REPUBLIC OF GHANA

PUBLIC HEALTH RISK MAPPING AND CAPACITIES ASSESSMENT IN GHANA

Prepared for GHS/MoH with support from WHO

JULY 2016

Ministry of Health

GHANA HEALTH SERVICE

Your Health • Our Concern

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ACKNOWLEDGEMENTS

A number of individuals and organizations contributed to the risk mapping and capacities assessment with their knowledge, publications and financial support.

We would like to thank the Incident Commander and members of the Emergency Operation Centre (EOC) and the IHR National Focal Point for leadership and initiation of this activity.

To those who were interviewed to elicit information and those who participated in stakeholders' dissemination meeting and made invaluable inputs we wish to thank them all.

Furthermore, we would like to thank the World Health Organization (WHO) for their financial and technical support.

Finally, we would like to commend the hard work, dedication, and the untiring efforts of Dr Lawson Ahadzie, the lead consultant, and the field officers.

ACRONYMS

APHEF	African Public Health Emergency Fund
AU-IBAR	African Union Inter Bureau for Animal Resources
CDC	Centers for Disease Control and Prevention
CHO	Community Health Officer
CHPS	Community Health Planning and Services
CZ	Coastal Zone
EOC	Emergency Operations Centre
EPA	Environmental Protection Agency
EVD	Ebola Virus Disease
FAO	Food and Agriculture Organization
FDA	Food and Drug Authority
FELTP	Field Epidemiology and Laboratory Training Program
FZ	Forest Zone
GDP	Gross Domestic Product
GHS	Ghana Health Service
GLIDE	Global unique disaster Identifier system
GoG	Government of Ghana
GPHA	Ghana Ports and Harbours Authority
GSS	Ghana Statistical Service
HF	Health Facility
HPAI	Highly Pathogenic Avian Influenza
IDSR	Integrated Disease Surveillance and Response
IHR	International Health Regulations
IHR NFP	International Health Regulations National Focal Point
ILI	Influenza-Like Illness
IMC	Inter-Ministerial Committee
IOM	International Organization for Migration
IPC	Infection Prevention and Control
JICA	Japan International Cooperation Agency
KCCR	Kumasi Centre for Collaborative Research in Tropical Medicine
KIA	Kotoka International Airport
LI	Legislative Instrument
MEST	Ministry of Environment Science and Technology
MoF	Ministry of Finance
MoFA	Ministry of Food and Agriculture
MoH	Ministry of Health
NADMO	National Disaster Management Organization
NCC	National Coordinating Committee
NGO	Non-Governmental Organization
NMIMR	Noguchi Memorial Institute for Medical Research

NPHRL	National Public Health and Reference Laboratory
NSZ	Northern Savannah Zone
NTCC	National Technical Coordination Committee
OIE	World Organization for Animal Health
PH	Port Health
PHA	Public Health Act
PHE	Public Health Emergency
PHEIC	Public Health Emergency of International Concern
PHEM	Public Health Emergency Management
PHEMC	Public Health Emergency Management Committee
PHEPR	Public Health Emergency Preparedness and Response
PHL	Public Health Laboratory
PHU	Public Health Unit
PoE	Point of Entry
PPE	Personal Protective Equipment
RCC	Regional Coordinating Council
RDT	Rapid Diagnostic Test
RRT	Rapid Response Team
UG	University of Ghana
UNCCD	United Nations Convention to Combat Desertification
UN DHA	United Nations Department of Humanitarian Affairs
UNDP	United Nations Development Programme
UNISDR	United Nations International Strategy for Disaster Reduction
USAID	United States Agency for International Development
UST	University of Science and Technology
VSD	Veterinary Services Directorate
WARDS	West Africa Regional Disease Surveillance Capacity Strengthening
WCO	World Health Organization Country Office
WHO	World Health Organization
WHO AFRO	World Health Organization Regional Office for Africa

GLOSSARY OF TERMS

Capacity: The combination of all the strengths, attributes and resources available within a community, society, organization or a system that can be used to achieve agreed goals or reduce disaster risks (UNISDR, 2009).

Coping Capacity: The ability of people, organizations and systems using available skills and resources, to face and manage adverse conditions, emergencies and disasters (UNISDR 2009).

Hazard: 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 (UNISDR, 2009).

Risk: The probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, social and economic activities disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions (UNISDR, 2009).

Risk Map is a map of a community or geographical zone that identifies the places and the structures that might be adversely affected in the event of a hazard.

Public Health Emergency is any situation or event whose health consequences, particularly those whose scale, timing, or unpredictability threatens to overwhelm routine capabilities (RAND Health, 2008)

Secondary Hazard: A hazard that occurs as a result of another hazard or disaster, i.e., fires or landslides following earthquakes, epidemics following famines, food shortages following drought or floods. (UN DHA)

Vulnerability: Characteristics and the circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard (UNISDR, 2009).

EXECUTIVE SUMMARY

Ghana has been exposed to periodic pandemics and major epidemics including Avian and Pandemic Influenza, Cholera, Meningitis, Yellow fever and Viral Haemorrhagic Fevers in addition to other hazards and events of public health concerns such as flood, drought, transport accidents and environmental pollution. The public health impact from these hazards has far reaching implications on individuals and the country at large. The protracted cholera epidemic in the country in 2014 that spilled over to 2015 and the Ebola outbreak that ravaged the West African sub-region in 2014, especially Guinea, Liberia and Sierra Leone and threatened the security of many countries in the sub-region including Ghana, have brought to the fore the urgent need for the country to adequately prepare and respond to public health emergencies of national and international concern.

As part of efforts to strengthen the emergency preparedness and response systems, risk mapping of public health emergencies in Ghana as well as assessment of existing capacities to respond to these emergencies and other public health threats was undertaken from March to May 2016. A draft report of the risk mapping and capacity assessment was presented to a large group of experts, and stakeholders from MOH, GHS, Development Partners (DPs), regions, academia, NGOs in the first week of July to solicit further input, and validate the findings and scoring of risks, vulnerability and coping mechanism. This final report which is the product of these processes is expected to guide prioritization of public health interventions to support the implementation of International Health Regulations (2005) and the overall response to public health emergencies and other public health threats.

Public Health Risk Mapping

Public health risk mapping is a graphical representation of specific adverse health effects the population of a community or geographical zone might experience as a result of exposure to a hazard. It helps inform on the location of major hazards and communicate to policy makers and other stakeholders a better understanding of the country's public health risk profile and facilitates prioritization in planning for response interventions.

The main objective of the risk mapping exercise described in this document is to provide an overview of hazards that can lead to public health emergencies in Ghana and the level of risk they pose in the three ecological zones of the country.

Historical data on hazards was reviewed from sources such as the Ghana Health Service/Ministry of Health, National Disaster Management Organization (NADMO) and other agencies to identify hazards that have health consequences. These hazards were analysed to establish those that have the potential to result in public health emergencies. Risk analysis was done using as a guide the pseudo equation, Risk (R) = Hazard (H) x Vulnerability (V)/Coping Capacity (C). In order to guide prioritization of the response interventions to the public health risks, the hazards were ranked by the public health risk they pose using the criteria of **S**eriousness, **M**anageability, **A**cceptability, **U**rgency and Growth (SMAUG).

Assigning scores by an individual to mostly qualitative variables is subjective. This is the major limitation in the methodology used in the risk assessment and mapping presented in this document. The influence of subjectivity in the results can be minimised through consensus if the assessment is conducted by stakeholders in group discussions. The results presented here are therefore to be used as a guide for further national, regional and district level risk mapping.

