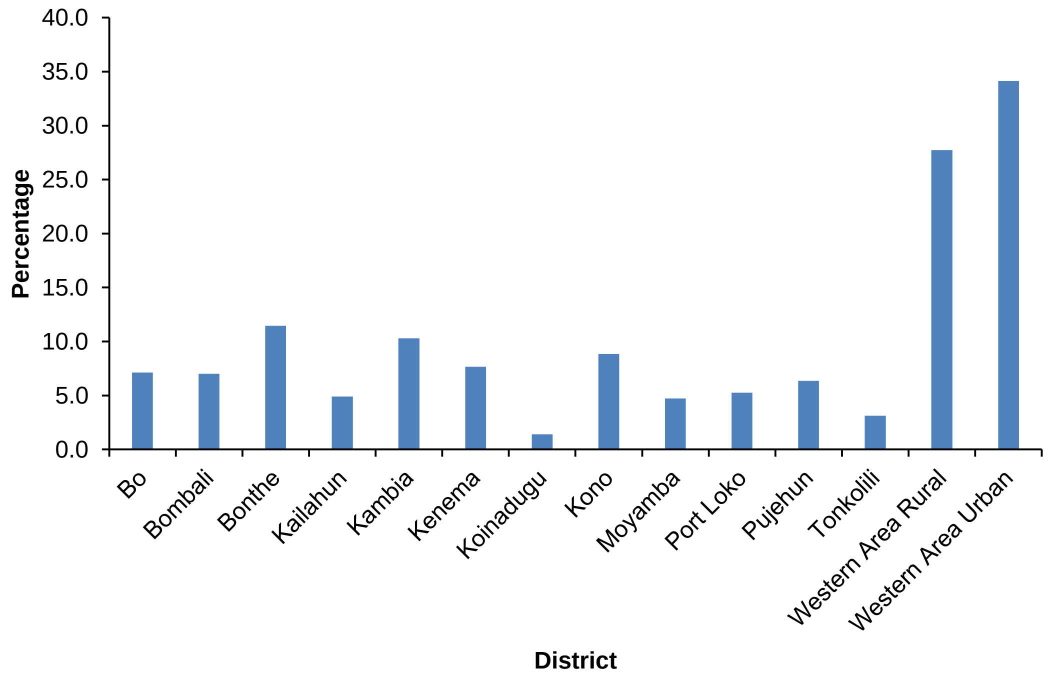
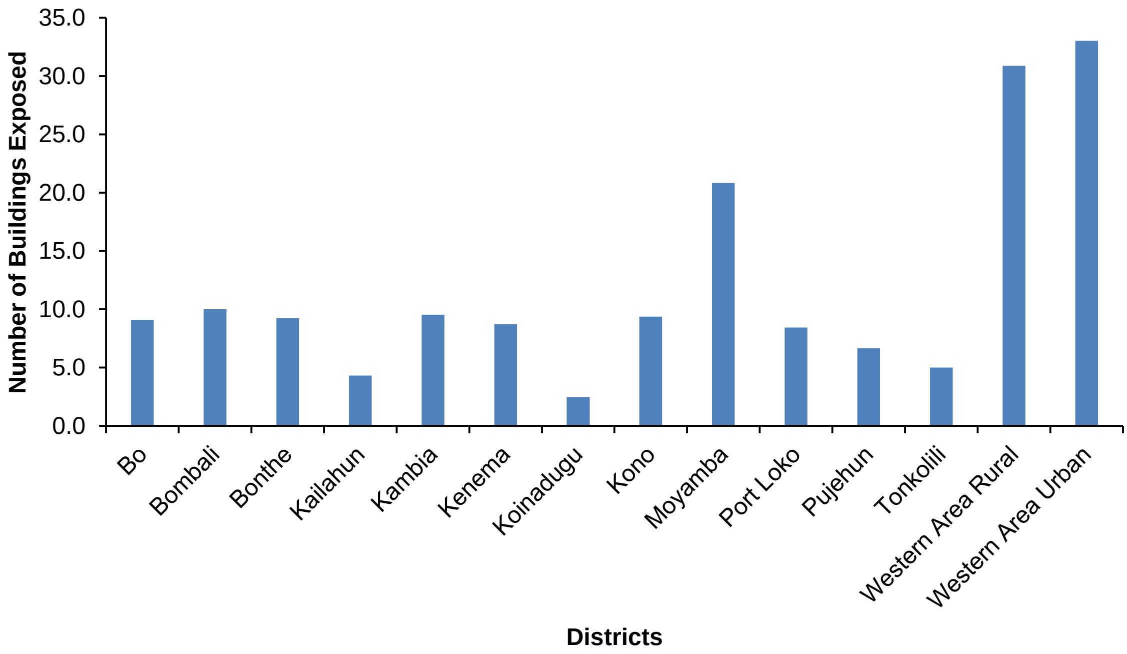


Table 7-3: Buildings exposed to flood

District	Buildings Exposed	Percentage	Total Number of Buildings
Bo	3,625	9.1	39,989
Bombali	3,245	10.0	32,451
Bonthe	330	9.2	3,570
Kailahun	2,826	4.3	65,366
Kambia	1,180	9.5	12,382
Kenema	6,941	8.7	79,715
Koinadugu	440	2.5	17,772
Kono	5,173	9.4	55,157
Moyamba	1,679	20.8	8,058
Port Loko	2,029	8.4	24,088
Pujehun	580	6.6	8,724
Tonkolili	768	5.0	15,355
Western Area Rural	24,556	30.9	79,520
Western Area Urban	31,082	33.0	94,082
National	**84,454**	**12.0**	**536,229**

Figure 7-5: Buildings exposed to flood



7.3.3 Education Sector

The exposure assessment for the education sector analyses the exposure of educational institutions (i.e. schools, colleges/universities, and vocational institutions) to floods in areas which have been mapped as at risk of flood inundation.

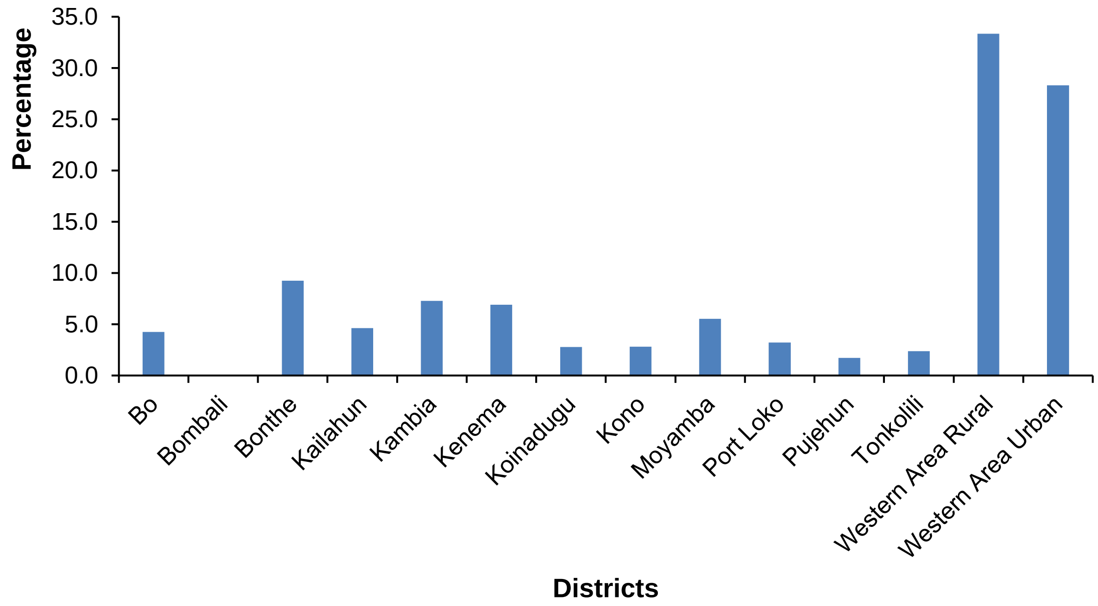
Academic institution datasets have been sourced from UNICEF. A total of about 3330 academic institutions have been mapped in the entire country to extract the number of institutions located in areas at risk of flood inundation. The datasets captures only one academic institution in Bombali District. Therefore, the exposure of academic institutions does not include Bombali District.

The ensuing table and chart (Figure 6-7 and Table 6-8) show the exposure of academic institutions to floods at three risk levels: moderate, high, and very high. A total of in the 13 districts were 261 academic institutions were found to be exposed in flood prone areas, with Western Area alone accounting for over 100 of that figure (see Table 7-4).

Table 7-4: Academic institutions exposed to flood

District	Number	Percentage	Total Number of Buildings
Bo	16	4.3	375
Bombali	NA	NA	NA
Bonthe	10	9.3	108
Kailahun	12	4.6	259
Kambia	11	7.3	151
Kenema	27	6.9	390
Koinadugu	4	2.8	144
Kono	6	2.8	213
Moyamba	21	5.5	380
Port Loko	12	3.2	373
Pujehun	3	1.7	172
Tonkolili	8	2.4	337
Western Area Rural	52	33.3	156
Western Area Urban	79	28.3	279
National	**261**	**8.7**	**3,337**

Figure 7-6: Academic institutions exposed to flood



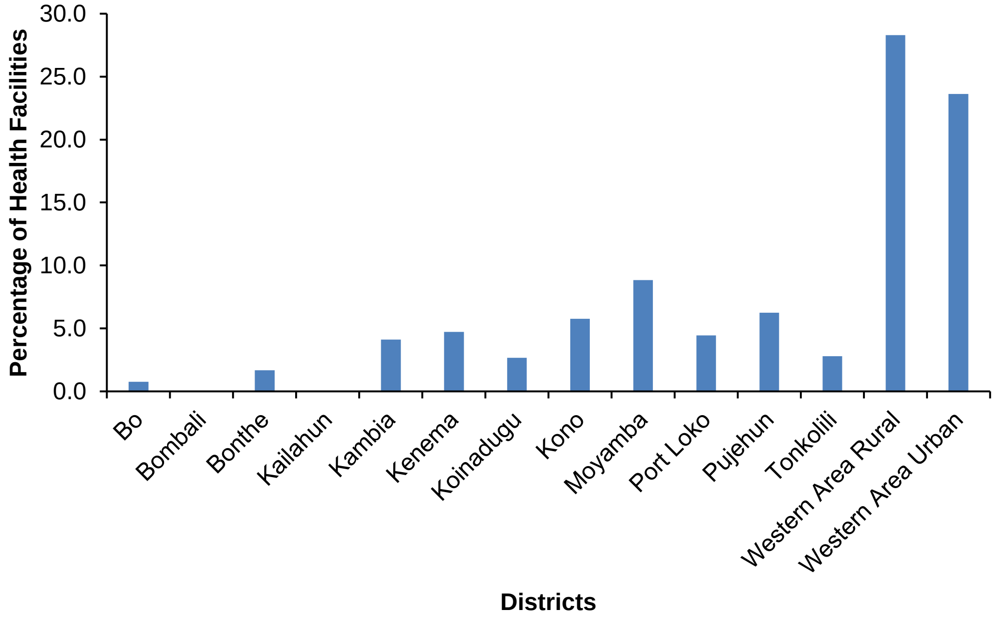
7.3.4 Health Sector

Using GIS analysis a total of 81 health facilities were found to be exposed to floods, with Kailahun and Bombali being the only districts without a health facility located in areas mapped as at risk to flood inundation. Detail of the number of health facilities exposed to floods in the 14 districts are given in Figure 7-7.

Table 7-5: Health facilities exposed to flood

District	Number	Percentage	Total Number of Health Facilities
Bo	1	0.8	133
Bombali	0	0.0	111
Bonthe	1	1.7	60
Kailahun	0	0.0	85
Kambia	3	4.1	73
Kenema	6	4.7	127
Koinadugu	2	2.7	75
Kono	5	5.7	87
Moyamba	9	8.8	102
Port Loko	5	4.4	113
Pujehun	5	6.3	80
Tonkolili	3	2.8	108
Western Area Rural	15	28.3	53
Western Area Urban	26	23.6	110
National	**81**	**6.7**	**1,317**

Figure 7-7: Health facilities exposed to flood



8 NATURAL HAZARD PROFILES

Detailed hazard profiling and assessment of the nine major natural hazards (i.e., landslide, flood, drought, epidemics, coastal erosion, sea level rise, storm surge, tropical storm and lightning and thunder) in Sierra Leone has been undertaken to achieve the objectives of the Project. The comprehensive hazard and risk assessment mapping generated significant findings that pertains to the nine major natural hazards that are currently or may potentially affect Sierra Leone as well as to the exposure and vulnerability of the country to these hazards, including some qualitative estimates of potential risks.

The disaster event data found in detailed hazard profiling and assessment of the nine major natural hazards (i.e., landslide, flood, drought, epidemics, coastal erosion, sea level rise, storm surge, tropical storm and lightning and thunder) in Sierra Leone has been undertaken to achieve the objectives of the Project. The comprehensive hazard and risk assessment mapping generated significant findings that pertains to the nine major natural hazards that are currently or may potentially affect Sierra Leone as well as to the exposure and vulnerability of the country to these hazards, including some qualitative estimates of potential risks.

Key findings from the Project will support the mainstreaming of disaster risk reduction and disaster risk management in planning, preventing, mitigating, responding and recovering from disasters, including investments, education and awareness, research and other interventions to achieve the goals of the UN SDGs and the Sendai Framework. This document contains a series of background and hazard-specific tables, maps and infographics, including hazard profile tables and maps, risk maps and base maps in the relevant sections and chapters.

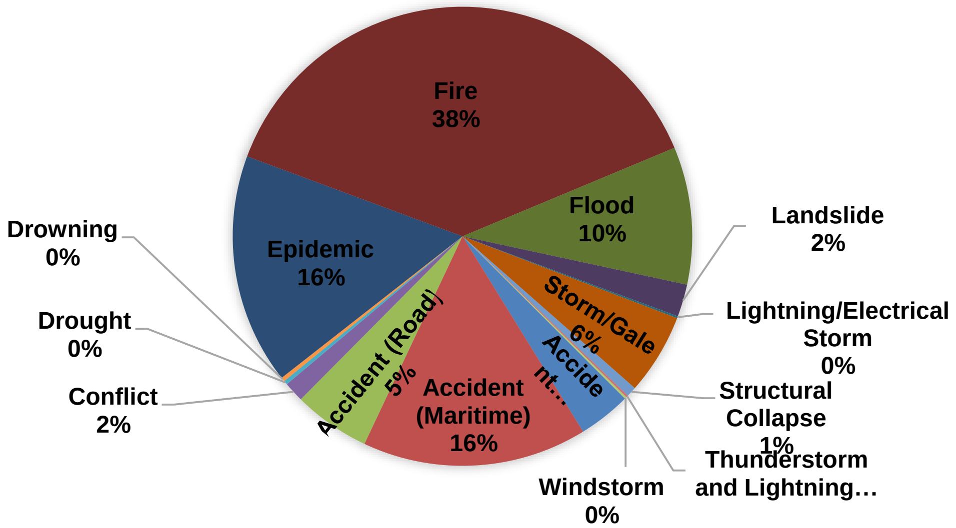
Table 8-1 and associated pie chart show the types and frequency counts of various hazards recorded in Sierra Leone from 2006 to 2017. Figure 8-1 shows a map of the recorded disaster events in Sierra Leone during the same time period. Table 8-2 graphically illustrates the hazard profiles of the major natural hazards, at both national and district levels, assessed in this study.

Below is a summary of the key findings from the hazard and risk assessments:

- The hazard assessment and mapping revealed that the country is highly prone to flood, landslide and coastal erosion, tropical storms and sea level rise hazards. The high level of population exposure to flood and landslide hazards and coastal erosion and sea level rise hazards is clearly evident in the hilly and low lying areas of the Western Areas and along the coastal areas in the Western Area and the Northern and Southern Provinces of Sierra Leone. For landslide hazards, the identified elements at risk in the study areas are: population, buildings, education facilities, health facilities and transportation (roads). For flood hazards, the identified elements at risk in the study areas are: population, buildings, agriculture sector (cultivated area and livestock), education facilities, health facilities and transportation (roads). It should be noted that the vulnerability and risk assessments were only undertaken for landslides and floods. The other seven hazards were not assessed in terms of vulnerability and risks due to inadequate data.
- The landslide hazard, vulnerability and risk assessment showed that the hilly and steep-sided slope areas in the Western Area, especially in Leicester, Regent, Granville Brook, Cline Town, Moa Wharf, Hill Court Road, Kissy Brook, Dwarzark, and Charlotte in the Mountain Rural District of the Western Area are prone to landslides due to their moderate to very high slope susceptibility and heavy precipitation received in the Wet Season.
- The flood hazard, vulnerability and risk assessment revealed that floods are more likely in areas around the ten catchments analysed close to the estuaries and along the entire coastline of Sierra Leone, based on a 10-year return period. In addition, based on historical flood events data, it also indicated that flood hazards are likely to occur in many different locations in the country; however, due to data limitations only analysis by catchment was possible for this study. Nonetheless, the study also revealed that parts of Freetown City, including Karningo, Kamayama, Dwarzark, Kroo Bay, Congo Town, Kissy Brook, and Culvert community in Granville Brook are prone to floods due to their moderate to very high slope susceptibility and heavy precipitation received in the Wet Season.

Table 8-1: Summary of disaster events in Sierra Lone, 2006-2017[59]

Disaster	No of Records
Accident	26
Accident (Maritime)	111
Accident (Road)	38
Conflict	10
Drought	2
Drowning	2
Epidemic	114[60]
Fire	267
Flood	68[61]
Landslide	16[62]
Lightning/Electrical Storm	1
Storm/Gale	40
Structural Collapse	5
Thunderstorm and Lightning	1
Windstorm	1



[59] Table 8-1 have been obtained and processed from the ONS-DMD, DesInventar, CRED EM-DAT and other third party sources "as is" without a robust quality assurance/quality control checks. No warranty, expressed or implied, is made regarding accuracy, adequacy, completeness, legality, reliability or usefulness of this information. This applies to both isolated and aggregate uses of the information. The information is provided on an "as is" basis. All warranties of any kind, express or implied, including but not limited to the implied warranties of merchantability, fitness for a particular purpose and non-infringement of proprietary rights are disclaimed. It is recommended that careful attention be paid to its contents and that the originators of the data be contacted with any questions regarding appropriate use.

[60] Excluding the EVD crisis data from May 2014 to November 2015.

[61] Excludes data from the disaster events of 14 August 2017.

[62] Excludes data from the disaster events of 14 August 2017.

Figure 8-1: Historic disaster events in Sierra Leone

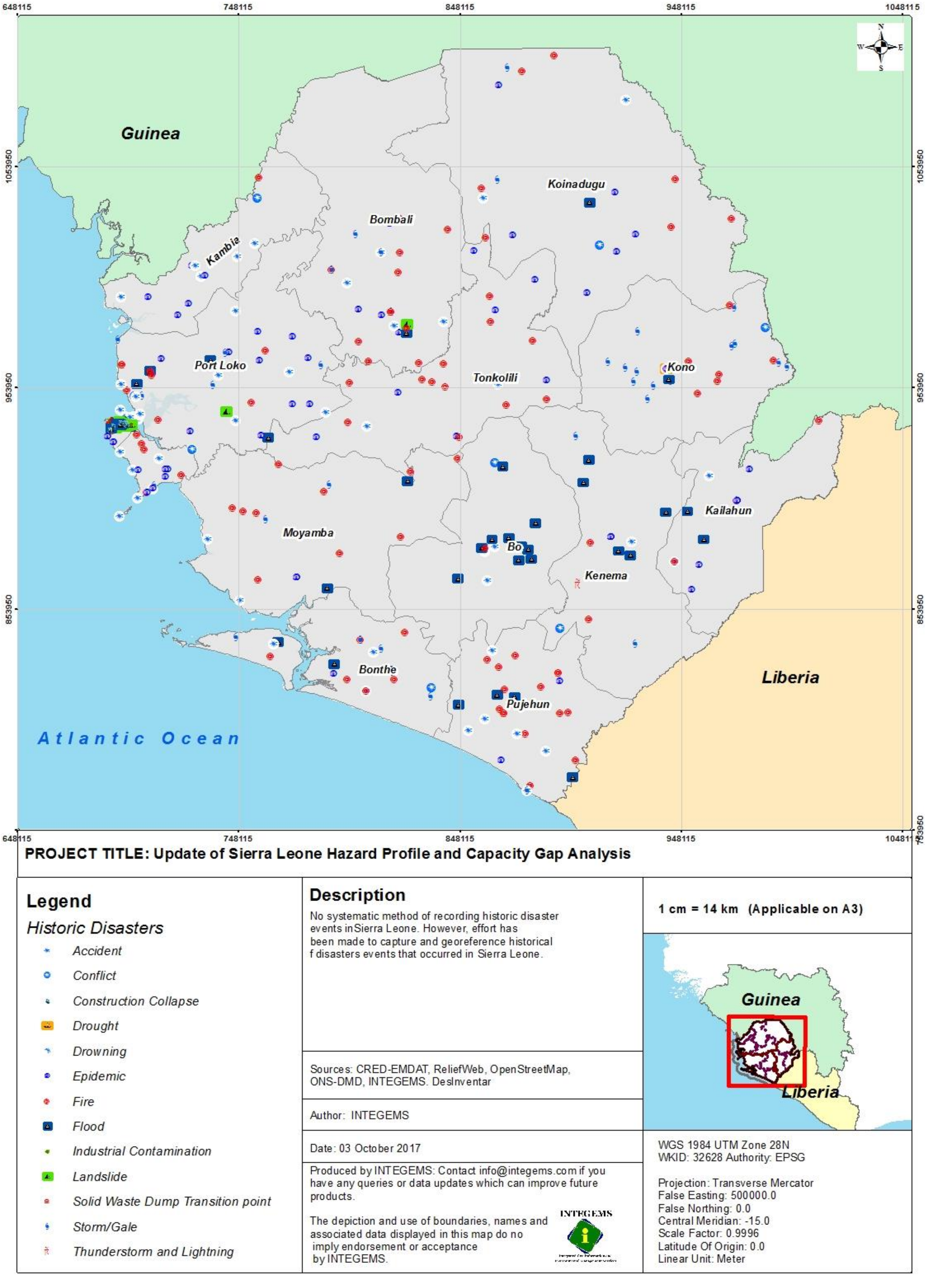


Table 8-2 Summarized hazard profiles at national and district levels

Frequency Scale		Magnitude Scale	
1	Very Rarely	1	Trivial
2	Rarely	2	Small
3	Sometimes	3	Moderate
4	Often	4	Large
5	Frequently	5	Very Large

National Level

Country	Hazards	Frequency Scale 1	2	3	4	5	Magnitude Scale 1	2	3	4	5
Sierra Leone	Landslides		■						■		
	Flooding					■		■			
	Coastal Erosion		■						■		
	Drought	■							■		
	Epidemics		■								■
	Storm Surge		■					■			
	Tropical Storm				■				■		
	Thunder and Lightning					■		■			
	Sea Level Rise	■							■		

District Level

District	Hazards	Frequency Scale 1	2	3	4	5	Magnitude Scale 1	2	3	4	5
Western Area	Landslides			■						■	
	Flooding					■				■	
	Coastal Erosion				■					■	
	Drought	■					■				
	Epidemics		■								■
	Storm Surge		■						■		
	Tropical Storm			■				■			
	Thunder and Lightning					■			■		
	Sea Level Rise	■									■

Southern Province

District	Hazards	Frequency Scale 1	2	3	4	5	Magnitude Scale 1	2	3	4	5
Bo	Landslides	■						■			
	Flooding				■			■			
	Coastal Erosion	■					■				
	Drought	■							■		
	Epidemics		■								■
	Storm Surge	■					■				
	Tropical Storm				■				■		
	Thunder and Lightning					■		■			
	Sea Level Rise	■					■				
Bonthe	Landslides	■						■			
	Flooding			■					■		

District	Hazards	Frequency Scale					Magnitude Scale				
		1	2	3	4	5	1	2	3	4	5
	Coastal Erosion										
	Drought										
	Epidemics										
	Storm Surge										
	Tropical Storm										
	Thunder and Lightning										
	Sea Level Rise										
Moyamba	Landslides										
	Flooding										
	Coastal Erosion										
	Drought										
	Epidemics										
	Storm Surge										
	Tropical Storm										
	Thunder and Lightning										
	Sea Level Rise										
Pujehun	Landslides										
	Flooding										
	Coastal Erosion										
	Drought										
	Epidemics										
	Storm Surge										
	Tropical Storm										
	Thunder and Lightning										
	Sea Level Rise										
Northern Province											
District	**Hazards**	**Frequency Scale**					**Magnitude Scale**				
		1	2	3	4	5	1	2	3	4	5
Koinadugu	Landslides										
	Flooding										
	Coastal Erosion										
	Drought										
	Epidemics										
	Storm Surge										
	Tropical Storm										
	Thunder and Lightning										
	Sea Level Rise										
Bombali	Landslides										
	Flooding										
	Coastal Erosion										
	Drought										
	Epidemics										
	Storm Surge										
	Tropical Storm										
	Thunder and Lightning										
	Sea Level Rise										

Tonkolili	Landslides										
	Flooding										
	Coastal Erosion										
	Drought										
	Epidemics										
	Storm Surge										
	Tropical Storm										
	Thunder and Lightning										
	Sea Level Rise										
Kambia	Landslides										
	Flooding										
	Coastal Erosion										
	Drought										
	Epidemics										
	Storm Surge										
	Tropical Storm										
	Thunder and Lightning										
	Sea Level Rise										
Port Loko	Landslides										
	Flooding										
	Coastal Erosion										
	Drought										
	Epidemics										
	Storm Surge										
	Tropical Storm										
	Thunder and Lightning										
	Sea Level Rise										
Eastern Province											
District	**Hazards**	**Frequency Scale**					**Magnitude Scale**				
		1	2	3	4	5	1	2	3	4	5
Kailahun	Landslides										
	Flooding										
	Coastal Erosion										
	Drought										
	Epidemics										
	Storm Surge										
	Tropical Storm										
	Thunder and Lightning										
	Sea Level Rise										
Kenema	Landslides										
	Flooding										
	Coastal Erosion										
	Drought										
	Epidemics										
	Storm Surge										
	Tropical Storm										

	Thunder and Lightning										
	Sea Level Rise										
Kono	Landslides										
	Flooding										
	Coastal Erosion										
	Drought										
	Epidemics										
	Storm Surge										
	Tropical Storm										
	Thunder and Lightning										
	Sea Level Rise										

8.1 Landslides

Landslides cover down slope movements of soil and rock material in masses under gravity. Many of the natural hill slopes that are considered safe in the past are now recording landslides due to human interventions in hill slopes. Landslides are normally associated with intense rains.

In the landslide hazard profile, hazard maps were prepared using relative contribution of causative factors, namely, geology, lithology, slope angle, soils and land cover along with assigned weights and ratings based on their relative contribution. The weights and ratings have been decided on considering expert opinion and statistical analysis of historical data. Considering the complex nature of landslides, the potential of a landlside occurring was decided based on the variations of causative factors. The landslide hazard maps are expressed more in descriptive terms such as landslides are most or less likely to occur.

Landslide hazard maps are useful in planning human settlements, infrastructure and other development activities and investments in mitigation. Same information provides the base for landslide guidelines and local authority level permitting in landslide prone areas. Landslide hazards in Sierra Leone have had severe negative impacts through loss of lives and properties as well as economic productivity. However, the impact of landslides and mudslides in Sierra Leone is highly concentrated in the Western Area where the combined effects of steep slopes, heavy rainfall, and unabated deforestation and construction provide a perfect recipe for mass movements.

Over the last decades landslides have affected thousands of people across the country. Landslide disasters in Sierra Leone as a whole accounted for 42.7 % of nationally reported geophysical/geohazard mortalities between 1990 and 2014[63], a proportion higher than that from flood, fire, and electric storms[64].

The 14 August 2017 landslide disaster alone left over 500 people dead, some 600 missing, with about 50,000 directly or indirectly affected in the densely populated Freetown. The most severe disaster occurred in Regent and Lumley districts with a massive 6 kilometres mudslide submerging and wiping out over 300 houses along the banks of the Lumley Creek[65].

From DesInventar data, around 250 people were affected by landslides between 2009 and 2016, among them 57 died and 50 others were injured and about 20 houses were damaged or destroyed. Between

[63] Prevention Web Sierra Leone Disaster and Risk Profile (http://www.preventionweb.net/countries/sle/data/, accessed 14 July 2017)

[64] A thunderstorm or other violent disturbance of the electrical condition of the atmosphere.

[65] Sierra Leone: Flash Update OCHA West & Central Africa. (2015). (https://reliefweb.int/report/sierra-leone/sierra-leone-flash-update-ocha-west-central-africa-15-august-2017, accessed 9 September 2017)

1980-2010 mass movements, mainly landslides and mudslides affected 5 people and killed 16 people (16% of the total)[66].

Leicester, Regent, Granville Brook, Cline Town, Moa Wharf, Hill Court Road, Kissy Brook, Dwarzark, and Charlotte in the Mountain Rural District have been identified as areas prone to landslides[67].

National Profile

Parameters	Landslide Hazard Profile Scale				
	1	2	3	4	5
Frequency	*Very Rarely*	*Rarely*	*Sometimes*	*Often*	*Frequently*
Magnitude	*Trivial*	*Small*	*Moderate*	*Large*	*Very Large*
Duration	*Very Short*	*Short*	*Average*	*Long*	*Very Long*
Areal Extent	*Limited*	*Very Sparsely*	*Sparsely*	*Densely*	*Widespread*
Spatial Predictability	*Highly Predictable*	*Predictable*	*Likely*	*Randomly*	*Very Randomly*
Speed of onset	*Very Slow*	*Slow*	*Moderate*	*Fast*	*Very Fast*
Importance	*Not Important*	*Somewhat Important*	*Moderately*	*Important*	*Very Important*
Spatial Dispersion	*Very Concentrated*	*Concentrated Moderately*	*Moderately*	*Diffused*	*Widely Diffused*

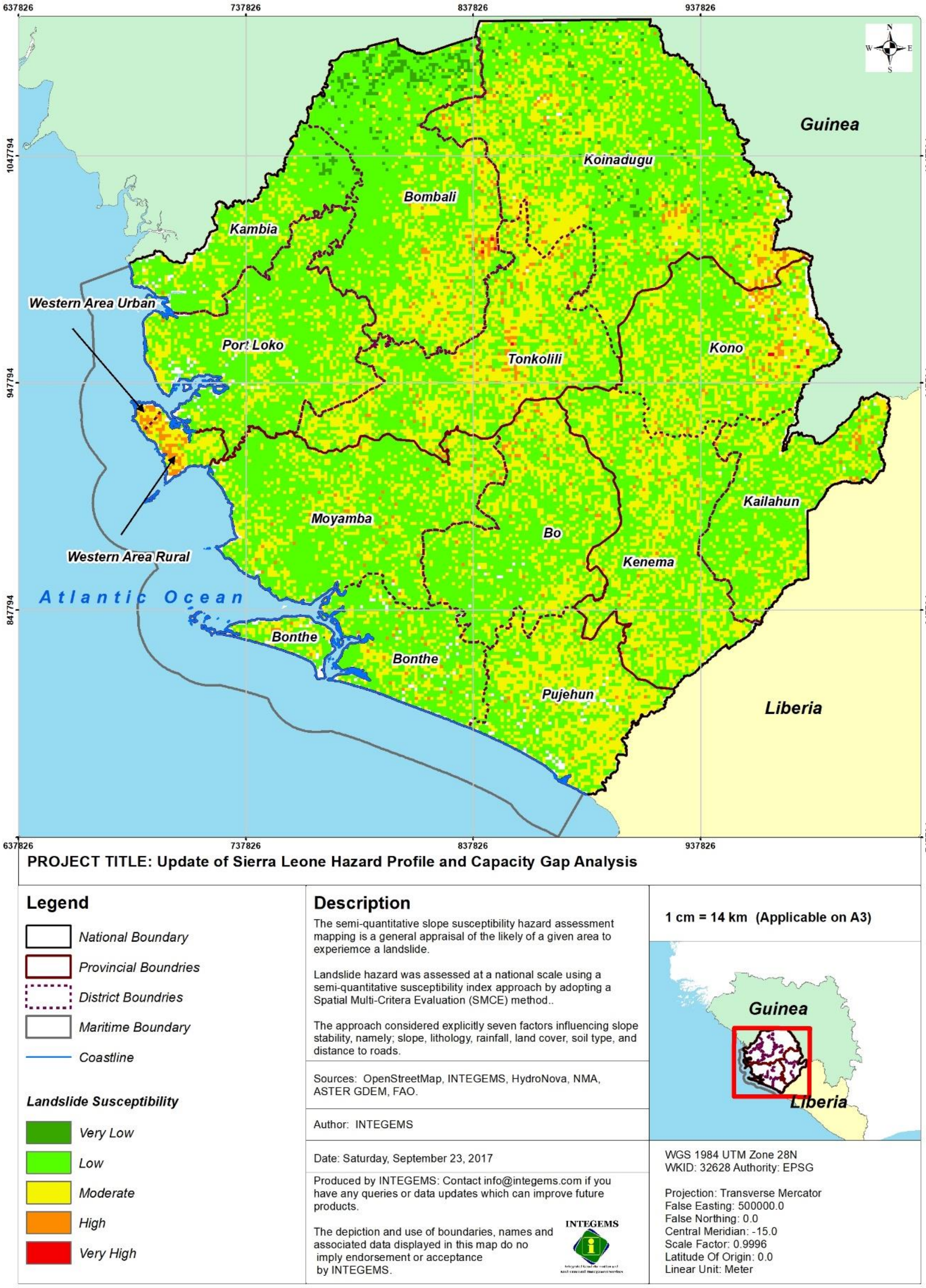
District Profiles

Area/District	Frequency Scale					Magnitude Scale				
	1	2	3	4	5	1	2	3	4	5
Western Area										
Bo										
Bonthe										
Moyamba										
Pujehun										
Bombali										
Port Loko										
Tonkolili										
Kambia										
Koinadugu										
Kenema										
Kono										
Kailahun										

[66] Tarawalli, P. (2012). Diagnostics Analysis of Climate Change and Disaster Management in Relation to the PRSP III in Sierra Leone. Freetown: UNDP - SL.

[67] Tarawalli, P. (2012). Diagnostics Analysis of Climate Change and Disaster Management in Relation to the PRSP III in Sierra Leone. Freetown: UNDP - SL.

Figure 8-2: Landslide hazard map of Sierra Leone



8.2 Flooding

In-depth understanding of flood hazard and appropriate investments and management can increase ecosystem benefits of floods while reducing the vulnerabilities. Floods are categorized as Riverine, Flash and Localized floods that are mostly urban. Inundation maps were prepared using data obtained through satellite images and historic records. In this flood hazard profile development computation of inundation areas for different return periods using digital elevation model (DEM) based hydrologic modeling was not used due to time and elevation data limitations. Flood hazard information can be used in flood protection or mitigation using structural and non-structural means, planning relief operations and awareness. Structural methods involve construction of flood levees, flood protection reservoirs, flood ways or channel improvements. Non-structural methods consist of catchment and land use management improved warning and evacuation.

The human, socio-economic and environmental impacts of floods in Sierra Leone has seen a skyrocketing trend over the last decades - Between 1980 and 2010, floods affected approximately 221,204 people, killing some 145 people (11% of people killed by disasters other than the war) [68]. This number has seen an upward trend over the last few years.

On 24 June 2017, heavy downpour of rain flooded two towns of Largor Jasawabu in the Nongowa Chiefdom and Foindu Mameima in the Lower Bambara Chiefdom, near Kenema. About 100 houses were reportedly destroyed leaving some 824 people homeless[69].

Torrential rainfall in the month of August 2017 led to widespread flooding across different parts of Freetown City. On the same night of the most devastating landslide disaster in Sierra Leone (14 August 2017), torrential rains led to a series of significant floods in several areas of Freetown, including Karningo, Kamayama, Dwarzark, Kroo Bay, Congo Town, Kissy Brook, and Culvert community in Granville Brook.

A health centre, the bridge and a school at Kroo Bay were flooded on the night between Saturday and Sunday 26/27 August 2017 in downtown Freetown, resulting in one fatality and two injuries[70].

In 2015 alone, over 20,000 people were affected by floods in several districts across the country. Sustained heavy downpour of rain from the 5 to the 6 September 2015 (48 hours) burst river banks and caused destruction in eight communities in Bo and two in one Chiefdom in Pujehun District in southern Sierra Leone. Some 2,630 (463 males 614 females, 645 boys, 607 girls and 301 children under five years) in 239 households were directly affected, with about 339 houses reportedly destroyed in Bo alone. In Pujehun District about 272 persons were affected by the floods with 16 houses destroyed[71].

On the 23 September 2015, floods ravaged the city of Freetown causing tremendous damage to property, loss of livelihood and displacing over 14,000 people.

Specific areas which have been identified over the years as being vulnerable to floods include: Kroo Bay, Susan's Bay, Granville Brook, Lumley, Newton catchment area – all of which are in the Western Area, Port Loko and Kambia Districts, the, Pujehun and Bo areas, Kenema and Moyamba Districts, and coastal beaches of the Western Area Peninsular[72].

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[68] Tarawalli, P. (2012). Diagnostics Analysis of Climate Change and Disaster Management in Relation to the PRSP III in Sierra Leone. Freetown: UNDP - SL.

[69] Bah Saidu. (2017). *'More Flooding in Eastern Chiefdoms'*, Awoko Newspaper, 27 June, p. 6.

[70] Sierra Leone: Landslide and Floods Situation Update no.7, 29 August 2017 (https://reliefweb.int/report/sierra-leone/sierra-leone-landslide-and-floods-situation-update-no7-29-august-2017, accessed 9 September 2017).

[71] International Federation of Red Cross and Red Crescent Societies (MDRSL006). (2015). Sierra Leone Floods, 18 September

[72] Government of Sierra Leone, Ministry of Transport and Aviation. (2007, December). Sierra Leone National Adaptation Programme of Action (NAPA) – Final Report " – "Government of Sierra Leone. (2006). Initial Communication (INC) in Climate Change" – "Office of National Security. (2004). National Hazard Assessment Profile".

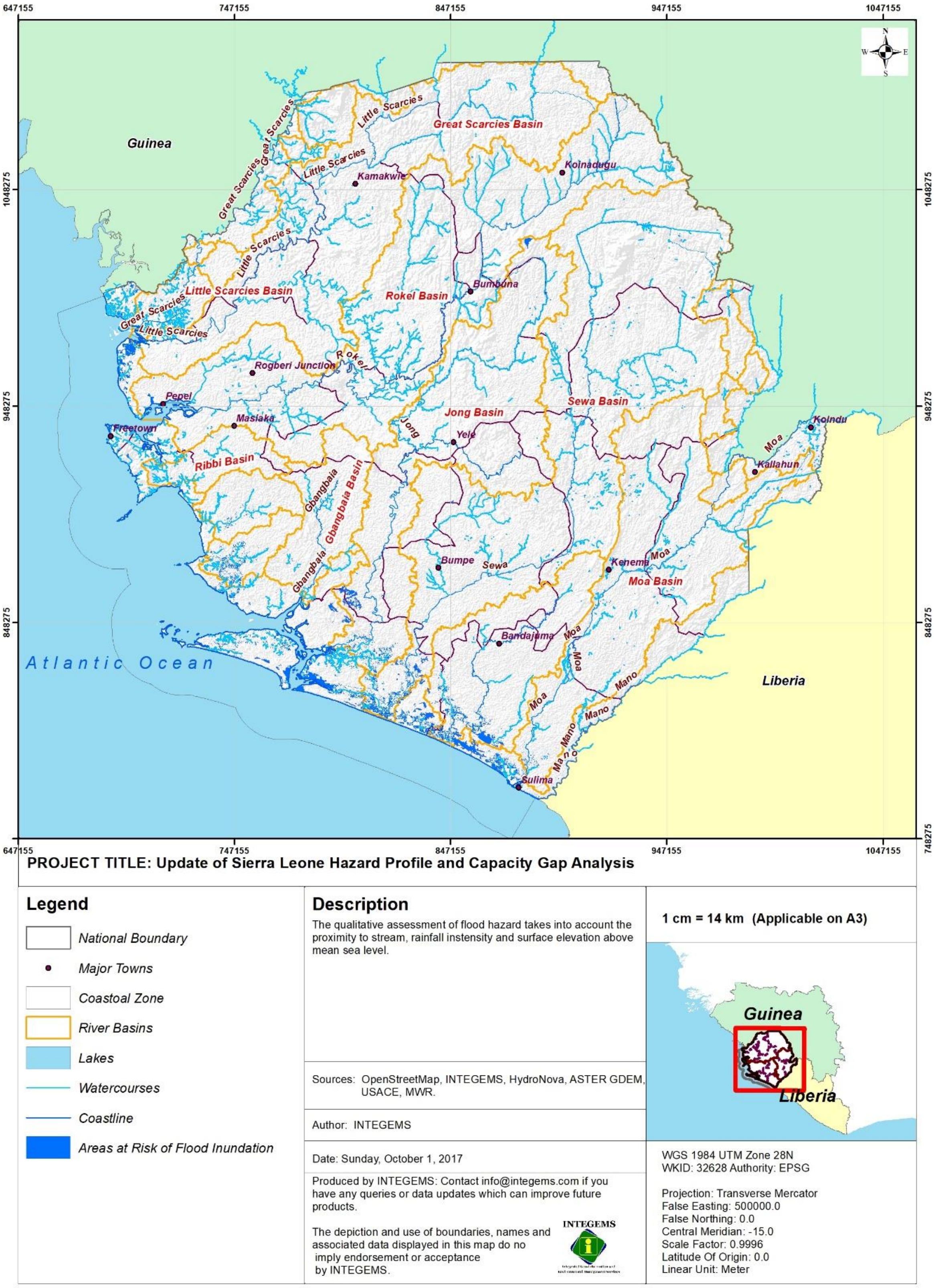
National Profile

Parameters	Scale				
	1	2	3	4	5
Frequency	*Very Rarely*	*Rarely*	*Sometimes*	*Often*	*Frequently*
Magnitude	*Trivial*	*Small*	*Moderate*	*Large*	*Very Large*
Duration	*Very Short*	*Short*	*Average*	*Long*	*Very Long*
Areal Extent	*Limited*	*Very Sparsely*	*Sparsely*	*Densely*	*Widespread*
Spatial Predictability	*Highly Predictable*	*Predictable*	*Likely*	*Randomly*	*Very Randomly*
Speed of onset	*Very Slow*	*Slow*	*Moderate*	*Fast*	*Very Fast*
Importance	*Not Important*	*Somewhat Important*	*Moderately*	*Important*	*Very Important*
Spatial Dispersion	*Very Concentrated*	*Concentrated Moderately*	*Moderately*	*Diffused*	*Widely Diffused*

District Profiles

Area/District	Frequency Scale					Magnitude Scale				
	1	2	3	4	5	1	2	3	4	5
Western Area										
Bo										
Bonthe										
Moyamba										
Pujehun										
Bombali										
Port Loko										
Tonkolili										
Kambia										
Koinadugu										
Kenema										
Kono										
Kailahun										

Figure 8-3: Flood hazard map of Sierra Leone



8.3 Coastal Erosion

Coastal erosion in Sierra Leone is accelerated due to anthropogenic activities and poorly planned coastal infrastructure development adding stresses on the coastal ecosystems. The complex coastal environment processes and shoreline stability or the dynamics of accretion or erosion are driven by coastal hydrodynamics, sediment balance and coastal geomorphology etc. influenced by wave climate and shoreline geometry.

The coastal erosion hazard profile uses a sediment cell approach that considers wave incident angle, sediment balance and length of the cell on the shoreline stability. The coastal erosion driver significances have been adjusted in the study using the coping capacities corresponding to each cell, based on the physical coast protection structures. The final rank of the degree of erosion in each cell was determined in a reference scale. The coastal erosion profile is useful for designing setback systems in coastal management and strategic planning bearing in mind the uncertainties associated in modelling and data limitations.

Coastal erosion has been and is still posing a serious problem for coastal management authorities and the population along the coast of Sierra Leone. This phenomenon which is very evident along the Sierra Leone coastline has attained rates of some 4 -6 metres per year in some locations (e.g. Konakridee, Lumley, Lakka, Hamilton etc.)[73]. Other areas with visible erosion signs along coast include: Krim area, Shenge, Plantain Island, Katta and Bunce Island, Adonkia, Mahera beach in Lungi area, Bullom shores, Moa wharf, and Man of War Bay[74].

National Profile

Parameters	Scale				
	1	2	3	4	5
Frequency	*Very Rarely*	*Rarely*	*Sometimes*	*Often*	*Frequently*
Magnitude	*Trivial*	*Small*	*Moderate*	*Large*	*Very Large*
Duration	*Very Short*	*Short*	*Average*	*Long*	*Very Long*
Areal Extent	*Limited*	*Very Sparsely*	*Sparsely*	*Densely*	*Widespread*
Spatial Predictability	*Highly Predictable*	*Predictable*	*Likely*	*Randomly*	*Very Randomly*
Speed of onset	*Very Slow*	*Slow*	*Moderate*	*Fast*	*Very Fast*
Importance	*Not Important*	*Somewhat Important*	*Moderately*	*Important*	*Very Important*
Spatial Dispersion	*Very Concentrated*	*Concentrated Moderately*	*Moderately*	*Diffused*	*Widely Diffused*

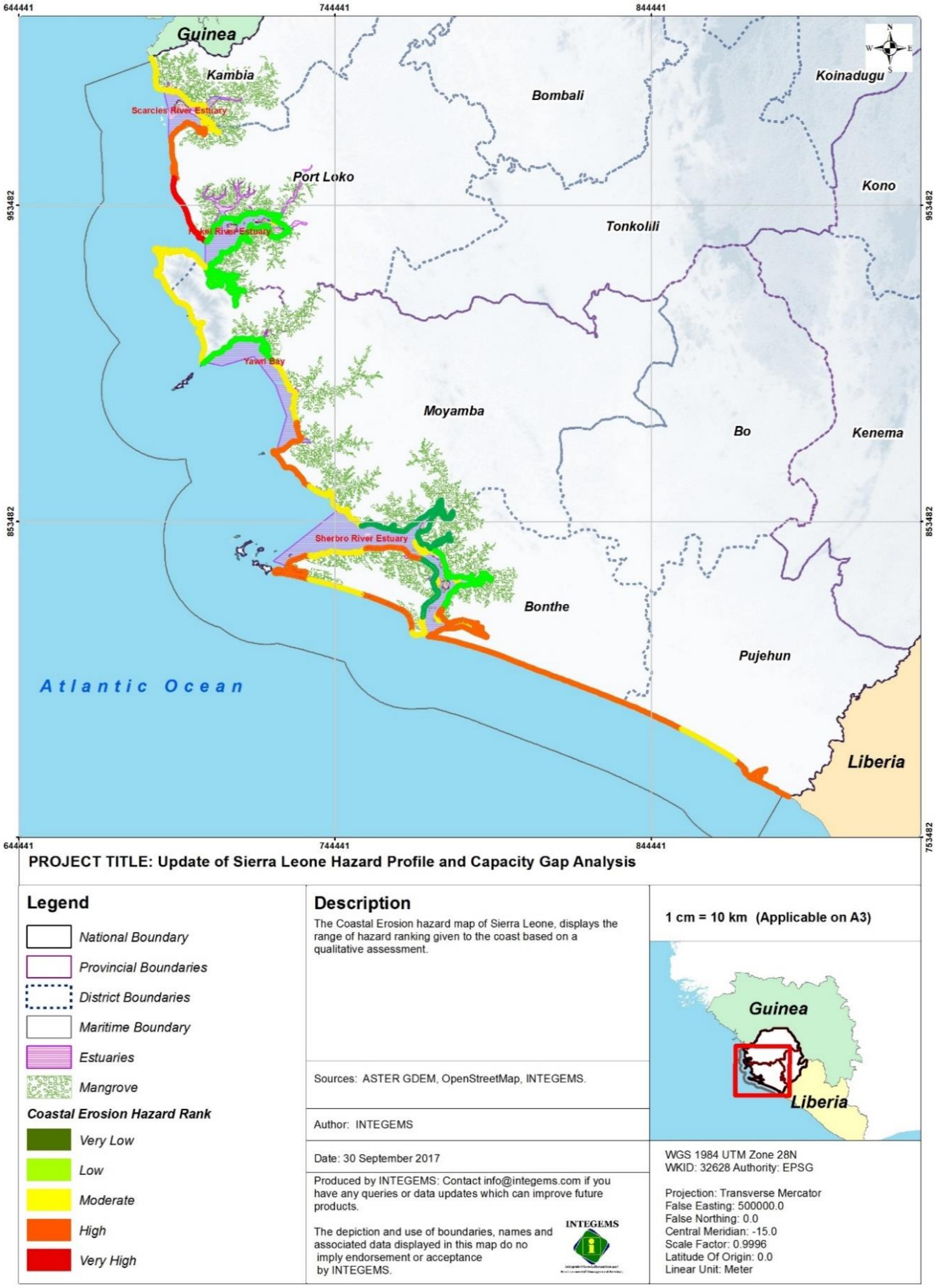
[73] Johnson, R. G. (2006). *Coastal Erosion Issues in Sierra Leone*: Adaptation, planning and implementation relating to the Sierra Leone coastal zone. National Adaptation Programme of Action (NAPA) Project for Sierra Leone. UNFCCC African Regional Workshop on Adaptation, Accra. Ghana, September.

[74] Tarawalli, P. (2012). Diagnostics Analysis of Climate Change and Disaster Management in Relation to the PRSP III in Sierra Leone. Freetown: UNDP - SL.

District Profiles

Area/District	Frequency Scale					Magnitude Scale				
	1	2	3	4	5	1	2	3	4	5
Western Area										
Bo										
Bonthe										
Moyamba										
Pujehun										
Bombali										
Port Loko										
Tonkolili										
Kambia										
Koinadugu										
Kenema										
Kono										
Kailahun										

Figure 8-4: Coastal erosion hazard map of Sierra Leone



8.5 Sea Level Rise

Sea level rise hazard profile development used the worst case scenario of maximum level of sea rise of about 59 cm in 100 years predicted in 2007 by the IPCC. However, literature indicates high uncertainly in sea-level rise predictions due to the lack of understanding of the dynamics of ice sheets, glaciers and oceanic heat. The accuracy in the modelling of sea level rise depends on two parameters namely the accuracy of sea level prediction and accuracy of ground level heights.

National Profile

Parameters	Scale				
	1	2	3	4	5
Frequency	*Very Rarely*	*Rarely*	*Sometimes*	*Often*	*Frequently*
Magnitude	*Trivial*	*Small*	*Moderate*	*Large*	*Very Large*
Duration	*Very Short*	*Short*	*Average*	*Long*	*Very Long*
Areal Extent	*Limited*	*Very Sparsely*	*Sparsely*	*Densely*	*Widespread*
Spatial Predictability	*Highly Predictable*	*Predictable*	*Likely*	*Randomly*	*Very Randomly*
Speed of onset	*Very Slow*	*Slow*	*Moderate*	*Fast*	*Very Fast*
Importance	*Not Important*	*Somewhat Important*	*Moderately*	*Important*	*Very Important*
Spatial Dispersion	*Very Concentrated*	*Concentrated Moderately*	*Moderately*	*Diffused*	*Widely Diffused*

District Profiles

Area/District	Frequency Scale					Magnitude Scale				
	1	2	3	4	5	1	2	3	4	5
Western Area										
Bo										
Bonthe										
Moyamba										
Pujehun										
Bombali										
Port Loko										
Tonkolili										
Kambia										
Koinadugu										
Kenema										
Kono										
Kailahun										

Potential impacts of sea level rise in coastal areas within the next 25 to 100 year period was studied. The sea level rise maps covering the entire coastal belt indicating the inundation areas in 2025, 2050 and in 2100 were prepared. It is important to note that sea level rise predictions used only one type of elevation data, namely the ASTER GDEM that are of a coarser resolution (30m). Users should be mindful of the inaccuracy in the areas modelled using the ASTER datasets.

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 destruction of infrastructure.

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 sea level rise include population displacements, flooding and saline intrusion, and threats to coastal aquifers, fresh water resources and agricultural water resources, undermining subsistence of local communities (UNDP)[75].

[75] UNDP: Adapting to Climate Change Induced Coastal Risks in Sierra Leone

Figure 8-5: Sea level rise hazard map of Sierra Leone

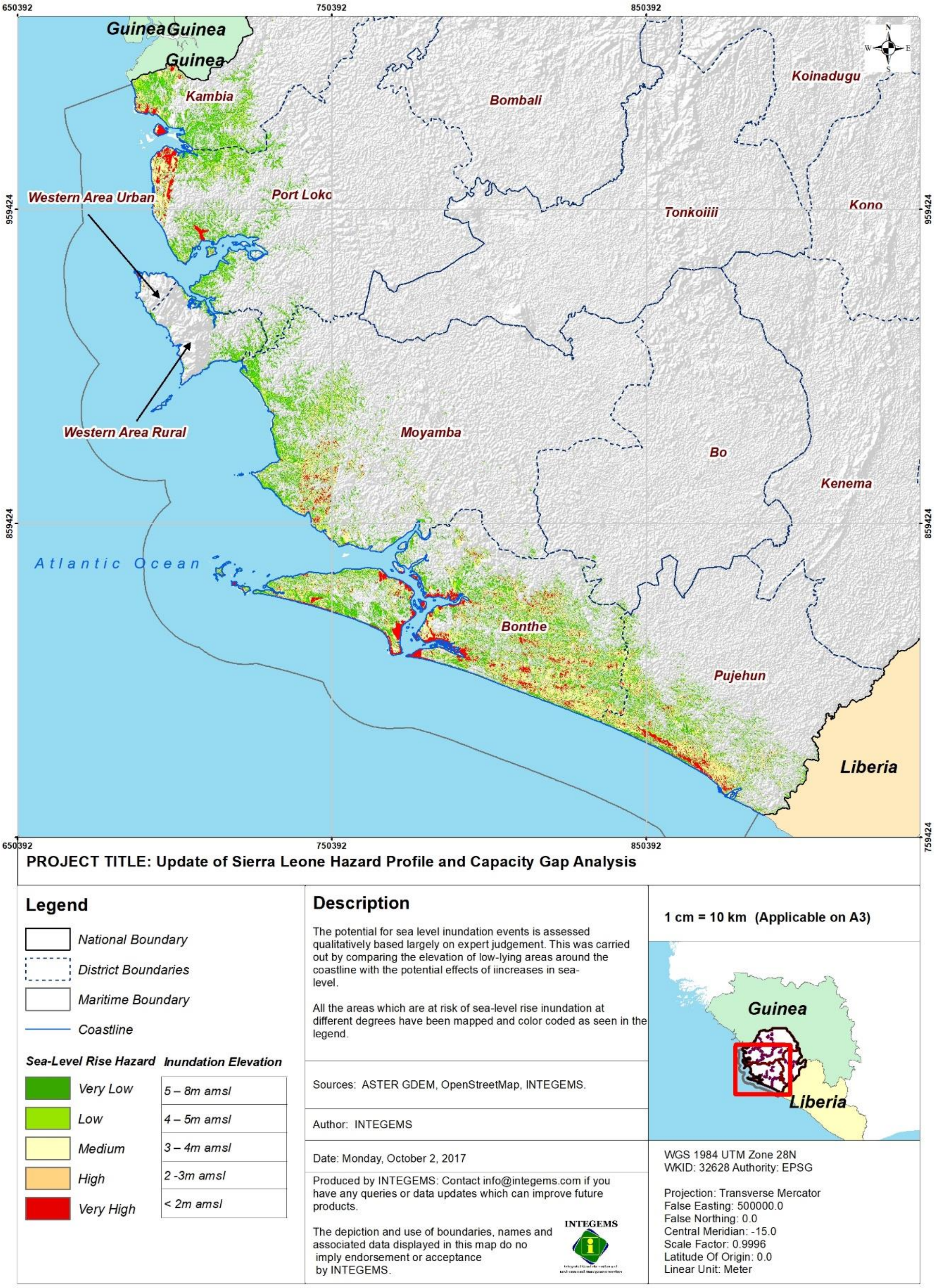


Figure 8-6: Sea-level rise hazard map - Scarcies and Sierra Leone River Estuaries

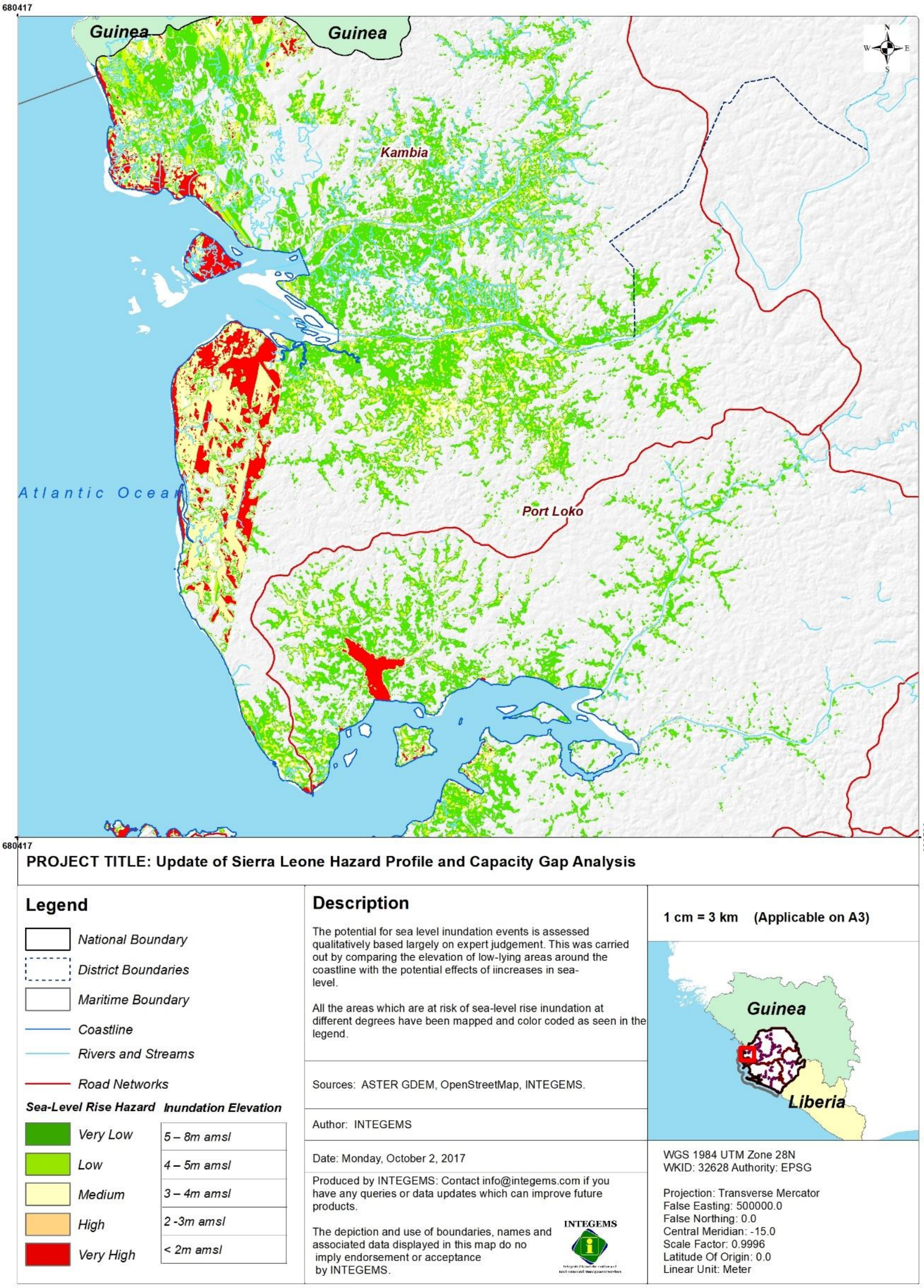


Figure 8-7: Sea-level rise hazard map - Western Area Urban

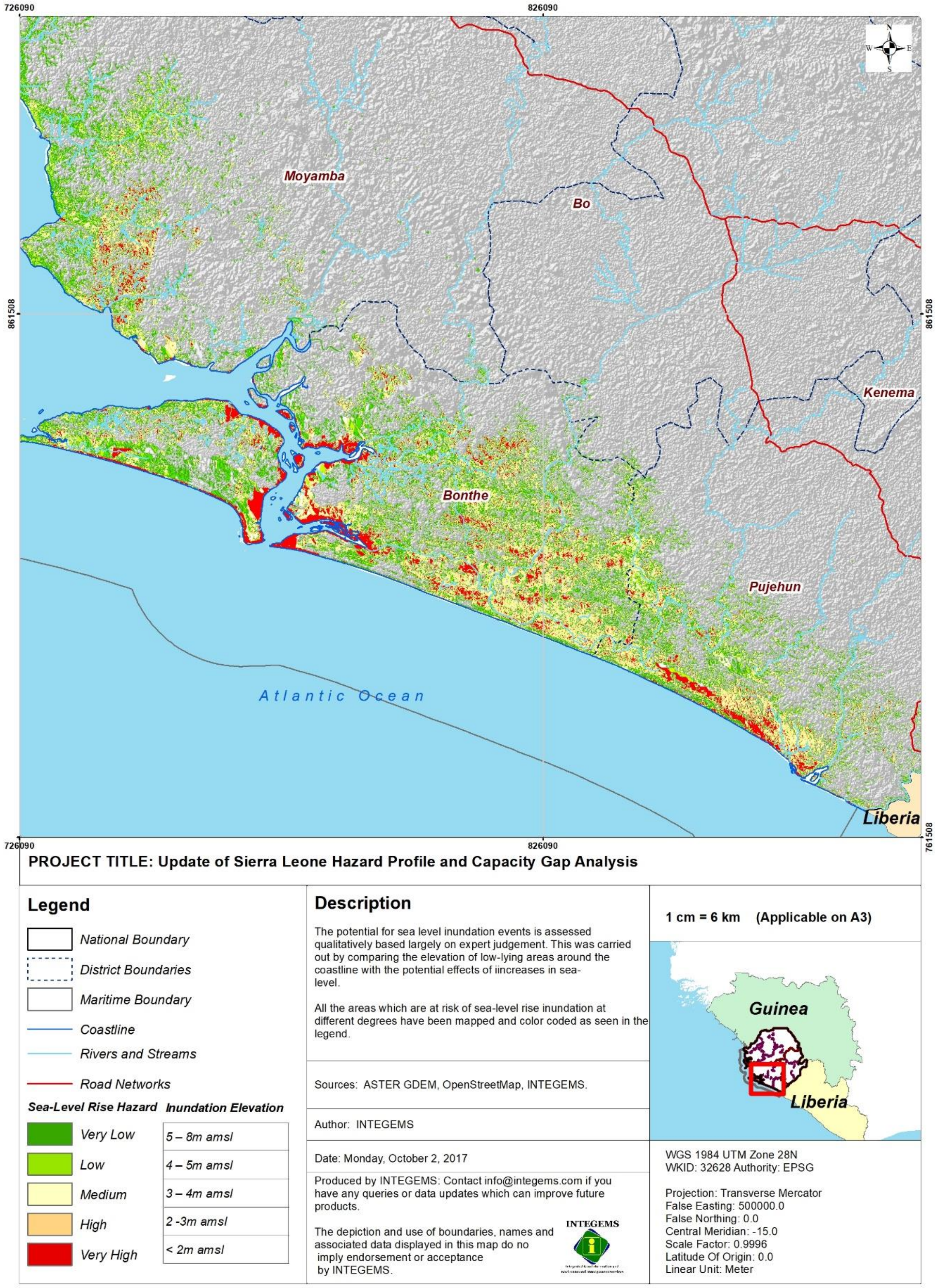


Figure 8-8: Sea-level rise hazard map - Yawri Bay

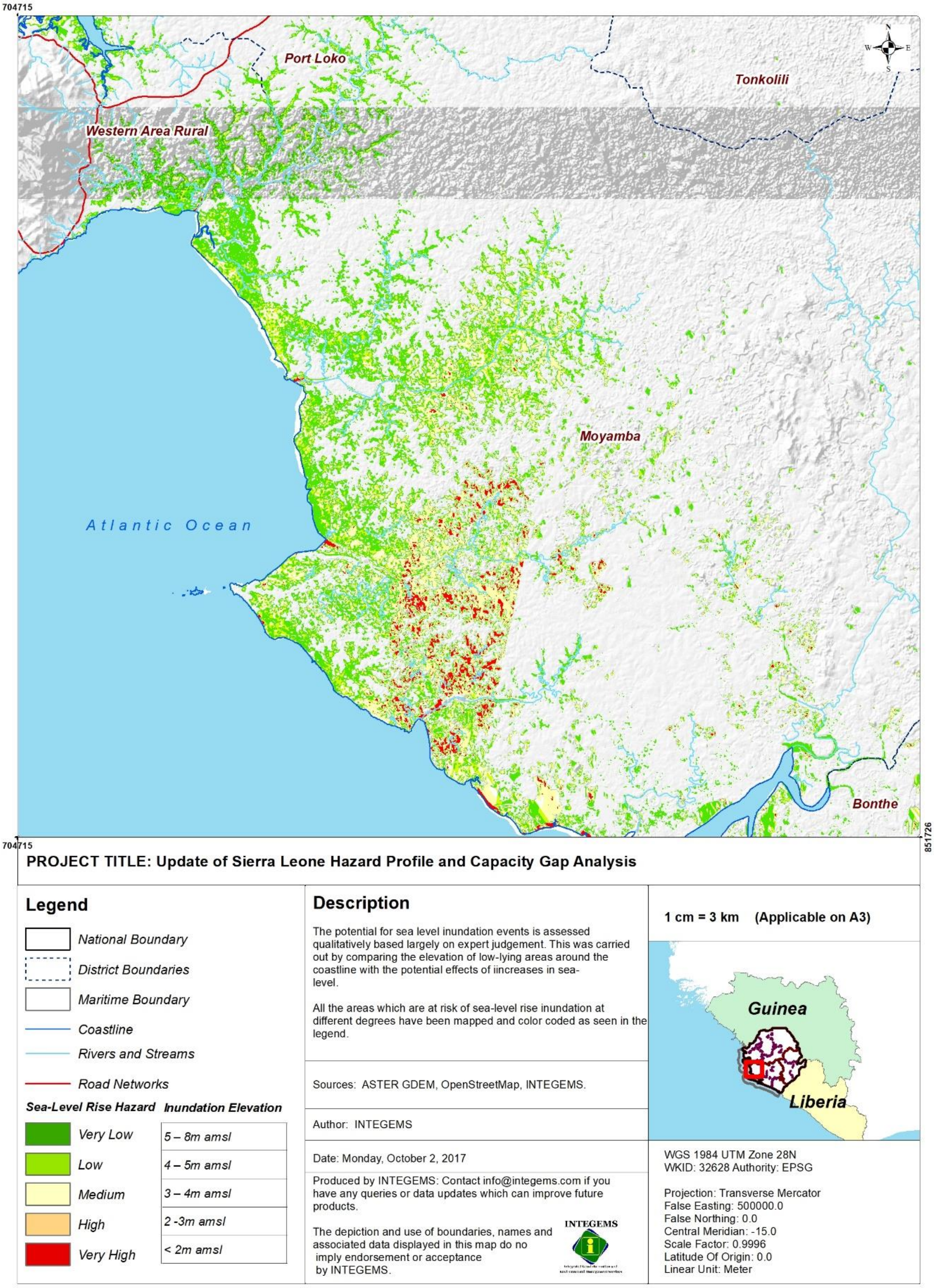
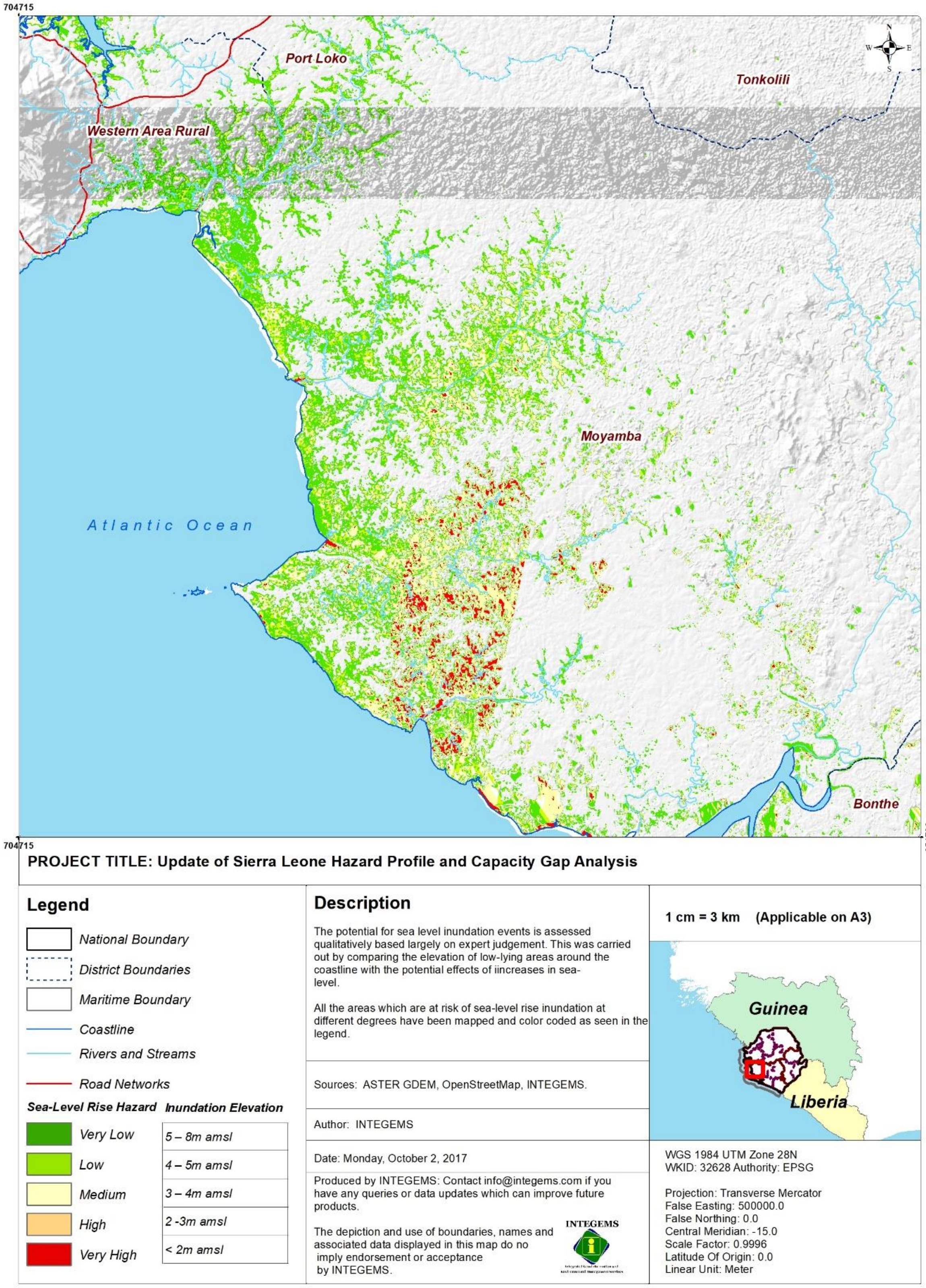


Figure 8-9: Sea level rise hazard map - Shebro River Estuary and Pujehun axis



8.6 Drought

Drought is a result of extreme negative rainfall anomalies. Drought management strategies in vulnerable regions involve reduction of drought risk and targeting resources by better understanding the spatial and temporal variability of drought proneness. Drought hazard profile was developed by combining rainfall and evapotranspiration related indices derived from yearly and monthly data series.

The drought hazard profile is helpful in formulating climatic zone based management strategies and plan activities to mitigate drought impacts. Application of drought profile may include sustainable land and water use practices combined with early warnings, drought relief and insurance, etc. Inputs of scientists in soil-water-plant related policy interventions is also critical. The future population growth along with anticipated rapid development will add more pressure to water resources in all climatic zones, therefore important, beyond the level of water demand considered in the assessment.

With a very slow speed of onset (mostly months or in some cases years), droughts (or long dry spells) are becoming prevalent in some parts of Sierra Leone. The north-eastern parts of the country experiences longer usual dry spells at the peak of the normal dry season between February and March, with rainfall averaging below the normal expected downpours. This leads to reduction in the water table which eventually causes low moisture content and drought-like conditions.

Crop failure, fresh water shortage, wildfires and disease outbreaks, have been attributed to longer dry spell periods, countrywide.

Areas which have been identified as vulnerable to long dry spells communities in the extreme north of Koinadugu district (Kabala) and Kono district.