Hazards identified as having the potential of resulting in public health emergencies include:

1. Biological – Epidemics - Cholera, Meningitis, Yellow Fever, Avian and Pandemic Influenza, Viral Haemorrhagic Fevers (e.g. Ebola Virus Disease (EVD), Lassa Fever)
2. Physical – Flood, Drought, Earthquake
3. Technological - Transport accidents (Road, Air, Water), Structure failures, Fire, Oil and Gas Spillage, Chemical, Nuclear and Radiological accidents
4. Societal Hazards – Civil Disorders, Terrorism

These hazards may occur alone or in combination or as secondary hazard (hazard that occur as a result of another hazard e.g. cholera outbreak following flooding).

The top three ranked hazards posing major public health risks are biological hazards (Table 1). Although EVD has not been confirmed in Ghana it ranked highest because of the propensity to cause devastating outbreaks with high case fatality rate due to difficulty in recognizing and quickly diagnosing it in its early stages as presenting symptoms are similar to common prevalent infectious conditions such as malaria; rapid spread; vulnerability of health care workers and absence of an approved vaccine and effective cure. In addition to EVD, the top public health risk hazard in northern savannah zone is meningitis, whilst those for the forest and coastal zones are road traffic accident and cholera respectively.

Table 1: Ranking of Hazards by Risk in Ghana, 2016

Rank	Hazards			
	National	**Northern Savannah Zone**	**Forest Zone**	**Coastal Zone**
1	EVD	EVD	EVD	EVD
2	Cholera	Meningitis	Road Traffic Accidents	Cholera
3	Meningitis	Pandemic Influenza	Pandemic Influenza	Flooding
4	Pandemic Influenza	Drought	Fire	Pandemic Influenza
5	Road Traffic Accidents	Road Traffic Accidents	Water Transport Accident	Terrorism
6	Flood	Water Transport Accident	Failure of Structures	Road Traffic Accidents
7	Terrorism	Fire	Civil Disorders	Aviation Accidents
8	Yellow Fever	Civil Disorders	Cholera	Failure of Structures
9	Fire	Cholera	Meningitis	Oil/Gas spillage
10	Avian Influenza	YF	YF	Fire
11	Aviation Accidents	Flooding	Flooding	Civil Disorders
12	Water Transport Accident	Aviation Accidents	Earthquake	Avian Influenza
13	Structure Failures	Failure of Structures	Aviation Accidents	Earthquake
14	Drought	Oil/Gas spillage	Oil/Gas spillage	Water Transport Accident
15	Earthquake	Terrorism	Chemical	Chemical
16	Oil/Gas spillage	Avian Influenza	Terrorism	Meningitis
17	Civil Disorders	Earthquake	Avian Influenza	YF
18	Chemical	Chemical	Drought	Drought
19	Radio nuclear Accidents	Radio nuclear Accidents	Radio nuclear Accidents	Radio nuclear Accidents

The risk mapping document is important in enhancing the focus of public health emergency management in determining prevention, preparedness, and mitigation, response and recovery activities based on risk.

The goal of the risk analysis in public health emergency management is to reduce risk level by targeting interventions aimed at reducing vulnerability and increasing the coping capacities. The hazards listed as posing high risk are those that must be very high priority for prevention, preparedness, and mitigation, response and recovery programmes in the country and in the specific zones; attempts should be made to minimize the risks of those hazards. The hazards that are listed as medium are those that should be addressed after the hazards with high risk.

The main vulnerability factors cutting across all the ecological zones are geographical location, poor access to water, sanitation and hygiene (WASH) facilities, and climate change. Not much can be done about some of the factors such as geographic location and climate change. The focus should be on reducing the other vulnerabilities and increasing the coping capacities.

The following recommendations are made to reduce the risks posed by the identified hazards:

Reducing vulnerabilities:

1. Increase access to WASH facilities
2. Enforce all laws relating public health and safety of the populace.

Increasing Coping Capacity:

1. Establish early warning systems for all identified hazards likely to lead to public health emergency
2. Strengthen surveillance to ensure early detection of events
3. Intensify risk communication and social mobilization to ensure that the population is adequately informed about various hazards and action to prevent or mitigate the risks at personal, household and community levels
4. Strengthen and enforce good infection prevention and control practices in the health facilities
5. Build and equip isolation wards, treatment centres for infectious diseases across the country

Since occurrences of hazards vary depending on factors such as location, scale and topography, it is necessary for the various regions and districts to conduct regional and district level risk mapping tailored to their own location to determine the hotspots for identified hazards for targeted local preparedness and response interventions.

Capacities Assessment

Certain minimum capacities are required to ensure adequate response to public health emergencies and other health threats. The status of existing capacities was assessed. Desktop review of documents and key informant interviews at selected national, regional and district level institutions, laboratories and health facilities were undertaken using structures questionnaire to assess the capacities; summarizing the strengths and weaknesses of each core capacity. The following capacities were assessed: legislation, policy and financing; coordination and partnership; surveillance; laboratory; preparedness and response; risk communication; points of entry; human resources; and special events including food safety, zoonotic, chemical, nuclear and radiological events. The assessment findings are summarised in table 2 below:

Table 2: Summary of Strengths and Weakness of Core Capacities

Capacity	Strengths	Weaknesses
1. Policy, Legislation and Financing	• Public Health Act, 2012 (Act 851) consolidates all the laws relating to public health and provides the policy and legal framework to prevent disease, promote, safeguard, maintain and protect the health of humans and animals. • IHR (2005) provides the legal and policy framework for notification, verification and containment at source internationally.	• Legislative Instrument (LI) for Public Health Act not ready • There are no dedicated funds to finance public health emergencies, especially funds to support preparedness activities and Rapid Response Teams (RRTs) for immediate investigation and initial response to emergencies.
2. Partnership and Coordination	• Various coordinating and stakeholder committees and forum in place - Inter-ministerial committee (IMC) - National Technical Coordination Committee (NTCC), - Emergency Operations Centre (EOC) - Health Partners Forum - Public Health Emergency Management Committee (PHEMC) at Regional and District levels - IHR Steering committee	• Non-representation at the highest level of other sectors in IMC • The terms of reference (ToR) for some of the committees are not well defined • Line of communication, reporting and exchange of information and engagement between NADMO and MoH not defined
3. Surveillance	• Integrated Disease Surveillance and Response (IDSR) established since 1998 - Indicator based (IBS), Event based (EBS), and Community-based (CBS) surveillance systems • Influenza sentinel surveillance • A contact tracing software for EVD has been developed. Software to be adapted for use in the investigation and contact tracing of other infectious diseases such as cholera and meningitis. • A weekly epidemiological bulletin (GWEB) for dissemination of surveillance information	• Late case detection • Clinicians involvement in the surveillance system is minimal • Case definitions are not applied • Non-application of the IHR Decision Instrument to determine whether an event is a potential PHEIC
4. Laboratory	• Network of Laboratories - District, Regional and Teaching Hospitals - National Public Health and Reference Lab (NPHRL) and Zonal Public Health Labs (PHL) - Labs with Biosafety 3 level facilities Noguchi Memorial Institute for Medical Research (NMIMR) and Kumasi Centre for Collaborative Research in Tropical Medicine (KCCR) to diagnose highly infectious pathogens • Introduction of Cholera Rapid Diagnostic Test (RDT)	• Irregular supply of reagents and other laboratory supplies • There is no national regulatory legislation or policy that defines the role and responsibilities of laboratories at different levels in the health sector. • No policy to monitor antimicrobial resistance