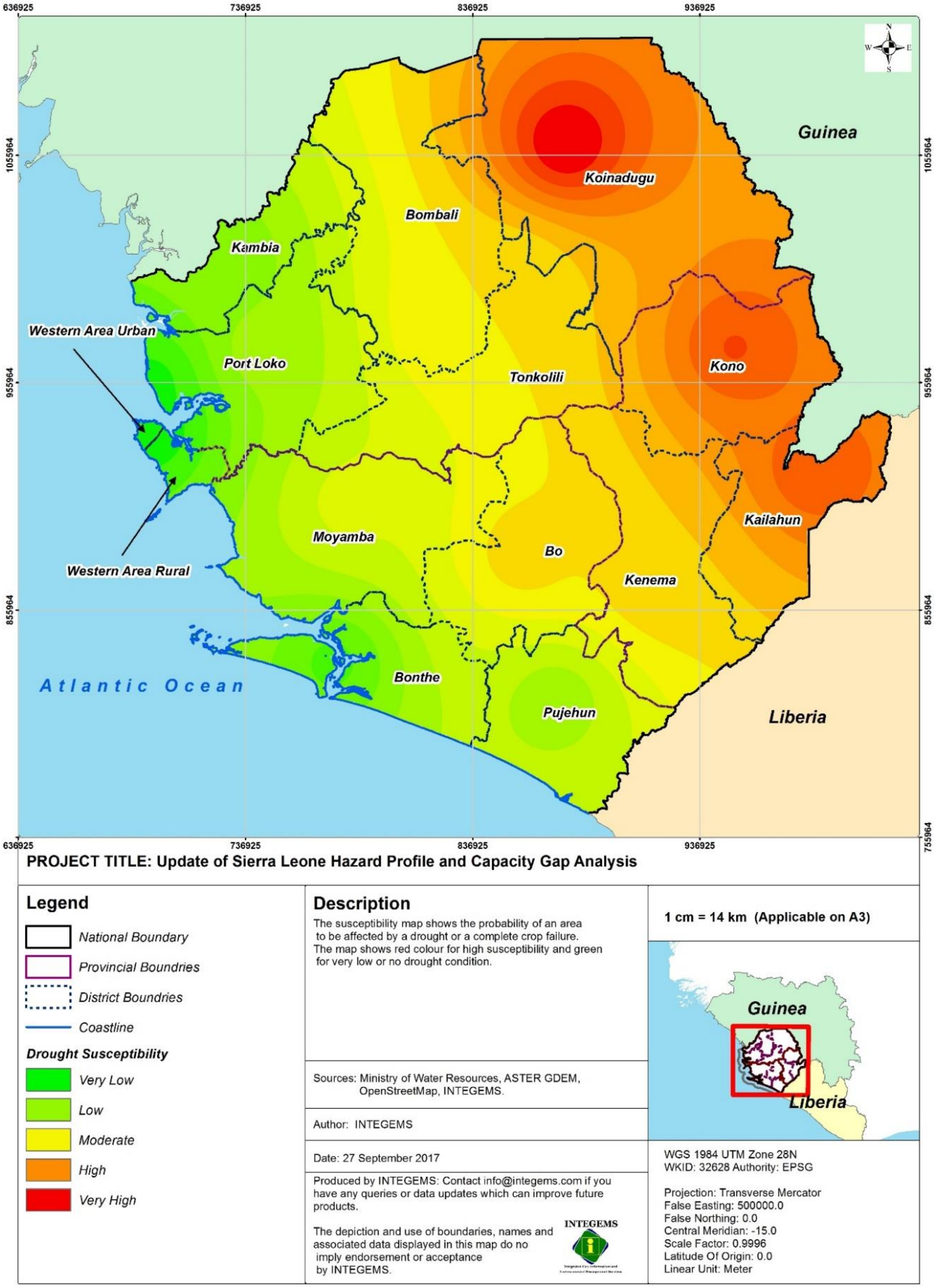
National Profile

Parameters	Scale				
	1	2	3	4	5
Frequency	*Very Rarely*	*Rarely*	*Sometimes*	*Often*	*Frequently*
Magnitude	*Trivial*	*Small*	*Moderate*	*Large*	*Very Large*
Duration	*Very Short*	*Short*	*Average*	*Long*	*Very Long*
Areal Extent	*Limited*	*Very Sparsely*	*Sparsely*	*Densely*	*Widespread*
Spatial Predictability	*Highly Predictable*	*Predictable*	*Likely*	*Randomly*	*Very Randomly*
Speed of onset	*Very Slow*	*Slow*	*Moderate*	*Fast*	*Very Fast*
Importance	*Not Important*	*Somewhat Important*	*Moderately*	*Important*	*Very Important*
Spatial Dispersion	*Very Concentrated*	*Concentrated Moderately*	*Moderately*	*Diffused*	*Widely Diffused*

District Profiles

Area/District	Frequency Scale					Magnitude Scale				
	1	2	3	4	5	1	2	3	4	5
Western Area	■					■				
Bo	■								■	
Bonthe	■					■				
Moyamba	■							■		
Pujehun	■						■			
Bombali	■								■	
Port Loko	■						■			
Tonkolili	■								■	
Kambia	■					■				
Koinadugu	■									■
Kenema	■								■	
Kono		■								■
Kailahun	■									■

Figure 8-10: Drought hazard map of Sierra Leone



8.7 Epidemics

The effects of epidemics on Sierra Leone's human and economic resources is unparalleled by any other form of disasters from natural hazards. The Ebola Virus Disease (EVD) which broke out in Sierra Leone in 2014 is the most overwhelming disaster the country has faced in its post-conflict era. More than 14,000 Sierra Leoneans were infected, of whom nearly 4,000 died.

The unprecedented emergence of EVD in Sierra Leone placed enormous strains on national systems and on the resources and capacities of the government to cope with the public health crisis. The rapid spread of EVD, from isolated outbreaks in Kailahun and Kenema, to all 14 districts of the country demanded the introductory of extraordinary measures to contain the epidemic, including the declaration of a State of Emergency and special security powers to quarantine affected areas, place restrictions on internal movement, close markets and schools and reduce public gatherings[76].

Between 1980 and 2010 epidemics were the deadliest hazards in Sierra Leone. During those 30 years, epidemics were responsible of 83% of the total number of death due to disaster. From 1980 to 2010, epidemics killed 1,103 people and affected 13,447 (5% of people affected by disaster)[77]. Malaria, cholera and typhoid are the most regular and important killer diseases in the country, which is plagued with inadequate access to sanitation and clean water, ineffective waste management and pollution control mechanism, and inadequate household hygiene.

Urban areas, where the majority of the population lives without access to pipe borne water, are the most vulnerable communities. Lassa fever, a viral haemorrhagic fever with symptoms similar to those of Ebola Virus Disease, is endemic in much of West Africa, including Sierra Leone and her most immediate neighbours. The disease which usually sparks a seasonal outbreak from December to March remains a major public health threat in Sierra Leone. Three people died of Lassa fever in Kenema during the second week of February 2017, with concerns of continued increase in the number of positive cases of Lassa fever[78].

National Profile

Parameters	Scale				
	1	2	3	4	5
Frequency	*Very Rarely*	*Rarely*	*Sometimes*	*Often*	*Frequently*
Magnitude	*Trivial*	*Small*	*Moderate*	*Large*	*Very Large*
Duration	*Very Short*	*Short*	*Average*	*Long*	*Very Long*
Areal Extent	*Limited*	*Very Sparsely*	*Sparsely*	*Densely*	*Widespread*
Spatial Predictability	*Highly Predictable*	*Predictable*	*Likely*	*Randomly*	*Very Randomly*
Speed of onset	*Very Slow*	*Slow*	*Moderate*	*Fast*	*Very Fast*
Importance	*Not Important*	*Somewhat Important*	*Moderately*	*Important*	*Very Important*
Spatial Dispersion	*Very Concentrated*	*Concentrated Moderately*	*Moderately*	*Diffused*	*Widely Diffused*

[76] Government of Sierra Leone. (2014).The Economic and Social Impact of Ebola Virus Disease in Sierra Leone. October

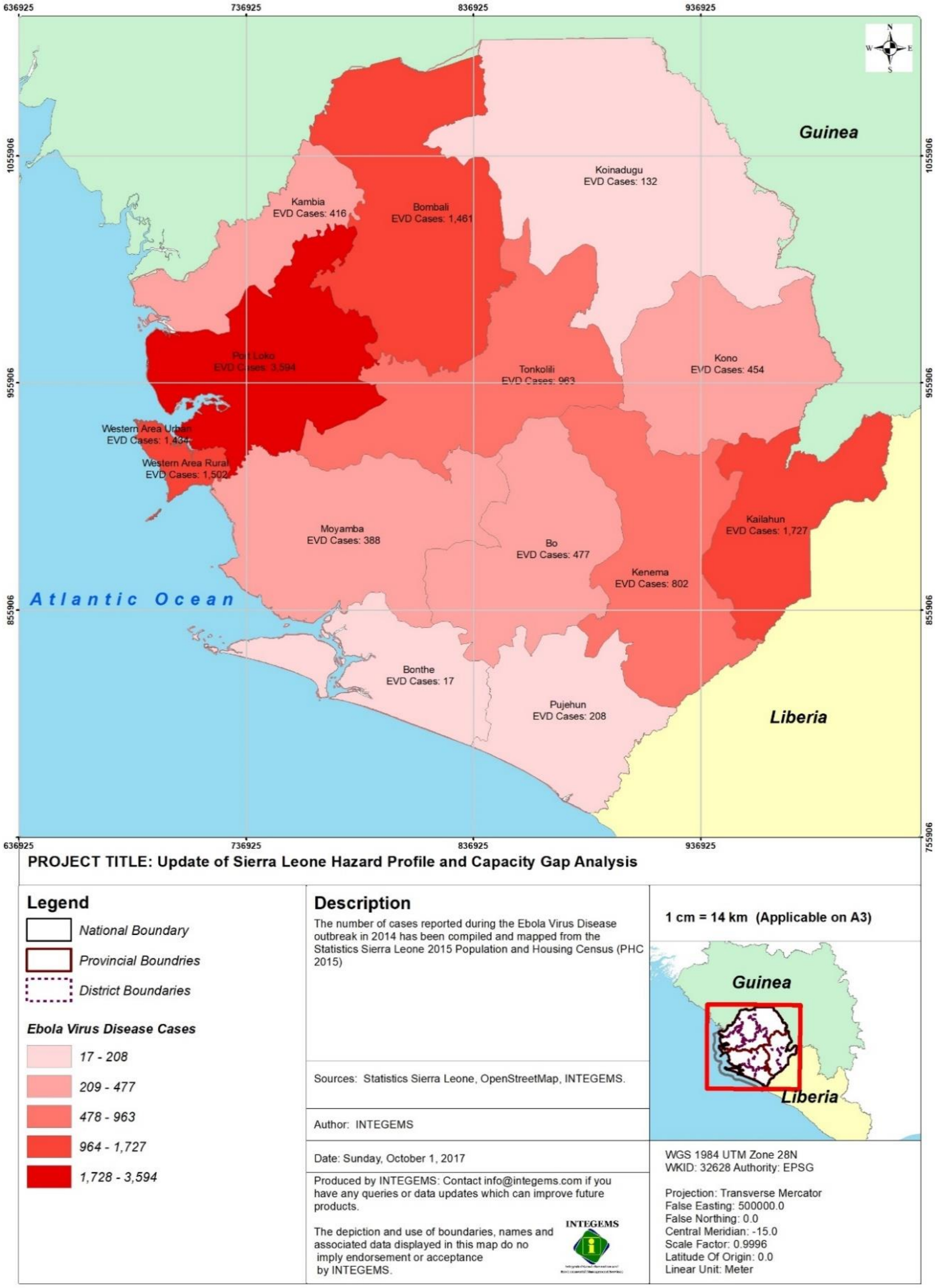
[77] Tarawalli, P. (2012). Diagnostics Analysis of Climate Change and Disaster Management in Relation to the PRSP III in Sierra Leone. Freetown: UNDP - SL.

[78] Sierra Leone News: Health Alert – Lasa fever in Kenema. 3 deaths (http://awoko.org/2017/02/27/sierra-leone-news-health-alert-lassa-fever-in-kenema-3-deaths/, accessed, 3 October 2017)

District Profiles

Area/District	Frequency Scale					Magnitude Scale				
	1	2	3	4	5	1	2	3	4	5
Western Area										
Bo										
Bonthe										
Moyamba										
Pujehun										
Bombali										
Port Loko										
Tonkolili										
Kambia										
Koinadugu										
Kenema										
Kono										
Kailahun										

Figure 8-11: Ebola Virus Disease cases in Sierra Leone



8.8 Storm Surge

Damage to life and property due to tropical storm-induced storm surges occur as a result of inundation of low-lying lands in the shore. Storm surge is primarily originated by pressure induced on ocean surface by high winds resulting in an unusual rise in water level causing coastal flooding.

The storm surge hazard profile is intended for coastal disaster risk mitigation planning, evacuation planning and public education and awareness. Due to uncertainties associated with modelling the hazard profile is derived using expert judgment. Limitations of the study as well as recommendations for improving the storm surge hazard maps are provided as on output of this study.

National Profile

Parameters	Scale				
	1	2	3	4	5
Frequency	*Very Rarely*	*Rarely*	*Sometimes*	*Often*	*Frequently*
Magnitude	*Trivial*	*Small*	*Moderate*	*Large*	*Very Large*
Duration	*Very Short*	*Short*	*Average*	*Long*	*Very Long*
Areal Extent	*Limited*	*Very Sparsely*	*Sparsely*	*Densely*	*Widespread*
Spatial Predictability	*Highly Predictable*	*Predictable*	*Likely*	*Randomly*	*Very Randomly*
Speed of onset	*Very Slow*	*Slow*	*Moderate*	*Fast*	*Very Fast*
Importance	*Not Important*	*Somewhat Important*	*Moderately*	*Important*	*Very Important*
Spatial Dispersion	*Very Concentrated*	*Concentrated Moderately*	*Moderately*	*Diffused*	*Widely Diffused*

District Profiles

Area/District	Frequency Scale					Magnitude Scale				
	1	2	3	4	5	1	2	3	4	5
Western Area										
Bo										
Bonthe										
Moyamba										
Pujehun										
Bombali										
Port Loko										
Tonkolili										
Kambia										
Koinadugu										
Kenema										
Kono										
Kailahun										

8.9 Tropical Storm

Tropical storms are a part of tropical weather systems and has the potential to produce strong winds along with torrential rainfall and associated storm surge near the centre of the storm. Tropical storms can also be very destructive to coastal communities, infrastructure and ecosystems. The tropical storm hazard profile is expected to guide the formulation of disaster management practices and procedures, improve preparedness and target resources for disaster risk reduction.

National Profile

Parameters	Scale				
	1	2	3	4	5
Frequency	*Very Rarely*	*Rarely*	*Sometimes*	***Often***	*Frequently*
Magnitude	*Trivial*	*Small*	***Moderate***	*Large*	*Very Large*
Duration	*Very Short*	***Short***	*Average*	*Long*	*Very Long*
Areal Extent	*Limited*	*Very Sparsely*	*Sparsely*	***Densely***	*Widespread*
Spatial Predictability	*Highly Predictable*	***Predictable***	*Likely*	*Randomly*	*Very Randomly*
Speed of onset	*Very Slow*	*Slow*	*Moderate*	*Fast*	***Very Fast***
Importance	*Not Important*	*Somewhat Important*	*Moderately*	***Important***	*Very Important*
Spatial Dispersion	*Very Concentrated*	*Concentrated Moderately*	***Moderately***	*Diffused*	*Widely Diffused*

District Profiles

Area/District	Frequency Scale					Magnitude Scale				
	1	2	3	4	5	1	2	3	4	5
Western Area										
Bo										
Bonthe										
Moyamba										
Pujehun										
Bombali										
Port Loko										
Tonkolili										
Kambia										
Koinadugu										
Kenema										
Kono										
Kailahun										

8.10 Lightning and Thunder

Sierra Leone is more vulnerable to lightning and thunder due to more convective activities triggered by direct incidence of solar energy to the Earth surface. Life time of a lightning flash is about 20 milliseconds but it carries energy in the order of megawatts and currents ranging from 30,000 to 200,000 Amperes. Modes of lightning strike include side flash, contact potential, step potential and surge propagation of lightning causes property damages and down time in data and communications are significant. In the lightning hazard profile, data from eight AWS were collected and analysed for spatial and temporal distribution lightning events. Potential regions with high frequency for lightning were identified.

Lightning hazard profile is useful to understand the spatial distribution of lightning events and for awareness and mitigation activities.

National Profile

Parameters	Scale				
	1	2	3	4	5
Frequency	*Very Rarely*	*Rarely*	*Sometimes*	*Often*	*Frequently*
Magnitude	*Trivial*	*Small*	*Moderate*	*Large*	*Very Large*
Duration	*Very Short*	*Short*	*Average*	*Long*	*Very Long*
Areal Extent	*Limited*	*Very Sparsely*	*Sparsely*	*Densely*	*Widespread*
Spatial Predictability	*Highly Predictable*	*Predictable*	*Likely*	*Randomly*	*Very Randomly*
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District Profiles

Area/District	Frequency Scale					Magnitude Scale				
	1	2	3	4	5	1	2	3	4	5
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Kambia										
Koinadugu										
Kenema										
Kono										
Kailahun										

9 HAZARD AND RISK PROFILE INFORMATION SYSTEM (HARPIS)

The **Hazard And Risk Profile Information System – Sierra Leone** (**HARPIS-SL**) integrates Geographic Information Systems (GIS) and Management Information System (MIS) systems and mobile data collection technology to provide a family of sophisticated tools and Web services for collecting, managing, visualizing, mapping, analysing, monitoring, evaluating and reporting on various aspects of disaster risks, hazards, vulnerability, exposure and disaster management in Sierra Leone. This integrated and holistic platform puts the HARPIS-SL on a more sturdy foundation. The ability of the ONS-DMD and various stakeholders to make sound disaster risks, hazards, vulnerability, exposure and disaster management decisions can be greatly enhanced by the cross-sectoral integration of information within the HARPIS-SL.

The ability of the ONS-DMD to make sound disaster management decisions – to analyse risks and decide upon appropriate counter-measures - can be greatly enhanced by the cross-sectoral integration of disaster risks, hazards, vulnerability, exposure and disaster management information within the HARPIS-SL. For example, to understand the full short- and long-term implications of floods and to plan accordingly requires the analysis of combined data on hazards, vulnerability, exposure, meteorology, topography, soil characteristics, vegetation, hydrology, settlements, infrastructure, transportation, population, socio-economics and material resources. This information comes from many different sources and at present, it is difficult in the ONS-DMD to bring it all together.

The hazard and vulnerability assessments and mapping components of the HARPIS-SL are the cornerstone of preparedness planning as well as planning and implementation of mitigation programmes. All HARPIS-SL data and information are of critical use in the preparedness plan as well as in the actual response operations. The HARPIS-SL has been built bottom up from the lowest administrative unit (Administrative Section) to the level (national) for disaster risks, hazards, vulnerability, exposure and disaster management assessments. The Administrative Section and Chiefdom databases feed into the District and Provincial databases and then into the National database.

Key components of the HARPIS-SL are:

- Hazard, vulnerability and exposure assessment mapping
- Socio-demographic distribution
- Infrastructure, lifelines and critical facilities
- Logistics and transportation routes
- Human and material response resources
- Communication facilities
- Environmental, natural resources
- Meteorological
- Hydrological, topographical and geological

9.1 Development of the HARPIS-SL

INTEGEMS, under the supervision of the UNDP Energy, Environment & Natural Resource Management (EENRM) Cluster Team Lead[79], developed the HARPIS-SL to standardize, interoperate, integrate and centralize information about disaster risks, hazards, vulnerability, exposure and disaster management in Sierra Leone. HARPIS-SL has been developed to disseminate data and information to the Government of Sierra Leone (GoSL) ministries, departments and agencies (MDAs); international and national non-governmental organisations (NGOs); community-based organisations (CBOs);

[79] UNDP through its Energy, Environment and Natural Resource Management Cluster works in vulnerable communities to reduce the impacts of climate change and risks of natural and man-made disasters in Sierra Leone by reinforcing and supporting institutions and communities to properly prevent or manage natural disasters.

Development Partners; private sector organisations; academia and the general public to enable early preparation against hazards and disasters.

The technical approach to the design, development and deployment of the HARPIS-SL was to:

- Build a robust, scalable, flexible and interoperable HARPIS-SL with an integrated browser-based[80] MIS and high-quality production ready databases (on hired dedicated servers in the Cloud), including preconfigured mobile data capture applications, for collecting, managing, visualizing, mapping, analysing and monitoring disaster risks, hazards, vulnerability, exposure and disaster management information in Sierra Leone.
- Build a network-enabled HARPIS-SL that can be accessed over the Internet, local Intranet, as well as a locally installed system using the latest Information & Communication Technology (ICT) so that all Project stakeholders can access accurate, timely, secured and reliable HARPIS-SL resources from any device (desktops, smartphones/tablets and the Web), from any place, and at any time.
- Build interactive and user-friendly browser based interfaces, including dashboards and maps, using the latest MIS, GIS, mobile, server, network and Web technologies so that all stakeholders can access accurate, timely, secured and reliable HARPIS-SL data and information right from any device (desktops, smartphones/tablets and the Web), from any place (both online and offline), and at any time.
- Build an integrated GIS and MIS System using a combination (i.e., hybrid approach) of commercial (proprietary) and free open source software (FOSS) and web services. This hybrid approach will help reduce risk and add value in several ways: avoiding single software vendor lock-in; reducing costs associated with licensing; and promoting interoperability with existing software and architecture.

During the design of the HARPIS-SL, INTEGEMS considered and examined how various communities can use social media to improve their resilience to both man-made and natural hazards and disasters. Specifically, INTEGEMS:

- Examined how social media can be used to crowdsource information during a crisis situation and how this information can help reduce response and recovery times and raise awareness about the risk of future hazards and disasters.
- Examined how community representatives and those involved in emergency management can use social media to create early-warning systems that can be activated during such events.
- Identified examples of good practice for information dissemination to the public during crises. These will be used to develop widgets for emergency services and incident managers that will raise public awareness about the risks associated with hazard and disaster events.
- Explored how members of the public can be empowered to provide accurate and timely information during disaster events that decrease response and recovery times.

9.2 Key Features of the HARPIS-SL

The key features of the HARPIS-SL are as follows:

- Provides a comprehensive data management solution based on data warehousing principles and a modular structure which can easily be customised to the different requirements of the Project's management information system, supporting analysis at different levels of the Project's organisational hierarchy (national, district, chiefdom, section, town).
- Customisation and local adaptation through the user interface. No programming required to start using the HARPIS-SL in a new setting within or outside the SLMD, ONS, EPA-SL and MWR.

[80] The only real requirement to interact with the System is with a web browser on any desktop or mobile device.

- Serves as a data collection, recording and compilation tool, and all data (be it in numbers or text form) can be entered into it. Data entry can be done in lists of data elements or in customised user-defined forms which will be developed to mimic paper based forms in order to ease the process of data entry. Provides data quality checks that help to improve the quality of the data being collected or entered.
- Provides easy to use one-click reports with charts and tables for selected indicators or summary reports using the design of the data collection tools. Allow for integration with popular external report design tools to add more custom or advanced reports.
- Flexible and dynamic (on-the-fly) data analysis in the analytics modules and widgets. Dashboards to provide quick access to different analytical objects (maps, charts, reports, tables, etc.) to an individual user.
- Integrated GIS module to easily display temporal and spatial data on maps, both on polygons (e.g., districts, chiefdoms, sections) and as points, and either as data elements or indicators.
- Temporal data and periodicity are organised according to a set of fixed period types: daily, weekly, monthly, bimonthly, quarterly, six-monthly, yearly, etc. This becomes an important factor when analysing HARPIS-SL data over time e.g. when looking at cumulative data, when creating quarterly or annual aggregated reports.
- All data, including meta-data, reports, maps and charts, can be retrieved in most of the popular representation formats of the Web of today, such as XML, JSON, PDF and PNG.
- A user-specific dashboard for quick access to the relevant tools, including indicator charts and links to favourite reports, maps and other key resources in disaster risks, hazards, vulnerability, exposure and disaster management.
- User management module for passwords, security, and fine-grained access control (user roles). HARPIS-SL allows for multiple users to access the system simultaneously, each with a defined set of permissions, which can be finely tuned so that certain users can only enter data, while others may generate reports. Multiple user roles can be created, each with their own set of permissions, and then assigned to users which grant them certain privileges within the system.
- Messages can be sent to users for feedback and notifications. Messages can also be delivered to email and SMS.
- Users can share and discuss their data in charts and reports using interpretations, enabling an active information-driven user community.
- Functionalities of export-import of data and metadata, supporting synchronisation of offline installations as well as interoperability with other applications.
- Using the Web-API, allows for integration with external software and extension of the core platform through the use of custom apps.
- Further modules can be developed and integrated as per user needs, either as part of the user interface or a more loosely-coupled external application interacting through the Web-API.
- The HARPIS-SL can be deployed: offline; online; and hybrid. The GPRS/3G mobile module provides a mechanism for remote clients using mobile phones to enter data directly into the HARPIS-SL.

9.3 GIS-enabled and Web-based

GIS-enabled and Web-based hazard and risk profiling and decision support system like the HARPIS-SL enables timely insights and better communication, thus making the information rapidly available for better preparedness and action. Early warning and preparedness heavily depends on inputs like reliable, accurate real/near real data on the hazard causing parameters, forecasting, data analyses, alert recognition and dissemination of alerts. The HARPIS-SL comprises geospatial databases for decision making and management in an event of natural hazards, envisages a system to capture the data in a near real-time manner and automates the generation of reports, alerts and early warnings to various stakeholders and end user communities.

The HARPIS-SL comprises GIS tools to allow users to report information about unfolding disaster using mobile devices and Internet/Web based enabled devices. It makes it easier to plot disaster location on Web map without necessarily having mapping skills. The reported information becomes readily available to both survivors and disaster management personnel so that they can make well informed decisions about unfolding events of a given hazard or disaster that is being reported. The HARPIS-SL platform also allows collection of data through crowdsourcing with the use of mobile and Internet/Web enabled device applications. This information gathering and sharing can be effectively achieved through voluntary data collection by use of mobile devices and social media which currently dominate the revolution of Web 2.0 and growth in Internet use.

9.4 Crowdsourcing and Social Networking

Crowdsourcing is seen a major breakthrough in information sharing and data collection through techniques known as voluntary geographic information. The HARPIS-SL allows interactive information sharing through three major information blocks i.e. submit reports, get alerts and view reports. The HARPIS-SL platform creates a new era of disaster communication through the use of mobile technologies. The role of the user of the HARPIS-SL platform is reduced to interaction with the interface; since no computation knowledge or mapping skills are required. Instead, a customized interface with clear instruction on how to report information is provided. Summarisation algorithms for crowdsourced disaster risks, hazards, vulnerability, exposure, disaster management and early warning information and data has been incorporated with spatial and geo-analytical statistical summaries.

In the design and development of the HARPIS-SL, attention was paid to climatological, hydro-meteorological and disaster reporting, especially information dissemination with geo-location on Web maps through the developed application to report hazards and disasters. The users of HARPIS-SL are able to only zoom to the location of the hazard or disaster, mark it and report it with the possibility of uploading video and picture of the type of disaster which unfolds. This approach is elaborated to exclude the role of phone operators or service providers in negotiation for information retrieval which can be frustrating to access in most cases, since the users have to wait for long before they talk to an operator.

The role of social media has been fully integrated in the HARPIS-SL and it allows users of HARPIS-SL to share information about disaster risks, hazards, vulnerability, exposure and disaster management on their social network, which helps circulate information to a wider audience within a protracted period of time. The information can also be verified easily at no cost as people post their comments about hazards and disasters reports on the social network. Integration of the role of mobile technologies with social media in disseminating hazard and disaster information is fully incorporated into the HARPIS-SL paradigm and approach to disaster reporting and information dissemination.

9.5 Service-Oriented Architecture (SOA)

HARPIS-SL involves the integration of a broad spectrum of free and open source software (FOSS) and proprietary software and hardware technologies, including database servers, Web servers, map servers, desktop and server GIS software, Web services, storage area networks, etc. Thus, a Service-Oriented Architecture (SOA)[81] technical approach has been successfully employed in delivering the CIDMEWS-SL. Building a HARPIS-SL that leverages SOA to author, publish and serve intelligent data and maps empowers the SLMD to utilize best-of-breed components in delivering the right data, information and services to the right beneficiaries at the right time in the right place in a robust, scalable and efficient manner. The SOA approach includes multiple access layers connecting the SLMD, ONS, EPA-SL and MWR with various stakeholders, based on client/software technology and service communication tiers. With desktop (ArcGIS for Desktop) and enterprise server-based GIS (ArcGIS Enterprise) and database management solutions (PostgreSQL and MS SQL Server), the SLMD and

[81] Services-oriented architecture (SOA) is an approach for building distributed computing systems, based on encapsulating business functions as services which can be easily accessed in a loosely coupled fashion. The core components supporting a service-oriented architecture (SOA) are: Service Providers - developers provide component services available for consumption over the web; Service Consumers - Web applications are developed from the available component services; and Service Directory - connects web applications with available component services. Common web protocols and network connectivity are essential to support this type of architecture.

partners can now integrate mapping into their existing workflows and solve the challenges of providing Web and mobile access to MIS/GIS-based data and information and mapping services.

The HARPIS-SL is based on the integration of both open-source and proprietary software - ESRI ArcGIS Enterprise 10.5 (ArcGIS Server, Portal for ArcGIS and GeoEvent Server), ESRI ArcGIS for Desktop 10.5, and PostgreSQL/PostGIS 9.5 and Microsoft SQL Server 2014 Database Management Systems (DBMS), Joomla 3.3 Content Management System (CMS) and/or Microsoft Internet Information Services (IIS)/Apache Tomcat, employing a multi-tier server configuration. The backbone of the HARPIS-SL is a cabled and wireless LAN/WAN interconnected via the Transmission Control Protocol (TCP)/Internet Protocol (IP). The foundation of the CIDMEWS-SL's physical infrastructure and data storage architecture is a Cloud-based dedicated server (Windows Server 2012 R2) and storage device that has the capacity to store nine terabytes of data, utilize a RAID system and intelligent backup mechanisms.

In addition, various interactive maps and data are available from the HARPIS-SL Website through various web browsers (e.g., IE, Safari, Chrome, FireFox, etc.). Compressed files of data, maps, and metadata are available by direct download from data catalogue and atlas/map gallery pages on the HARPIS-SL Website, which also provides a gateway to interactive map services built with ESRI ArcGIS API for JavaScript, HTML, and CSS. Basic and advance map and geo-processing services allow visualisation of pre-packaged sets of data layers (vector and raster) and metadata. Users are able to zoom and pan maps, turn on and off layers, and query the attribute tables associated with the data and metadata. The HARPIS-SL Website also provides feature-streaming capabilities, in which data will be downloaded and/or streamed to the client machine to allow advanced GIS and MIS functionality, including data import/export capabilities, direct download of public-access data and maps, and interactive visualisation of related spatial, non-spatial data, data management and hydrometeorological data and information. HARPIS-SL Web Hosting and Management

An ISP provides Managed Services for deploying the HARPIS-SL Website, which includes providing external HTTP/HTTPS access to the HARPIS-SL Website, operational hosting and monitoring, and troubleshooting technical support incidents through Hosted Environment Support. The ISP has set up the base components comprising the underlying Hosting Environment infrastructure, including the relevant hardware, power, facilities and network infrastructure to enable external HTTP/HTTP access to the HARPIS-SL Website.

To facilitate unified public access to the HARPIS-SL data and data services, a combination of Joomla Content Management System (CMS) and Rich Internet Web Application (using ArcGIS API for JavaScript) technologies was developed and deployed within the IaaS (Dedicated Server).

9.6 HARPIS-SL Mapping Application

The **HARPIS-SL Mapping Application** (accessed via **www.harpis-sl.website**) is a Geographic Information Systems (GIS) Web mapping application that provides easy and convenient ways to collect, map, explore, query, analyze and freely share available disaster risks, hazards, vulnerability, exposure and disaster management data and information resources from any device, anywhere, at any time.

A primary goal of the HARPIS-SL is to allow people who are not GIS professionals to do self-service mapping on any device (i.e., desktop, tablets and smartphones using Internet browsers) and expand the creative use and sharing of disaster risks, hazards, vulnerability, exposure and disaster management data and information resources about Sierra Leone.

It is hoped that by using the HARPIS-SL from any device, anywhere and at any time will encourage collaboration and information sharing, and promote efficiency and effectiveness in providing individuals and organisations with timely and accurate disaster risks, hazards, vulnerability, exposure and disaster management data and information resources for better and more informed decision making in preparedness and planning, mitigation, response and recovery.

9.7 HARPIS-SL Geoportal Applications

The HARPIS-SL Geoportal includes the following Applications:

Preparedness: Empowers the relevant MDAs to map and model potential plans, communicate with citizens regarding resources within their communities, analyze hazards and critical vulnerabilities, and plan for special events.

1. The **Situational Awareness Viewer** can be used by emergency management staff to identify the impact of an incident on public infrastructure and human populations. It helps officers analyze and understand potential impacts to the community while planning for an impending incident.
2. **My Hazard Information** helps residents discover hazards that exist in their community and obtain information about evacuation routes and government facilities provided by government agencies. This application provides access to the ONS 24 hours a day, seven days a week, and typically supplements customer service phone numbers staffed by the ONS-DMD. My Hazard Information can be deployed by MDAs and emergency responders for delivering hazard and facility information to the general public from their desktop computers, smartphones, and tablet devices.
3. The **Incident Briefing** application can be used by ONS management staff to provide map-based briefings and reports during an incident. Incident Briefing can be deployed and used by response personnel on desktop computers, smartphones, and tablet devices.
4. **Evacuation Zones** can be used by ONS staff to notify the public when evacuations are required. Evacuation zones are typically referenced when people and property must be removed from a neighbourhood or community because of safety concerns.
5. **Emergency Assistance** can be used by the general public to register for emergency assistance. Emergency assistance is typically provided by public safety or emergency management personnel to vulnerable populations whose needs are not fully addressed by traditional service providers. During an emergency, response personnel may enter the residents of those enrolled in an emergency assistance programme to assure the safety and welfare of an individual.

Mitigation: Assess and analyze risk and vulnerabilities, evaluate potential impacts, engage organisations in mitigation efforts, understand the status of mitigation projects, and communicate the status of mitigation plans.

Response: Deliver situational awareness, assess impacts to the community post-event, communicate state of infrastructure with the public, and understand the impact of an event using focused applications and common tools.

1. **Shelter Locator** can be used by the ONS-DMD and emergency management agencies responsible for providing citizens a safe place when they are displaced from their residence during a natural or man-made incident. Emergency shelter status and shelter-specific information (capacity, current occupancy, special needs, etc.) is provided and managed by the ONS-DMD and partners. Shelter Locator allows citizens to locate emergency shelters in their community from a smartphone, tablet, and desktop computer.
2. The **Situational Awareness Viewer** can be used by emergency management staff to identify the impact of an incident on public infrastructure and human populations. It helps officers analyze and understand potential impacts to the community while planning for an impending incident.
3. The **Public Information** application is configured to utilize authoritative event based information in conjunction with social media feeds to present both organisational content, and content being contributed by the public. The application enables the ONS to quickly deploy an application that is accessible to the various stakeholders across an impacted area.
4. **Photo Survey** can be used by the ONS and other emergency response organisations to publish aerial and street-level photo collections and conduct surveys that identify damaged areas and structures within the images. Photo Survey expedites damage assessments by

leveraging photos produced by many commercially available cameras. It combines these photos with a series of questions in the form of an online survey and associates the answers to points or administrative units on the ground. The simple to use application will enable ONS staff, and optionally the general public, to review time sensitive images after a disaster, thus allowing emergency response organisations to quickly estimate damage costs and determine potential financial impacts of an event.

5. The **Operations Response** application can be used by the ONS staff to understand the current status of emergency facilities and response teams. It can be deployed by emergency management organisations and used by response personnel on desktop computers, smartphones, and tablet devices.
6. The **Impact Summary Map** can be used by emergency management organisations to quickly communicate impact of an event to interested parties. It utilizes enriched content to facilitate quick summary information for the affected population. The application enables you to quickly configure, deploy and communicate impact using the application.
7. The **Incident Status Dashboard** can be used by ONS management staff to monitor response activities and measure progress toward the incident objectives. It can be deployed by emergency management organisations and used by response personnel on desktop computers and tablet devices.
8. The **Incident Briefing** application can be used by the ONS staff to provide map-based briefings and reports during an incident. It can be deployed by other emergency management organisations and used by response personnel on desktop computers, smartphones, and tablet devices.
9. **Debris Reporting** can support the ONS and the EPA-SL in collecting and monitoring debris. The solution facilitates the collection of debris type and its location in order to assess and report back where debris clean-up is needed.
10. The **Damage Assessment** solution can be configured by the ONS to conduct detailed damage assessments in the field. It can also be used to monitor field assessments and determine whether damage costs exceed ONS declaration thresholds. Damage Assessment supports the collection of structural damage to residential and commercial structures; and damage to public facilities during emergency response activities.
11. **Citizen Reports** can be used by citizens to report non-emergency incidents. Citizen Reports is used by the public as a means to provide non-emergency reports and observations throughout the community. This information will be immediately available to public safety personnel.
12. **Health and Safety Reports** allows the general public and public safety personnel to file reports important to the health and safety of a community. The ONS and EPA-SL personnel can monitor, verify and assign those reports to responsible agencies for resolution. If appropriate, health and safety reports can also be incorporated into an incident management system for further action. Health and Safety Reports can be used by the ONS and other emergency management organisations during severe weather, power outages, and other events to collect information vital to response and recovery efforts.

Recovery: Provide applications for the public to report information about the community, and deploy tools within the organisation to collect and communicate status regarding debris and damage.

1. **Community Mitigation** enables the ONS and relevant organisations to submit, manage and track the status of mitigation projects and local mitigation plans. It also facilitates the management of mitigation projects, funding status and enables the ONS and relevant organisations to submit projects around localities where vulnerabilities have been identified.
2. **Hazard Vulnerability Analysis** can used by ONS-DMD staff to map infrastructure, community and government owned assets. This can then be enhanced with demographic, social vulnerability and hazard data, allowing a broad assessment of vulnerability and exposure across jurisdictions. This solution delivers a set of tasks to walk disaster management staff through the process of sourcing authoritative content, analyzing potential vulnerabilities, and sharing the results of the work with various stakeholders.

3. **Hazard Assessment and Analysis** can used by ONS-DMD management staff to map and analyze hazards and their potential impacts. The solution delivers a set of tasks to walk emergency management staff through the process of sourcing authoritative content, analyzing historic hazard events, assessing the likelihood of future events and sharing the results of the work. It provides a way of comparing different jurisdictional areas (for instance tribal areas, tracts or counties).

9.8 HARPIS-SL Website

The HARPIS-SL Content Management System (CMS) Website (http://harpis-sl.website) takes full advantage of the flexibility of features offered by Joomla CMS with array functions and modules that can be easily added to over time without costly redesigns to interfaces and templates. Designed with end users in mind, the HARPIS-SL Website's responsive web design (RWD) and multi-device design technologies uses the gantry framework to ensure the site is highly mobile-accessible and viewable on all screen sizes (from desktops to smartphones).

Visitors to the site can access relevant HARPIS-SL information in a timely and consistent manner. Disaster risks, hazards, vulnerability, exposure and disaster management information are presented in a non-technical and visually appealing manner incorporating a well thought out site-flow and information architecture. Information is organised clearly to facilitate access to relevant information and content easily searchable. All pages feature similar and consistent navigation controls with a minimum number of clicks required for navigation. Clear and intuitive labels, controls are grouped into logical units.

An integrated and interactive HARPIS-SL Web Mapping Application has been embedded in the HARPIS-SL CMS Website's Home Page and menu to allow users to interactively and effectively create, edit, publish, review, and collaborate on disaster risks, hazards, vulnerability, exposure and disaster management mapping, updating and managing development project locations and attributes through a robust, easy-to-use Web browser. The HARPIS-SL Web mapping application exposes SLMD meteorological data and geospatial services from the server and streams the results, expediting the discovery, transfer and utilisation of disaster risks, hazards, vulnerability, exposure and disaster management data and information by the ONS-DMD and SLMD to various stakeholders.

The HARPIS-SL Website promotes the SLMD, ONS-DMD, EPA-SL and MWR to all stakeholders using media (picture, audio, and video) to highlight disaster risks, hazards, vulnerability, exposure and disaster management events at SLMD, ONS-DMD, EPA-SL and MWR. Acting as a discussion forum on disaster risks, hazards, vulnerability, exposure and disaster management projects, HARPIS-SL CMS informs and connects to a larger audience by integrating social media (Twitter, Facebook).

Figure 9-1: The HARPIS-SL Website – Home page

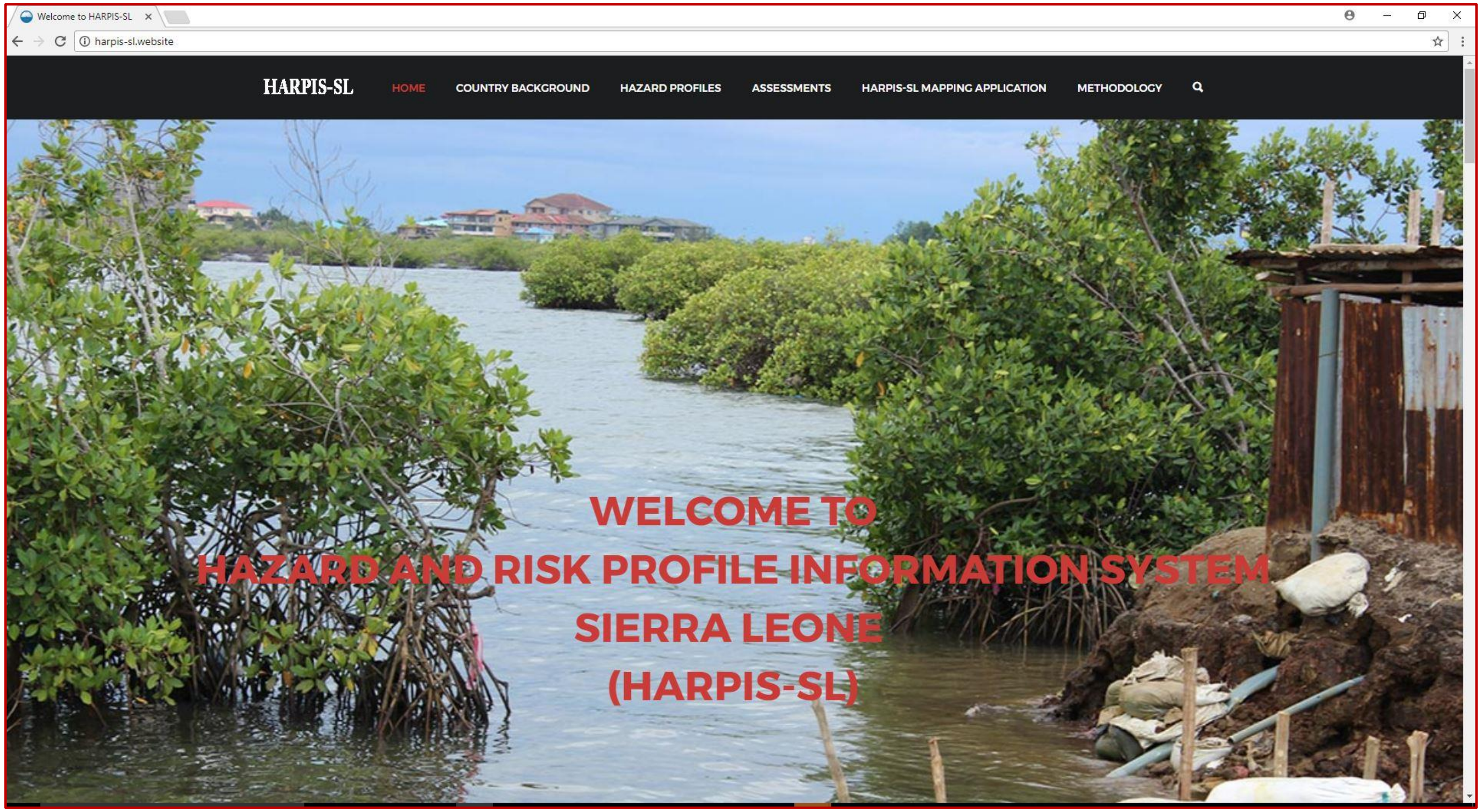


Figure 9-2: The HARPIS-SL Website – Hazard Profile page

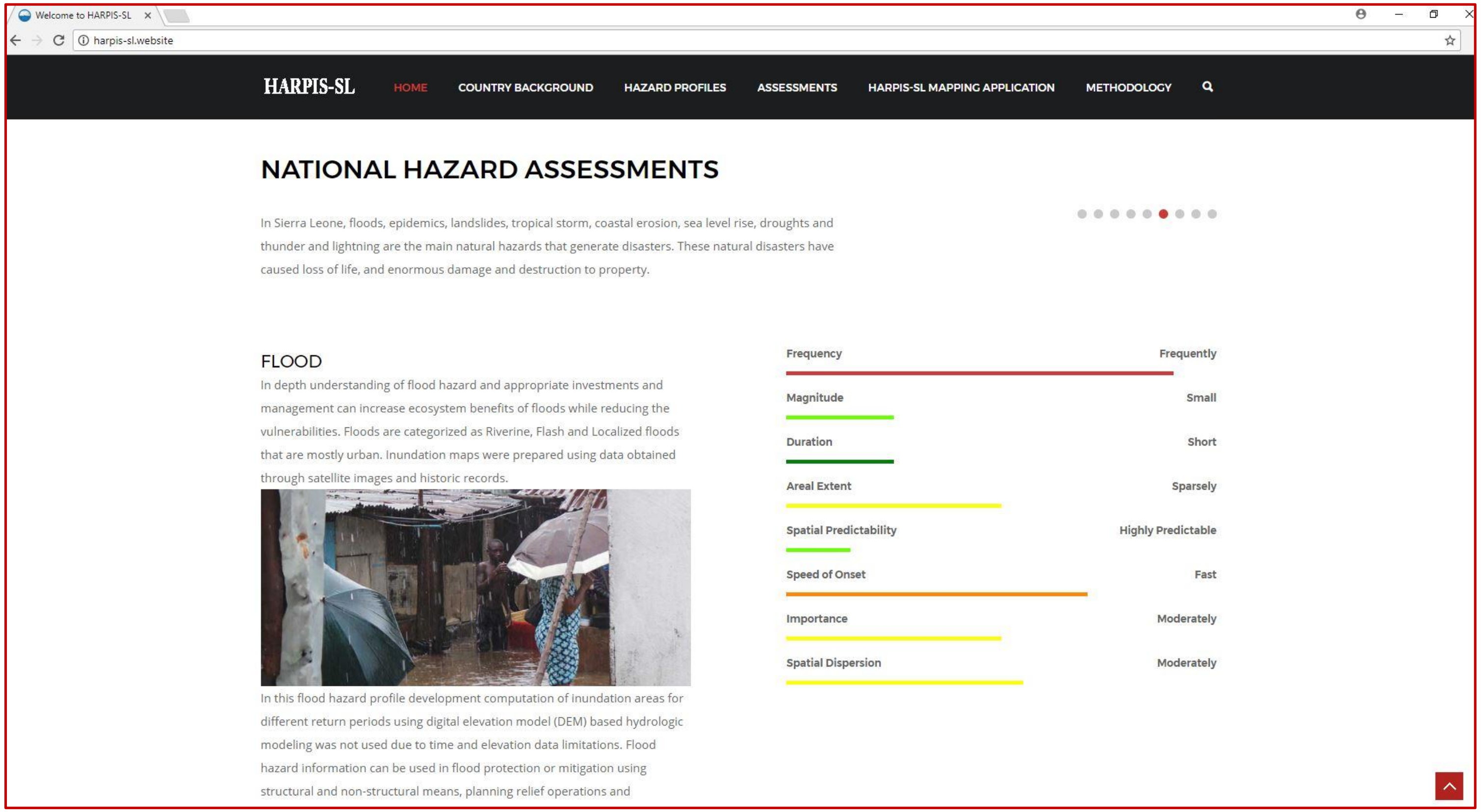
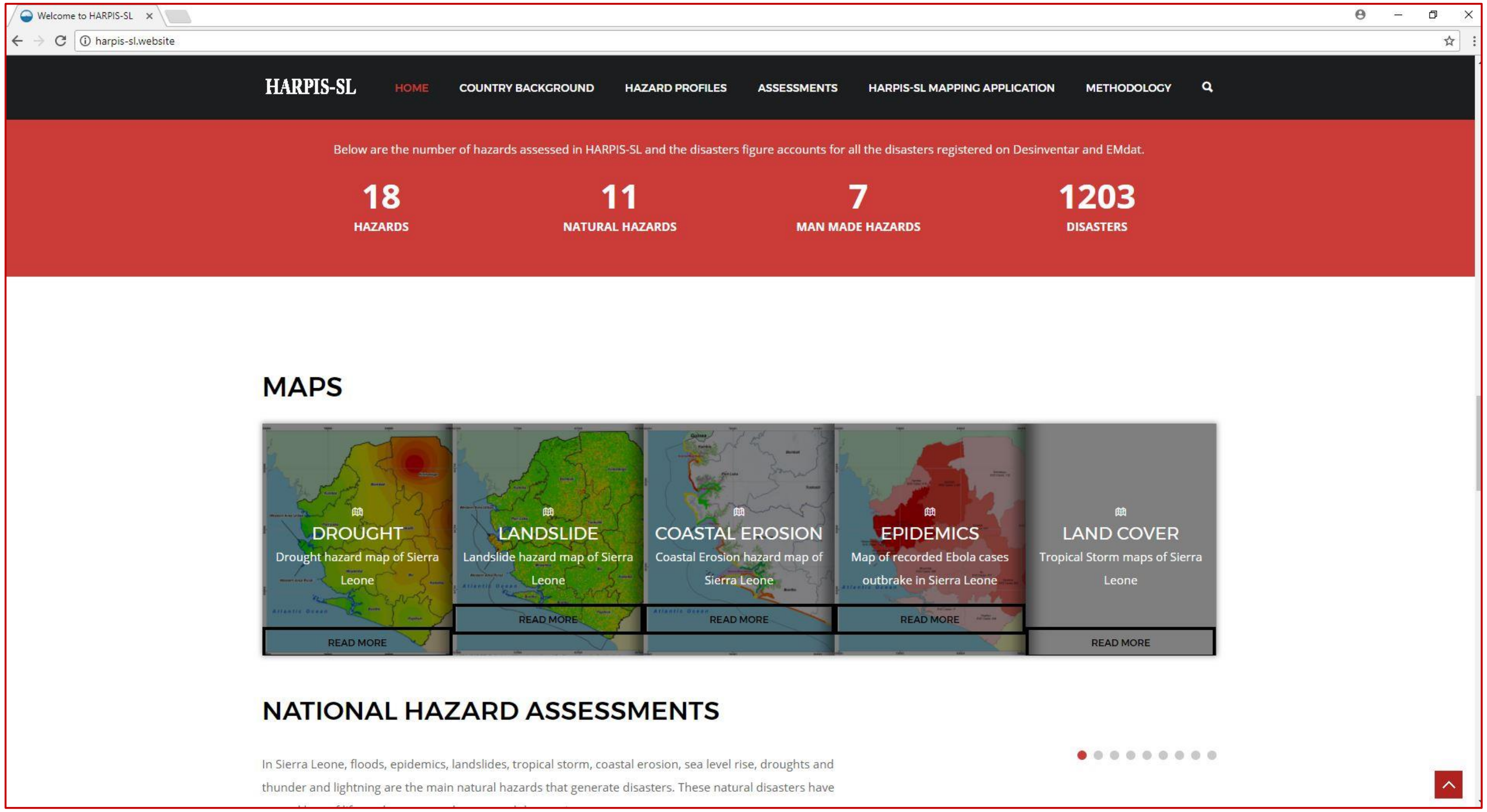


Figure 9-3: The HARPIS-SL Website - Maps



10 CAPACITY GAP ANALYSIS

10.1 Background

DRR is gradually becoming one of the key priorities of the GoSL and has even assumed greater urgency following the recent devastating flooding and landslide in the Freetown on 14 August 2017. There has been an obvious progress in addressing prevention issues but traditional approaches focuses more on emergency response rather than risk reduction. The consequences of the flooding and landslides have led to the recognition of the need to develop and strengthen policies in implementing disaster prevention, risk management and to promote cooperation and coordination for DRR and DRM to enhance the national DRR system in order to define a roadmap to overcome capacity gaps, particularly in terms of prevention and risk reduction.

In this context capacity is defined as “the ability of individuals, organisations, organisational units and / or systems to perform functions effectively and in a sustainable manner”. The UNISDR terminology views capacity as the combination of all the strengths, attributes and resources available within a community, society or organisation that can be used to achieve agreed goal. Thus, the capacity needs assessment is a structured analytical process designed to assess and evaluate various dimensions of capacity within the broader institutional and/or indigenous systems as well as assessment of the capacity specific units and individuals within the system.

The capacity gap assessment was structured according to the priority areas of the SFDRR. It aimed to take stock of the institution’s existing capacities, needs and gaps and provide a set of prioritized recommendations for capacity development in areas identified as requiring adjustment. The assessment highlights the current need and gaps and present a selected number of crucial recommendations on further capacity strengthening of the DRR and DRM system in the key institutions.

The SFDRR sets out four key priority areas as outlined below:

- **Priority 1:** Understanding disaster risk – This is focused on the degree of awareness and understanding of DRR and DRM concepts and practices of all stakeholders involved in the DRR and DRM system at all levels. A good level of understanding of DRR and DRM at both strategic/ policy level, as well as at operational level is a prerequisite of informed decision-making.
- **Priority 2:** Strengthening governance for managing disaster risk – This Priority Area 2 outlines the requirements of a performing legislative, policy and institutional system for DRR and DRM as enabling factors for the implementation of DRR and DRM measures.
- **Priority 3:** Investing in disaster risk reduction for resilience – The Priority Area 3 is centred on public and private investment in disaster risk prevention and reduction through the planning and implementation of structural and non-structural measures at sector level to reduce the risk arising from disasters and increase the resilience of at-risk populations
- **Priority 4:** Enhancing preparedness for effective response, and building back better in recovery and reconstruction – The Sendai Framework Priority Area 4 has a specific focus on structures, tools and operational capacities related to disaster preparedness, response, recovery, rehabilitation and reconstruction. The recovery, rehabilitation and reconstruction phase is a critical opportunity to build back better, including through integrating disaster risk reduction into development measures.

10.2 Capacity Gap Assessment Results

10.2.1 Summary Tables

10.2.1.1 Sierra Leone Meteorological Agency (SLMA)

Key Areas/Themes	Current Capacities	Gaps	Reasons for Gaps	Proposed Recommendation
Priority 1. Understanding disaster risk				
Understanding of key concepts	The institution has very limited knowledge about disaster risk	Lack of awareness, poor communication and information sharing among departments and institutions.	There is inadequate information for raising awareness and coordination among departments, ministries and agencies with regards to disaster risk.	There is need for comprehensive and robust training on the key concepts of disaster risk. The CIDMEWS-SL and HARPIS-SL will help in providing the necessary information and support.
Risk monitoring, identification and mapping	The institution does not conduct any risk mapping. However, monitoring of extreme weather events is done but to a limited extent.	Lack of appropriate and robust systems, equipment and manpower.	Lack of appropriate systems, equipment and technical competencies.	There is need to invest in skills development and adequate equipment that should be fully operational.
Early warning – early action	The Meteorological Agency is mandated to monitor and provide weather data to aviation and to disseminate climatic and meteorological information through various means including radio and television stations. Currently, through the UNDP and other partners eight Automatic Weather Stations have been installed across the country.	Information is not widespread but limited to very few people.	Lack the resources especially the financial resources for implementing early warning activities	The CIDMEWS-SL and HARPIS-SL will strengthen the capacity of the Sierra Leone Meteorological Agency to carry out climate information and early warning dissemination through improved data collection and management, and climate modelling. It will also address the shortfalls in the architecture,

Key Areas/Themes	Current Capacities	Gaps	Reasons for Gaps	Proposed Recommendation
				development and communication of early warning systems.
Public awareness	The Meteorological Agency through the Ministry of Transport and Aviation do share climatic and meteorological information to the public via radio and television to raise awareness particularly for vulnerable communities.	Information is not widespread but limited to very few people.	Limited resources hamper the regularity of such events.	The CIDMEWS-SL and HARPIS-SL will strengthen the capacity of the Sierra Leone Meteorological Agency to carry out climate information and early warning dissemination through improved data collection and management, and climate modelling. It will also address the shortfalls in the architecture, development and communication of early warning systems.
Training and education	The institution has been funded by the UNDP for some key trainings and education. Also they do conduct basic in house trainings.	There is still a wide gap in knowledge of skills required to adequately perform their jobs.	Limited financial support to conduct capacity development activities and roll out the trainings, due to a limited understanding of what these activities entail.	Increase the capacity training for more staffs and develop a training work plan for training to be organized within the agency and locally delivered by partners.
Priority 2. Strengthening governance and institutions to manage disaster risk				
Legislative and policy frameworks for DRR and DRM	The institution has not yet developed any policy statement of framework for DRM	Lack the indigenous knowledge systems to complement scientific knowledge for climate change	Lack the indigenous knowledge and systems to complement scientific knowledge for climate change forecasting and	Align the institution's strategic objectives and outcomes with the SFDRR

Key Areas/Themes	Current Capacities	Gaps	Reasons for Gaps	Proposed Recommendation
		forecasting and early warning systems with DRR and DRM.	early warning systems with DRM.	
Institutional framework and coordination mechanisms for DRR and DRM	The institution's risk reduction capacity and capabilities are apparently very limited.	They do not have adequate knowledge and expertise or related operating procedures to mainstream disaster risk management into their broader development plans.	There is currently no clear coordination mechanism for DRR and DRM within the institution.	There is need for improvement in capacities in terms staff, technical capacity, and resources with explicit roles in their terms of reference.
Priority 3. Investing in disaster risk reduction for resilience				
DRR and DRM mainstreaming	DRR and DRM is not mainstreamed in the institution's policies and plans	DRR and DRM is not mainstreamed in the institution's policies and plans	They do not have adequate knowledge and expertise or related operating procedures to mainstream disaster risk management into their broader development plans.	Mainstream DRR and DRM into the work program and policies and development plans.
Financing and investment in DRR and DRM	The institution does not receive any funding or financing for DRM as it has not been mainstreamed into their policies.	N/A	N/A	Mainstream DRR and DRM into the work program and policies and development plans
Local-level resilience building	Resilience building initiatives are being promoted but at a small scale by development partners like the UNDP particularly in	Weak institutional and coordination capacity required for	Limited resources hamper the regularity of such events.	Scale up community-based DRM initiatives by increasing capacity in local level climatic and weather

Key Areas/Themes	Current Capacities	Gaps	Reasons for Gaps	Proposed Recommendation
	communities considered more vulnerable.	effective DRR implementation		prediction, mapping, training, simulation and coordination
Women's empowerment and gender equality	Gender perspective is inclusive but the focus is more in institutional capacity rather than DRR and DRM.			Inclusiveness of gender perspectives in every phase of policy development and DRR and DRM activities
Priority 4. Enhancing preparedness for effective response, and building back better in recovery and reconstruction				
Information management and communication	The institution provide regular climatic and aviation information to the key relevant institutions.	Lack of staff and appropriate skills and training has been identified	Lack the basic skills and techniques in information management and communication	The institution should put in place data collection, analysis, and information dissemination protocols in cooperation with relevant institutions specifically the ONS
Preparedness and response planning	There is limited capacity in terms of preparedness however the institution provide important weather forecast and prediction information to prepare the community of any imminent disasters. This is disseminated on TV and radio	Lack of staff and appropriate skills and training has been identified	Lack the required tools and resources	Preparedness capacities should be developed with the essential tools and skills

Key Areas/Themes	Current Capacities	Gaps	Reasons for Gaps	Proposed Recommendation
Disaster response at local level	The institution is not mandated with disaster response responsibilities but however do get involved in collaborative activities by providing meteorological or climatic information useful for impending disasters	Because this is not a key or mandated aspect of their work they have not really assessed the gaps.	N/A	N/A
Emergency services	N/A	N/A	N/A	N/A
Post-disaster recovery and reconstruction	N/A	N/A	N/A	N/A

10.2.1.2 Office for National Security-Disaster Management Department

Key Areas/Themes	Current Capacities	Gaps	Reasons for Gaps	Proposed Recommendation
Priority 1. Understanding disaster risk				
Understanding of key concepts	There is an excellent understanding of disaster risk in the different sectors. All the staffs	Awareness is less common in other line ministries and	Inadequate trainings and awareness	Enhanced understanding on hazards, risks and how to

Key Areas/Themes	Current Capacities	Gaps	Reasons for Gaps	Proposed Recommendation
	in the ONS-DMD have a good command of the topic as it relates to their expertise.	department that are not directly involved in DRM and DRR.		prepare for hazards and respond to warnings Increased awareness raising and training on DRR and DRM concepts.
Risk monitoring, identification and mapping	Several hazard/ risk identification and mapping initiatives have been undertaken by the institution with support from government and international partners and 26 disaster prone areas have been identified within Freetown. The national multi-hazards/risks profile is outdated and is currently being updated. A national vulnerability and capacity assessment is ongoing and report exists on three administrative districts.	Systems are in place to monitor, archive and disseminate data on key hazards and vulnerabilities but the institution lacks the capacity and technical skills for mapping.	Lack of funding and human resource	Urgent need to scale up trainings in the department especially GIS trainings Extensive multi-hazard vulnerability mapping, focusing on individual communities.
Early warning – early action	There is no proper structure for early warning system in place but relevant information on disasters is available and regularly accessible at all levels. There is strong and regular engagement of the media (both print and electronics) for publications and broadcasting on DRR and DRM issues nationwide.	Lack the related technical support to strengthen capabilities. Lack of communication systems and arrangements for ensuring that early warnings are acted on successfully	Limitations in technical capacities and resources	The CIDMEWS-SL that has been developed will help the ONS to develop data collection, analysis, and information dissemination protocols in cooperation with relevant institutions.
Public awareness	Countrywide public awareness strategy and activities exists to stimulate a culture of disaster	Lack technical capacities and funding resources	Lack technical capacities and funding resources for public	Scale up awareness campaigns in risk-prone communities.

Key Areas/Themes	Current Capacities	Gaps	Reasons for Gaps	Proposed Recommendation
	resilience, with outreach to urban and rural communities. These activities are usually conducted with support from development partners. Public education and awareness raising programmes (regular radio and television discussions, jingles, short video documentaries)		education and increased awareness to enhance national and community level resilience building	Mobilize funding resources for public education and increased awareness to enhance national and community level resilience building
Training and education	In collaboration with the EPA-SL Save the Children and World Vision the institution has conducted training for volunteer groups in risk assessment and risk reduction activities across Freetown mainly in the disaster prone communities from Calaba Town Goderich. Establishment of Schools clubs for disaster risk reduction	Lack of harmonisation among the instruments, tools and institutions involved	Limited financial resources and lack of technical capacity	Increase the technical capacity of ONS in training and develop a training and public education work plan to be organized across the country. Scale up DRR and DRM training and education at all levels; District, Provincial and local Community
Priority 2. Strengthening governance and institutions to manage disaster risk				
Legislative and policy frameworks for DRR and DRM	National policy and legal framework and policies for disaster risk reduction exists with decentralized responsibilities and capacities at all levels. • National Disaster Risk Management Policy.	Insufficient and outdated national legislative frameworks	Limited financial and human resources. Legal expertise is limited in certain areas of DRR and DRM	Scaling up the national legal framework to mainstreaming and converting regulations and decrees into law. Development of a comprehensive, long-term

Key Areas/Themes	Current Capacities	Gaps	Reasons for Gaps	Proposed Recommendation
	• National Disaster Risk Management Strategy and Action Plan • Sierra Leone Disaster Management Policy • Disaster Management Preparedness plan			disaster risk management strategy. Appropriate legislation, policies and institutional structures
Institutional framework and coordination mechanisms for DRR and DRM	The National Disaster Risk Reduction Platform has been established with eleven (11) thematic areas, each addressing specific hazard conditions and meetings are held periodically to deliberate on key issues. The institution also coordination of stakeholders and partners meetings for DRR and DRM initiatives and activities	Most of the MDA's do not have key focal persons or officers dedicated DRR and DRM	Lack of awareness on the paradigm shift of DRR and DRM and long approval processes hinders implementation	Strengthen coordination and collaboration at all levels via institutional, policy and research coordination and the development of joint strategies to integrate the DRR and DRM into national planning processes and strategies
Priority 3. Investing in disaster risk reduction for resilience				
DRM and DRR mainstreaming	There are national and local mainstreaming initiatives as DRR and DRM is fully incorporated in the institution however the institution is advocating the inclusion of DRR and DRM into strategic sectoral polices and plans An activity plan has been developed and shared with key	Lack of coordination among agencies and among the government departments	Roles are not clearly defined. Incorporation and integration of DRR and DRM knowledge is very poorly emphasised	DRR and DRM are cross sectoral and thus increased awareness-raising on the needs for mainstreaming is required to secure a solid appreciation and understanding of the relevance of disaster risk reduction for sustainable development

Key Areas/Themes	Current Capacities	Gaps	Reasons for Gaps	Proposed Recommendation
	MDAs for roll out and implementation			
Financing and investment in DRM	Funding is received locally through The Ministry of Finance and Economic Development and the office of the vice president and also from international partners including IOM, WFP , WASH, MoHS, World Vision , IMF, DFID and the World Bank National Emergency Response Trust Fund was established but consequently this fund has not been operational/effective	Limited DRR and DRM activities at all administrative and local levels	Inadequate resources available to implement disaster risk reduction plans and activities at all administrative and local levels	Contingency finance to strengthening financial mechanisms for disaster reduction. Increase public-private partnerships
Local-level resilience building	Countrywide public awareness strategy and activities exists to stimulate a culture of disaster resilience, with outreach to urban and rural communities. Establishment of Community-based Disaster Risk Reduction Volunteers Establishment of District Disaster Management Committees (DDMCs)	Limited community participation	A major constraint is and communities are not sensitized well enough to treat DRR as an integral part of sustainable development	Strengthen community-based EWS for incorporating relevant indigenous knowledge and capacitate communities at village level to conduct community based risk assessments.
Women's empowerment and gender equality	Gender and social inclusion issues is mainstreamed in all DRR and DRM Policies, frameworks and initiatives	Lack of women's traditional knowledge and perceptions in the analysis and evaluation of disaster risks, coping strategies and solution	Limited participation of women in DRR and DRM	DRR and DRM efforts need to be gender aware. Increase women's participation and representation in all levels of decision making processes

Key Areas/Themes	Current Capacities	Gaps	Reasons for Gaps	Proposed Recommendation
Priority 4. Enhancing preparedness for effective response, and building back better in recovery and reconstruction				
Information management and communication	National Disaster Database using the UNISDR DesInventar to collect and share information. Procedures are in place to exchange relevant information during hazard events and disasters, and to undertake post-event reviews Public education and awareness raising and advocacy programmes specific areas include Bumbuna, Bonthe and Pujehun.	Information warning messages does not reach the wider audience especially those at risk Lack of effective methods of communication for DRR.	Use of information and communication technologies for the communication and dissemination of warnings in weak Clarity and packaging of the warnings	Integration of traditional knowledge in risk assessments information and communication is highly required. Information management should be a routine activity and should begin in the preparedness phase and continue through the early recovery period.
Preparedness and response planning	Disaster preparedness plans and contingency plans are in place at all administrative levels, and regular training drills and rehearsals are held to test and develop disaster response programmes. Also the National Emergency Response Trust Fund which sustainability has largely been dependent on pledges was established but consequently this fund has not been operational/effective	General preparedness planning is weak	Shift from response focus to preparedness focus. Lack capacity to predict, monitor and reduce or avoid possible damage or addressing potential threats	There is need for an integrated, multi-sectoral and multi-hazard contingency plan for effective disaster response and recovery at national and local levels Improving risk information and early warning

Key Areas/Themes	Current Capacities	Gaps	Reasons for Gaps	Proposed Recommendation
Disaster response at local level	Response to localized and national-scaled disasters have been entirely ad-hoc	Limited capacity and human resources.	Communities are not sensitized well enough to treat DRR as an integral part of sustainable development.	Need for effective response and recovery strategies.
Emergency services	Search and rescue and evacuation is within the purview of institution. No emergency centres available rather public infrastructures like school buildings are used. Incident command centres have been set up. A functional central call number for all emergency services have been established.	Lack human resources and technical skills and capabilities.	Lack the requisite skills and trainings in the key areas of response and emergencies. No warehouse stock with relief materials for quality and rapid response exist at national and local levels	Strengthening contingency and response plan to enable efficient action during times an emergency
Post-disaster recovery and reconstruction	The transition to early recovery activities is considered and planned for in contingency and other preparedness planning processes.	Lack the capacities and expertise in build-back-better measures.	Limited funding to support effective preparedness, response and early recovery.	A framework for post disaster recovery activities should be established, and training on post disaster needs assessment methodology should be provided to technical staff in all institutions involved in DRR and DRM.

10.2.1.3 Environmental Protection Agency-Sierra Leone

Key Areas/Themes	Current Capacities	Gaps	Reasons for Gaps	Proposed Recommendation
Priority 1. Understanding disaster risk				
Understanding of key concepts	There is a fair understanding of the concept of disaster risk	Very limited knowledge on the SFDRR	This is out of their mandate and thus is given low priority in their area of work	Develop trainings in DRR and DRM
Risk monitoring, identification and mapping	The Institution does have the GIS department that conducts regular mapping exercises and activities	Very limited technical knowledge	Lack the requisite tools and knowledge for comprehensive monitoring and mapping	Increase the capacity of in training (dedicated staff), and develop a training work plan for training to be organized across the key sectors in the institution; Make use of existing hazard maps in local planning.
Early warning – early action	No structured early warning system in place but the institution do coordinate with the government and local stakeholders in sensitizing communities on environment management to promote behaviour that reduces vulnerability and exposure to hazards,	No structured early warning system in place	N/A	Scale up awareness campaigns and activities in especially risk-prone communities
Public awareness	Raise awareness on environmental management at both national and local levels.	Information is not widespread but limited to very few people	Limited funding and human resources capacity	Scale up awareness campaigns in risk-prone communities. Mobilize funding resources for public education and increased awareness to enhance national and

Key Areas/Themes	Current Capacities	Gaps	Reasons for Gaps	Proposed Recommendation
				community level resilience building.
Training and education	The institution collaborate with various MDAs like the ONS and SLMA to organise training and educational programmes and activities across the countries.	Lack of harmonisation among the instruments, tools and institutions involved.	Limited financial resources and lack of technical capacity.	Develop a training work plan and increase the capacity and technical skills of staffs.
Priority 2. Strengthening governance and institutions to manage disaster risk				
Legislative and policy frameworks for DRR and DRM	There are regulations for environmental standards that are aligned with DRR and DRM Environment and Social Management Framework.	Insufficient and outdated national legislative frameworks	Insufficient and outdated national legislative frameworks.	Review the current thematic focus of their policies and plans to integrate DRR and DRM perspectives.
Institutional framework and coordination mechanisms for DRR and DRM	DRR and DRM are not part of EPA-SL's mandate, but provides support through technical, financial and awareness raising strategy Collaboration with other MDAs, CSOs, CBOs, NGOs, Media on environmental management.	The institution because it is not part of their mandate do not key focus in this area of DRR and DRM.	The institution because it is not part of their mandate do not key focus in this area of DRR and DRM.	Review the current thematic focus of their policies and plans to integrate DRR and DRM perspectives.
Priority 3. Investing in disaster risk reduction for resilience				
DRR and DRM mainstreaming	DRR and DRM is not mainstreamed in the institution however some key areas link with climate change is incorporated	N/A	N/A	N/A

Key Areas/Themes	Current Capacities	Gaps	Reasons for Gaps	Proposed Recommendation
	climate change adaptation and mitigation strategies and this is solely coordinated by climate change secretariat.			
Financing and investment in DRR and DRM	Mobilize finance from donors to but mainly to support climate change related project.	N/A	N/A	N/A
Local-level resilience building	Promote best environmental practices in waste management	There is still a considerable lack of awareness of the interrelated nature of human activities and the environment	Insufficient information	Strengthen community-based EWS for incorporating relevant indigenous knowledge and capacitate communities at village level to conduct community based risk assessments
Women's empowerment and gender equality	Gender mainstreaming is integrated in policies and plans along with other cross-cutting issues like youth empowerment.	Lack of women's traditional knowledge and perceptions in the analysis and evaluation of disaster risks, environmental coping strategies and solution.	Limited participation of women in DRR and DRM	Strengthen gender and social inclusion issues
Priority 4. Enhancing preparedness for effective response, and building back better in recovery and reconstruction				
Information management and communication	Maintains data on environmental quality which is shared among various MDAs.	Limited information is available.	Information is not widely circulated.	Streamline and formalized information production and sharing for increased awareness accountability and transparency.

Key Areas/Themes	Current Capacities	Gaps	Reasons for Gaps	Proposed Recommendation
Preparedness and response planning	Environmental Impact Assessment is regularly conducted and early warning messages are frequently communicated and disseminated locally and nationally.	No structured early warning system in place.	N/A	Early warning messages should be tailored to each ecological or hazard-prone zone audience.
Disaster response at local level	The institution only play a coordinating role and provide financial and logistical support but disaster response is outside of their mandate.	N/A	N/A	N/A
Emergency services	N/A	N/A	N/A	N/A
Post-disaster recovery and reconstruction	N/A	N/A	N/A	N/A

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12 APPENDIX 1: STAKEHOLDER CONSULTATIVE WORKSHOPS

12.1 Introduction

To achieve early and effective stakeholder participation in the development and implementation of the Project, INTEGEMS held four Stakeholder Consultative Workshops (hereafter, Workshops) in Freetown, Makeni, Bo, and Kenema in July/August 2017 to allow discussion of the issues that will need to be addressed and to identify potential options for addressing those issues. This section presents the outcomes of the Workshops and sets out factual information relating to the Project implementation with recommendations from the participants. Each of the four workshops involved the Project's overview, presentations and group discussions.

12.2 Facilitation of the Stakeholder Consultative Workshops

INTEGEMS, in coordination with ONS-DMD and UNDP, organised and facilitated the Workshops in Freetown, Makeni, Bo and Kenema. The ONS-DMD and UNDP were responsible for organising (i.e., publicity and invitation of stakeholders, Workshop venue hire, catering/hospitality, etc.) the Workshop, while INTEGEMS was responsible for the facilitation of the Workshop, including technical presentations and working group sessions. At the Workshops, presentations were made by various Subject Matter Experts and stakeholders directly or indirectly involved in the Project and were encouraged to share their experience and expertise with others.

12.3 Objectives of the Workshops

The objectives of the Workshops include were to:

- Present the project and proposed work plans to a wider audience and obtain their feedback on the project and draft term of reference;
- Obtain government support and commitment at the senior decision-making level;
- Convey the government's overall policy orientation/guidance for the assessment and risk profiling;
- Agree on key issues to be addressed during the assessment and risk profiling process;
- Agree on the disaster prone-areas to be covered by the assessment and risk profiling process; and
- Explore for availability of data and technical know-how about the hazard/risk assessment and profiling.

12.4 Statements by the Workshop Participants

12.4.1 Statement by the Representative from ONS-DMD

Nabie Kamara, Deputy Director – ONS-DMD

"I bring you greetings from the Office of National Security, particularly the National Security Coordinator, who is unavoidably absent due to his involvement in other state matters.

At the end of the war in 2001, Sierra Leone through a reform process called the Security Sector Reform (SSR) saw the need to rebuild the country by trying to address the underlying causes of the 11 year war. On the overall national threats that were identified, it became abundantly clear that Sierra Leone put in place a robust Disaster Management component to deal with the underlying issues of environmental shocks.

So in August 2002, the Office of National Security was established by an act of parliament with the mandate to serve as the principal adviser to the government of Sierra Leone on matters of internal security and external aggression and the coordinator of all forms of emergencies affecting the sovereign state. To deliver further on this function, the disaster management department was set up within the (ONS) in 2004, to provide the fulcrum for the domestication of the disaster management cycle which is disaster prevention, mitigation, preparedness, response, recovery and rehabilitation.

Owing to the fact that disaster management is multi-disciplinary, the (DMD) has enjoyed the opportunity of working closely with both local and internal partners in the implementation of international best practices, especially the United Nation International Strategy for Disaster Reduction (UNISDR).

The (UNISDR) through global consensus with a battery of experts set up (5) main thematic areas to deal with disaster risks. This strategy started with the Hyogo framework for action (2005-2015) that has now been transformed to the Sendai Declaration for Resilience and Building Back Better (2015-2030)."

12.4.2 Statement by the Representative from UNDP

Tanzila Sankoh, Acting Team Leader EENRM, UNDP

"Representatives of the Ministry of Transport & Aviation; Mr. Gabriel Kpaka, Sierra Leone Meteorological Agency; Mr. Deputy Director, Disaster Management Department, Office of National Security; Representative of the Ministry of Water Resources; Representatives of Government of Sierra Leone Ministries, Departments, Agencies and International Development Partners; Distinguished Ladies and Gentlemen…

Let me hasty to apologize on behalf of the Country Director who is unavoidably absent. He is currently attending the land policy conference which is also supported by UNDP in collaboration with other development partners and he has kindly asked me to represent him. I am Mrs. Tanzila Watta Sankoh and I am the Acting Team Leader for the Energy, Environment and Natural Resource Management.