Capacity	Strengths	Weaknesses
5. Preparedness and Response	• Health sector preparedness and response plans for biological hazards are available at all levels. • Laboratory protocols for specimen collection and shipment have been developed. • Case management guidelines are available for infectious diseases hazards. • National stockpiling of logistics exists for infectious diseases. • RRTs have been formed to investigate and conduct initial response to public health emergencies at all levels. • Infection Prevention and Control (IPC) policy and guidelines have been developed. • Training of trainers haven been conducted and IPC training is being rolled out to all health facilities.	• Irregular meeting of NTCC to provide technical input to IMC • There is no approved PHE strategic plan for use by all partners and agencies that would guide response in a coordinated manner and with strategic focus. • Case management guidelines are not available for other hazards (including guidelines for mass casualty management) apart for biological hazards. • Mapping of available resources and their location has not been conducted. • Directory or roster of experts for potential hazards has not been compiled. • RRTs have not been trained or oriented as teams • There are no facilities to quarantine humans exposed to infections. • Most health facilities do not have adequately equipped isolation wards
6. Risk Communication	• Communication plans developed for some hazard such as pandemic influenza H1N1, EVD and cholera • The Health Promotion Department (HPD) of GHS is leading the efforts in communication activities, supported by communication sub-committee of the NTCC. • The HPD has focal persons at the regional level and there is an ongoing process to have focal persons at the district level.	• Little or no public awareness, information, education, and communication materials on chemical, food safety, and radiological and nuclear emergencies. • Non-availability of written and agreed protocols or SOPs defining the roles and responsibilities of various stakeholders including clearing house for risk communication messages • No guidelines for designated spokespersons identified for communication during emergencies
7. Points of Entry (PoEs)	• 22 out of 56 approved PoEs are manned by Port Health staff and 13 are designated as per IHR (2005) • The PoEs have contingency plans • Screening for early detection of infectious public health events instituted at the PoEs. • Walk through scanners installed at major PoEs – Kotoka International Airport (KIA), Elubo and Aflao • Prefabricated holding rooms at 4 major PoEs • Good collaboration among key stakeholders (Port Health, Immigration and Customs staff) • Communication established between PoEs and identified first referral health facilities where ill travellers could be further investigated and treated.	• Inadequate staff and premises for Port health activities • There is lack of quarantine facilities • Inadequate IPC logistics (gloves, sanitizers etc.) for PH staff • Apart from KIA, no vehicles readily available to transport ill travellers to referral health facilities • There are no written protocols or memoranda of understanding on port health issues among agencies at border crossings, internally and with the counterparts of the neighbouring countries.

Capacity	Strengths	Weaknesses
8. Human Resource	• A number of pre-service and post graduate training institutions producing public health practitioners - Kintampo College of Health and Well being - Schools of Public Health - MPH, Field Epidemiology and Laboratory Training Program (FELTP) - Veterinary degree programmes by University of Ghana (UG) and University of Science and Technology (UST) - A number of private schools or colleges of public health have also been established • In-service training support from WHO, CDC and West Africa Regional Disease Surveillance Capacity Strengthening (WARDS) programme.	• Maldistribution of health staff with most health staff concentrated in urban areas, particularly Accra and Kumasi • No training needs assessment • No regular update of skills of health staff in public health emergency response
9. Zoonotic Events	• Veterinary Services Directorate (VSD) of Ministry of Food and Agriculture (MoFA) has been involved in surveillance and outbreak response of zoonotic diseases in animals. • Increasing collaboration between human and animal health sectors since the emergence of Avian Influenza in the country in 2007	• Inadequate human resources in the VSD • Inadequate training of both human and animal health practitioners on zoonotic diseases • Slow pace of collaboration between the MoH and MoFA. • Inadequate financial and logistics support for VSD
10. Food Safety	• Food and Drug Authority (FDA) regulates and provides technical support to the food industry to promote the production of safe and quality food. • Ghana adopted a Food Safety Policy on 27 April 2015	• Little risk communication on food safety
11. Chemical Events	• GHS working hand in hand with the Ministry of Environment, Science and Technology (MEST) and MoFA to train health workers, farm workers and agricultural extension officers in safe handling of chemicals, prevention and recognition of poisoning. • Poison Information Centre established by GHS in 2003 to facilitate the prevention, recognition and management of chemical and other poisonings.	• No surveillance system for chemical events • No or little risk communication for chemical events
12. Radiological and Nuclear Events	• Ghana Atomic Energy Commission (GAEC) identified major installations with potential radiation exposure sources • GAEC with NADMO developed National Nuclear and Radiological Emergency Response Plan (NNRERP) to cope with nuclear and radiological emergencies • Drills were conducted in 2015 on handling of radiological and nuclear events.	• There is little or no risk communication for nuclear and radiological events.

In conclusion, the assessment has documented the strengths and weaknesses of each of the core capacities. Currently, adequate policy and legal framework for the preparedness and response to public health emergencies exist, but what is needed is translation of these policies into guidelines, protocols, standard operating procedures and job aids to guide those who are actually involved in the implementation of the public health emergency preparedness and response activities, supported by regular updating of their knowledge and the necessary logistics.

The following recommendations are made:

1. Expedite action on completion of the LI for the Public Health Act.
2. Set up Ghana Public Health Emergency Fund (GPHEF) similar to the African Public Health Emergency Fund (APHEF) established by the Regional Committee of the World Health Organization, African Region.
3. Strengthen surveillance at all levels.
    a. Sensitize clinicians and involve them in surveillance activities.
    b. Institutionalize Public Health Units (PHU) in hospitals.
    c. Institute induction courses on surveillance for new staff and regular refresher courses for health staff at all levels.
4. Establish/ strengthen early warning systems for all hazards.
5. Ensure adequate, timely supply of diagnostic kits and reagents to all laboratories in the laboratory network for public health emergencies.
6. Compile and distribute to all stakeholders a roster of experts for all hazards.
7. Develop guidelines, SOPs, protocols and job aids for preparedness and response on all prioritized hazards, particularly for mass casualty management.
8. Stockpile adequate and appropriate logistics for response to identified hazards and prioritize their prepositioning based on level of risk.
9. Make Infection Prevention and Control (IPC) the cornerstone of preparedness and response to public health emergencies.
    a. Roll out the planned IPC trainings and enforce compliance with standard IPC practices in health facilities.
    b. Accelerate the building and equipping of isolation wards or treatment centres for infectious diseases.
10. Institutionalize regular update of skills of health staff in public health emergency response
11. Develop communication plans for all identified hazards.
12. Develop protocols and SOPs defining the roles and responsibilities of various stakeholders in risk communication including clearing house for risk communication messages.
13. Develop guidelines for designated spokesperson for communication during public health emergencies.
14. Increase risk communication activities on IPC practices at personal, household and community levels.
15. Provide adequate staff and premises at the designated PoEs
16. Sign memorandum of understanding between MoH and other agencies at the PoEs to enhance collaboration and facilitate the work of Port Health staff.

17. Strengthen all coordinating structures and ensure their functionality.
    a. Review and formally approve the terms of reference (ToRs) of all coordinating committees and technical sub-committees at the highest level of the health sector to guide the activities of these committees to avoid duplication of efforts and maximize their potentials to synergy and efficiency.
    b. Define the power and mandate of EOC including control over resources and accountability.
    c. Clarify the line of communication, reporting and exchange of information and engagement between the health sections of NADMO and the public health emergency coordination structures in the MoH.
    d. Reconstitute various coordinating committees based on ToRs.
    e. Orientate all members of committees on their ToRs.
    f. Establish linkages with other relevant stakeholder committees outside the MoH
    g. Provide adequate resources to support the committees.
18. Establish institutional structures for one-health concept - steering committee and secretariat
19. Develop a strategic plan for public health emergencies, and incorporating it within the Health Sector Medium Term Development Plan (HSMTDP). This would ensure in-built mechanisms for implementation, monitoring, evaluation and building the systems and capacities. If this starts with the next HSMTDP (2018 onwards), it would be a very big step to institutionalize public health emergency preparedness and response in Ghana.

Furthermore, since the recommended actions are meant to strengthen the core capacities to ensure early detection and prompt and effective response to **public health emergencies**, it is suggested that the following under listed recommended activities should be implemented within a short-term period of three months whilst the remaining are implemented within a period of 18 months (medium-term) from the receipt of this report; and where an activity has an end point it should completed during the suggested time period.

1. Expedite action on completion of the LI for the Public Health Act.
2. Ensure adequate, timely supply of diagnostic kits and reagents to all laboratories in the laboratory network for public health emergencies.
3. Stockpile adequate and appropriate logistics for response to identified hazards and prioritize their prepositioning based on level of risk.
4. Review the terms of reference of all coordinating committees.
5. Define the power and mandate of EOC including control over resources and accountability.
6. Reconstitute various coordinating and technical committees based on terms of reference.
7. Orientate all members of committees on their terms of reference.

CHAPTER ONE - INTRODUCTION

1.1 Introduction

Ghana has been exposed to periodic pandemics and major epidemics including Avian and Pandemic Influenza, Cholera, Meningitis, Yellow fever and Viral Haemorrhagic Fevers in addition to other hazards and events of public health concerns such as flood, drought, transport accidents and environmental pollution. The public health impact from these hazards has far reaching implications for individuals and the country at large. The protracted cholera epidemic in the country in 2014 that spilled over to 2015 and the Ebola virus disease (EVD) outbreak that ravaged West Africa in 2014, especially Guinea, Liberia and Sierra Leone and threatened the security of many countries in the sub-region including Ghana have brought to the fore the urgent need for the country to adequately prepare and respond effectively to these public health emergencies of national and international concern.

As part of efforts to strengthen the emergency preparedness and response systems, risk mapping of public health emergencies in Ghana as well as assessment of existing capacities to respond to these emergencies and other public health threats was undertaken from March to May 2016. A draft report of the risk mapping and capacity assessment was presented to a large group of experts, and stakeholders from MOH, GHS, Development Partners (DPs), regions, academia and NGOs in the first week of July 2016 to solicit further input, and validate the findings and scoring of risks, vulnerability and coping mechanism. This final report is the product of these processes.

1.2 Structure of the Report

The report is presented in four chapters: chapter one is the introduction including the rationale; chapter two deals with background information on Ghana; chapter three discusses the public health risk mapping whilst chapter four focusses on the capacities assessment.

1.3 Rationale

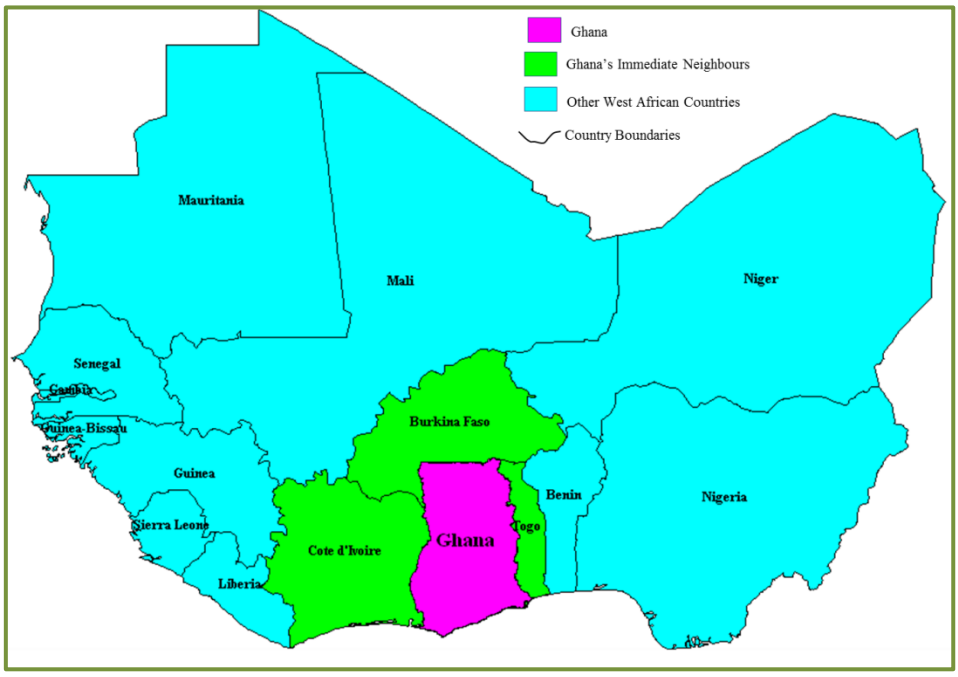
The purpose of the public health risk mapping is to provide at a glance the geographical distribution of specific adverse health effects the country might experience as a result of exposure to various hazards. This helps to communicate to policy makers and other stakeholders a better understanding of the country's public health risk profile so that interventions can be prioritized. The capacities' assessment provides an overview of the current available capacities to respond to public health emergencies and threats. These two processes form an integral part of the prevention, surveillance and response systems in the management of public health emergencies and their product will inform prioritization of public health interventions to support the implementation of International Health Regulations (2005) and the overall response to public health emergencies and other public health threats.

CHAPTER TWO – COUNTRY PROFILE

2.1 Geography

Ghana is located in the West African sub-region and extends inlands from the Gulf of Guinea and bordered on the south by the Atlantic Ocean, on the north by Burkina Faso, on the east by Togo, and on the west by la Côte d'Ivoire (Figure 1). It has an area of 238,537 square kilometres and a coastline of 560 kilometres.

Figure 1: Map of West Africa showing location of Ghana



Ghana is a lowland country except for a range of highlands on the eastern border. The country can be divided into three ecological zones: the low, sandy coastal plains, with several rivers and streams; the middle and western parts of the country, characterised by a heavy canopy of semi-deciduous rainforests, with many streams and rivers; and northern savannah, which is drained by the Black and White Volta Rivers.

The country lies entirely within the northern tropics between latitudes 4°N and 12°N, and longitudes 4°W and 2°E and has a tropical climate with temperatures and rainfall patterns that vary according to distance from the coast and elevation. The eastern coastal area is comparatively dry, the southwestern corner is hot and humid, and the north of the country is hot and dry. The average annual temperature is about 26°C. There are two distinct rainy seasons in the southern and middle parts of the country, from April to June and September to November. The north is, however, characterised

by one rainfall season that begins in May, peaks in August, and lasts until September. Annual rainfall ranges from about 1,015 millimetres in the north to about 2,030 millimetres in the southwest. The harmattan, a dry dusty desert wind, blows from the northeast and covers much of the country between December and March, lowering the humidity and visibility, and also creates very warm days and cool nights in the north. In the south, the effects of the harmattan are felt mainly in January (GSS, GHS and ICF International, 2015).

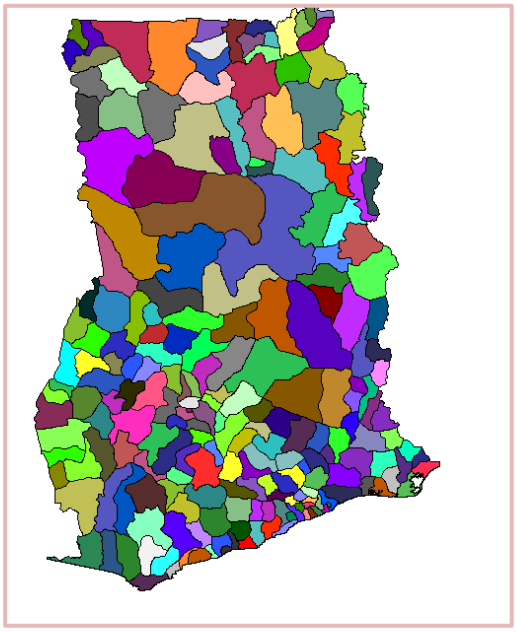
2.2 Political History and Administration

Ghana is divided into 10 administrative regions (Figure 2) that are further sub-divided into 216 administrative districts (Figure 3). The government administrative machinery is decentralized to the region and district levels.