I am very pleased to be with you today for the start of efforts to review Sierra Leone's national hazard profile and assess capacity gaps for managing natural hazards in Sierra Leone. I convey the continued commitment of the United Nations Development Programme (UNDP) to this important activity, which marks the continued progress that Sierra Leone is making towards becoming more resilient to the impacts of global climate change.

The workshop today builds on the installation of 8 new automatic weather stations and hydrological monitoring equipment in 5 waterways; training of hydrological and meteorological professionals in meteorology, watershed monitoring and hydrological modeling and development of a Climate Information, Disaster Management and Early Warning Systems (CIDMEWS) online web portal, all geared towards ensuring that Sierra Leoneans are able to benefit from daily weather forecasts on the radio, television, and in newspapers by the end of 2017. These have marked the beginning of a new chapter in making available and communicating real-time and reliable climate and early warning information for the country.

The review of Sierra Leone's hazard profile, which will clearly show the common hazards, their peculiarities, regions of occurrence, impact and vulnerability per population, and how they can be managed is part of a regional initiative on Strengthening Climate Information and Early Warning Systems for Climate Resilient Development and Adaptation to Climate Change Project, in which ten other African countries also take part. The initiative is financed by the Global Environment Facility (GEF), with support from UNDP and implemented by the Ministry of Transport & Aviation in partnership with the Office of National Security, the Sierra Leone Environment Protection Agency, the Ministry of Water Resources, and other partners.

We cannot overemphasize enough the importance of mapping out hazard-prone areas; identifying and assessing exposures, vulnerability and risk of people, property, critical facilities, infrastructure and economic activities to those hazards prone areas; and creating national multi-hazard profile. In recent years, Sierra Leone has experienced impromptu and torrential rainfall and attendant flooding in the Western Area and the vulnerable areas in the country's 3 provinces. Other hazards experienced include drought, extreme temperature, wild bushfires; landslides, disease outbreaks, low agricultural productivity etc., often with devastating impacts. These serve not only as stark reminders of how powerful climate related impacts can be, but emphasizes the need for feasible strategies, developed based on reliable information, for managing such hazards.

Additionally, the outcomes of this workshop and in broader picture the reviewed national hazard profile review are expected to positively influence decisions for future investments in disaster risks management in Sierra Leone. This, in turn, is expected to strengthen Sierra Leone's capacity to adapt to climate change impacts, and also in greater resilience of the country from expected climate related shocks.

This will be critical for sectors such as agriculture, water and sanitation, hydropower, and aviation facilities, which are among the sectors that are most vulnerable to extreme weather events, and will be *hit the hardest by the impacts of climate change. As a whole, climate change has the potential seriously to impede progress made towards economic and social independence as well as security. Review of the national hazard profile and assessing capacity gaps for informed decision making is part of preparation for and responding to such impacts by Sierra Leone. This will be crucial in protecting vulnerable population groups, in helping vulnerable sectors plan ahead, and in enabling the country as a whole to prepare for, and adapt to the impacts of climate change.*

I would like to take this opportunity, on behalf of the UNDP, to commend the Ministry of Transport and Aviation, and its Meteorological Agency, the Office of National Security, The Sierra Leone Environment Protection Agency and the Ministry of Water Resources for their continued efforts in contributing to making Sierra Leone and its people more resilient to the local impacts of global climate change.

Also, let me cease this opportunity to congratulate the Sierra Leone Meteorological Agency on becoming a semi-autonomous agency. We look forward to continued working relationship in order to deliver on your national mandates in an efficient and timely manner."

12.4.3 Statement by the Representative from Sierra Leone Meteorological Agency

Gabriel Kpaka, Deputy Director – Sierra Leone Meteorological Agency

"Mr. Chairman, Representatives from UNDP, ladies and gentlemen; I greet you all. The Science of attributing extreme weather and climate events has progressed in recent years, to enable an analysis of the role of human causes. The Weather seems to be getting wilder and weirder.

And People are noting:

- *What are the connections to human-caused climate change?*
- *And how can we best communicate what the most recent science is telling us about human-induced and natural change to weather and climate?*

When heavy rains led to devastating floods in 2015 in Freetown, the Minister of Transport and Aviation, Hon. Leonard Balogun Koroma aka Logus stated that he is "very much convinced" that the flood was linked to climate change. A Scientific analysis had concluded that climate change had increased the chances of rainfall that caused flooding by an estimated 43% globally (Schaller et al 2016). The fact is that warmer air holds more moisture, which generally lead to heavier rainfall.

The potential for damage from such extreme events is also increasing, as higher river levels put more properties at risk from flooding. In Niger, dry season of 2013 was hottest on record. The 2015 flooding, heat wave and the recent strong wind are just recent extreme events that the SLMET and regional MET Agencies have determined that, they were considerably more likely to occur due to human-caused climate change. Also, heat waves and heavy downpours are among the classes of extreme events that tend to be more frequent and or more severe in a warmer world.

The IPCC in its 2012 report on extreme wrote: "A changing Climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather and Climate events, and can result in unprecedented extreme weather and Climate events"

Mr. Chairman, Ladies and gentlemen, a key function of the SLMET is to "provide meteorological information, early warning for agriculture, civil and military aviation, surface and marine transport, operational hydrology and management of energy and water resources, in order to mitigate the effects of natural disasters such as floods, storms, droughts and disease"

But I must confess this had been very challenging for SLMET after the decade civil war. But with funding from the Global environment facility through IFAD and UNDP, The SLMET is now on good footing to perform some of its key function.

Mr. Chairman, Ladies and Gentlemen, I am pleased to inform you that the GEF funded project through UNDP (which is the CIEWS-project) have installed 8 AWS, trained 2 staffs as Chartered Meteorologist and will be training 8 mores staffs, reconstruction of the MET head quarter and the Tower hill forecasting studio.

Nonetheless, it is my greatest honor to be part of this consultation workshop on the "Update of Sierra Leone Hazard Profile and Capacity Gap Analysis Project" as: Scientific findings that specific extreme weather and climate events which are attributed to human-caused climate change, have not been widely reflected in public understanding.

Thank you all."

12.5 Workshop Presentations

12.5.1 Presentation 1: INTEGEMS

Topic: Project Approach Methodology and Management

Julius Mattai, Principal Consultant – INTEGEMS

The presentation by Julius Mattai included an introduction of INTEGEMS Consultancy, the Project overview including its objectives, scope, methodology, work plan and deliverables. The introduction of INTEGEMS included presentation of key information on the background and core areas of expertise and competencies of the consultancy.

Mr. Mattai provided a narrative to the background of the Project emphasizing the key objectives for the Update of the Sierra Leone's Hazard Profile and Capacity Gap Analysis. He highlighted that the main aim of the Project is to build a national risk profile of Sierra Leone, with an understanding of the fundamentals of hazard and risk identification, assessment, modelling and mapping, including exposure, vulnerability and institutional capacity assessment.

He added that the project will also develop and implement user-friendly hazard and disaster risk profiles and a National Risk Information System for Disaster Risk Reduction and Disaster Management in Sierra Leone. He stated that at the successful completion of the Project, the MDAs and institutions will be expected to integrate the National Hazard Profile into national and local development plans.

Listing the key Project partners which are ONS-DMD, EPA-SL, SLMA and the MWR he stated that the primary responsibility for successful implementation depends on the coordination amongst these ministries but also with other stakeholders who are directly or indirectly involved with the Project. He outlined the scope of work and went on to briefly explain the Project approach and technical methodology, which he noted is divided into four key phases as listed below;

- **Phase 1:** Project planning, documents review and stakeholder & capacity gap analyses
- **Phase 2:** Field data Collection and hazard mapping and profiling
- **Phase 3:** Exposure, Vulnerability and Risk Assessment
- **Phase 4:** National Risk Profile Mapping and Reporting

Furthermore he presented a more technical perspective of the methodology with keen focus on the design, development and implementation of the integrated information System – HARPIS-SL. He pointed out that the HARPIS-SL will integrate GIS, Management Information System (MIS), building partnerships and gender mainstreaming. He explained in detailed the proposed mechanism INTEGEMS is using in the capacity gap assessment taking into consideration the deficiencies of the 2004 NHAP.

He presented the 2004 Hazard Profile specifically highlighting the deficits and inadequacies particularly with regards classification of the hazards. Mr. Mattai specifically spoke on the prevalent hazards in Sierra Leone with references to the various hazard assessment and profiling parameters (frequency, magnitude, duration, and areal extent, and spatial predictability, speed of onset, importance and spatial desperation). He concluded by emphasizing on the need for all stakeholders to coordinate to make this project a success and presented a couple of photo plate slides of common disasters in Sierra Leone.

12.5.2 Presentation 2: ONS-DMD

Topic: The Sendai Framework for Disaster Risk Reduction 2015-2030: Sierra Leone's approach for Implementation

Nabie Kamara, Assistant Director – ONS-DMD

Nabie A. Kamara, Deputy Director of ONS-DMD delivered his presentation on the Sierra Leone's approach for the implementation of SFDRR. In his introductory statement he made mention of four key issues including; sharp global increase in the number of occurrence and frequency of disaster events during 2010-2015, heightened effects of climate change on ecosystems and investments, world leaders

(UN) considering the state of affairs worrisome, initiated global discussions to emerging problems, the UNISDR forum from assessing states' progress on DRM.

His presentation focused on six sub topics with regards to the implementation of the SFDRR, including:

- SFDRR as a successor to HFA;
- The goal of the SFDRR;
- The seven targets of the SFDRR;
- Priorities for Action;
- DRR priorities at National Level; and
- Challenges in implementing the SFDRR.

Referring to the adaptation of the SFDRR at the 3rd UN World Conference in Japan on the 18 March 2015, he highlighted the guidelines for disaster prevention, preparedness and mitigation and mechanisms to monitor implementation through national focal points. He noted that the aim is to look into the domestication of international best practices of Disaster Risk Management (SFDRR) by the ONS-DMD.

Nabie Kamara highlighted the goals of the SFDRR, which he stated are to:

- Emphasize a paradigm shift from disaster management to disaster risk management from reactive emergency relief to proactive DRR;
- Prevent new, and reduce existing risk and to strengthen resilience to natural and man-made hazards, in order to achieve reductions in disaster losses; and
- And understanding the nexus of risk hazards vulnerability and exposure.

He highlighted the seven key targets and four core thematic areas of the SFDRR, which include: (i) Understanding disaster risks; (ii) Strengthening Disaster risk governance to manage disaster risk, (iii) Investing in disaster risk reduction for resilience; and (iv) Enhancing disaster preparedness for effective response and to 'Build Back Better' in recovery, rehabilitation and reconstruction.

He also elaborated on Sierra Leone's Disaster Management Strategy which he informed the audience looks forward to the next 5 years (2016-2021). Nabie Kamara made references to the strategy's direction providing agreements on the overarching end goal of the department and the strategy's 6 components and their interrelations. The components as he highlighted include:

- Implementation of risk identification, assessment and surveillance and multi-hazard early warning systems across the country;
- Coordination and monitoring of robust preparation and mitigation activities for priority hazards;
- Coordination of both response planning and execution planning across MDA's and partners for priority Hazards/locations;
- Strengthening the capacity of the disaster management department, training new staff and embedding new processes;
- Strengthening ability of key MDAs to run a tactical response with training and simulation programs for priority hazards and finally; and
- Implementation of robust data and information management systems and use data for decision making.

In conclusion, he presented the challenges hampering the effective implementation of the SFDRR. These he stated, include inadequate local capacity of understanding risks and changing patterns; inadequate risk financing investment opportunities; weak or lack of mainstreaming of DRR and Climate Change Adaptation (CCA) strategies; and lack of robust and effective early warning information systems.

12.5.3 Presentation 3: EPA-SL

Topic: The Role of effective Environmental Management Systems for Disaster Risk Reduction-

E. Baines Johnson, Policy Advisor – EPA-SL

Mr Baines Johnson in an introductory statement said that disaster risk development and environmental disasters are not random, but their occurrence are the convergence of hazard and vulnerable conditions. He highlighted that disasters not only reveal underlying social, economic, political and environmental problems, but unfortunately contribute to worsening them. Such events he mentioned pose serious challenges to development, as they erode hard-earned gains in terms of political, social and educative progress, as well as infrastructure and technological development.

Given the definitions and descriptions of specific environmental terms, he clearly distinguished the difference between environmental risk and ecological risk, in which he stated that environmental risk arises from the relationship between humans and human activity and the environment where as ecological risk deals with risk associated with past, present and future human activities on flora, fauna and ecosystems. He added that ecological risk is a sub-set of environmental risk management.

Presenting on the nexus between environmental sustainability and disaster risk he alluded to the SDGs which triangulates Man, the Environment and Development. He stated that there is no dispute that development and disasters are connected, but the multi-dimensional role of environment has caused considerable confusion. He noted that, while it is often recognized that ecosystems are affected by disasters, it is forgotten that protecting ecosystem services can both save lives and protect livelihoods. The following framework maps five pathways that connect environment to disaster risk – and ultimately link environmental management to disaster risk reduction.

He mentioned that risks and disasters that stem from poor environmental management pose a serious challenge to sustainable development and that this concern has attracted the attention of the global community in intensifying collective efforts to reduce the number and effects of both natural and man-made disasters. He reiterated that climate change increases environmental degradation and loss of natural defences as drivers of disaster risk. However, he added that appropriate risk assessment and management will address immediate and long-term impacts.

Baines-Johnson, stated that, many ecosystems, if intact and/or well managed, act as natural dynamic barriers that absorb the force of certain hazards, protect vulnerable communities and their assets while at the same time preserve local biodiversity and encourage ecological productivity.

Highlighting some of the challenges in Sierra Leone particularly the Western Area, he noted that demographic explosion and the sprouting of new settlements have triggered the reoccurrence of disasters. He added that, human activities have an impact on the timing, magnitude and frequency of these events, which have triggered global warming and thereby affected the frequency and intensity of extreme climate events.

The EPA-SL Policy Advisor reiterated the need to strengthen coordination and collaboration among key stakeholders such as the MLCPE, SLRA, FCC, MWHID, and EPA-SL for sustainable environmental management and risk reduction.

During his presentation he emphasized the need for sound environmental management as it plays an important role in reducing many of the risks and challenges posed by natural hazards.

Mr Baines concluded that in order to respond to all these challenges there is need for:

- Developing Healthy ecosystems to provide natural defenses;
- Fully engaging environmental managers in national disaster risk management mechanisms;
- Utilizing local knowledge in community-based disaster risk management;
- Engaging the scientific community to promote environmental research and innovation;
- Considering environmental technologies and designs for structural defenses
- Increase level of education and awareness;
- Addressing non-compliances raised in the environmental risk assessment; and
- Encouraging eco-friendly innovations and increase recycling efforts.

12.5.4 Presentation 4: MWR

Topic: Hydrological hazards and disaster risk reduction

Ishmail Kamara, Water Analyst – MWR

Ishmail Kamara started his presentation with a quick overview of the hydrological status of the country in DRR perspectives focusing on mitigation, preparedness and response. In his overview he mentioned that the main hydrological monitoring infrastructure was destroyed during the civil war and that the growing population and developing industry (mining and commercial agriculture) are adversely affecting that which is left in the country.

He noted that the country has suffered from past over-estimates of renewable water resources and that monitoring and managing water resources is fundamental to the nation's water security. He highlighted that the desired situation will be to; effectively manage land and water resources at transboundary, national and local levels; continuously assess the water availability, monitor data that inform decisions on water allocation and ensuring that there are robust laws and regulation in place.

The MWR Water Analyst, noted that clearly defined roles and responsibilities at multiple levels and improvements in water supply infrastructure and early warning systems are also key areas to integrate for effective management.

He presented a snapshot of the main river basin in the country drawing attention to the Sierra Leone Water Security project as one of the major projects that has been implemented in the ministry. According to Ishmail, the project lays the foundations for establishing water resources management activities in Sierra Leone and assists in enacting national water resources legislation which will support the creation of a water resources management agency with regulatory functions. He added that the project is also intended to offer education and guidance to stakeholders whose activities impact on surface and ground water resources. Maps and snapshots of the Middle catchment, Bumbuna HEP, Tonkolili Iron Ore Mining Site, Lower catchment, Addax water abstraction, Gauging river flows, Monitoring springs and streams were included in his presentation.

According Ishmail, the key outcomes of their work include: Reestablishment of hydrological monitoring in Sierra Leone; providing guidance for the establishment of national monitoring networks; increased understanding of local hydrology; and collaboration with a wider range of stakeholders and pragmatic & realistic approach developed for water security planning.

He drew the audience's attention to a list of more projects that have been implemented by the MWR, including:

- The Early Warning System and Climate Adaptation Project-UNDP/GEF project;
- Training of MWR staff in Nigel on hydrological monitoring;
- The Assessment of all hydrological stations in Sierra Leone; and
- Procurement of monitoring equipment from Sutron (SW, GW and P).

He further mentioned that the Ministry is in the process of installing 15 SW and 13 GW stations across Sierra Leone. Ishmail also presented a map showing hydrological monitoring stations across the country. In concluding his presentation, he mentioned the strategies the ministry intend to put in place for effective hydrological monitoring emphasizing on four key areas, which include: obtaining long term data to understands pattern of rainfall intensity and duration; establishment of EWS to help mitigate the impacts of floods; community empowerment and climate change resilience at the community levels; and improve coordination with stakeholders on disaster response

12.5.5 Presentation 5: Sierra Leone Meteorological Agency

Topic: *Meteorological hazards and disaster risk reduction*

Gabriel Kpaka, Deputy Director – Sierra Leone Meteorological Agency

Mr. Gabriel Kpaka in his presentation gave a background introduction of the Sierra Leone Meteorological Agency with a special focus on some meteorological instrument, the agency's forecast reporting cycle for public disaster management, meteorological hazards, and some natural disasters.

He stated that the Agency (then Sierra Leone Meteorological Services) had its beginning in 1827 as part of the British West Africa Meteorological Services, whose headquarter was in Sierra Leone, with the responsibility of monitoring weather patterns and providing necessary information to the public. He highlighted that in June 1938, the Sierra Leone Meteorological Services (SLMS) became an independent body and was renamed *Sierra Leone Meteorological Department*. Gabriel added that the Meteorological Department has just been upgraded into an agency – now the Sierra Leone Meteorological Agency.

He mentioned some key parameters such as rainfall, dew point, and sunshine which they use to execute forecast. He clearly pointed out that meteorological hazards can be single, sequential or combined in their origin and effects; and identified some meteorological hazards like droughts, storm surges, thunder/hailstorms, rain and wind storms, cyclones, blizzards and other severe storms, desertification, wildfires, extreme temperatures, sand or dust, snow, and some natural disasters like flooding, winter storms, and wildfires.

In conclusion, the Deputy Director of the newly upgraded Agency recommended some flood risk management strategies and encourages the public to stay safe

12.6 Thematic Working Group Sessions in Freetown (26 July 2017)

Having gone through the technical methodology presentation and the guidelines, it was prudent to give the participants a platform to discuss and comment on the findings and recommendations for the update of the national hazard profile, including recommendation to address identified gaps. After each group session, participants were handed a leaflet with information on the key concepts and terminologies to help them get a clear understanding of the topic and to enable them participate fully and make valuable contributions. At the end of the group sessions, a participant from each group was selected to present their inputs and provide feedback from the group discussions. The Workshop facilitators provided the concluding remarks.

12.6.1 Thematic Working Group 1

Topic 1: *Understanding disaster risk in Sierra Leone in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment.*

No	Name	Institution
1	Samuella Faulkner	INTEGEMS Facilitator
2	Kenneth V.S. Koker	INTEGEMS Facilitator
3	Amilia Conteh	INTEGEMS Facilitator
4	Ibrahim Aziz Bangura	INTEGEMS Facilitator
5	Nabie A. Kamara	Office of National Security (ONS)
6	Christopher Harding	Sierra Leone Meteorological Agency
7	Marilyn George	SALWACO
8	E-Baines-Johnson	EPA-SL
9	Alie Kabba	Guma Valley Water Company (GVWC)
10	Alimamy Kargbo	National Fire Force, Sierra Leone
11	Samuel Turay	Ministry of Transport Aviation
12	Zainab Jay	MLCPE
13	Janneh A James	World Food Programme

In line with the topic of discussion, this group focused on three important areas;

- Understanding hazard and disaster risk;
- Elements/drivers of disaster risks; and
- Impact of hazards/disasters

The group discussed the main trends of disaster risk at the national, regional and local levels. They were able to give a detailed list of all the known hazards that are prevalent in the country citing specific disaster prone locations (Mountain Rural District, the Peninsular, Aberdeen Creek, Kroo Bay and

Susan's Bay…) They further went on to explain the key concepts of DRR and DRM specific to Sierra Leone context. Flooding, landslides, mudslides, erosion, drought, sea level rise were amongst the list of many recognized hazards highlighted. The level of detailed information provided demonstrated a core strength in their knowledge of disasters and risk.

Participants discussed a number of elements and drivers of risk with keen focus on factors of exposure and vulnerability. Vulnerability in the broad sense as defined by the participants are the underlying causes and unsafe conditions that makes an individual or community predisposed to be affected (suffer damage and loss of lives) by different hazards. Some of the factors of vulnerability identified include age, gender, socio-economic status, economic systems, physical environment, disability, lack of appropriate information, population growth, and inappropriate urban development amongst others.

People differ in their exposure to risk as a result of their social group, gender, ethnic and other factors. Elements of exposure listed were people, property, systems, and other elements present hazard zones that are subject to potential losses. They emphazised the need to understand vulnerability and exposure as these factors together increases the overall risk.

The lack of urban planning, deforestation and improper waste management were identified as key causative factors for increased vulnerability and risk in Sierra Leone particularly in Freetown. These areas of concern are the biggest challenges faced in effectively implementing DRR and DRM. Participants strongly expressed that to effectively and successfully implement DRR and DRM, there should be a strong political will and commitment from all sectors. In conclusion, the participant's emphazised the need to update the current state of data and to increase the knowledge and technical capacity on disaster risks reduction

12.6.2 Thematic Working Group 2

Topic 2: *Strengthening disaster risk governance to manage disaster risk in Sierra Leone at the national, regional and local levels in all sectors; define roles and responsibilities; and ensure the coherence of laws, regulations and public policies.*

No	Name	Institution
1	Mansa-Musa Kamara	INTEGEMS Facilitator
2	Mamoud Mansaray	INTEGEMS Facilitator
3	Louisa Mattai	INTEGEMS Facilitator
4	Hafisatu Sillah	INTEGEMS Facilitator
5	Ishmail Kamara	Ministry of Water Resources (MWR)
6	Olaimatu S Karim	Ministry of Water Resources (MWR)
7	Duramani K. Sesay	Sierra Leone Maritime Administration (SLMA)
8	Sheku Alaka T. Mansaray	Building Resilience Across Communities (BRAC)
9	Fonigay Lavahun	Food and Agricultural Organisation (FAO)
10	Gabriel Kpaka	Sierra Leone Meteorological Agency

In this session participants had a chance to discuss key focus areas in line with priority 2 and 3 of the Sendai Framework:

- Strengthening disaster risk governance at national, regional and local levels;
- Roles and Responsibilities of Entities involved in Disaster Risk Management; and
- Understand how disaster risk reduction can be integrated into development planning.

The participants have a good knowledge of the key players in DRR and DRM in Sierra Leone with ONS having the sole mandate for the coordination of all DM initiatives and activities. There were uncertainty with regards to the functions, roles and responsibilities of various stakeholders in implementing the Sendai Framework, including responsibilities for undertaking specific activities, as designated in the disaster management policy and plans. However, some other institutions and organisations involved in DRR and DRM were also listed making references to specific work done and contributions in DRR and DRM. Amongst the list of institutions are BRAC, SLMA, MWR, SLMET MSWGCA and FAO. These institutions do contribute in their respective areas of interest ranging from prevention, mitigation, preparedness and response. There are obviously overlaps in some areas but the key focus is to ensure that there is substantial capacity for resilience in every phase of DM.

The effective implementation of the Sendai Framework requires an integrated approach that recognises the roles of the various stakeholder groups at regional, national and local levels. Thus participants strongly recommended the following actions and mechanisms:

- Integrated and collaborative approach to DRR and DRM across disciplines, and policy sectors in order to achieve the outcome of the Sendai Framework for Disaster Risk Reduction.
- Increased political commitment and social demand for disaster resilient and sustainable development.
- Increased engagement of national actors in the field of national development and planning with the DRR and enhance country planners and decision makers' ability and commitment to promote DRR and DRM through relevant systems, policies and processes.
- Implementation of all-hazards approach that incorporates natural and mad-made hazards and incorporating all elements at risk will is required
- Draft Road-map to align DRR and DRM with development priorities.
- Gender mainstreaming in every phase of policy development and DRR and DRM
- Strengthen community-based EWS for incorporating relevant indigenous knowledge and capacitate communities at village level to conduct community based risk assessments.
- Provide a platform to exchange in-depth learning from experts in working with local governments to undertake local government self-assessment and develop city resilience action plan.

12.6.3 Thematic Working Group 3

Topic 3: *Institutional capacity gaps and capacity building needs in Sierra Leone for prevention, mitigation, preparedness, response, recovery, rehabilitation and reconstruction*.

No	Name	Institution
1	Koinguima Baimba	INTEGEMS Facilitator
2	Prince Kemoi	INTEGEMS Facilitator
3	Malal Jalloh	INTEGEMS Facilitator
4	Joseph Kaindaneh	UNDP
5	Dr. Victor Kabba	Njala University
6	Christopher Harding	Sierra Leone Meteorological Agency
7	Ronald Turay	Office of National Security
8	Theresa Williams	MMMR
9	Momodu	RSLAF
10	Andrey J Kamanda	SLRCS
11	James A Medo	Ministry of Transport Aviation
12	Gbangay Kanu	MSWGCA

The group covered topics on:

- Institutional capacity gaps in Sierra Leone for prevention, mitigation, preparedness, response, recovery, rehabilitation and reconstruction; and
- Institutional capacity building needs in Sierra Leone for prevention, mitigation, preparedness, response, recovery, rehabilitation and reconstruction.

During this session participants had a chance to identify the institutional capacity gaps and propose solutions and recommendations for improvements. The prominent institutional gaps highlighted are:

- Lack of/ limited knowledge of DRR and DRM;
- Lack of required skills and technology for implementation;
- Lack of coordination among the MDAs and weak governance; and
- Lack of existing training and education mechanisms.

Based on the above findings, in the institutional capacity gaps the participants identified key priority actions that need to be undertaken immediately to strengthen DRR. These include:

- Raising awareness and improving understanding of disaster risks and their impact;
- Promoting the mainstreaming of disaster risk reduction and disaster risk management into planning and other policy development and implementation;
- Developing, maintaining and innovating technology for people-centred, low cost early warning systems and emergency communication mechanisms;
- Increasing knowledge of disaster risk by training, sensitisation and capacity development programmes; and
- Implementing robust policy and legal frameworks.

In conclusion, participants also emphasised on the necessity of an emergency fund to enable effective and timely response to disasters. Mobilisation of additional resources to support emergency fund by country authorities in their respective communities by involving the private sector organisations in their DRR activities.

12.7 Summary of Contributions and Recommendations

12.7.1 Freetown Stakeholders Consultative Workshop (26 July 2017)

12.7.1.1 Contributions and Comments

There was a clear understanding on the hazards and disasters in Sierra Leone. Participants were able to give a detailed list of all the known hazards that are prevalent in the country as well as explaining the key concepts in Disaster Risk Reduction and Disaster Risk Management in the Sierra Leone context. Flooding, landslides, mudslides, erosion, drought, sea level rise were amongst the list of many hazards highlighted. The level of detailed information provided demonstrated a core strength for the successful implementation of the Project.

Furthermore, the participants identified the negative impacts of disasters emphasizing on the main factors of vulnerability and exposure which poses the biggest challenge in managing hazards and disasters in Sierra Leone. The negative impacts identified centred mainly the lack of urban planning, deforestation and lack of proper waste management amongst others. The fact that there are no proper and sustainable measures in place to effectively manage hazards and disasters pose a big threat to the communities. Participants were also able to list all the known disaster prone areas in Freetown particularly in the western urban area. This included the deforested Mountain Rural District, the Peninsular, Aberdeen Creek, Kroo Bay and Susan's Bay amongst others.

Under the topic of disaster risk governance, the general consensus was that there is lack of political will and commitment in implementing DRR and DRM strategies. They mentioned good governance and economic incentives as some of the several ways of creating political will to sustain efforts in disaster risk reduction.

In discussing the capacity gaps and capacity needs, the participants generally noted this area as one of the biggest challenge generally in the nation and specially in addressing DRR and DRM in Sierra Leone. The benefits of capacity building should be made clearer and more tangible to key decision makers.

12.7.1.2 Recommendations

The following are the recommendations gathered from the group discussions:

- Strengthening disaster risk governance at the national, regional and local levels for effective management of disaster risk reduction in all sectors. This will ensure the coherence of national and local frameworks that guide, encourage and incentivize the public and private sectors to take action and address disaster risk.
- Proper coordination mechanisms to properly address disaster risk in all facets or dimensions. This include defining and clarifying roles and responsibilities of various parties involved, and establishing links with MDA'S development partners and other relevant institutions.
- Increasing public accountability by strengthening local-scale democracy including decentralisation of DRR-related activities.
- Education and preparedness programmes, this play a key role in disaster management thus the participants emphasized the necessity for disaster management plans to be in place and ensure that they are tested and well-practiced to suit the Serra Leonean context.
- Strengthening political will and commitment for improved governmental action for DRR and DRM by joining forces among different interest groups, creating alliances among those working on issues such as social justice, poverty, environmental protection, climate change, and food security.
- Community engagement and capacity building of local authorities/communities. Raising critical awareness of disaster risk amongst vulnerable people and 'social demand' for risk reduction measures. This will increase community resilience thus reducing the impacts of disasters.
- Build and strengthen institutional capacity in the respective institutions by providing the technical support and the necessary resources to address DRR and DRM.
- Undertaking research to demonstrate the value of DRR investments.

12.7.2 Makeni Stakeholders Consultative Workshop (15 August 2017)

12.7.2.1 Contributions and Comments

Participants discussed their understanding of disaster risk by first defining a disaster as an occurrence induced by man that interferes with the environment leading to loss of lives and properties. They further discussed the different components or factors of disaster risk outlining people, services, infrastructure and livelihoods as elements at risk, with women, children, physically challenged and the aged as most vulnerable.

In classifying the hazards, participants listed the various hazard occurrences along with hazard prone locations within the northern region of the country. They identified some disaster prone areas as follows:
Rock Fall: Cow Yard (Kabala); Mena Hill (Makeni); One mile (Kabala) and Wara wara hill (Kabala), mud slide, rock fall; Wind storms and bush fire: Gbandakarifai, Koinadugu district
Rock mining: Wusum hills, Makeni; Flooding: Hydroelectric dam, Bumbuna and Mining in Laminaya, Bombali. They emphasized the need for urgent assessment and action to be taken to prevent massive destruction and loss of life.

12.7.2.2 Recommendations

Many of the recommendations are aimed at improving the institutional and capacity gaps which the participants feel are the areas of priority in DRR and DRM. The following are the recommendations that participants feel will address the issues of disaster risk in their communities.

- Develop a robust early warning system that will provide timely and relevant information.
- Develop a disaster preparedness and mitigation plan in the Northern Province context.
- Involvement of the local communities in DRR and DRM process that will help make valuable contributions in decision-making.
- Improve on preparedness and mitigation plan by enforcing bylaws for DRR at community levels.
- Align incentives promoting disaster cost reduction and resilience.

- Enable resilient recovery and support disaster risk reduction nationally.
- Assessing the threat of rising floodwaters; which requires analysis of real-time stream gage data, modeling river basin and channel hydraulics, predicting the ability of levees and other defense structures to contain the flow, and anticipating problems.

Rapid information integration would also be of critical value in predicting or responding to environmental problems caused by a natural hazard

12.7.3 Bo Stakeholders Consultative Workshop (16 August 2017)

12.7.3.1 Contributions and Comments

Presentation on the methodology and scope of work was done by INTEGEMS which was followed by a round table discussion. Participants expressed varied views and opinions on the different topics presented to them. Starting with the understanding on disaster risk, participants highlighted all the hazards and risk facing their communities in the southern region of the country.

The group approached the exercise from the starting point of explaining the concept of DRR and DRM particularly in context to their region and listing all the known hazards and disaster prone areas in the Southern Province. Participants highlighted flooding (mainly in Bonthe and Bo Districts) as the major threat, deforestation (Bo and Pujehun District,) sea level rise (Bonthe Island), bush fire (all four districts in the south), pest infestation (all four districts in the south) and mining (Rutile mining sites in Moyamba and Bonthe Districts) amongst others.

In terms of disaster risk governance, the key point identified by all related to lack of political will and commitment in addressing DDR and DRM. Economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional measures are all hinged on political will and commitment to increase preparedness and thus strengthen resilience.

There was a clear commonality on the impacts of the hazards and disasters as well as the factors responsible for the negative impacts. These included bad practices like deforestation and improper waste management. Lack of information and awareness was also listed as factors for increased negative impacts.

Participants also discussed the importance of inclusive and integrated education for DRR and DRM. Once potential hazards, vulnerabilities and exposure have been identified, it is important that the communities within the region understand the risk involved and the impacts so that they are able to conceptualize and take the necessary measures in addressing the potential risks. Women, children, physically challenged, illiterates, and the aged were listed as the most vulnerable groups in disaster risk.

12.7.3.2 Recommendations

Based on their understanding of hazards and disaster risk, participants were able to identify and suggest priority mitigation actions to address these potential risks. The following recommendations were made by the group.

- Restructure the national policy on DDR AND DRM reflecting the holistic approach involving preparedness, mitigation (pre-disaster) with appropriate funding, along with the far extent policy of the post-disaster relief and rehabilitation.
- Develop an early warning system for all and increase the number of participants in disaster education programs.
- Invest in disaster preparedness measures and mechanism in all dimensions.
- Develop comprehensive planning processes between public and private sectors to address the needs in disasters
- Effective decentralisation to ensure full participation of local communities in all phases of DRR and DRM.

12.7.4 Kenema Stakeholders Consultative Workshop (17 August 2017)

12.7.4.1 Contributions and Comments

Following the presentation by INTEGEMS, participants first discussed the concept of disaster risk, particularly with reference to the Eastern Region. Participants in this region clearly understand their communities in the context of DRR and DRM. This was demonstrated by first listing all the known hazards prevalent in their communities. Weather-related hazards such as flooding, drought and windstorm were listed as the most prominent of all hazards and participants stated that these hazards affects almost all the Districts in the Eastern Region. Other hazards such as fire (wild and bush), pitfall, landslide, epidemic, political violence, social conflict, thunder and lightning, wild animals and pest infestations do have local variances and pose relatively high threat to the communities.

For each identified hazard the following disaster prone areas were recorded:

- **Flooding:** Kakajama Dam Gbo-lambayama, Kpetewoma Foindu Mamiema Largor town (Kenema); Segbwema, Sandru-Pengua (Kailahun);
- **Landslide:** Kambui Hills Chemadu, Kaiewa, Koima, Konero Hill along Tongo road Lomabu Boajibu (Kenema);
- **Windstorm:** Chemadu, Kaiewa, Koima, Konero (Kenema);
- **Fire:** Nyanadama;
- **Land conflicts:** (almost all regions in the Eastern Province); and
- **Mining**: (Koidu, Kono and almost all regions in the Eastern Province).

Participants underlined exposure and vulnerability as the key elements of disaster risk because the severity of the impacts of hazards and disasters depends strongly on the level of vulnerability and exposure to these events. They emphasized the importance of understanding how the nature of vulnerability and exposure contribute to the occurrence of disasters.

Individuals, communities infrastructure, services, ecosystems, livelihood and technology are differentially exposed and vulnerable and this is based on factors such as age, gender, education, wealth, race/ethnicity/religion, social status, class/caste, disability, and health status. Lack of resilience and capacity to anticipate, cope with, and adapt to extremes and changes were also listed as important causal factors of vulnerability.

12.7.4.2 Recommendations

There are many approaches and tools used to implement disaster risk reduction successfully. Most of these approaches would yield similar results if implemented well. Each approach has its strengths and weaknesses. A combination of the different suggestions and recommendations put forward by the participants are listed below:

- Early warning systems to be integrated in our daily scope of work as environmentalists.
- Strengthening institutional capacities for DRR and DRM at national and decentralized levels.
- Community-based and participatory disaster preparedness and risk assessment for DRR and DRM activities.
- Operationalizing the paradigm shift from reactive emergency relief to pro-active DRR and DRM measures.
- Conduct comprehensive assessment approach that should include risk beyond natural hazards (e.g. conflict).
- Enhance the proper education, information and awareness at community levels.
- Make available standing fund for immediate response to disasters.
- A nationwide review and proper monitoring of the leadership of the DDMC's.
- Build local capacity and resilience in particularly in those areas of growing exposure and vulnerability.