The country's fourth attempt at democratic rule since independence in 1957 started in 1992 after previous attempts were interrupted by military interventions. There is an executive presidency with its cabinet, parliament and an independent judiciary. Each region is headed by a Regional Minister appointed by the President, and who is supported by a Regional Coordinating Council (RCC) to coordinate and formulate integrated district plans and programmes within the framework of approved national development policies and priorities. Each district is headed by a District Chief Executive, who is nominated by the President and approved by the District Assembly. The District Assembly is the highest political and administrative authority in the district. The districts are also divided into unit areas and are headed by elected executives.

Figure 2: Map of Ghana showing 10 Regions

Figure 3: Map of Ghana showing 216 Districts



2.3 Demography

The 2010 population and housing census put the population of Ghana at 24.7 million with a population growth rate of 2.5% per annum, although there are regional variations. The Ashanti region has the highest population with Upper West with the least. The population density was 103 persons per square kilometres and ranged from 35.2 persons per km^2 in Northern region to 1235.8 persons per km^2 in Greater Accra region. There has been increasing proportion of urban population over the years, from 23.1% in 1960 to 50.9% in 2010 (GSS, 2012). The estimated population for the year 2016 (projected from the 2010 population census figure) is 28.6 million.

2.4 Socio-economic status

Ghana's economy has seen a competitive business environment, and sustained reductions in poverty levels. In late 2010, Ghana was re-categorized as a lower middle-income country. The structure of the Ghanaian economy has seen minimal changes over the past two decades. The agriculture sector, previously the largest contributor to the Ghanaian economy, has been overtaken by the service and industry sectors. By 2014, the service sector was the fastest growing sector of the economy, contributing 52 percent of the gross domestic product (GDP), followed by the industry sector, at 27 percent, and the agriculture sector, at 22 percent. About 45 percent of the economically active population is engaged in agriculture, and 41 percent provide services. A high proportion of the employed population of Ghana works in the informal sector, the majority being self-employed (GSS 2015). The leading export commodities of Ghana are cocoa, gold, and timber. Oil production began in 2010 and the growing oil industry is expected to boost economic growth.

2.5 Health status

The overall epidemiological picture of Ghana is that of a developing country at the onset of health transition. It is characterized by predominance of communicable disease conditions, with emerging importance of non-communicable diseases such as cancers, diabetes and cardiovascular diseases and injuries, especially those due to road traffic accidents. In general, the health of Ghanaians is improving. Between 1998 and 2014, infant mortality dropped from 57 to 41 deaths per 1,000 live births (GSS, GHS and ICF International, 2015). Life expectancy increased from 55 years for males and 60 years for females in 2000 to 60 and 63 years respectively in 2010 (GSS, 2013).

2.6 Health System

The Ministry of Health (MoH) has the overall responsibility of health care delivery in the country. The goal of the health sector is to ensure a healthy and productive population that reproduces itself safely by ensuring that people live long, healthy and productive lives and reproduce without an increased risk of injury or death; reducing the excessive risk and burden of morbidity, mortality and disability (MoH, 2014).

The health sector in Ghana is both public and private. The public sector is run by the Ghana Health Service (GHS) and Teaching Hospitals. The private sector is made up of faith-based and private-for-profit health institutions. The public sector is a three-tier health delivery system of primary, secondary and tertiary levels. The primary level is the district and sub-district levels up to the community level. In some sub-districts are Community Health Planning & Services (CHPS) zones where Community Health Officers (CHOs) work with community volunteers to increase access to health care. A typical district with a population of 100,000 has one hospital, 5 health centres and 10-15 CHPS zones.

The regional hospitals receive referrals from districts and provide outreach support to the districts. Korle-Bu, Komfo Anokye, Tamale and Cape coast are the current Teaching Hospitals providing tertiary care and training of doctors. There were about 2,173 doctors in Ghana as of 2010 (1 per 11,480 population) with many of them concentrated in Greater Accra and Ashanti regions to the detriment of the three northern regions (MoH, 2011). There were about 11,000 Community Health Nurses and 11,800 professional nurses on MoH payroll as of June 2013 (MoH, 2013b). The human resource problem in the health sector, although can be partially attributed to inadequate numbers, the main challenge is maldistribution with majority of health staff concentrated in the urban areas, especially Accra and Kumasi.

2.7 Ecological Zones

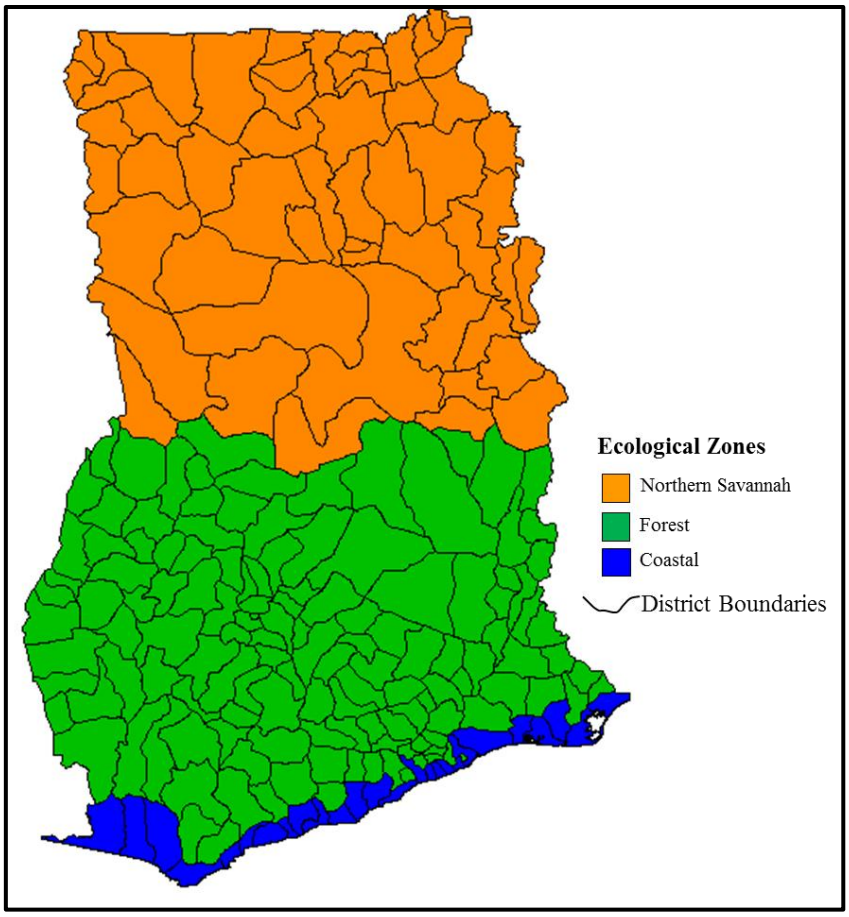
There is a strong link between human health, hazards and ecosystem. Most of the risk factors for health are influenced by the elements of the ecological system. Keith Smith states that natural hazards are best seen in an ecological framework in order to distinguish between natural events and natural hazards. He says "natural hazards, therefore, result from the conflict of geophysical processes with people and they lie at the interface of what has been called the natural events system and the human interface system." He says that "this interpretation of natural hazards gives humans a central role. Firstly through location, because it is only when people and their possessions get in the way of natural processes that hazard exists" (Smith Keith, 2001). According to Andrés Izeta, an ecological zone is a landscape unit that unites certain interrelated animal and plant communities with a particular social formation and environmental conditions as part of an integrated system. Rainfall, humidity, altitude, temperature, climate and vegetation are key elements that define ecological zones (Izeta, 2016). The risk analysis was therefore discussed per the three ecological zones of the country, namely Northern Savannah, Forest and Coastal (Figure 4).

2.7.1 Northern Savannah Zone

The Northern Savannah zone (NSZ) consists typically of a ground cover of grasses of varying heights interspersed with fire resistant, deciduous, broad-leaved trees at the forest margins in the south. The northern savannah is hot and dry, characterised by one rainfall season that begins in May, peaks in August, and lasts until September. Annual rainfall averages 1,015 millimetres in the zone. The harmattan, a dry dusty desert wind, blows from the northeast between December and March, and creates very warm days and cool nights in the zone. The predominant occupation is agriculture with grain and cattle production being the major economic activities.

This zone covers 56 (26%) districts of the country including all districts in Upper West (11), Upper East (13) and Northern (26) regions, 3 districts of Brong Ahafo region bordering southern part of Northern region and 3 districts of the Volta region bordering south-eastern part of Northern region. It covers almost half (47.1%) of the entire area of Ghana and has the least population (19%) of the three zones and therefore the lowest population density (48 persons /km^2), although Upper East region in the zone has above average population density in the country.

Figure 4: Map of Ghana showing Ecological zones



2.7.2 Forest Zone

The Forest Zone (FZ) is characterised by rain and deciduous forests broken by heavily forested hills and many streams and rivers. There are two distinct rainy seasons in this zone, from April to June and September to November. There are drier months in between these periods. Generally, temperatures are between 21^o and 31^o. The predominant occupations of this zone are agriculture and mining.

The forest zone covers the largest number, 134 (62%) of districts, including all the districts in the Ashanti (30) and Eastern (26) regions and most of the districts in Brong Ahafo (24), Volta (19) Western (16), Central (12) regions, and 7 districts from the Greater Accra region. Over half of the population (58%) of the country lives in this zone (population density of 144 persons /km^2).

2.7.3 Coastal Zone

The Coastal Zone (CZ) is the smallest of the zones. This is a narrow strip of grassy and scrubby coast, intersected by several rivers and streams. The 560 kilometre coastline is mostly a low, sandy shore most of which are navigable only by canoe. The land is flat with some of the areas below sea level. There are two distinct rainy seasons in this zone, from April to June and September to November. The eastern coastal area is comparatively dry; the southwestern corner is hot and humid. The Earth's natural processes, particularly sea level rises, waves and various weather phenomena have resulted in erosion and reshaping of coast as well as flooding. The human influence on climate change is thought to contribute to an accelerated trend in sea level which threatens coastal habitat. The predominant occupation of the coastal inhabitants is fishing by dug-out canoe.

This zone includes only districts with coastline and therefore has its southern boundary as the Gulf of Guinea. There are 26 (12%) districts in this zone from 4 regions, Western (6), Central (8) Greater Accra (9) and Volta (3). It has about a fourth (23.3%) of the population and the highest population density (615 persons/ km^2). The capital of the country and the capitals of three of the four regions that contribute districts to this zone are located in this zone and also endowed with more health human resources than the other zones.

2.8 International Health Regulations (2005)

International Health Regulations (2005) or IHR (2005) are international laws which help countries working together to save lives and livelihoods caused by the international spread of diseases and other health risks. It is a legally binding text with rights, obligations and procedures that Ghana and other member countries of the World Health Organization (WHO) must comply with.

International Health Regulations (IHR) was first adopted by the World Health Assembly in 1969, and initially covered six diseases. The regulations were amended in 1973 and 1981 to cover 3 diseases (Cholera, Yellow fever and Plague). Due to increase in international travel and trade, and the emergence and re-emergence of international disease threats, a substantial revision of the IHR was carried out and the revised regulations, IHR (2005) was adopted by the 58th World Health Assembly in 2005 and entered into force on 15 June 2007. The purpose of IHR (2005) is ‘‘to prevent, protect against, control and provide a public health response to the international spread of disease in ways that are commensurate with and restricted to public health risks, and which avoid unnecessary interference with international traffic and trade’’. IHR (2005) has a broadened scope to include any event of international public health concern and not limited to communicable diseases with epidemic and pandemic potential but may include emergencies due to contamination with toxins, chemicals or radioactive materials due to industrial leaks or intentional release. It uses unofficial information sources and reports to trigger verification processes. The notification to the World Health Organization marks the beginning of a confidential dialogue between a State and WHO to assess the potential serious public health implications of the event.

Member countries or State Parties are required to develop certain minimum core public health capacities to enable them detect and to notify WHO and respond to all events which may constitute a public health emergency of international concern (PHEIC). The core capacities required are legislation and policy, coordination and partnership, surveillance, preparedness, response, laboratory, risk communication, points of entry, human resources, logistics and other resources. (WHO, 2008)

In the WHO African region and for that matter Ghana, IHR is being implemented within the context of Integrated Disease Surveillance and Response (IDSR) since the IDSR serves as a vehicle for implementation of IHR while IHR serves as driving force for IDSR.

CHAPTER THREE – PUBLIC HEALTH RISK MAPPING

3.1 Introduction

Public health risk mapping is a graphical representation of specific adverse health effects the population of a community or geographical zone might experience as a result of exposure to a hazard. It helps inform and communicate to policy makers and other stakeholders a better understanding of the geographical distribution of hazards and the country's public health risk profile; and facilitates prioritization in planning for response interventions. Risk mapping involves hazard analysis to identify hazards that have major public health impact and then risk analysis to understand the likelihood and consequences of these hazards occurring and leading to public health emergencies depending on the vulnerability of the population and the ability to cope in the various geographic zones of the country.

A hazard is 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 (UNISDR, 2009). This includes but not limited to microbial pathogens, motor vehicles, nuclear power plants, pesticide and X-rays. Hazards could be classified as biological, technological, physical or societal.

Biological hazard is a process or phenomenon of organic origin or conveyed by biological vectors, including exposure to pathogenic micro-organisms, toxins and bioactive substances that may cause loss of life, injury, illness or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. Examples of biological hazards include outbreaks of epidemic diseases, plant or animal contagion, insect or other animal plagues and infestations caused by bacteria (e.g. cholera, meningitis), viruses (e.g. yellow fever, pandemic influenza, viral haemorrhagic fevers) etc.

A technological hazard is one originating from technological or industrial accidents, dangerous procedures, infrastructure failures or specific human activities that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Examples of technological hazards include industrial pollution, nuclear radiation, toxic wastes, structure failures, transport, industrial or technological accidents (explosions, fires, chemical spills etc.).

A physical hazard is a naturally occurring process that has the potential to create loss or damage. Physical hazards include floods, tornadoes, earthquakes, coastal erosions tsunamis, and drought. Physical hazards often have both human and natural elements.

Societal hazards are ones which result from direct human action or inaction, either intentional or unintentional. These include civil disorders, ethnic conflicts and terrorism.

Risk is defined as the probability that exposure to a hazard will lead to a negative consequence. A hazard poses no risk if there is no exposure to that hazard. David Alexander thus defined risk as the likelihood or probability of a given hazard of a given level causing a particular level of loss or damage and further outlined the elements of risk as populations, communities, the built environment,

the natural environment, economic activities and services which are under threat of disaster or are vulnerable in a given area (Alexander, 2000).