12.8 Annexes

12.8.1 Workshop Agenda

Time	Activity	Owner
09:30 to 10:00	Arrival and registration of participants	INTEGEMS
PART 1: INTRODUCTION AND STATEMENTS		
10:00 to 10:20	Official Opening – Prayers and welcome 1. Introduction of Chairperson 2. Chairperson's opening statement	INTEGEMS
10:20 to 11:00	**Official Opening Statements** 3. Representative, Office of National Security-Disaster Management Department (ONS-DMD) 4. Representative, Sierra Leone Meteorological Department (SLMD) 5. Representative, Environment Protection Agency-Sierra Leone (EPA-SL) 6. Representative, Ministry of Water Resources (MWR)	
11:00 to 11:15	**Keynote Speech** 7. Country Director, UNDP Sierra Leone	
11:15 to 11:45	TEA BREAK	
PART 2 – PRESENTATIONS BY MDAs AND INTEGEMS		
11:45 to 12:00	8. **Presentation 1:** Sendai Framework for Disaster Risk Reduction 2015-2030: Sierra Leone's approach for implementation	ONS-DMD
12:00 to 12:15	9. **Presentation 2:** Meteorological hazards and disaster risk reduction**:** Mitigation, preparedness and response	SLMD
12:15 to 12:30	**10. Presentation 3:**The role of effective environmental management systems for disaster risk reduction	EPA-SL
12:30 to 12:45	**11. Presentation 4:** Hydrological hazards and disaster risk reduction: Mitigation, preparedness and response	MWR
12:45 to 13:30	**12. Presentation 5:** Project Approach, Methodology and Management	INTEGEMS
13:30 to 14:30	LUNCH	

PART 3 – WORKING GROUP SESSIONS		
14:30 to 15:30	13. Working Group Sessions • **<u>Working Group Session 1</u>**: Understanding disaster risk in Sierra Leone in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment • **<u>Working Group Session 2:</u>** Strengthening disaster risk governance to manage disaster risk in Sierra Leone at the national, regional and local levels in all sectors; define roles and responsibilities; and ensure the coherence of laws, regulations and public policies. • **<u>Working Group Session 3:</u>** Institutional capacity gaps and capacity building needs in Sierra Leone for prevention, mitigation, preparedness, response, recovery, rehabilitation and reconstruction.	Participants
15:30 to 15:45	TEA BREAK	
15:45 to 16:30	14. Presentations and Recommendations from the Working Group Sessions	Lead, Working Group Sessions
16:30 to 16:40	15. Closing Remarks	ONS
16:40 to 16:45	16. Vote of Thanks	UNDP/INTEGEMS
16:45	17. End of Workshop	

12.8.2 Workshop Participants

12.8.2.1 Freetown, 26 July 2017

No	Full Name	Organisation/Institution	Designation
1	Julius Mattai	INTEGEMS	Managing Director, Principal Consultant
2	Samuella Faulkner	INTEGEMS	Operation Manager, Senior Consultant
3	Kenneth V.S. Koker	INTEGEMS	Consultant
4	Ibrahim Aziz Bangura	INTEGEMS	Consultant
5	Sheku Alaka Mansaray	BRAC	
6	Alie Kabba	Guma Valley Water Company (GVWC)	Monitoring and Evaluation
7	Alimamy Kargbo	National Fire Force, Sierra Leone	Station Officer
8	Dr. Victor Kabba	Njala University	Head, Geography Dept.
9	Nabie A. Kamara	Office of National Security (ONS)	Asst. Director, DRR
10	Samuel Baimba	Sierra Leone Meteorological Agency	
11	Lawrence J Light	AYV.TV	Reporter
12	James Steven	SLRSA	Planning Manager
13	Joseph Kaindaneh	UNDP	Technical Adviser
14	Marilyn George	SALWACO-Makeni	Production Engineer
15	Christopher Harding	Sierra Leone Meteorological Agency	
16	Ronald Turay	ONS	A.R.O
17	Theresa Williams	MMMR	A.S
18	Mohamed S Koroma	MoHS	EHO
19	Mariama Mansaray	AYV-TV	Reporter
20	Momodu	RSLAF	Captain
21	E-Baines-Johnson	EPA-SL	Policy Adviser
22	Gabriel Kpaka	Sierra Leone Meteorological Agency	Deputy Director
23	Fatu Koroma	Sierra Leone Meteorological Agency	Met Observer
24	Oredola Saint- John	Sierra Leone Meteorological Agency	Observer
25	Zinta Zommers	FAO	Policy Officer
26	Andrey J Kamanda	SLRCS	DM Officer
27	James A Medo	MTA	Statistician
28	Samuel Turay	MTA	Rail Policy Officer
29	Ishmail Kamara	MoWR	Water Analyst
30	Olaimatu S Karim	MoWR	Hydrologist
31	Tanzila Sankoh	UNDP	Acting Team Leader Cluster
32	Duramani K. Sesay	SLMA	Environmental Officer
33	Gbangay Kanu	MSWGCA	SSSO-DM
34	Janneh A James	WFP	Program Associate
35	Dr. Hamza Bangura	MIC	Natural Cyber Security Coordinator
36	Sellu Macarthy	MoFED	Senior Economist
37	Zainab Jay	MLCPE	Environmental Officer
38	Fonigay Lavahun	FAO	Projects Coordinator

12.8.2.3 Makeni, 15 August 2017

No	Name	Institution	Designation
1	Julius Mattai	INTEGEMS	Managing Director, Principal Consultant
2	Samuella Faulkner	INTEGEMS	Operation Manager, Senior Consultant
3	Kenneth V.S. Koker	INTEGEMS	Consultant
4	Ibrahim Aziz Bangura	INTEGEMS	Consultant
5	Mustapha KemoKai	Koinadugu District council	Environmental &Social Officer
6	Kellie K. Jalloh	ONS - Koinadugu	District Coordinator
7	Alusine Bangura	Bombali District Council	Environmental &Social Officer
8	Alie B. Fofanah	ONS – Portloko	District Coordinator
9	Joseph B.Thullah	ONS - Tonkulili	District Coordinator
10	Alpheus F. Koroma	ONS- Bombali	PS Coordinator
11	Alimamy F. Turay	MOWR – Bombali	District WASH Engineer
12	Angela T.M. Roger	Koinadugu District MOMOS/DMMT	DMO
13	Farah Fofanah	DHMT, Koinadugu	

12.8.2.4 Bo Town, 17 August 2017

No	Full Name	Organisation/Institution	Designation
1	Julius Mattai	INTEGEMS	Managing Director
2	Samuella Faulkner	INTEGEMS	Operations Manager
3	Kenneth V.S. Koker	INTEGEMS	Consultant
4	Ibrahim Aziz Bangura	INTEGEMS	Consultant
5	Amadu Koroma	Bo City Council	Environmental Officer
6	Sadiq Silla	Pujehun District Council	District Chairman
7	Rashid Ngele Mallah	Bo District Council	M&E Office
8	Abu Barkarr Jalloh	Bo District Council	Waste Officer
9	Ibrahim B Sondu	ONS Moyamba	District Coordinator
10	Hardyu Massaquoi	ONS- Bonth	District Coordinator
11	Dr A.S. Turay	DHMT-Bo	DMO
12	Ibrahim M. Turay	ONS-Bo	District Coordinator
13	Mohamed B. Bangura	ONS- Region South	Regional Coordinator
14	Duraman Kargbo	ONS-Pujehun	District Coordinator
15	John Dewhing	SLRA	
16	Alhaji Dumbuya	SLP	C.R.D.Bo East
17	Amadu Shaw	EPA-SL	GI/ Environment
18	Ibrahim C Jalloh	Red Cross	DM-Officer
19	Ralph CC J	LPPB-Bo East	Chairman
20	Almamy Mansaray	MLCPE	Lands Officer
21	Abu Bakarr Fofanah	Socia Welfare	
22	Foday M. Sesay	DSO 2 Pujehun	DSO
23	Victor P Puh	WFP	Program Associate
24	Bockarie Saffa	National Fire Force	Staff Officer

12.8.2.5 Kenema Town, 18 August 2017

No	Full Name	Organisation/Institution	Designation
1	Julius Mattai	INTEGEMS	Managing Director, Principal Consultant
2	Samuella Faulkner	INTEGEMS	Operation Manager, Senior Consultant
3	Kenneth V.S. Koker	INTEGEMS	Consultant
4	Ibrahim Aziz Bangura	INTEGEMS	Consultant
5	Sam Musa	K.D.E (Kono)	E.H.O
6	Brim K. Ngombulango	Nongowo	
7	Alfred Kamara	O.N.S Kailahum District	District System Coordinator
8	Prince J. Musa	S.L.B.C./Kenema	Media
9	Sahr Kanneh	Council (Kailahum)	Environmental Officer
10	Mohamed Abdulai	DHWT-Kono	D.M.O. Rep
11	Leslie I Kemokai	Kenema District Council	Environmental Officer
12	Ishaka Konneh	Kenema city Council	ESO-KCC
13	Ibrahim D. Turay	Kailahum Government	DMO Rep
14	Samba Sei Benedict	Kambia Radio Kenema	Media
15	Sahr M.L. Mansaray	ONS- Kono District	District system Coordinator
16	Doriso G. Saidu	Gola radio	Media
17	Samuel A.J.Bullie	ONS – East	Director
18	Kamal M. Barrie	Media/ Starline	Correspondent
19	Ausumana Kaneh	MOHS/AHMT	
20	Mohamed Sankoh	SALWACO	CPHE Officer
21	Mohamed Joe	ONS	P.R.O Kenema
22	Esther	Kenema City Council	Mayor
23	Hassan Sheriff	Air Radio	Reporter
24	Desmond G. Vandy	S.C.P	OPS
25	Major M.M Maxwell	RSLAF	DPS Officer
26	Tommy T.Yimbo	CISU	P.R.O
27	Abass Alim Kamara	ONS	District Coordinator
28	Hassan Konneh	C.W.C.	Chairman

12.8.3 Workshop Photo Plates

12.8.3.1 Stakeholder Consultative Workshop, Freetown

Figure 12-1: Stakeholder Consultative Workshop, Freetown

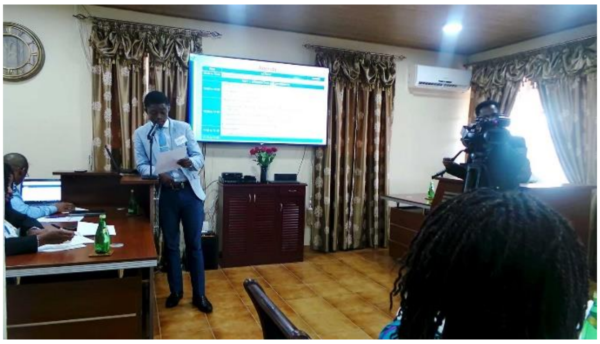
Cross-section of stakeholders

(Photo Credit: INTEGEMS)

E-Baines-Johnson of EPA-SL giving his statement

(Photo Credit: INTEGEMS)

Ishmail Kamara of MWR during his presentation



(Photo Credit: INTEGEMS)

Joseph Kaindaneh of UNDP delivering the opening remarks

(Photo Credit: INTEGEMS)

Cross-section of participants during the lunch break

(Photo Credit: INTEGEMS)

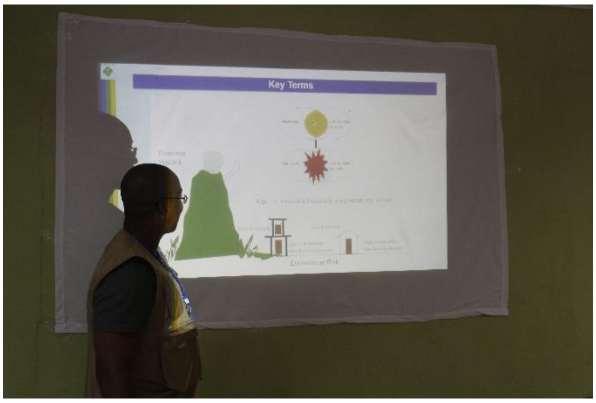
Cross-section of stakeholders

(Photo Credit: INTEGEMS)

12.8.3.2 Stakeholder Consultative Workshop, Makeni City

Figure 12-2: Stakeholder Consultative Workshop, Makeni City

Presentation of the methodology and scope of work



(Photo Credit: INTEGEMS)

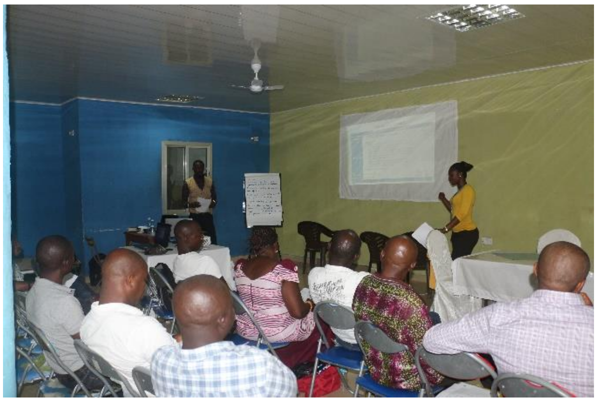
Cross-section of stakeholders and INTEGEMS staffs

(Photo Credit: INTEGEMS)

Contribution by a stakeholder

(Photo Credit: INTEGEMS)

Felicitation of the discussion session



(Photo Credit: INTEGEMS)

Cross-section of stakeholders

(Photo Credit: INTEGEMS)

Cross-section of stakeholders

(Photo Credit: INTEGEMS)

12.8.3.3 Stakeholder Consultative Workshop, Bo City

Figure 12-3: Stakeholder Consultative Workshop, Bo City

Registration of Stakeholders

(Photo Credit: INTEGEMS)

Presentation of the methodology and scope of work

(Photo Credit: INTEGEMS)

Contribution by a stakeholder

(Photo Credit: INTEGEMS)

Landslide disaster in Kissy Brook (2009)

(Photo Credit: INTEGEMS)

Cross-section of stakeholders

(Photo Credit: INTEGEMS)

Cross-section of stakeholders

(Photo Credit: INTEGEMS)

12.8.3.4 Stakeholder Workshop Kenema City

Figure 12-4: Stakeholder Consultative Workshop, Kenema City

Registration of Stakeholders

(Photo Credit: INTEGEMS)

Contribution by a stakeholder

(Photo Credit: INTEGEMS)

Presentation of the methodology and scope of work

(Photo Credit: INTEGEMS)

Felicitation of the discussion session

(Photo Credit: INTEGEMS)

Cross-section of participants during the lunch break

(Photo Credit: INTEGEMS)

Cross-section of stakeholders

(Photo Credit: INTEGEMS)

13 APPENDIX 2: STAKEHOLDER VALIDATION WORKSHOP

13.1 Introduction

The Stakeholder Validation Workshop (hereafter, Workshop) on the Update of Sierra Leone Hazard Profile and Capacity Gap Analysis was held in Freetown, Sierra Leone, on 5 October 2017 at the INTEGEMS Geo-innovation Centre, Congo Cross, Freetown, Sierra Leone. In collaboration with the UNDP and ONS-DMD, INTEGEMS organised and facilitated the Workshop (hereafter, Workshop) in Freetown. About 42 participants from various government ministries department and agencies, research organisations, NGOs and international organisations participated in the Workshop.

At the Workshops, statements were made by representatives from the ONS-DMD, the UNDP Team Leader and the UNDP Country Director. The Draft Report was presented to the stakeholders, whom were also provided an update on the feedbacks from the Stakeholder Consultative Workshops held in Freetown, Makeni, Bo, and Kenema as part of the Project.

The main purpose of the Workshop was to give key stakeholders an opportunity to review and "validate" the Draft Update of Sierra Leone Hazard Profile and Capacity Gap Analysis Report (hereafter, Draft Report) that was compiled and submitted to the UNDP and ONS-DMD for validation. The specific objective of the Workshop was to share the preliminary results of the ongoing work on the Project with the stakeholders and to discuss questions, issues and preliminary findings with the stakeholders. The inputs from the stakeholders will be used to finalise the Draft Report.

The Workshop entailed the following:

- Statements by the key implementing institutions and UNDP on the background and overview of the Project.
- Technical presentations on the scope of work and detailed methodology
- Presentation and review of the Draft Report
- Discussions with recommendation and way forward

13.2 Objectives of the Stakeholder Validation Workshops

The general objective of the Workshop was to solicit inputs from relevant stakeholders in order to validate the Draft Report that was submitted by INTEGEMS to the UNDP and ONS-DMD. Specifically, the purpose of the Workshop was to:

- Present the Draft Report to stakeholders and obtain their feedback on the Draft Report and maps;
- Convey the government's overall policy orientation/guidance for hazard assessment and risk profiling; and,
- Agree on key issues to be addressed during the finalisation of the Draft Report.

13.3 Facilitation of the Stakeholder Validation Workshop

13.4 Statements by Workshop Participants

13.1.1 Chairperson's Opening Statement

John Vandy Rogers, Director – ONS-DMD

''*In recent times, we have seen an increase in the occurrence and severity of disasters across the country. The most devastating one been the three disasters that occurred on the 14th of August 2017. We are here today as institutions and organisations invited by courtesy of the United Nations Development Program and INTEGEMS to contribute towards the validation process of an extensive work that has been done by INTEGEMS which is a research based institution that has the responsibility to take forward the process of examining events and issues that surround natural and manmade disasters. The very first time Sierra Leone had her national profile was way back in 2004. That was the time when the disaster management department within the office of national security* *was in the embryonic stage. We constituted at that time the working group session to look at the challenges in the country. Just like a patient becoming infected by a disease without knowing it, will want to go to a medical doctor to tell him give me treatment for malaria or give me treatment for typhoid. As the doctor, the first thing you want to do is to diagnose the patient. By compressive diagnostic study, you are able to ascertain the challenges faced by that particular patient.*

The same is applicable here, you want to address disaster related issues of the country, you want to examine risk reduction approaches by the country, you want to examine the hazards of the country and the level to which the impact upon the population, there is only one channel through which you can do that; which is through a comprehensive national hazard profile. Taking a look at 2004 and 2017 is been quite a while since the last national hazard profile was developed, we consider it pertinent that there is a need for a review for that work that was done. I must underscore the point that over time and present and in future to come the UNDP have been in the driving seat ensuring that the requisite support needed by Sierra Leone to take forward issues in addressing disasters are properly examined. The last national hazard developed in 2004, support towards that particular exercise was given by no less an institution but the UNDP.

In this engagement again the UNDP is considered very pivotal in what you are doing here. It is in that respect on behalf of the government, I want to commend the organisation; Madam Tanzila Sankoh for all that you have done for this government, for this country and for the people of Sierra Leone. I will entreat you and your organisation to continue to do that by mandate of the United Nations. INTEGEMS is a very special organisation that has the proven track record in examining and bringing out issues related to not only hazards but risk and vulnerability faced by the country. Over time with my experience with them, they have always gone beyond reasonable doubt in ensuring that they deliver on the assignment given to them. As the director in charge of the disaster management department, this is the second classical engagement that I have with INTEGEMS. The first one been on Climate Change collation for which the result continue to resonate across the length and breadth of Sierra Leone and even other parts of Africa. Today again ladies and gentlemen we are here to validate a document that has been so hardly worked upon by INTEGEMS. You will recall and agree with me that since 2004 up to date, the issues that we were plagued with since 2004 no longer exist; and we now have in place new issues coming up in the stage. A classic example is Ebola which falls within the category of epidemic hazards.

In 1976, we are talking about Ebola in East Africa. Today we are talking about Ebola in West Africa particularly in Sierra Leone, which tells you that a lot had happened and there are many changes over time. The last time Sierra Leone had a landslide was in 1950 around Bathurst. 1950 to 2017 is quite a period. Look at the devastation caused by the twin disasters of landslide and flood, we have buried over 502 people as a result of these disasters and we are still mourning a good number of our loved ones who surrendered to the cold hands of the disaster.

It has often been stated that information is power, a research done by INTEGEMS will help us all as leaders of our institutions especially when we are trying to mainstream disaster management and as disaster managers to ensure that; that information will help us to determine how to manage disaster risk management in Sierra Leone. It is in that respect that this gathering has been commemorated to this room to ensure that the valuable input you can make towards that particular document to make it more meaningful towards most of us who are in the business of disaster risk management in Sierra Leone to make our work easy. It is only in your valuable contribution that can put us in a better position to determine what next and how next in the management of national emergencies. In the language of Frantz Fanon in his book the Legend of the Earth, he made his statement and I quote, "Every generation out of relative obscurity; has a task to perform; either you perform it or you betray it.

Ladies and gentlemen we have been gathered here to perform a small task, and that task is to add value to the document that has been worked upon so hardly by INTEGEMS. It is expected that your role will go a long way to identify the challenges that we have in the occurrence of future emergencies in Sierra Leone. In the language of William Hauswirth, he made a statement and I quote "In your hands my satisfaction country men are not in mind, is therefore a momentous issue of national emergencies; you have no oath registered to sixteen prior or have the right to preserve, protect and defend it.

The most common thing you look at in disaster management is saving lives and protecting property across the length and breadth of the globe. Any other thing you will want to have is an addition to those two phenomena, and therefore, as institutions and leaders representing our various organisation; I entreat you to add value to the work that have been done by INTEGEMS. I believe when the managing director of INTEGEMS starts to open up on that particular document, you will be the first to start to build on it. What we expect of you from the perspective of your organisation and institution; what you consider pertinent that can take us from one point to the other in preparing us towards disaster, prevention, and mitigation and response will be considered very important. It is in that respect that we are all gathered here to solicit your learning process, knowledge, and experiences to pair upon the overall document that is in front of us that we have presented. I believe at the end of the day, posterity will judge us by the contribution we have made to this particular document. I encourage all of us to ensure that we don't keep quiet about an opinion that we may have, even the minutest of the opinion that you want to share in this particular gathering will go a long way to solve the problem of a small area of Sierra Leone in future.

On that note, without much ado, I want to take this golden opportunity on behalf of the Office of National Security and the government to give that commendation to INTEGEMS for such a hard work done over the period and to commend the UNDP support given to ONS-DMD and by extension government of Sierra Leone in addressing disaster risk reduction. By way of extension, INTEGEMS for every little bit of contribution done by your staff towards the development of this document; it's highly appreciated. Therefore without much ado ladies and gentlemen I wish you a very good day with in my capacity as Chairman tentatively. I wish you all the best in your discussion, let us be very frank, and let us be very open, don't keep quiet about any issue, please ensure that we discuss every issue in this forum.''

13.1.2 Statement by the Representative from UNDP

Tanzila Sankoh, Programme Specialist- Environment Cluster, UNDP

''*I will like to say that the support is given and funded by the Global Environmental Facility (GEF) and the UNDP we need people to know that the funding is from them together with the UNDP. They are not on the ground but we think we need to recognize the support they are giving to the UNDP initiatives. This project was delayed as it should have started in 2013 but due to the Ebola outbreak it was shifted and started in 2015. To date, I will like to report that eight in one automatic weather stations have been installed all over the country and they are currently providing climate data covering all regions of Sierra Leone to servers installed at the Sierra Leone Meteorological Agency and an online portal for all regions of Sierra Leone. We will be launching that portal and I am sure most of you in this room will be invited. One more station has been procured by us, the contract will soon be signed for the weather station at the Lungi international airport to be changed because we think we need to have a latest model at the airport which is a very important place for all of us who travel in and out of the country. Since the start of the project, a number of capacity building effort have been made. We have trained a number of staffs of the Sierra Leone Meteorological Agency, both the director and deputy director were sent to the University of Reading in the UK to have their masters in meteorology and they are back now heading the institution.*

Couple of weeks ago, I took seven other staffs to the West African Meteorological Centre in Nigeria and they are currently doing courses in class three weather observation and reporting. We are also supporting a number of on the job trainings and a number of refresher courses. I spoke a little bit earlier about a web portal that we call the CIDMEWS which is a one stop web portal which can facilitate real time and reliable climate information, that one is being finalised and in the next couple of weeks our target is to have that launched latest by the third week of this month. It is a fantastic outfit and I am sure on that day you will learn a lot about that portal.

This project is like an integrated support not only to SLMA but as you heard from the director also to the ONS-DMD, EPA-SL and MWR because we think when you talk about climate change those are the hard hit areas and we think we should have a consolidated approach in supporting each and every sector that can be affected. During the tenure of this project, we have supported a number of staffs of the MWR that have been trained both in Niamey Niger and also in Accra Ghana on *hydrological monitoring and we have also installed a number of monitoring systems all over the country in order to provide data to the MWR on water levels as the seasons goes by. This is to help them keep an eye on what is going on underground because we don't want to have scarcity of water as it happened in 2016.*

A communication network has also been established for the SLMA, ONS-DMD, EPA-SL and MWR to support early warning system and the dissemination mechanisms. Even though SLMA is having real time data, there are still a number of challenges in terms of interpreting these information and also putting that out to the people and partners who might be interested. As we speak, we have a contract ongoing right now with legal firm that is working with both private sectors, mobile companies, newspapers, radio stations as we are trying to establish a mechanism where in information that is gathered from the server can be transmitted to these institutions for circulation to the people of Sierra Leone because I think that is where we need to be in order for the people to be informed about the early warning in terms of disasters.

One of the support as the director have already mentioned is the review of the Sierra Leone Hazard Profile which we are here today to validate the document. This document once validated will be turn over to the ONS and I think that document is going to go a long way in helping to put strategies in place in terms of disaster response and preparedness to save lives and properties.

We know there are financial challenges in managing some government institutions and due to the fact that SLMA is an important outfit going forward with regards to climate change, we are also trying to put strategies in place so that they can be sustainable on their own with little or no budgetary support from the government. With that, we hired a consultant which had work with the SLMA and a document has been prepared to help them on how they could mobilize resources from the information they are having from all the weather stations so that they could be sold out to relevant institutions and make some money out of it. We already have that framework and that has been turn over to the SLMA.

We have also supported a community based early warning systems in the Bumbuna and dodo community as we all know we have two dams, Bumbuna hydro dam and dodo dam and for us those are high risk areas in case there is flooding as those communities will be highly affected. Those communities have been engaged and trained on how they can prepare and also response to disaster. As we speak, seventy most vulnerable communities were targeted in those two areas and strategies are in place in case issue of water overflow arises on how they could respond so that lives and properties could be save.

Like I said we still have a number of challenges and we are in discussion with the regional office to see how we could have an extension of this program to make sure capacity gaps that have been identified in all four of these institutions can be capacitated before the final closure of the project. I want to re-iterate the importance of your input towards this document because at the end of the day we want a document as the chairman said that can stand the end of times especially at this point that we have started seeing the impact of climate change in the country. Please be aware that this a very important document, it is a national document so please feel free to make whatever input that you think is right. I want to wish you all a fruitful deliberations and I want to thank you all for honouring the invitation. Thank you very much''.

13.1.3 Statement by UNDP Sierra Leone Country Director

Dr Samuel G Doe, Country Director – UNDP

''This morning, let me begin by thanking all of you for coming. I think we have all of the best minds or most of the best minds in Sierra Leone and those who are partnering with Sierra Leone here in the room on the subject that we want to talk about or we are talking about, which is really having a more robust hazard profile of Sierra Leone and ensuring that; that profile is useable and it contributes to the prevention, some of the preventive work we need to do, some of the mitigating work we need to do, some of the policy transformation necessary for Sierra Leone's readiness for a lot of these hazards have been really well elegantly documented by Julius and his team.

This is a project that is financed by GEF (Global Environment Facility) that many of you know of and the UNDP. We are keen to work with the government, with ONS and other agencies of the government to ensure that the challenges that Sierra Leone faces - whether induced by the exacerbating factors of climate change, induced by human tendency, induced by other factors we are talking about that we have a more deliberate response to those hazards. That's the idea behind this project and we are happy for all your efforts.

I need not tell you how important this is, I think recent development should make it very clear how imperative it is that every development agency, every development partner or every national policy has got to be risk informed. Your country, during this age of climate variability is not going to have any steady progress in its development if it is not really paying attention to these risks. But if I were to even break it down Sierra Leone; with 77 percent rural poverty, 59 percent head count poverty nationally will not make any progress, being the third most vulnerable in terms of sea rise if it is not paying attention to these risks. That is why the government is increasingly realizing; I think they have plans to really strengthen the disaster response, policy, institutions and resourcing that are necessary here.

We are looking forward to all of you really contributing to these efforts and with start to some of these efforts the validation of this report. As Julius said this is tentative until some of the experts in the room can give us feedback on how useable it is, how readable it is, how accessible it is to those who will be most affected by these disasters and how is it influencing policy change in the country. Those are the areas that we hope that as you are reading it; if it has a lot of diagrams, if it is too complicated by the IT, many of us are still learning are still becoming literate when it comes to this IT thing. If it is not really friendly to those especially in the rural areas please raise those issues so that we are able to pay attention to them.

In conclusion, I just want to say again thank you very much and I look eagerly to the outcome of the validation workshop and what goes beyond the validation to make this an important instrument, provide the message that risk inform sustainable development in Sierra Leone. Thank you''.

13.5 Workshop Presentations

13.1.4 Presentation 1: Draft Hazard and Risk Profile Report

Julius Mattai, Managing Director and Principal Consultant – INTEGEMS

Julius Mattai presented a summary of the Project's objectives and methodology, highlighting the key areas of focus, specifically natural hazards. He then presented the Draft Report which was then reviewed by the stakeholders through a plenary session.

Starting his presentation, Julius thanked the ONS, particularly Mr John Vandy Rogers (Director of ONS-DMD) and Tanzila Sankoh (Programme Specialist- Environment Cluster, UNDP) for their consistent support and cooperation in ensuring the successful implementation of the Project. After giving a brief background of the Project, Julius highlighted the basis for the Project stating that the existing Hazard Profile Report that was developed in November 2004 by the University of Sierra Leone (FBC) is now grossly outdated. He added that the challenges and opportunities that exist now are completely different from those that existed 13 years ago when the first National Hazard Assessment Profile (NHAP) was compiled. He went on to ask whether the stakeholders are aware and well-informed about the 2004 NHAP report. It was revealed that the 2004 NHAP has not been widely disseminated and publicised.

Copies of the 2004 HNAP report were distributed to the stakeholders to peruse as Julius continued with his presentation. Julius informed the stakeholders that all the documents (including the NHAP 2004 report) and maps will be uploaded for the public to access and download from the Hazard and Risk Profile Information System (HARPIS) website, which has been developed as part of the Project. He emphasized the need for updating the 2004 NHAP report stating that the report predates or does not take into consideration most of the internationally recognized disaster risk reduction and disaster risk management strategies and development frameworks, including the Hyogo Framework for Action (HFA, 2005-2015), the Sendai Framework for Disaster Risk Reduction (SFDRR, 2015-2030), the Millennium Development Goals, the Sustainable Development Goals; as well as Sierra Leone's development frameworks – the Agenda for Change, and the Agenda for Prosperity. Julius intimated that the aforementioned documents must be taken into consideration if the ONS-DMD is to meaningfully fulfil its mandates as stipulated in the National Security and Central Intelligence Act, 2004 (NSCIA 2004).

Furthermore, he pointed out that the main deficit of the 2004 NHAP report is the dearth of hazard maps that should have been included in the 2004 NHAP report; hence, it is very prudent to update the report.

Presenting details of the methodology used, he underscored that INTEGEMS has extensively reviewed the 2004 NHAP report and other relevant documents and reports. He explained that INTEGEMS employed the most up-to-date techniques and skills in the development of the Draft Report. In addition, he mentioned that INTEGEMS also conducted Stakeholder consultative workshops in the main cities of Freetown, Makeni, Bo, and Kenema to get input and contributions from the key stakeholders that will aide in the development of the updated Project report.

Key areas of Mr Mattai's presentation on the methodology were, as follows:

Hazard Identification: Identifying data and information on past hazards and disasters and their impacts on communities was done by reviewing and collating secondary information from reports and other historical disaster event records; reviewing existing ONS, GoSL MDA and Local Council reports; consulting with the local experts, MDAs, international and national NGOs, civil society, academia and the private sector, as well as national, provincial and district disaster management officers. Valuable secondary data such as historic disaster events and record, maps, images and photographs were also collated from various sources like local communities, ONS-DMD, GoSL MDAs, UN Agencies, and NGOs, research papers on hazards, websites, DesInventar, CRED EM-DAT and reports of academia.

Hazard Assessment and Mapping: Development of hazard scenarios and intensity maps, which was quite challenging in that expert judgement was key in some areas, and where quantitative assessment was impossible qualitative methods where used. Furthermore, he added that INTEGEMS has developed interactive applications to enhance national capacity on risk assessment and dynamic mapping, noting that a National Risk Information System (NRIS) that empowers the end users to do analysis and make decisions has been developed.

Exposure Vulnerability and Risk Assessment: The methodology for hazard vulnerability and risk assessments differed per hazard but were generally done by overlaying geo-referenced inventory maps of elements at risk with hazard maps in ArcGIS applications. The elements at risk dataset were aggregated at both national and district levels, as required. The elements at risk considered in the assessment are: population, agriculture, health, education, building and transportation. The risk profiles are analysed, mapped and presented at national and district levels.

Furthermore, Julius mentioned that a detailed data collection and field mapping and analysis was conducted immediately following the 14 August 2017 landslides and floods in Regent, Western Area, which has greatly informed the report. This exercise was supported by UNDP who provided the funding for recruiting and training of 12 volunteers for mobile data collection for the Damage and Losses Assessment (DaLA) study. Over 500 data was collected in three days between Regent and Lumley (the 6.5 km path of the mudflow and floods) for the World Bank DaLA study too.

He went on further to inform the stakeholders that INTEGEMS has produced lots of maps using ArcGIS technology throughout the Project. He also added that, atlases will be developed and designed to allow school children to understand and interpret the issues that are addressed in the Final Project report.

The Draft Report was then presented to the stakeholders for validation with a brief explanation on each chapter, highlighting the significance with regards the hazard and risk profile. Key areas of focus were hazard profile and risk assessment methodology, including the hazard profiling, assessment, and mapping; and the vulnerability and disaster risk assessment sections. Maps for all the hazards (landslide, flood, drought, coastal erosion, sea level rise, epidemics, storm surge, tropical storm, and lightning and thunderstorms) assessed were presented to the stakeholders with detailed description of the models and methodology used. These maps and models have been developed for all the hazards at both national and district levels to help in identifying areas at risk of the aforementioned hazards. He particularly pointed out that a model is as good as what goes in", highlighting that if the model relies on third party and historical datasets which may not be accurate it will be reflected in its output. However, the methodologies used in developing the models were verified to the greatest extent possible and can always be applied to provide better outputs when more reliable datasets are available in the future.

He encouraged all the stakeholders to review the Draft Report and provide their valuable feedback that will enhance the Final Report. He informed that the Draft Report will be made available online to allow stakeholders to make additional valuable inputs which because of time cannot be captured during the workshop. In conclusion, Julius Mattai noted that all the details in the Draft Report have been put together and will be made available through the online portal developed – the HARPIS, which is integrated with the CIDMEWS.

13.1.5 Presentation 2: Feedback from Stakeholder Consultative Workshops

The feedback from the stakeholder consultative workshops and findings from the capacity gap assessment was presented by Samuella Faulkner, Senior Consultant, INTEGEMS. She stated that four stakeholder consultative workshops were conducted in the process of preparing the Draft Report. The first workshop was conducted on 26 July 2017 in Freetown and three more in the provinces - in Makeni City, Bo City and Kenema City on 15, 16 and 17 August 2017, respectively. She mentioned that the main purpose was to solicit further inputs into the Project as well as review and agree on the methodologies proposed.

. The presentation was focused on four key areas:

- Overview and objectives of the workshops;
- Workshop structure and process;
- Feedback from the stakeholders; and
- Capacity Gap Analysis.

In the opening statements she mentioned that the main theme of the Workshops were centred on the four key priorities of the Sendai Framework for Disaster Risk Reduction (SFDRR) guidelines. She briefly described the Workshop process, which included the presentations and working group sessions and gave a summary of presentations delivered at the Workshops by INTEGEMS, and the key implementing partners – ONS-DMD, SLMA, EPA-SL, and MWR.

Summary of the key recommendations from the Workshops' group sessions which she presented are as follows:

- Strengthening disaster risk governance at the national, regional and local levels for effective management of disaster risk reduction in all sectors;
- Development of proper coordination mechanisms to address disaster risk to strengthen disaster preparedness for effective response at all levels;
- Identification, assessment and monitoring of disaster risks and enhancing early warning;
- Increasing community engagement and capacity building of local authorities/communities;
- Reducing the underlying risk factors, by "mainstreaming" activities into development sectors and programme;
- Reviewing and updating existing plans and legislative frameworks;
- Scaling of capacity of education training programmes;
- Increasing political will and commitment for improved governmental action for DRR and DRM;
- Developing a robust early warning system that will provide timely and relevant information;
- Develop a disaster preparedness and mitigation plan that specifically befits the challenges faced in the Northern Province;
- Improve on preparedness and mitigation plan by enforcing bye laws for DRR at community levels;
- Aligning incentives promoting disaster cost reduction and resilience;
- Enabling resilient recovery and support disaster risk reduction nationally;
- Restructuring of the national policy on DDR and DRM reflecting the holistic approach;
- Investing in disaster preparedness measures and mechanism in all dimensions;

- Developing comprehensive planning processes between public and private sectors to address the needs in disasters;
- Effective decentralisation to ensure full participation of local communities in all phases of DRR and DRM;
- Strengthening political will and commitment;
- Strengthening institutional capacities for DRR and DRM at national and decentralized levels;
- Shift from reactive emergency response to pro-active DRR and DRM measures;
- Conduct comprehensive assessment approach including man-made hazards (e.g. conflict mining);
- Enhancing training and education, information and awareness at community levels;
- A nationwide review and proper monitoring of the leadership of the DDMCs; and
- Building local capacity and resilience in particularly in those areas of growing exposure and vulnerability.

She also presented the findings from the capacity gap assessment as follows:

- No systematic risk identification assessment and mapping available;
- Training and public awareness and capacity building programmes are in place but very limited;
- Management, planning and coordination for DRR and DRM is limited/weak;
- Disaster management activity/initiatives focuses mainly on response than mitigation and preparedness;
- There is a designated fund for DRR and DRM but resources are limited;
- Preparedness and contingency plans but needs to be updated;
- Response process is inadequate and do not usually meet the immediate needs of disaster victims; and
- Limited recovery and reconstruction recourses and support.