Vulnerability is the characteristic and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard (UNISDR, 2009). Alexander further distinguishes between risk and vulnerability saying that "vulnerability" refers to the potential for casualty, destruction, damage, disruption or other form of loss in a particular element whilst risk combines this with the probable level of loss to be expected from a predictable magnitude of hazard (which can be considered as the manifestation of the agent that produces the loss).

As per WHO guidelines, health sector risk mapping and management are based on the following key assumptions:

- Vulnerability elements are those elements which predispose the health system, individual or community to the impact of hazards while coping capacity elements are those elements which enhance the ability of the health system, individual or community to respond to or cope with hazards.
- The public health of any area comprises of its health system and the health of the community, hence health vulnerabilities, coping capacity and risks are considered from this perspective.
- The general political and socio-economic context of a community may also influence their health vulnerabilities.

In the context of public health, risk assessment is the process of characterizing the nature and likelihood of a harmful effect to individuals or populations from certain human activities. Health risk assessment can be mostly qualitative or can include statistical estimates of probabilities for specific populations. To determine the level of risk a hazard poses in area, the intensity of the hazard, the vulnerability of the population including the coping mechanisms can be summed up in the Risk formula, R = H * V/C. The risk (R), hazard (H) vulnerability (V) and coping capacity (C) are the factors or elements which are being considered in the formula or pseudo equation (WHO, 2013).
Each of the variables in this formula is made up of smaller elements, the summation of which results in actual value of the variable.

The variables for measuring hazards levels include

- Probability - Number of episodes of the event over a period of time e.g. number of outbreak over period of five years
- Exposure - Average length between episode
- Impact - Average case fatality rate or number of people displaced

The variables for measuring health vulnerability include:

- The geographic location, architectural or structural safety and critical systems, equipment and infrastructural safety of health facilities
- The health status of the community including health service coverage, community herd immunity, disease prevalence etc.
- Social determinants of health such as access to good housing, water, sanitation and hygiene, education, food security and behaviour and challenges including food culture, sanitation and hygiene practices that may have implications on transmission and carriage of certain diseases.

The variables for measuring health coping capacity include:

- The capacity of the health system to implement disaster risk management programmes
- The functional capacity of health facilities, ports, veterinary services and facilities, food marketing and storage companies, meteorological agencies, and regulatory agencies, agencies for disposal and management of chemical waste etc.
- Community knowledge, attitude and practice of preventive and healthy lifestyle such as hand washing, first aid, hygiene education, health seeking behaviour, food culture, food marketing situation, systems for industrial food and chemical products storage, quarantine, disposal and regulation. (WHO, 2013)

The SMAUG approach designed by Benjamin Tregoe and Charles Kepner provides an effective means of prioritizing hazard risks based upon selected criteria in order to address the risks posed by the hazards to the avail of effecting effective interventions (Lunn, 2003). SMAUG stands for **S**eriousness, **M**anageability, **A**cceptability, **U**rgency and **G**rowth and are the criteria used for prioritization of hazard risks.

Seriousness - The relative impact including the potential for lives to be lost and potential for injury as well as the physical, social and economic losses that may be incurred

Manageability - The relative ability to mitigate or reduce the hazard (through managing the hazard, or the community or both).

Acceptability - The degree to which the risk of hazard is acceptable in terms of political, environmental, social and economic impact

Urgency - This is related to the probability of risk of hazard and is defined in terms of how imperative it is to address the hazard

Growth - This is the potential for the hazard or event to expand or increase in either probability or risk to community or both. Should vulnerability increase, potential for growth may also increase.

3.2 Objectives

The **main objective** of the risk mapping described in this document is to provide an overview of hazards that can lead to public health emergencies in Ghana and the level of risk they pose.

The **Specific Objectives** are to

1. identify hazards that may negatively impact on health in the country
2. describe the physical characteristic of the hazards
3. analyse and describe the public health risks that the identified hazards pose
4. rank the hazard risks
5. map the public health risks across the three ecological zones of the country

3.3 Description of the Methodology

Historical data on hazards were reviewed from sources such as the Ghana Health Service/Ministry of Health, National Disaster Management Organization (NADMO) and other agencies to determine the occurrence of these hazards.

The hazards were analysed to establish which of them have the potential to lead to public health emergencies and then further analysed for the risk they pose. Variables were selected and indicators developed for the elements in each hazard identified for risk analysis and scores apportioned where possible to determine the aggregate summation of the elements in each of the components - Hazard (H), Vulnerability (V) and Coping capacity (C) in the Risk formula: R=H * V/C. The risk level was then determined for each hazard using the scale - Low, Medium or High. The risks of the hazards were prioritised (ranked) using the criteria - seriousness, manageability, acceptability, urgency and growth (SMAUG model). The public health risks were also mapped by the three ecological zones. Data analysis and mapping was done using Microsoft Excel and Epi Info soft wares.

Limitation

Assigning scores by an individual to mostly qualitative variables is subjective. This is the major limitation in the methodology used in the risk assessment and mapping presented in this document. The influence of subjectivity in the results can be minimised through consensus if the assessment is conducted by stakeholders in group discussions. The results presented here are therefore to be used as a guide for further national, regional and district level risk mapping.

3.4 Hazard Analysis

The results of the hazard analysis were the identification and description of the characteristics of hazards that can lead to public health emergencies in Ghana. The key questions that were answered in the hazard analysis were:

1. What are the hazards the country has experienced in the past and what are the potential hazards the country is likely to experience?
2. What are the health consequences (direct and indirect)?
3. Which of these hazards are likely to lead to public health emergency?
4. What is the extent of the problem the hazard poses in terms of person place and time?
    a) What is the geographic coverage of the hazard?
    b) When does the event occur (period, seasonality and frequency?
    c) Who are usually affected and number of people affected?

3.4.1 Hazard Identification

NADMO identified natural hazards that might occur in Ghana as pest and insect infestation, disease epidemics, fires, hydro-meteorological, geological and man-made hazards such as ethnic conflicts, aviation and lake/maritime accidents, pollution of water bodies, industrial accidents, failure of structures

(collapse of buildings, dams and mines), nuclear and radiological accidents, oil spillage (NADMO, 2010). Public health practitioners from the ten regions of the country identified cholera, meningitis, yellow fever, avian and pandemic influenza, Ebola virus disease and other viral haemorrhagic fevers, rabies, anthrax, road traffic accidents, flood, drought, and oil spillage as the main public health threats the country may encounter. Almost all the identified hazards have either direct or indirect health consequences. Those with the potential to lead to public health emergency (PHE) are prioritised (Table 3) using the criteria - scale, timing, unpredictability and likelihood to overwhelm routine capabilities, the key elements in the definition of PHE (RAND Health, 2008) and discussed in the next section (hazard description).