13.6 Questions and Answers Sessions

After the break the stakeholders had the opportunity to discuss the Draft Report in-depth and provide their inputs. The discussions were moderated by Nabie Kamara, Deputy Director – ONS-DMD. Mr Kamara gave insights from the viewpoint of disaster management alluding to the presentations by INTEGEMS. Mr Kamara also questioned why the focus was just on natural hazards and not man-made hazards and also why vulnerability was also not studied in-depth. He also wanted to understand the criteria use in classifying the hazards, particularly for the regions in the provinces. This information he said is very important as it will help in the development of preparedness and response plans, including a demonstration of the shift from disaster management to disaster risk reduction.

Responding to Mr Kamara questions and concerns, Julius Mattai stated that there are inadequate quality data/information for some of these man-made hazards and thus the information presented in the Draft Report is based on qualitative assessment, specifically taking into consideration the historic trends of events that has been happening over the years. The decision to initially exclude man-made hazards was based on the fact that the 2004 Hazard Profile Report focused more on the natural hazards. He particularly emphasized that the dearth of reliable and quality data/information is also major reason why man-made hazards was not dealt with in-depth.

Julius went on further to state that most of the datasets provided from various sources, including DesInventar and EM-DAT, were validated to the extent possible and INTEGEMS has put a disclaimer to that extent. The major problem with not having sufficient data/information is the misrepresentation of facts and information and INTEGEMS is very cognizant of that fact and thus it is quite prudent to leave some components out especially the man-made hazards. In addition Julius also presented the Climate

Information, Disaster Management and Early Warning Systems-Sierra Leone (CIDMEWS-SL) mapping application developed by INTEGEMS which he said has lot of information that will help answer most of their queries and encourage stakeholders to explore. However, he stated that some data fields are still empty due to the unavailability of the datasets

Mr Kamara also wanted to understand why the element of coping and resilience was not included in the Draft Report. He said these are very important components especially with regards to impact on economic development and that they should be included to properly understand the risk faced by people and how they can be sustainably managed.

In his response to the concern of coping and resilience Julius Mattai stated that the coping aspect is a bit more complex, especially within the current Sierra Leonean context and in his opinion that has to be done as a separate assignment/project. The frameworks (HFA and SFDRR) on which these components are built are also a bit more diffused and requires more time to be dealt with. The aspect of resilience was not part of the remit and thus was not dealt with. He further went on to say that this update is particularly important to review the hazards in a broader and more holistic context to enable us to make well informed decisions. On the issue of linking economic development, Julius stated that this aspect has been considered; however, this is a bit more complex and because it was not within the scope of work, hence much studies was not done but merely to understand the nexus with disasters.

Mohamed Kabba (Deputy Chief Administrator, Pujehun District) asked if studies were done for the known disaster prone areas particularly the forest reserves. He was very concerned with the issue of deforestation and wanted to know to what extent the study considered these aspects.

Emmanuel Bonga, Staff of the Ministry of Lands Country Planning and Environment, commented on the systematic approach to risk and hazard management. He said that the report should have been sent prior to the Workshop to enable stakeholders to review in-depth. However he highlighted that some aspects of the studies have been left out and gave a brief summary of what he said is the correct approach. He listed the following topics and wanted to know since he has not had time to fully read the report if these topics have been included.

1. Identify the hazard.
2. Identify the associated risk.
3. Assessment of risk (with livelihood consideration in context, consequences, and priorities and control)
4. Elimination or reduction of the hazards
5. Substitution
6. Isolation
7. Engineering applications
8. Administrative controls, including trainings on the use of Standard Operating Procedures
9. Personal Protection Equipment (PPE)

Morrison, Deputy Secretary Ministry of Energy, thanked INTEGEMS for the good job but commented he observed that some of the key institutions like the Ministry of Energy that plays critical role in such a process are not fully involved and that is a very big concern. A project of such nature should have full participation and cooperation from all the key ministries departments and agencies of the government. He went on further to comment on the Ministry's contribution in the response to the mudslide and flooding on 14 August 2017, stating that electricity was provided for those who were relocated to the various camps. Electricity is a very big component in addressing disaster and disaster risk and thus should be very much involved in every step of the process.

Hawa Kandeh, Acting Team Leader (BWMA), was concerned about the issues of wildfire and bushfire and particularly mentioned the risk of transmission lines along those wildfire and bushfire routes in Bumbuna. She stated that, it is very important to conduct a more detailed study on those areas to see how to best mitigate the impacts.

Lieutenant. Col. Richard Saidu Conteh, RSLAF, is particularly concerned that he has not seen much of RSLAF involvement in the process judging from what has been presented in the report. He emphasized, has played pivotal role in areas of response and strongly pointed out that they should be involved in every phase of project to be able to share their perspective specifically in their areas of competence. Another serious concern he raised was the issue of the general mentality and attitude of the citizens with regards to disaster risk reduction and disaster management. People are very resistant to the law or right process and this can be an obstruction to the success of such projects. He was keen to know if that area was addressed in the document and if so what the best solution is proffered.

Julius Mattai in his response to the questions and comments first commented on the issue of forest degradation and stated that this area was mentioned in the context but however not delved into deeply. He said some historical data/information is available but the biggest challenge is the spatial component. He said this area is quite crucial and as is a major influence in impact of flooding and will be greatly considered and incorporated in the final version of the report. The area of risk management is out of scope for this project but rather more focus is being placed on hazard and risk identification which has been clearly highlighted in the Draft Report. He stated that INTEGEMS after the landslide and flooding on 14 August 2017 has been under tremendous pressure to finish the report and is pushing really hard to produce accurate, substantive and quality report that will be very useful for all. He apologised that the Draft Report has not been sent out earlier for review before the Workshop. He is very cognizant of the fact that the validation will not be completed at the Workshop therefore INTEGEMS has created a Website to allow stakeholders to download the Draft Report and share their comments and suggestions.

On the methodology, Julius stated that careful analysis of hazard profiling, risk assessment, vulnerability was done but the areas of risk estimation capacity and resilience, is a management issue which is outside the remit for the Project. On the Bumbuna issue, INTEGEMS has visited the communities and the list of disaster prone areas have been shared by the BWMA and these areas have been mapped out and digital elevation model developed to identify the potential of the hazards occurring particularly landslide .The geology does not favour landslide and there is a need for comprehensive study to be conducted. The maps have been developed at national and districts level but still awaiting disaggregated data from Statistics Sierra Leone to incorporate administrative chiefdoms and sections.

Bushfire is again something we have discussed in this document. Although they are sporadic, we know exactly when they happen at temporal scale. Bushfire is more in the planting season, and thunder and lightning in October. Most of the data given by ONS on disaster were anecdotal and will be reviewed further. To the issue of RSLAF involvement he stated that INTEGEMS has always invited them to all workshops but many times people do not show up but regardless their efforts and contributions is greatly recognised. He concluded that INTEGEMS is open to suggestions information that will be useful to the project so all are encouraged to make their contributions.

Because of limited time stakeholders were asked to provide their inputs suggestions and comments via the website link provided and INTEGMS will provide feedback on progress. However some of the suggestions and recommendations made are listed as follows:

- Contacting more stakeholders to get their full participation and contributions.
- Challenges in getting relevant and accurate information
- The need for coordination within the ministries departments and agencies.
- There is need to broaden the scope of the assignment to incorporate geological controls on hazards.
- The way forward after the August 14 landslide and flooding and the strategies and mechanisms put in place to mitigate the risk of hazard occurrence.
- More information or study should be done on drought.
- Pollution from vehicular transportation should be included as well as the impact of mining.
- Man-made hazards should also be prioritized.

13.7 Workshop Agenda

Time	Activity	Owner
09:30 to 10:00	Arrival and registration of participants	INTEGEMS
PART 1: INTRODUCTION AND STATEMENTS		
10:00 to 10:20	Official Opening – Prayers and welcome 1. Introductions 2. Chairperson's opening statement	INTEGEMS
10:20 to 11:00	TEA BREAK	
PART 2 – PRESENTATIONS		
11:00 to 11:20	3. Summary of Project aims and objectives (Update of Sierra Leone Hazard Profile and Capacity Gap Analysis)	UNDP/ONS
11:20 to 12:00	*4.* Feedback from the workshops in Freetown, Makeni, Bo & Kenema	INTEGEMS
12:00 to 13:00	**5.** Presentation of the Draft Profile Report	INTEGEMS
13:00 to 14:00	LUNCH	
PART 3 –DISCUSSIONS AND REVIEW		
14:00 to 15:30	6. Discussion of the Report	Participants
15:30 to 15:45	TEA BREAK	
15:45 to 16:30	7. Presentation of key recommendations to update the Report	Participants
16:30 to 16:40	8. Next steps and closing remarks	INTEGEMS/UNDP
16:40 to 16:45	9. Vote of Thanks	INTEGEMS/UNDP
16:45	10. End of Workshop	

13.8 Workshop Participants

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13.9 Workshop Photo Plates

Figure 13-1: Stakeholder Validation Workshop, Freetown

Dr Sam G Doe, UNDP Country Director making a statement

(Photo Credit: INTEGEMS)

Julius Mattai of INTEGEMS presenting the Draft Hazard and Risk Profile Report

(Photo Credit: INTEGEMS)

John V. Rogers (ONS-DMD) and Tanzila Sankoh UNDP

(Photo Credit: INTEGEMS)

Samuella Faulkner of INTEGEMS during her presentation

(Photo Credit: INTEGEMS)

Cross-section of Stakeholders

(Photo Credit: INTEGEMS)

Joseph Kaindaneh of UNDP contributing to the workshop

(Photo Credit: INTEGEMS)

14 APPENDIX 3: SOCIO-DEMOGRAPHICAL DATASETS

Table 14-1: Distribution of total population

District	All Residence			Rural			Urban		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
EASTERN	**1,642,370**	**814,441**	**827,929**	**1,092,723**	**543,359**	**549,364**	**549,647**	**271,082**	**278,565**
Kailahun	**526,379**	**260,586**	**265,793**	**373,093**	**185,495**	**187,598**	**153,286**	**75,091**	**78,195**
Dea	13,414	6,715	6,699	10,432	5,225	5,207	2,982	1,490	1,492
Jawie	50,951	24,938	26,013	34,930	17,072	17,858	16,021	7,866	8,155
Kissi Kama	20,421	10,201	10,220	20,421	10,201	10,220	0	0	0
Kissi Teng	45,149	22,965	22,184	35,663	18,126	17,537	9,486	4,839	4,647
Kissi Tongi	50,950	25,820	25,130	40,981	20,608	20,373	9,969	5,212	4,757
Kpeje Bongre	25,169	12,026	13,143	19,296	9,173	10,123	5,873	2,853	3,020
Kpeje West	27,544	14,135	13,409	21,852	11,178	10,674	5,692	2,957	2,735
Luawa	81,044	38,665	42,379	38,258	18,140	20,118	42,786	20,525	22,261
Malema	37,095	18,980	18,115	29,603	15,377	14,226	7,492	3,603	3,889
Mandu	30,984	14,791	16,193	19,153	9,087	10,066	11,831	5,704	6,127
Njaluahun	61,216	30,951	30,265	42,530	21,591	20,939	18,686	9,360	9,326
Penguia	26,272	13,193	13,079	21,507	10,814	10,693	4,765	2,379	2,386
Upper Bambara	26,848	12,793	14,055	14,208	6,853	7,355	12,640	5,940	6,700
Yawei	29,322	14,413	14,909	24,259	12,050	12,209	5,063	2,363	2,700
Kenema	**609,891**	**301,104**	**308,787**	**338,192**	**167,250**	**170,942**	**271,699**	**133,854**	**137,845**
Dama	30,751	14,721	16,030	30,218	14,464	15,754	533	257	276
Dodo	22,858	11,738	11,120	22,858	11,738	11,120	0	0	0
Gaura	18,217	8,723	9,494	18,217	8,723	9,494	0	0	0
Gorama Mende	43,359	21,609	21,750	37,360	18,679	18,681	5,999	2,930	3,069
Kandu Lekpeama	18,229	9,274	8,955	18,229	9,274	8,955	0	0	0
Koya	13,482	6,732	6,750	13,482	6,732	6,750	0	0	0
Langrama	3,584	1,673	1,911	3,584	1,673	1,911	0	0	0
Lower Bambara	76,281	39,206	37,075	45,429	23,154	22,275	30,852	16,052	14,800
Malegohun	20,544	10,195	10,349	14,250	7,026	7,224	6,294	3,169	3,125
Niawa	7,815	3,661	4,154	7,815	3,661	4,154	0	0	0

District	All Residence			Rural			Urban		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Nomo	5,491	2,838	2,653	5,491	2,838	2,653	0	0	0
Nongowa	45,562	22,018	23,544	38,555	18,612	19,943	7,007	3,406	3,601
Simbaru	17,397	8,642	8,755	12,492	6,181	6,311	4,905	2,461	2,444
Small Bo	29,498	14,133	15,365	22,401	10,738	11,663	7,097	3,395	3,702
Tunkia	36,054	17,848	18,206	31,787	15,731	16,056	4,267	2,117	2,150
Wandor	20,326	10,275	10,051	16,024	8,026	7,998	4,302	2,249	2,053
Kenema City	200,443	97,818	102,625	0	0	0	200,443	97,818	102,625
Kono	**506,100**	**252,751**	**253,349**	**381,438**	**190,614**	**190,824**	**124,662**	**62,137**	**62,525**
Fiama	15,455	7,563	7,892	15,455	7,563	7,892	0	0	0
Gbane	24,404	12,155	12,249	24,404	12,155	12,249	0	0	0
Gbane Kandor	11,903	5,662	6,241	11,903	5,662	6,241	0	0	0
Gbense	15,864	7,854	8,010	15,864	7,854	8,010	0	0	0
Gorama Kono	18,294	9,240	9,054	18,294	9,240	9,054	0	0	0
Kamara	19,412	10,218	9,194	19,412	10,218	9,194	0	0	0
Lei	26,966	13,012	13,954	26,966	13,012	13,954	0	0	0
Mafindor	13,703	6,687	7,016	13,703	6,687	7,016	0	0	0
Nimikoro	61,225	31,918	29,307	61,225	31,918	29,307	0	0	0
Nimiyama	28,168	14,505	13,663	28,168	14,505	13,663	0	0	0
Sandor	89,879	44,249	45,630	89,879	44,249	45,630	0	0	0
Soa	39,250	19,087	20,163	39,250	19,087	20,163	0	0	0
Tankoro	8,501	4,333	4,168	8,501	4,333	4,168	0	0	0
Toli	5,046	2,410	2,636	5,046	2,410	2,636	0	0	0
Koidu/New	128,030	63,858	64,172	3,368	1,721	1,647	124,662	62,137	62,525
NORTHERN	**2,508,201**	**1,224,828**	**1,283,373**	**1,893,227**	**922,650**	**970,577**	**614,974**	**302,178**	**312,796**
Bombali	**606,544**	**296,683**	**309,861**	**433,486**	**211,169**	**222,317**	**173,058**	**85,514**	**87,544**
Biriwa	47,305	22,720	24,585	47,305	22,720	24,585	000		
Bombali Sebora	36,413	17,785	18,628	36,413	17,785	18,628	000		
Gbanti0Kamaranka	28,491	14,011	14,480	28,491	14,011	14,480	0	0	0

District	All Residence			Rural			Urban		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Gbendembu Ngowahun	38,800	18,498	20,302	34,543	16,483	18,060	4,257	2,015	2,242
Libeisaygahun	16,199	7,798	8,401	16,199	7,798	8,401	0	0	0
Magbaimba Ndorhahun	12,688	6,347	6,341	12,688	6,347	6,341	0	0	0
Makari Gbanti	81,345	39,798	41,547	52,140	25,177	26,963	29,205	14,621	14,584
Paki Masabong	19,880	9,487	10,393	19,880	9,487	10,393	0	0	0
Safroko Limba	31,256	14,683	16,573	31,256	14,683	16,573	0	0	0
Sanda Loko	45,075	22,274	22,801	45,075	22,274	22,801	0	0	0
Sanda Tendaren	26,228	13,178	13,050	26,228	13,178	13,050	0	0	0
Sella Limba	58,401	28,497	29,904	43,439	21,113	22,326	14,962	7,384	7,578
Tambakka	38,493	19,468	19,025	38,493	19,468	19,025	0	0	0
Makeni City	125,970	62,139	63,831	1,336	645	691	124,634	61,494	63,140
Kambia	**345,474**	**165,541**	**179,933**	**244,630**	**116,820**	**127,810**	**100,844**	**48,721**	**52,123**
Bramaia	36,764	17,365	19,399	26,642	12,501	14,141	10,122	4,864	5,258
Gbinle0Dixing	23,433	11,140	12,293	23,433	11,140	12,293	0	0	0
Magbema	92,165	44,339	47,826	28,931	13,754	15,177	63,234	30,585	32,649
Mambolo	37,952	17,911	20,041	29,640	14,068	15,572	8,312	3,843	4,469
Masungbala	31,797	14,793	17,004	31,797	14,793	17,004	0	0	0
Samu	64,790	31,004	33,786	53,233	25,516	27,717	11,557	5,488	6,069
Tonko Limba	58,573	28,989	29,584	50,954	25,048	25,906	7,619	3,941	3,678
Koinadugu	**409,372**	**204,498**	**204,874**	**335,847**	**167,869**	**167,978**	**73,525**	**36,629**	**36,896**
Dembelia Sinkunia	21,449	10,879	10,570	21,449	10,879	10,570	0	0	0
Diang	29,063	14,699	14,364	26,602	13,398	13,204	2,461	1,301	1,160
Follosaba Dembelia	20,919	10,450	10,469	17,598	8,797	8,801	3,321	1,653	1,668
Kasunko	24,796	11,734	13,062	22,002	10,381	11,621	2,794	1,353	1,441
Mongo	47,836	23,553	24,283	45,006	22,161	22,845	2,830	1,392	1,438
Neya	42,704	21,741	20,963	39,564	20,176	19,388	3,140	1,565	1,575
Nieni	78,199	38,813	39,386	59,421	29,561	29,860	18,778	9,252	9,526
Sengbe	38,016	18,625	19,391	24,915	11,807	13,108	13,101	6,818	6,283

District	All Residence			Rural			Urban		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Sulima	35,639	18,686	16,953	35,639	18,686	16,953	0	0	0
Wara Wara Bafodia	34,606	17,320	17,286	28,257	14,256	14,001	6,349	3,064	3,285
Wara Wara Yagala	36,145	17,998	18,147	15,394	7,767	7,627	20,751	10,231	10,520
Port Loko	**615,376**	**294,954**	**320,422**	**455,159**	**216,731**	**238,428**	**160,217**	**78,223**	**81,994**
BKM	40,179	19,179	21,000	40,179	19,179	21,000	0	0	0
Buya Romende	34,281	16,083	18,198	31,139	14,641	16,498	3,142	1,442	1,700
Dibia	15,519	7,252	8,267	15,519	7,252	8,267	0	0	0
Kaffu Bullom	120,490	59,160	61,330	45,026	21,986	23,040	75,464	37,174	38,290
Koya	85,177	40,119	45,058	76,861	36,282	40,579	8,316	3,837	4,479
Lokomasama	78,276	37,331	40,945	72,685	34,458	38,227	5,591	2,873	2,718
Maforki	86,764	41,416	45,348	53,223	25,147	28,076	33,541	16,269	17,272
Marampa	59,323	28,737	30,586	25,160	12,109	13,051	34,163	16,628	17,535
Masimera	40,843	19,324	21,519	40,843	19,324	21,519	0	0	0
Sanda Magbolontor	23,731	11,161	12,570	23,731	11,161	12,570	0	0	0
TMS	30,793	15,192	15,601	30,793	15,192	15,601	0	0	0
Tonkolili	**531,435**	**263,152**	**268,283**	**424,105**	**210,061**	**214,044**	**107,330**	**53,091**	**54,239**
Gbonkolenken	67,705	33,497	34,208	59,837	29,437	30,400	7,868	4,060	3,808
Kafe Simira	36,670	18,467	18,203	29,258	14,754	14,504	7,412	3,713	3,699
Kalansogoia	35,864	17,976	17,888	23,582	11,765	11,817	12,282	6,211	6,071
Kholifa Mabang	16,666	7,996	8,670	16,666	7,996	8,670	0	0	0
Kolifa Rowalla	66,128	32,821	33,307	42,992	21,543	21,449	23,136	11,278	11,858
Kunike Barina	25,245	13,166	12,079	22,770	11,965	10,805	2,475	1,201	1,274
Kunike Sanda	74,415	37,519	36,896	59,408	29,896	29,512	15,007	7,623	7,384
Malal Mara	30,953	15,091	15,862	30,953	15,091	15,862	0	0	0
Sambaya	31,993	15,690	16,303	25,854	12,744	13,110	6,139	2,946	3,193
Tane	33,285	16,309	16,976	29,103	14,327	14,776	4,182	1,982	2,200
Yoni	112,511	54,620	57,891	83,682	40,543	43,139	28,829	14,077	14,752
SOUTHERN	**1,441,308**	**702,151**	**739,157**	**1,157,428**	**564,143**	**593,285**	**283,880**	**138,008**	**145,872**

District	All Residence			Rural			Urban		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Bo	**575,478**	**280,569**	**294,909**	**380,397**	**186,095**	**194,302**	**195,081**	**94,474**	**100,607**
Badjia	8,135	3,982	4,153	8,135	3,982	4,153	0	0	0
Bagbo	25,884	12,803	13,081	25,884	12,803	13,081	0	0	0
Bagbwe	20,926	10,444	10,482	20,926	10,444	10,482	0	0	0
Baoma	45,835	22,482	23,353	45,835	22,482	23,353	0	0	0
Bumpe Ngawo	44,279	21,718	22,561	44,279	21,718	22,561	0	0	0
Gbo	5,403	2,676	2,727	5,403	2,676	2,727	0	0	0
Jaiama Bongor	31,298	15,199	16,099	31,298	15,199	16,099	0	0	0
Kakua	51,074	24,377	26,697	51,074	24,377	26,697	0	0	0
Komboya	15,623	7,692	7,931	15,623	7,692	7,931	0	0	0
Lugbu	25,453	12,509	12,944	22,601	11,112	11,489	2,852	1,397	1,455
Niawa Lenga	13,955	6,789	7,166	13,955	6,789	7,166	0	0	0
Selenga	9,175	4,368	4,807	9,175	4,368	4,807	0	0	0
Tikonko	53,206	26,116	27,090	41,794	20,457	21,337	11,412	5,659	5,753
Valunia	35,558	18,177	17,381	29,110	14,757	14,353	6,448	3,420	3,028
Wunde	15,305	7,239	8,066	15,305	7,239	8,066	0	0	0
Bo City	174,369	83,998	90,371	0	0	0	174,369	83,998	90,371
Bonthe	**200,781**	**99,014**	**101,767**	**162,796**	**80,186**	**82,610**	**37,985**	**18,828**	**19,157**
Bendu Cha	7,168	3,500	3,668	7,168	3,500	3,668	0	0	0
Bum	24,339	11,841	12,498	24,339	11,841	12,498	0	0	0
Dema	7,411	3,749	3,662	7,411	3,749	3,662	0	0	0
Imperi	33,394	17,019	16,375	17,065	8,511	8,554	16,329	8,508	7,821
Jong	33,816	16,511	17,305	22,235	11,116	11,119	11,581	5,395	6,186
Kpanga Kemo	10,438	5,057	5,381	10,438	5,057	5,381	0	0	0
Kwamebai Krim	14,289	6,975	7,314	14,289	6,975	7,314	0	0	0
Nongoba Bullom	20,060	10,009	10,051	20,060	10,009	10,051	0	0	0
Sittia	21,347	10,522	10,825	21,347	10,522	10,825	0	0	0
Sogbini	10,863	5,236	5,627	10,863	5,236	5,627	0	0	0

District	All Residence			Rural			Urban		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Yawbeko	7,581	3,670	3,911	7,581	3,670	3,911	0	0	0
Moyamba	**318,588**	**153,699**	**164,889**	**295,891**	**142,978**	**152,913**	**22,697**	**10,721**	**11,976**
Bagruwa	27,623	13,705	13,918	27,623	13,705	13,918	0	0	0
Bumpeh	37,445	17,826	19,619	37,445	17,826	19,619	0	0	0
Dasse	13,217	6,369	6,848	13,217	6,369	6,848	0	0	0
Fakunya	27,646	13,133	14,513	27,646	13,133	14,513	0	0	0
Kagboro	34,862	16,811	18,051	34,862	16,811	18,051	0	0	0
Kaiyamba	25,749	12,240	13,509	15,500	7,332	8,168	10,249	4,908	5,341
Kamajei	10,165	4,934	5,231	10,165	4,934	5,231	0	0	0
Kongbora	10,328	4,979	5,349	10,328	4,979	5,349	0	0	0
Kori	30,514	14,797	15,717	25,754	12,571	13,183	4,760	2,226	2,534
Kowa	9,752	4,642	5,110	9,752	4,642	5,110	0	0	0
Lower Banta	37,317	18,129	19,188	29,629	14,542	15,087	7,688	3,587	4,101
Ribbi	33,165	15,730	17,435	33,165	15,730	17,435	0	0	0
Timdale	10,292	5,155	5,137	10,292	5,155	5,137	0	0	0
Upper Banta	10,513	5,249	5,264	10,513	5,249	5,264	0	0	0
Pujehun	**346,461**	**168,869**	**177,592**	**318,344**	**154,884**	**163,460**	**28,117**	**13,985**	**14,132**
Barri	36,905	17,697	19,208	32,395	15,578	16,817	4,510	2,119	2,391
Gallinas Peri	54,691	26,713	27,978	54,691	26,713	27,978	0	0	0
Kpaka	16,468	7,721	8,747	16,468	7,721	8,747	0	0	0
Kpanga0Kabonde	49,340	23,908	25,432	43,245	21,017	22,228	6,095	2,891	3,204
Makpele	31,080	15,425	15,655	21,958	10,948	11,010	9,122	4,477	4,645
Malen	49,263	25,164	24,099	40,873	20,666	20,207	8,390	4,498	3,892
Mano Sakrim	12,893	6,084	6,809	12,893	6,084	6,809	0	0	0
Panga Krim	8,969	4,296	4,673	8,969	4,296	4,673	0	0	0
Pejeh	13,600	6,576	7,024	13,600	6,576	7,024	0	0	0
Soro Gbema	42,292	20,291	22,001	42,292	20,291	22,001	0	0	0
Sowa	17,136	8,428	8,708	17,136	8,428	8,708	0	0	0

District	All Residence			Rural			Urban		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
WESTERN	**1,500,234**	**749,558**	**750,676**	**43,638**	**22,235**	**21,403**	**1,456,596**	**727,323**	**729,273**
Western Area Rural	**444,270**	**221,351**	**222,919**	**43,638**	**22,235**	**21,403**	**400,632**	**199,116**	**201,516**
Koya Mountain	70,423	34,381	36,042	20,584	10,229	10,355	49,839	24,152	25,687
Mountain	30,488	16,014	14,474	1,675	815	860	28,813	15,199	13,614
Waterloo	213,778	104,978	108,800	4,983	2,570	2,413	208,795	102,408	106,387
York Rural	129,581	65,978	63,603	16,396	8,621	7,775	113,185	57,357	55,828
Western Area Urban	**1,055,964**	**528,207**	**527,757**	**0**	**0**	**0**	**1,055,964**	**528,207**	**528,207**
Central 1	62,499	32,023	30,476	0	0	0	62,499	32,023	32,023
Central 2	21,413	11,623	9,790	0	0	0	21,413	11,623	11,623
East 1	61,244	30,380	30,864	0	0	0	61,244	30,380	30,380
East 2	89,530	45,336	44,194	0	0	0	89,530	45,336	45,336
East 3	448,572	222,544	226,028	0	0	0	448,572	222,544	222,544
West 1	53,981	26,564	27,417	0	0	0	53,981	26,564	26,564
West 2	130,149	64,657	65,492	0	0	0	130,149	64,657	64,657
West 3	188,576	95,080	93,496	0	0	0	188,576	95,080	95,080
Total Country	**7,092,113**	**3,490,978**	**3,601,135**	**4,187,016**	**2,052,387**	**2,134,629**	**2,905,097**	**1,438,591**	**1,466,506**

Table 14-2: Households by type of dwelling unit by region, district and area of residence

Region/ District/ Area of Residence	Total	Separate house	Semi-detached house	Flat/ Apartment	Compound house (rooms)	Huts/Buildings (same compound)	Huts/Buildings (different compound)	Tent	Improvised home (kiosk container board pan-body)	Uncomplete d building	other
National											
Number	1,265,468	685,348	89,124	261,181	131,072	30,758	18,031	10,02 5	27,578	9,467	2,884
Percent	100.00	54.20	7.00	20.60	10.40	2.40	1.40	0.80	2.20	0.70	0.20
Region											
Eastern	281,201	185,080	18,567	40,398	23,103	5,136	4,489	1,633	743	1,197	855
Kailahun	414,377	254,075	20,349	76,908	29,293	13,195	9,567	6,139	1,839	2,303	709
Kenema	248,655	161,553	13,967	42,154	18,396	5,101	3,238	1,503	910	1,195	638
Kono	321,235	84,640	36,241	101,721	60,280	7,326	737	750	24,086	4,772	682
Urban/Rural											
Rural	697,706	471,551	31,206	105,394	38,469	19,388	16,772	7,407	2,228	3,659	1,632
Urban	567,762	213,797	57,918	155,787	92,603	11,370	1,259	2,618	25,350	5,808	1,252
District											
Kailahun	83,348	60,230	3,722	9,298	5,934	1,583	1,062	619	262	314	324
Kenema	111,734	70,468	10,713	17,447	8,293	1,903	1,406	520	275	442	267
Kono	86,119	54,382	4,132	13,653	8,876	1,650	2,021	494	206	441	264
Bombali	105,902	52,387	5,041	28,027	9,917	4,176	2,974	2,205	455	484	236
Kambia	53,826	34,684	3,075	9,905	3,034	1,189	650	818	292	122	57
Koinadugu	56,108	35,316	1,608	6,373	3,134	3,571	3,524	2,152	121	224	85
Port Loko	111,701	76,254	6,196	17,262	7,677	1,470	703	397	624	924	194
Tonkolili	86,840	55,434	4,429	15,341	5,531	2,789	1,716	567	347	549	137
Bo	102,723	64,351	6,909	17,034	9,760	1,929	755	590	599	505	291
Bonthe	32,538	24,843	1,491	2,969	1,882	481	592	75	21	116	68
Moyamba	61,880	37,245	2,996	15,247	2,842	1,345	991	546	192	307	169
Pujehun	51,514	35,114	2,571	6,904	3,912	1,346	900	292	98	267	110
Western Area Rural	91,284	33,189	6,714	24,763	14,352	1,774	314	448	7,257	2,300	173
Western Area Urban	229,951	51,451	29,527	76,958	45,928	5,552	423	302	16,829	2,472	509

Table 14-3: Households by major material for construction of roof

Region/District/Area of Residence	Major Material for Construction of Roof							
	Total	Concrete	Asbestos	Zinc	Thatch	Tarpaulin	Tiles	other
National								
Number	126,5468	19,779	25,102	1,034,522	161,871	19,254	439	4,501
Percent	100.00	1.60	2.00	81.80	12.80	1.50	0.000	0.40
Region		1.56	1.98	81.75	12.79	1.52	0.03	0.36
Eastern	28,1201	1,289	5,380	241,627	28,665	3,481	129	630
Northern	41,4377	1,832	7,402	331,293	63,412	9,007	120	1,311
Southern	248,655	961	3,785	170,709	68,644	2,883	63	1,610
Western	321,235	15,697	8,535	290,893	1,150	3,883	127	950
Urban/Rural								
Rural	697,706	2,187	10,998	511,136	157,784	12,225	255	3,121
Urban	567,762	17,592	14,104	523,386	4,087	7,029	184	1,380
District								
Kailahun	83,348	319	1,478	73,314	6,711	1,257	75	194
Kenema	111,734	520	2,132	93,918	13,806	1,076	34	248
Kono	86,119	450	1,770	74,395	8,148	1,148	20	188
Bombali	105,902	418	1,725	86,161	14,728	2,526	16	328
Kambia	53,826	172	1,257	46,330	4,599	1,250	38	180
Koinadugu	56,108	156	706	33,640	18,820	2,484	13	289
Port Loko	111,701	761	2,220	100,026	7,002	1,513	19	160
Tonkolili	86,840	325	1,494	65,136	18,263	1,234	34	354
Bo	102,723	543	1,894	84,466	14,268	1,361	20	171
Bonthe	32,538	103	427	15,417	15,891	220	3	477
Moyamba	61,880	150	870	38,143	21,494	834	16	373
Pujehun	51,514	165	594	32,683	16,991	468	24	589
Western Area Rural	91,284	1898	2,084	83,275	910	2,766	38	313
Western Area Urban	229,951	13,799	6,451	207,618	240	1,117	89	637

Table 14-4: Total acreage of land cultivated by crops

Province/District Type of Residence	Total	Upland Rice	Lowland Rice	Cassava	Sweet Potato	Groundnut	Maize	Coffee	Cacao	Oil palm	Citrus	Vegetables	Cashew
Total Country													
Total	3,244,214	1,133,925	560,384	342,507	50,105	299,580	28,984	191,791	235,749	307,593	9,487	79,742	4,368
Rural	2,910,927	1,032,745	495,700	312,954	39,460	271,249	24,904	173,533	202,369	278,099	8,361	69,048	2,506
Urban	333,287	101,180	64,685	29,553	10,645	28,331	4,080	18,258	33,380	29,493	1,126	10,695	1,861
Province													
Eastern													
Total	1,170,590	400,988	136,415	54,275	10,880	53,533	7,815	162,701	215,442	111,472	3,378	12,659	1,031
Rural	991,713	342,585	111,278	43,000	7,609	44,610	6,240	147,111	183,025	93,070	2,824	9,939	421
Urban	178,877	58,403	25,137	11,275	3,271	8,923	1,576	15,589	32,417	18,402	554	2,720	610
Northern													
Total	1,220,327	424,654	335,440	111,309	22,781	178,889	11,445	9,045	3,660	84,798	3,602	32,218	2,487
Rural	1,110,180	393,265	300,527	101,532	19,471	164,333	10,260	7,129	3,397	77,167	3,271	28,199	1,628
Urban	110,148	31,389	34,912	9,777	3,310	14,555	1,185	1,916	263	7,631	331	4,019	859
Southern													
Total	825,816	302,132	84,918	172,187	13,087	63,943	8,655	19,752	16,473	110,476	2,329	31,259	605
Rural	801,707	294,544	82,394	167,070	11,971	61,544	8,289	19,288	15,938	107,773	2,240	30,220	436
Urban	24,109	7,589	2,525	5,117	1,116	2,398	366	464	535	2,703	89	1,039	169
Western													
Total	27,481	6,151	3,612	4,736	3,357	3,215	1,068	294	173	847	178	3,607	244
Rural	7,327	2,351	1,501	1,352	409	761	116	4	9	89	25	690	21
Urban	20,154	3,799	2,111	3,384	2,948	2,454	953	290	165	758	152	2,916	224
Districts													
Kailahun													
Total	499,264	153,687	51,907	17,706	3,699	20,980	2,006	66,814	114,125	62,658	1,327	4,311	44
Rural	387,076	119,120	39,063	11,829	2,328	14,634	1,286	55,205	89,865	49,811	1,073	2,841	20
Urban	112,188	34,567	12,844	5,877	1,371	6,345	720	11,609	24,260	12,847	254	1,469	24
Kenema													
Total	350,338	140,173	32,238	17,327	3,027	13,922	1,974	34,236	58,086	43,126	1,104	4,745	379

Province/District Type of Residence	Total	Upland Rice	Lowland Rice	Cassava	Sweet Potato	Groundnut	Maize	Coffee	Cacao	Oil palm	Citrus	Vegetables	Cashew
Rural	297,977	120,038	23,646	13,613	1,658	12,072	1,301	31,634	51,131	37,921	893	3,787	282
Urban	52,360	20,135	8,592	3,714	1,369	1,849	673	2,601	6,956	5,205	211	958	97
Kono													
Total	320,988	107,128	52,270	19,241	4,154	18,632	3,835	61,651	43,231	5,688	947	3,604	608
Rural	306,659	103,427	48,569	17,558	3,623	17,903	3,652	60,272	42,029	5,338	858	3,311	119
Urban	14,329	3,701	3,701	1,683	531	729	183	1,379	1,202	350	89	293	489
Bombali													
Total	196,812	77,478	45,264	15,388	3,912	41,849	953	38	112	7,270	405	3,829	316
Rural	181,803	72,185	41,784	13,903	3,239	38,862	726	33	81	6,732	394	3,573	291
Urban	15,009	5,293	3,480	1,486	673	2,987	227	5	31	538	11	255	25
Kambia													
Total	196,593	39,250	106,041	10,216	3,547	18,595	991	267	129	9,815	531	6,312	900
Rural	164,770	33,535	88,068	8,483	2,805	15,897	882	260	67	8,281	471	5,758	266
Urban	31,822	5,716	17,973	1,734	743	2,697	109	8	63	1,534	60	554	634
Koinadugu													
Total	252,895	107,047	67,928	9,958	2,762	36,750	2,000	7,964	2,310	7,978	396	7,777	27
Rural	223,270	96,604	61,355	7,144	2,475	32,429	1,840	6,113	2,209	5,884	201	6,991	26
Urban	29,625	10,443	6,573	2,814	286	4,321	160	1,851	101	2,094	195	786	1
Port Loko													
Total	310,294	101,556	78,774	44,779	8,929	35,404	3,563	196	478	25,101	1,221	9,405	888
Rural	295,646	98,176	75,406	42,725	7,945	33,811	3,215	171	439	24,511	1,198	7,250	800
Urban	14,647	3,381	3,368	2,055	984	1,594	348	25	39	590	23	2,155	88
Tonkolili													
Total	263,734	99,323	37,434	30,967	3,631	46,291	3,939	580	632	34,636	1,049	4,896	357
Rural	244,690	92,766	33,915	29,278	3,007	43,334	3,596	553	602	31,759	1,007	4,627	245
Urban	19,044	6,557	3,519	1,689	625	2,956	342	28	30	2,876	42	268	112
Bo													
Total	287,375	121,460	16,463	40,379	3,981	16,782	1,972	15,504	11,715	53,799	718	4,398	201
Rural	276,223	118,372	15,263	38,294	3,241	16,040	1,765	15,299	11,491	51,890	658	3,776	135

Province/District Type of Residence	Total	Upland Rice	Lowland Rice	Cassava	Sweet Potato	Groundnut	Maize	Coffee	Cacao	Oil palm	Citrus	Vegetables	Cashew
Urban	11,151	3,088	1 200	2,085	740	743	208	206	224	1,910	60	622	67
Bonthe													
Total	127,605	17,644	21 151	45,063	2,640	6,276	330	222	353	16,577	359	16,801	190
Rural	124,098	17,017	20 902	43,675	2,454	5,742	250	222	346	16,285	336	16,681	189
Urban	3,507	626	249	1,388	187	534	81	0	7	292	23	121	1
Moyamba													
Total	210,347	86,686	26,459	44,601	3,891	27,672	5,210	537	872	9,062	891	4,386	80
Rural	206,320	85,147	26,165	43,608	3,798	26,897	5,150	537	852	8,944	891	4,252	79
Urban	4,027	1,539	294	994	93	775	60	0	20	118	0	134	1
Pujehun													
Total	200,489	76,343	20,845	42,144	2,575	13,212	1,142	3,489	3,533	31,038	362	5,673	135
Rural	195,066	74,007	20,063	41,493	2,479	12,866	1,124	3,231	3,249	30,655	355	5,511	34
Urban	5,423	2,336	782	651	97	347	18	258	284	383	7	162	101
Western Area Rural													
Total	23,223	4,889	2,973	4,252	3,036	2,767	953	219	84	412	89	3,421	127
Rural	7,327	2,351	1,501	1,352	409	761	116	4	9	89	25	690	21
Urban	15,896	2,538	1,472	2,901	2,627	2,006	837	215	76	323	64	2,731	107
Western Area Urban													
Total	4,258	1,262	639	484	321	448	115	75	89	435	89	186	117
Rural	0	0	0	0	0	0	0	0	0	0	0	0	0
Urban	4,258	1,262	639	484	321	448	115	75	89	435	89	186	117

Table 14-5: Households engaged in agriculture by type of activity

Province/ District /Type of Residence	All Households	Agricultural Households		Crop Farming		Animal Husbandry		Fishery		Access to Agric Facility	
		Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number
Total Country											
Total	1,265,468	57.90	732,461	85.40	625,679	73.60	539,304	33.60	245,957	36.30	265,857
Rural	697,706	86.00	600,079	92.50	554,874	71.80	430,712	37.90	227,709	37.60	225,809
Urban	567,762	23.30	132,382	53.50	70,805	82.00	108,592	13.80	18,248	30.30	40,048
Province											
Eastern											
Total	281,201	72.30	203,286	93.60	190,210	67.40	137,077	37.00	75,175	46.70	94,942
Rural	182,637	89.20	162,991	96.60	157,376	66.00	107,570	41.40	67,529	45.40	73,931
Urban	98,564	40.90	40,295	81.50	32,834	73.20	29,507	19.00	7,646	52.10	21,011
Northern											
Total	414,377	74.80	310,073	86.70	268,902	77.40	239,973	26.40	81,943	32.20	99,966
Rural	306,946	86.20	264,714	92.20	244,139	76.10	201,469	28.80	76,320	32.60	86,300
Urban	107,431	42.20	45,359	54.60	24,763	84.90	38,504	12.40	5,623	30.10	13,666
Southern											
Total	248,655	73.40	182,402	86.10	157,114	71.50	130,419	46.30	84,428	37.60	68,645
Rural	199,225	83.90	167,214	90.20	150,792	70.20	117,406	49.60	82,997	38.90	65,045
Urban	49,430	30.70	15,188	41.60	6,322	85.70	13,013	9.40	1,431	23.70	3,600
Western											
Total	321,235	11.40	36,700	25.80	9,453	86.70	31,835	12.00	4,411	6.30	2,304
Rural	8,898	58.00	5,160	49.70	2,567	82.70	4,267	16.70	863	10.30	533
Urban	312,337	10.10	31,540	21.80	6,886	87.40	27,568	11.20	3,548	5.60	1,771
Districts											
Kailahun											
Total	83,348	89.20	74,361	95.40	70,970	75.80	56,341	38.10	28,318	66.30	49,271
Rural	57,316	94.40	54,090	97.90	52,963	75.60	40,886	43.60	23,597	63.00	34,060
Urban	26,032	77.90	20,271	88.80	18,007	76.20	15,455	23.30	4,721	75.00	15,211
Kenema											

Total	111,734	64.20	71,698	92.80	66,502	63.00	45,192	39.60	28,423	39.10	28,059
Rural	63,391	89.90	57,019	96.40	54,941	61.60	35,108	45.20	25,783	40.40	23,014
Urban	48,343	30.40	14,679	78.80	11,561	68.70	10,084	18.00	2,640	34.40	5,045
Kono											
Total	86,119	66.50	57,227	92.20	52,738	62.10	35,544	32.20	18,434	30.80	17,612
Rural	61,930	83.80	51,882	95.40	49,472	60.90	31,576	35.00	18,149	32.50	16,857
Urban	24,189	22.10	5,345	61.10	3,266	74.20	3,968	5.30	285	14.10	755
Bombali											
Total	105,902	63.50	67,229	87.00	58,463	69.70	46,866	15.80	10,626	31.70	21,316
Rural	73,128	81.80	59,831	91.90	54,993	67.90	40,617	17.10	10,225	33.10	19,830
Urban	32,774	22.60	7,398	46.90	3,470	84.50	6,249	5.40	401	20.10	1,486
Kambia											
Total	53,826	83.60	45,019	87.80	39,513	85.20	38,376	26.40	11,896	61.20	27,571
Rural	37,649	92.90	34,970	94.30	32,983	85.20	29,788	29.30	10,262	62.90	21,991
Urban	16,177	62.10	10,049	65.00	6,530	85.50	8,588	16.30	1,634	55.50	5,580
Koinadugu											
Total	56,108	87.90	49,302	94.00	46,350	79.00	38,968	45.50	22,417	34.30	16,914
Rural	45,944	92.90	42,681	96.30	41,101	78.80	33,639	49.10	20,941	32.20	13,763
Urban	10,164	65.10	6,621	79.30	5,249	80.50	5,329	22.30	1,476	47.60	3,151
Port Loko											
Total	111,701	73.70	82,353	79.10	65,101	81.40	67,071	20.40	16,821	24.70	20,309
Rural	81,778	85.30	69,795	86.90	60,658	80.30	56,057	22.50	15,704	27.00	18,879
Urban	29,923	42.00	12,558	35.40	4,443	87.70	11,014	8.90	1,117	11.40	1,430
Tonkolili											
Total	86,840	76.20	66,170	89.90	59,475	73.60	48,692	30.50	20,183	20.90	13,856
Rural	68,447	83.90	57,437	94.70	54,404	72.00	41,368	33.40	19,188	20.60	11,837
Urban	18,393	47.50	8,733	58.10	5,071	83.90	7,324	11.40	995	23.10	2,019
Bo											
Total	102,723	62.20	63,850	83.70	53,431	68.70	43,843	44.40	28,356	35.50	22,658
Rural	68,412	80.60	55,110	91.40	50,348	65.90	36,334	50.40	27,792	38.70	21,316

Urban	34,311	25.50	8,740	35.30	3,083	85.90	7,509	6.50	564	15.40	1,342
Bonthe											
Total	32,538	81.70	26,587	82.50	21,942	73.80	19,617	42.70	11,345	37.00	9,830
Rural	26,324	91.70	24,136	86.90	20,969	72.30	17,448	45.70	11,027	36.80	8,877
Urban	6,214	39.40	2,451	39.70	973	88.50	2,169	13.00	318	38.90	953
Moyamba											
Total	61,880	84.50	52,263	87.50	45,718	77.90	40,689	50.00	26,127	35.30	18,436
Rural	57,391	87.20	50,044	88.90	44,475	77.80	38,929	51.60	25,840	35.00	17,524
Urban	4,489	49.40	2,219	56.00	1,243	79.30	1,760	12.90	287	41.10	912
Pujehun											
Total	51,514	77.10	39,702	90.70	36,023	66.20	26,270	46.80	18,600	44.60	17,721
Rural	47,098	80.50	37,924	92.30	35,000	65.10	24,695	48.40	18,338	45.70	17,328
Urban	4,416	40.30	1,778	57.50	1,023	88.60	1,575	14.70	262	22.10	393
Western Area Rural											
Total	91,284	29.20	26,670	32.30	8,616	85.10	22,687	13.10	3,498	6.70	1,800
Rural	8,898	58.00	5,160	49.70	2,567	82.70	4,267	16.70	863	10.30	533
Urban	82,386	26.10	21,510	28.10	6,049	85.60	18,420	12.30	2,635	5.90	1,267
Western Area Urban											
Total	229,951	4.40	10,030	8.30	837	91.20	9,148	9.10	913	5.00	504
Rural	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
Urban	229,951	4.40	10,030	8.30	837	91.20	9,148	9.10	913	5.00	504

Table 14-6: Communities Exposed to Flood

District	Chiefdom	Section	Number of Households	Population		
				Male	Female	Total
Bo	Bagbwe(Bagbe)	Samawa	108	393	401	794
	Bo Town	East Ward-Batiema Layout	195	745	792	1,537
		East Ward-Bumpeh-Wo - Torkpoi Town	84	220	248	468
		East Ward-Kindia Town-Yimoh Town	622	2,050	2,204	4,254
		East Ward-Lower Samamie-Durbar ground	94	271	301	572
		East Ward-Moriba Town-New site	830	2,412	2,513	4,925
		North Ward-Bo Number Two-Borborkombo	629	1,534	1,748	3,282
		West Ward-Kandeh Town - Korwama	86	253	254	507
		West Ward-Moriba Town - Sewa Road	721	2,167	2,511	4,678
		West Ward-Njagboima-Coronation Field	1,197	2,877	3,240	6,117
	Boama	Bambawo	99	339	364	703
		Njeima	91	180	177	357
	Bumpe Ngao	Bumpe	383	739	777	1,516
	Gbo	Maryu	115	222	229	451
	Jaiama Bongor	Tongowa	89	242	242	484
	Kakua	Korjeh	83	302	405	707
		Kpandobu	81	288	283	571
		Nyallay	97	213	214	427
		Sewa	159	491	513	1,004
	Niawa Lenga	Lower Niawa	126	211	232	443
		Yalenga	230	443	461	904
	Selenga	Kaduawo	86	466	557	1,023
		Mokpendeh	195	597	672	1,269
		Old Town	118	342	428	770
	Tikonko	Morku	64	103	98	201
		Njagbla I	77	181	197	378
	Valunia	Lunia	211	452	468	920
		Seilenga	111	203	217	420
		Vanjelu	82	144	150	294

District	Chiefdom	Section	Number of Households	Population		
				Male	Female	Total
	Wonde	Lower Kargoi	126	561	555	1,116
Bo Total			7,189	19,641	21,451	41,092
Bombali	Biriwa	Bumban	232	892	891	1,783
		Kagbankuna	99	381	395	776
		Karassa	72	137	171	308
		Karina	177	469	532	1,001
	Bombali Sebora	Konta	57	202	201	403
		Matotoka	175	343	350	693
	Libeisaygahun	Mangaimor	115	120	149	269
	Magbaimba Ndorwahun	Makendema	128	254	295	549
	Makari Gbanti	Gborbana	96	159	185	344
		Mabanta	93	257	259	516
		Yainkassa	71	229	224	453
	Makeni City	Banana Ward	239	643	629	1,272
		Kagbaran Dokom A	440	1,244	1,382	2,626
		Maslasie Ward	177	476	470	946
		Mayanka I Ward	1,034	4,327	4,118	8,445
		Mayanka II Ward	522	1,346	1,426	2,772
		Rogbaneh Ward	285	768	720	1,488
		Wusum Ward	1,302	4,566	4,595	9,161
	Paki Masabong	Masabong Thoron	108	205	205	410
	Safroko Limba	Kagbo	80	404	422	826
	Sanda Loko	Banka	107	354	396	750
	Sella Limba	Kamakwie	76	298	308	606
	Tambakha	Paramount Chief	120	656	640	1,296
		Simibue	430	1,683	1,594	3,277
		Thalla	188	749	799	1,548
Bombali Total			6,423	21,162	21,356	42,518
Bonthe	Bendu-Cha	Sokenteh	80	99	122	221
		Yallan-gbokie	238	288	341	629

District	Chiefdom	Section	Number of Households	Population		
				Male	Female	Total
	Bum	Gbengain	151	362	317	679
		Koimato	97	197	223	420
	Dema	Yoh	80	222	139	361
	Imperri	Babum	120	536	382	918
		Moimaligie	92	274	282	556
	Jong	Basiaka	209	540	425	965
		Bayengbe	212	521	616	1,137
		Beyinga	207	679	677	1,356
		Landi-Ngere	309	443	483	926
		Sopan-Cleveland	206	516	478	994
		Tucker-Nyambe	157	109	132	241
	Kpanda Kemo	Bewoni	134	334	350	684
	Kwamebai Krim	Massa Settie	176	675	793	1,468
		Mosenten Sahen II	70	164	190	354
		Tubla	65	250	264	514
		Yikie Karbay	130	283	283	566
	Nongoba Bullom	Baoma	85	159	187	346
		Bohol	156	377	354	731
		Gbangbassa	81	202	194	396
		Gbap	81	384	442	826
		Hahun	94	145	134	279
		Kessie	75	167	137	304
		Manyyime	83	96	95	191
		Torma Subu	213	550	490	1,040
	Sittia	Bamba	116	435	331	766
		Gonoh	61	96	94	190
		Ngepay	81	209	192	401
		Saama	65	240	203	443
		Sahaya	182	412	334	746
		Sahn-Gbegu	86	203	244	447

District	Chiefdom	Section	Number of Households	Population		
				Male	Female	Total
		Yoni	76	189	169	358
	Sogbeni	Beyorgboh	273	637	716	1,353
		Ndopie	112	305	339	644
	Yawbeko	Baryegbe	103	240	300	540
Bonthe Total			4,756	11,538	11,452	22,990
Kailahun	Dea	Baiwalla	118	314	259	573
	Jawie	Lower Luyengeh	80	137	170	307
		Sowa	792	2,076	2,181	4,257
		Upper Giebu	222	731	581	1,312
	Kissi Teng	Lela	331	1,326	1,222	2,548
		Torli	310	1,467	1,360	2,827
	Kissi Tongi	Upper Konio	136	379	378	757
		Upper Tongi Tingi	97	284	300	584
	Luawa	Gbela	101	201	268	469
		Upper Kpombali	110	324	347	671
	Njaluahun	Kargbu	512	1,334	1,333	2,667
		Sei I	1,127	3,460	3,458	6,918
	Penguia	Jagor	98	166	176	342
	Upper Bambara	Golu	102	228	241	469
		Guma	87	166	196	362
	Yawei	Kuivawa	110	390	386	776
Kailahun Total			4,333	12,983	12,856	25,839
Kambia	Bramaia	Fortomboyie	105	225	243	468
	Gbinle Dixing	Katalan	114	399	432	831
		Rogberay	369	1,478	1,570	3,048
		Sanda	142	196	269	465
	Magbema	Bombe	240	705	762	1,467
		Kambia	159	529	532	1,061
		Kargbulor	328	750	845	1,595
		Robat	124	170	187	357

District	Chiefdom	Section	Number of Households	Population		
				Male	Female	Total
		Rokupr	948	2,325	2,680	5,005
	Mambolo	Kalenkay	380	562	556	1,118
		Mambolo	182	646	672	1,318
		Matetie	115	225	268	493
		Mayakie	52	194	191	385
		Robis	124	519	598	1,117
		Rotain Bana	506	1,294	1,529	2,823
		Rowollon	663	1,439	1,709	3,148
	Samu	Bubuya	114	360	418	778
		Kassiri	253	583	626	1,209
		Koya	239	531	529	1,060
		Kychom	198	349	386	735
		Mapotolon	332	887	1,097	1,984
		Moribaia	235	589	605	1,194
		Rokon	112	292	315	607
		Rosinor	227	418	499	917
	Tonko Limba	Kamassassa	202	682	670	1,352
		Kathanthineh	111	375	425	800
		Yebaya	112	127	143	270
Kambia Total			6,686	16,849	18,756	35,605
Kenema	Dama	Dakowa	85	289	282	571
		Lower Dabor	115	249	242	491
	Dodo	Bambara	92	302	292	594
		Golama	121	383	393	776
	Gorama Mende	Biatong	82	197	226	423
		Famanjo	557	1,299	1,134	2,433
	Kandu Leppiama	Karga	238	556	550	1,106
		Sonnie	326	590	538	1,128
	Kenema City	Gbo Kakajama A-Burma	482	2,491	2,462	4,953
		Gbo Kakajama A-Lambayama	526	1,454	1,541	2,995

District	Chiefdom	Section	Number of Households	Population		
				Male	Female	Total
		Gbo Kakajama A-Lumbebu	498	1,147	1,234	2,381
		Gbo Kakajama A-Shimbeck	462	1,660	1,651	3,311
		Gbo Kakajama A-Technical/Gbongbotoh	162	557	653	1,210
		Gbo Lambayama A-Gombu	340	1,137	1,221	2,358
		Gbo Lambayama A-Kondebotihun	95	391	385	776
		Gbo Lambayama A-Ndigbuama	537	1,461	1,344	2,805
		Gbo Lambayama A-Nyandeyama	1,856	4,890	5,077	9,967
	Koya	Upper Koya	95	216	230	446
	Lower Bambara	Bonya	320	760	857	1,617
		Nyawa	289	701	673	1,374
	Malegohun	Lower Torgboma	173	571	586	1,157
	Simbaru	Fallay	81	68	62	130
		Yalenga	107	205	224	429
	Small Bo	Niawa	98	219	177	396
	Tunkia	Daru	81	156	158	314
	Wandor	Kemoh	331	940	892	1,832
		Niawa	112	310	367	677
Kenema Total			8,261	23,199	23,451	46,650
Koinadugu	Diang	Gbenekoro	105	215	206	421
	Kasunko	Kasunko	183	500	528	1,028
	Mongo	Mongo I	96	453	390	843
		Morifindugu I	200	637	723	1,360
	Neya	Neya II	124	287	273	560
	Nieni	Kalian	141	310	308	618
	Sulima	Gberia-Timbako	110	254	286	540
	Wara Wara Yagala	Zone 4	112	163	187	350
Koinadugu Total			1,071	2,819	2,901	5,720
Kono	Fiama	Fiama	121	211	258	469
	Gbane Kandor	Gbane Tetema	95	343	474	817
	Gbense	Banyafeh	73	155	162	317

District	Chiefdom	Section	Number of Households	Population		
				Male	Female	Total
		Moindefeh	212	369	424	793
	Koidu City	Gbense-Moindefeh A	581	1,565	1,683	3,248
		Gbense-Moindefeh B	84	235	235	470
		Gbense-Moindekor	669	2,500	2,362	4,862
		Gbense-Vaama	695	1,742	1,547	3,289
		Moindefeh	160	687	643	1,330
		Tankoro-Kinsey	335	827	778	1,605
		Tankoro-Koakoyima	182	1,058	1,005	2,063
		Tankoro-New Sembehun	1,325	6,264	6,161	12,425
	Mafindor	Kutey	117	510	559	1,069
	Nimikoro	Bandafafeh	124	1,107	1,097	2,204
		Gbogboafeh	313	1,025	987	2,012
		Jaiama	115	452	377	829
	Nimiyama	Njaifeh	104	348	315	663
		Tama	120	306	269	575
	Sandor	Bafinfeh	91	403	385	788
		Sumunjifeh	111	210	215	425
		Yawatanda	196	864	891	1,755
	Soa	Kokongokuma	126	451	443	894
		Sawa Fiama	123	401	468	869
	Tankoro	Tankoro	113	475	471	946
Kono Total			6,185	22,508	22,209	44,717
Moyamba	Bagruwa	Mokassi	73	416	413	829
	Bumpeh	Bumpeh	96	246	263	509
		Greema	166	446	524	970
	Fakunya	Kunafoi	84	242	317	559
	Kagboro	Bumpetoke	213	766	731	1,497
		Mambo	94	299	312	611
		Mopaileh	110	251	302	553
		Thumba A	74	194	214	408

District	Chiefdom	Section	Number of Households	Population		
				Male	Female	Total
	Kaiyamba	Koromboya	523	1,525	1,717	3,242
		Mosoe	350	889	987	1,876
	Kori	Zone - 4	108	224	252	476
	Kowa	Tabe	91	240	264	504
	Lower Banta	Wulbange	70	250	291	541
	Ribbi	Masarakulay	116	186	239	425
		Mobureh	89	226	251	477
	Timdale	Mando	85	246	267	513
	Upper Banta	Kenafallay	110	238	269	507
		Songbo	126	265	276	541
Moyamba Total			2,578	7,149	7,889	15,038
Port Loko	Bureh Kasseh Makonteh	Kambia Morie	78	198	280	478
	Kaffu Bullom	Foronkoya	435	1,975	2,026	4,001
		Mahera	179	340	333	673
		Mamanki	113	456	523	979
		Mayaya	121	370	424	794
		Rosint	84	315	337	652
		Yongro	288	1,193	1,229	2,422
	Koya	Kagbala A	115	206	213	419
		Marefa	209	519	567	1,086
		Tumba	100	264	271	535
	Lokomasama	Gbainty	123	278	318	596
		Yurika	1,154	2,635	3,168	5,803
	Maforki	Falaba	30	218	235	453
		Kondato	199	645	690	1,335
		Old Port Loko	70	175	188	363
		Sanda	418	1,212	1,398	2,610
		Sendugu	514	1,570	1,706	3,276
	Marampa	Marampa A	81	112	114	226
		Rogballan	101	188	231	419

District	Chiefdom	Section	Number of Households	Population		
				Male	Female	Total
	Masimera	Maconteh	205	482	528	1,010
		Masimera	102	202	204	406
		Matuku	215	530	603	1,133
		Mayola-Thatha	119	349	328	677
		Rokon/Komboya	120	247	301	548
		Yoni-Pet	110	354	398	752
	Sanda Magbolont	Gbogbodo	112	352	387	739
Port Loko Total			5,395	15,385	17,000	32,385
Pujehun	Barri	Karjei	82	405	410	815
		Malla	80	151	188	339
	Galliness Perri	Dabeni	101	103	100	203
		Dakona	85	227	264	491
		Pelegbulor	100	360	365	725
	Kpaka	Jassende Masaoma	96	153	204	357
		Parvu	102	72	89	161
		Sarbah	430	784	891	1,675
	Makpele	Selimeh	268	1,039	1,063	2,102
	Malen	Kahaimoh	187	515	421	936
		Seijeila	89	148	127	275
		Taukunor	85	343	337	680
	Mono Sakrim	Massanda Majagbe	80	354	392	746
		Pembaar	188	630	718	1,348
		Pullie	105	231	267	498
		Sitta	74	388	361	749
		Sowa	185	386	486	872
	Panga Kabonde	Bakoi	91	226	169	395
		Panga	24	283	319	602
		Samba	110	110	114	224
		Setti - Yakanday	198	278	317	595
	Panga krim	Pemagbie	45	303	309	612

District	Chiefdom	Section	Number of Households	Population		
				Male	Female	Total
		Samba	175	507	521	1,028
		Somasa	82	66	62	128
	Soro Gbema	Massaquoi I	84	542	508	1,050
		Massaquoi II	106	63	79	142
	Sowa	Sabba I	107	234	306	540
		Sabba II	88	280	305	585
	Yakemu Kpukumu	Bapawa	85	355	410	765
		Kpukumu	89	384	367	751
		Seiwoh	78	298	360	658
		Yabai	207	465	532	997
Pujehun Total			3,906	10,683	11,361	22,044
Tonkolili	Gbonkolenken	Lower Polie	90	277	248	525
		Petifu Mayawa B	93	265	295	560
		Yele Manowo	281	603	492	1,095
		Yiben	183	235	251	486
	Kalansogoia	Bumbuna	120	332	340	672
		Kemedugu	120	336	406	742
		Makilla	75	75	82	157
	Kholifa Mabang	Mabang	110	207	194	401
		Mamanso	115	187	241	428
	Kholifa Rowala	Bo Road	174	444	484	928
		Lal-Lenken	387	686	743	1,429
		Mamuntha	338	647	713	1,360
		Mayatha	105	236	292	528
		Old Magburaka	208	563	616	1,179
	Kunike	Wana	120	310	270	580
		Yenkeh	116	645	531	1,176
	Malal Mara	Malal	108	244	206	450
		Manewa	85	88	89	177
		Mara	83	112	116	228

District	Chiefdom	Section	Number of Households	Population		
				Male	Female	Total
		Rochen	100	189	219	408
	Tane	Maboboh Koray	120	237	229	466
		Mathunkara	223	337	369	706
	Yoni	Foindu	405	349	406	755
		Mamaka	87	151	171	322
		Ronietta	102	397	462	859
Tonkolili Total			3,948	8,152	8,465	16,617
Western Area Rural	Koya Rural	Madonkeh	209	491	507	998
		Magbafti	102	268	290	558
		Malambay	1,210	3,528	4,000	7,528
		Newton	118	443	423	866
	Mountain Rural	Bathurst	100	254	279	533
		Charlotte	94	160	151	311
		Gloucester	294	658	649	1,307
		Leicester	85	496	508	1,004
		Regent	1,026	3,201	2,913	6,114
	Waterloo Rural	Deep Eye Water/Devil Hole	898	2,417	2,397	4,814
		Hastings-Yams Farm	82	835	866	1,701
		Jui-Grafton	937	5,659	6,014	11,673
		Rokel	400	1,333	1,409	2,742
		Waterloo Benguema	1,915	6,039	6,445	12,484
		Waterloo Lumpa	2,543	8,137	8,592	16,729
		Waterlooo Campbell Town	1,691	5,791	6,348	12,139
	York Rural	Gbendembu	1,796	5,374	5,501	10,875
		Goderich-Adonkia/Milton Margai	1,714	3,651	3,432	7,083
		Goderich-Funkia	441	942	880	1,822
		Hamilton	194	879	837	1,716
		Kent	126	362	354	716
		Sattia/Tombo	2,862	9,363	9,723	19,086
		York	89	246	230	476

District	Chiefdom	Section	Number of Households	Population		
				Male	Female	Total
Western Area Rur Total			18,926	60,527	62,748	123,275
Western Area Urb	Central I	Albert Academy	906	1,963	2,010	3,973
		Mountain Regent	2,051	6,002	6,172	12,174
		Sorie Town	324	1,286	1,340	2,626
		Susan' s Bay	2,334	6,471	5,569	12,040
		Tower Hill	82	170	177	347
	Central II	Connaught Hospital	176	384	242	626
		Sanders Brook	1,145	4,354	3,096	7,450
	East I	Cline Town	1,551	4,536	4,375	8,911
		Kossoh Town	1,718	4,749	4,756	9,505
	East II	Ashobi Corner	774	1,855	1,750	3,605
		Foulah Town	1,680	4,969	5,349	10,318
		Kissy Brook I	800	2,184	2,158	4,342
		Magazine	1,077	3,789	3,515	7,304
	East III	Allen Town I	367	1,413	1,488	2,901
		Allen Town II	261	859	805	1,664
		Bottom Oku	864	2,430	2,441	4,871
		Congo Water I	847	2,431	2,705	5,136
		Congo Water II	1,451	4,831	5,133	9,964
		Grass Field	1,712	3,712	3,792	7,504
		Industrial Estate	1,600	5,358	5,711	11,069
		Jalloh Terrace	1,806	6,820	6,854	13,674
		Kissy Brook II	1,599	4,116	4,162	8,278
		Kissy Bye Pass(Dock)	1,209	5,561	5,494	11,055
		Kissy Bye Pass(Term)	539	1,720	1,558	3,278
		Kissy Mental	172	697	589	1,286
		Kissy Mess Mess	1,721	7,087	7,350	14,437
		Kuntolor	180	375	319	694
		Lowcost Housing	663	2,393	2,569	4,962
		Mamba Ridge I	1,296	4,888	4,698	9,586

District	Chiefdom	Section	Number of Households	Population		
				Male	Female	Total
		Mayenkineh	1,270	4,231	4,338	8,569
		Old Warf	485	1,498	1,515	3,013
		Pamuronko	1,136	3,014	2,983	5,997
		Portee	750	1,875	1,971	3,846
		Robis	1,615	4,742	4,917	9,659
		Shell	1,811	6,249	6,439	12,688
		Thunderhill	1,486	3,963	4,067	8,030
	West I	Ascension Town	794	1,643	1,643	3,286
		Brookfields	1,409	4,022	4,041	8,063
		Kroo Town	1,316	2,982	3,263	6,245
	West II	Brookfields-Congo	3,119	5,682	5,991	11,673
		Brookfields-Red Pu	463	1,194	1,141	2,335
		CongoTown	1,710	3,624	3,635	7,259
		George Brook (Dwor	1,529	3,960	4,015	7,975
		New England-Hannes	636	1,288	1,221	2,509
		New England-Hill Cot	343	796	786	1,582
		Sumaila Town	260	690	612	1,302
		Tengbeh Town	2,021	5,180	5,196	10,376
	West III	Aberdeen	1,637	4,285	4,137	8,422
		Cockerill-Aberdeen	1,111	2,605	2,672	5,277
		Cockle-Bay /Collegiate	1,584	3,511	3,596	7,107
		Hill Station	697	1,611	1,628	3,239
		Juba/Kaningo	1,976	4,527	4,138	8,665
		Lumley	1,877	5,190	5,247	10,437
		Malama/Kamayama	683	2,350	2,324	4,674
		Murray Town	101	110	134	244
		Pipeline/Wilkinson	437	1,168	1,275	2,443
		Wilberforce	425	1,077	1,037	2,114
Western Area Urban Total			63,586	180,470	180,139	360,609
National			**143,243**	**413,065**	**422,034**	**835,099**

15 APPENDIX 4: HISTORIC DISASTER EVENTS IN SIERRA LEONE

The disaster event data found in this report have been obtained and processed from the ONS-DMD, DesInventar, CRED EM-DAT and other sources believed to be reliable. No warranty, expressed or implied, is made regarding accuracy, adequacy, completeness, legality, reliability or usefulness of this information. This applies to both isolated and aggregate uses of the information. The information is provided on an "as is" basis. All warranties of any kind, express or implied, including but not limited to the implied warranties of merchantability, fitness for a particular purpose and non-infringement of proprietary rights are disclaimed.

It is recommended that careful attention be paid to its contents and that the originators of the data be contacted with any questions regarding appropriate use.

Disaster	No of Records
Accident	26
Accident (Maritime)	111
Accident (Road)	38
Conflict	10
Drought	2
Drowning	2
Epidemic	114
Fire	267
Flood	68
Landslide	16
Lightning/Electrical Storm	1
Storm/Gale	40
Structural Collapse	5
Thunderstorm and Lightning	1
Windstorm	1

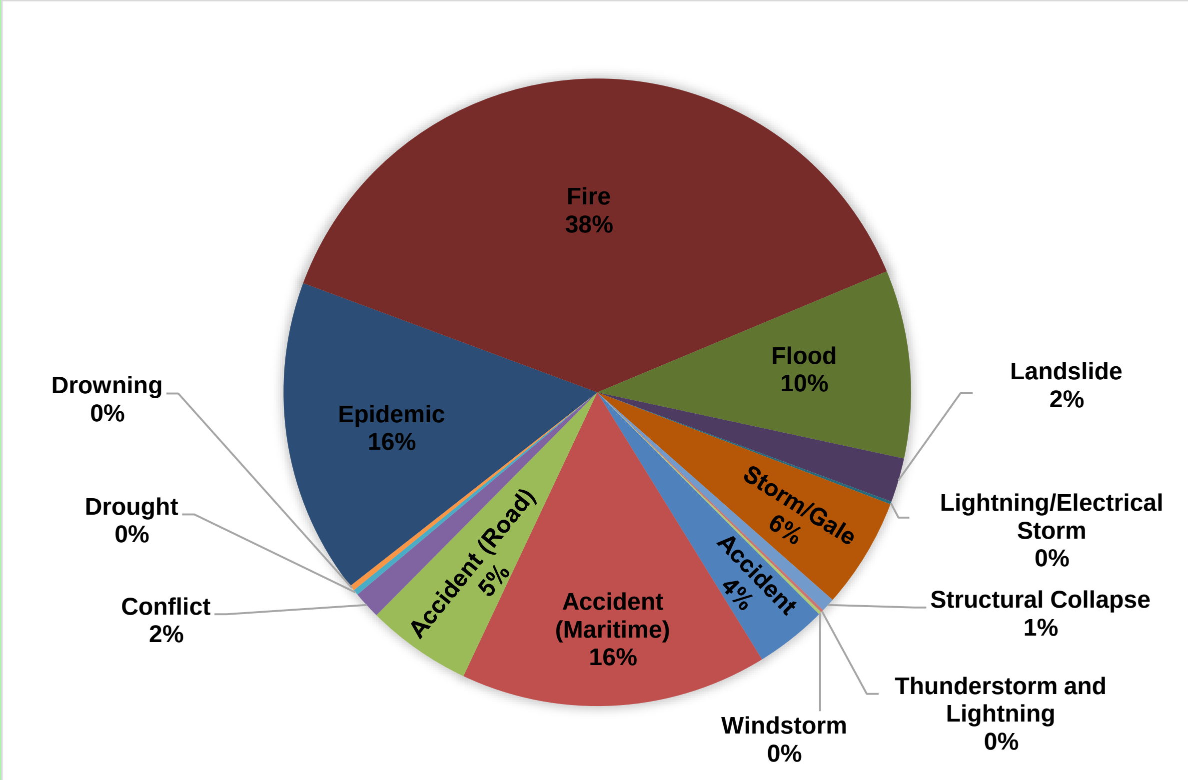

Table 15-1: Historic Disaster Events in Sierra Leone

Disaster	District	Chiefdom	Date	Deaths	Injured	Houses Destroyed	Houses Damaged	Victims	Affected	Comments
Accident	Bonthe		09/09/2009							Maritime Disaster
Accident	Kenema	Nongowa	15/09/2009	1						Motorcycle/Okada
Accident	Bonthe	Jong	07/02/2011		1				39	Passenger Boat
Accident	Kambia	Magbema	16/03/2011	2						Bomb Explosion
Accident	Bo	Kakua	20/08/2011	1						Electric Shock
Accident	Port Loko	Kaffu Bullom	09/09/2011	1	3					Explosion
Accident	Bonthe	Sittia	31/10/2011						4	Passenger Boat
Accident	Bonthe	Jong	18/07/2012						19	LMV
Accident	Kono		08/01/2013	21	29			50		Makali, Matotoka Road
Accident	Bonthe	Sittia	26/01/2013	1	1				35	LMV
Accident	Tonkolili		10/02/2013	3	3					Masiaka Highway (Road Accident)
Accident	Bonthe	Sittia	12/04/2013						4	Speed Boat
Accident	Bonthe	Nongoba Bullom	18/08/2013	1	1				3	Unmotorized Boat
Accident	Bonthe		28/08/2013						9	Fishing Vessel
Accident	Tonkolili		30/08/2013	1	3			5		Kabala Town (Road Accident)
Accident	Kenema	Nongowa	08/11/2013	1				1		Manslaughter (Road Accident)
Accident	Kailahun	Jawie	13/11/2013	2	5			7		Ferry Junction (Road Accident)
Accident	Bonthe	Sittia	14/11/2013	2	2				3	Canoe
Accident	Port Loko	Kaffu Bullom	24/12/2013	2	1					Atlantic Ocean between Kissy and Lungi
Accident	Western Area Rural		14/01/2014		1			1		Waterloo, Man Slaughter
Accident	Kenema	Nongowa	17/02/2014	1						Ahmadiyya Secondary School, Manslaughter (Road Accident)
Accident	Bonthe	Imperi	28/02/2014	1						Manslaughter
Accident	Kenema	Nongowa	02/04/2014	1						Koroma Street, Manslaughter (Road Accident)
Accident	Port Loko	Kaffu Bullom	06/04/2014	1				1		Manslaughter
Accident	Pujehun	Sowa Chiefdom	17/04/2014	2	8			10		Nyabuhun Village

Disaster	District	Chiefdom	Date	Deaths	Injured	Houses Destroyed	Houses Damaged	Victims	Affected	Comments
Accident	Kenema		11/05/2014	2	2			4		Western Area Urban highway
Accident	Bombali	Gbendembu Ngowa	09/02/2009	2						Maritime Disaster
Accident	Port Loko		10/07/2009							Maritime Disaster
Accident	Kambia	Magbema	07/03/2010	1						Maritime Disaster
Accident	Kambia		24/08/2010							Maritime Disaster
Accident	Pujehun		25/10/2010	5						Maritime Disaster
Accident	Port Loko	Kaffu Bullom	07/01/2011						12	Cargo Boat
Accident	Port Loko	Kaffu Bullom	07/01/2011		3				38	Passenger Boat
Accident	Western Area Urban		08/01/2011						42	Passenger/Cargo Boat
Accident	Port Loko	Kaffu Bullom	25/01/2011						8	Cargo Boat
Accident	Kambia	Masungbala	03/02/2011						17	Passenger Boat
Accident	Western Area Urban		05/02/2011						48	Passenger Boat

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