Table 3: Hazards and their Public Health Impact, Ghana, 2016

Hazard	Direct Health Consequences	Potential for Public Health Emergency*
Biological Hazard		
Cholera	• High morbidity • Mortality	++
Meningitis	• High morbidity • High mortality	++
Yellow Fever	• High morbidity • Mortality	++
Avian Influenza	• Morbidity • High mortality	++
Pandemic Influenza	• High morbidity • High mortality	+++
Viral haemorrhagic fevers e.g. Ebola, Lassa Fever	• High Morbidity • High mortality	+++
Physical Hazards		
Floods	• Minor trauma from debris • Post-traumatic stress syndrome • Damage to health facilities with interruption of health service delivery • Increased risk of respiratory and droplet infections, due to poor living conditions resulting from population displacement • Increased risk of water-borne diseases due to contamination of water sources resulting from destruction of sanitary facilities • Increased risk of vector-borne diseases such as malaria	++
Drought	• Malnutrition, micronutrient deficiencies caused by food shortage due to decline in soil fertility • Disease outbreaks (water-borne diseases) due to decline in water availability and quality • Population displacement	++

Hazard	Direct Health Consequences	Potential for Public Health Emergency*
Earthquake	• Severe trauma • Dust inhalation, asphyxiation and respiratory distress • Mental and psychosocial problems • Damage to health facilities with interruption of health service delivery, • Increased risk of respiratory and droplet infections, due to poor living condition resulting from population displacement • Increased risk of water-borne diseases due to contamination of water sources resulting from destruction of sanitary facilities • Increased risk of vector-borne diseases such as malaria	+++
Technological Hazard		
Transport Accidents (Road, Air, Water)	• Severe trauma • Mortality • Disability • Post-Traumatic Stress Syndrome	++
Failure of structures	• Severe trauma • Mortality • Disability • Post-Traumatic Stress Syndrome	++
Fires	• Burns (skin and lungs), Gas and fume inhalation resulting in asphyxiation and acute respiratory distress • Minor trauma and crush injuries due to explosions • Post-traumatic stress syndrome	++
Oil/Gas spillage	• Gas and fume inhalation resulting in asphyxiation and acute respiratory distress	++
Chemical	• Burns Chronic illness – leukaemia, cancers	++
Nuclear and radiological accidents	• Radiation sickness • Teratogenic effects • Cancers	++
Societal Hazards		
Civil Disorders	• Mild to moderate trauma, • Increased risk of respiratory and droplet infections due to poor living condition resulting from population displacement • Increased risk of water-borne diseases due to contamination of water sources resulting from destruction of sanitary facilities • Hospitals and clinics may be inaccessible if the civil disorder incident is nearby or they may be overwhelmed by a sudden increase in people requiring medical care.	+
Terrorism	• Severe trauma • Mortality • Disability • Post-Traumatic Stress Syndrome	++

* Potential for resulting in public health emergency +++ = High, ++ = Medium, + = Low

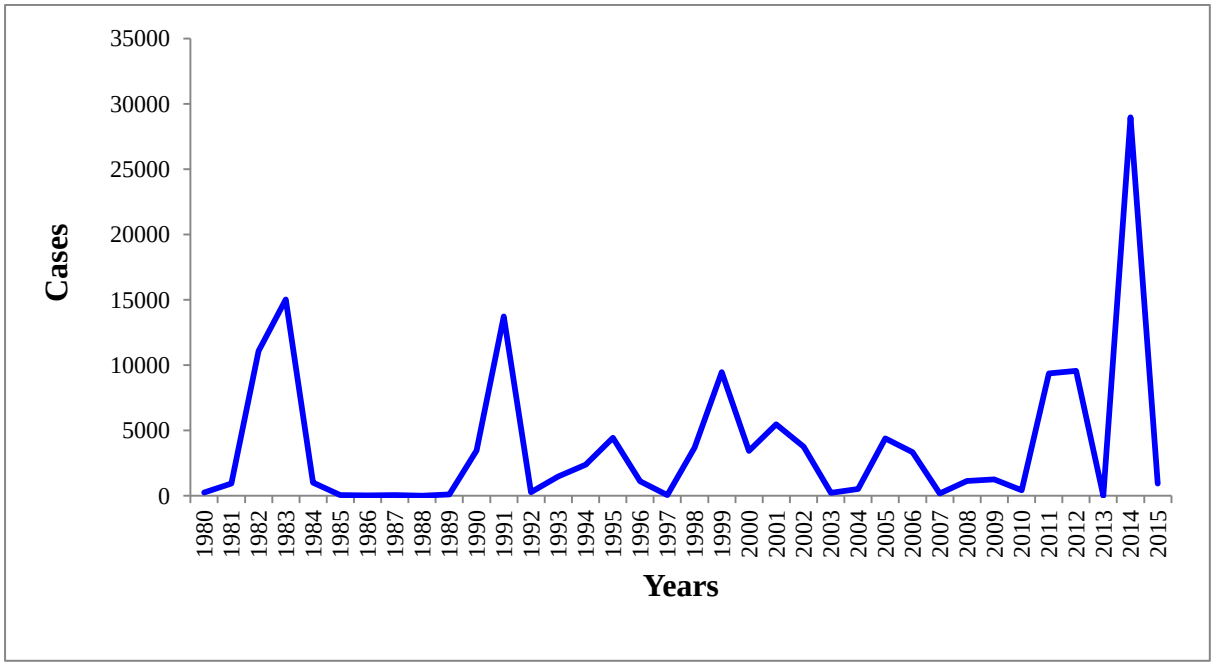
3.4.2 Hazard Description

3.4.2.1 Cholera

Cholera is an acute intestinal infection caused by ingestion of food or water contaminated with the bacterium, Vibrio cholera (V. cholera). After ingestion of an infectious dose of V. cholera, the bacteria produce entero-toxin which attaches itself to the lining of the gut, especially the small bowels. The entero-toxin causes the secretion of chlorine (Cl^-) radicals from the bowels and this leads to reduced re-absorption of water and sodium (Na+) resulting in diarrhoea and dehydration. Loss of sodium and chlorine is followed by loss of bicarbonate ($HCO3^-$) and potassium (K^+). This then leads to acidosis and hypokalaemia. Death results if treatment is not given promptly. Case fatality rate in untreated cases may reach 30-50%. However, if treated promptly and appropriately, case fatality rate can be below 1% (WHO, 2015a). The disease spreads by other persons taking in water or food contaminated by pathogen excreted in the diarrhoea stool or vomitus of a cholera patient and to lesser extent faeces of carriers of the vibrio cholera.

Since cholera was introduced into Ghana in 1970 following the seventh pandemic, the disease has spread across the country (Ashitey, 1994). Cholera is becoming endemic in Ghana with cyclical epidemics every 4 to 6 years. However, in recent years outbreaks have become more frequent and protracted (Figure 5). In 2014, Ghana was hit by a massive cholera outbreak which recorded the highest number of cases in the past 30 years claiming many lives and was reported from all the 10 regions and 130 out of the 2016 districts of the country. During this outbreak a total of 28,975 cases (Figure 5 and Table 4) including 243 deaths (case fatality rate of 0.8%) were reported (GHS DSD, 2015). The outbreak spilled over into 2015. Cholera outbreaks tend to occur during the rainy season (May to July) usually precipitated by occurrence of flood and at times during the dry season when there is scarcity of water.

Figure 5: Annual Trend of Cholera Cases, Ghana, 1980 – 2015



Data Source: Disease Surveillance Department, GHS

Table 4: Cholera Cases and Deaths by Region, Ghana 2010 - 2015

Region	2010		2011		2012		2013		2014		2015	
	C	D	C	D	C	D	C	D	C	D	C	D
Ashanti	37	4	56	2	528	6	0	0	287	3	15	0
Brong Ahafo	0	0	7	0	544	12	2	0	1,056	26	44	2
Central	163	2	285	1	44	6	0	0	3,868	60	14	0
Eastern	238	1	491	7	593	8	0	0	1,875	6	200	0
Greater Accra	0	0	8,160	55	6,609	47	16	0	20,197	121	310	5
Northern	0	0	31	0	55	3	0	0	282	2	0	0
Upper East	0	0	0	0	144	5	0	0	294	9	9	0
Upper West	0	0	9	1	0	0	0	0	36	1	2	0
Volta	0	0	87	3	652	9	0	0	651	8	45	0
Western	0	0	244	5	393	4	0	0	429	7	53	1
Total	**438**	**7**	**9,370**	**74**	**9,562**	**100**	**18**	**0**	**28,975**	**243**	**692**	**8**

C - Cases D - Deaths

Data Source: Disease Surveillance Department, GHS

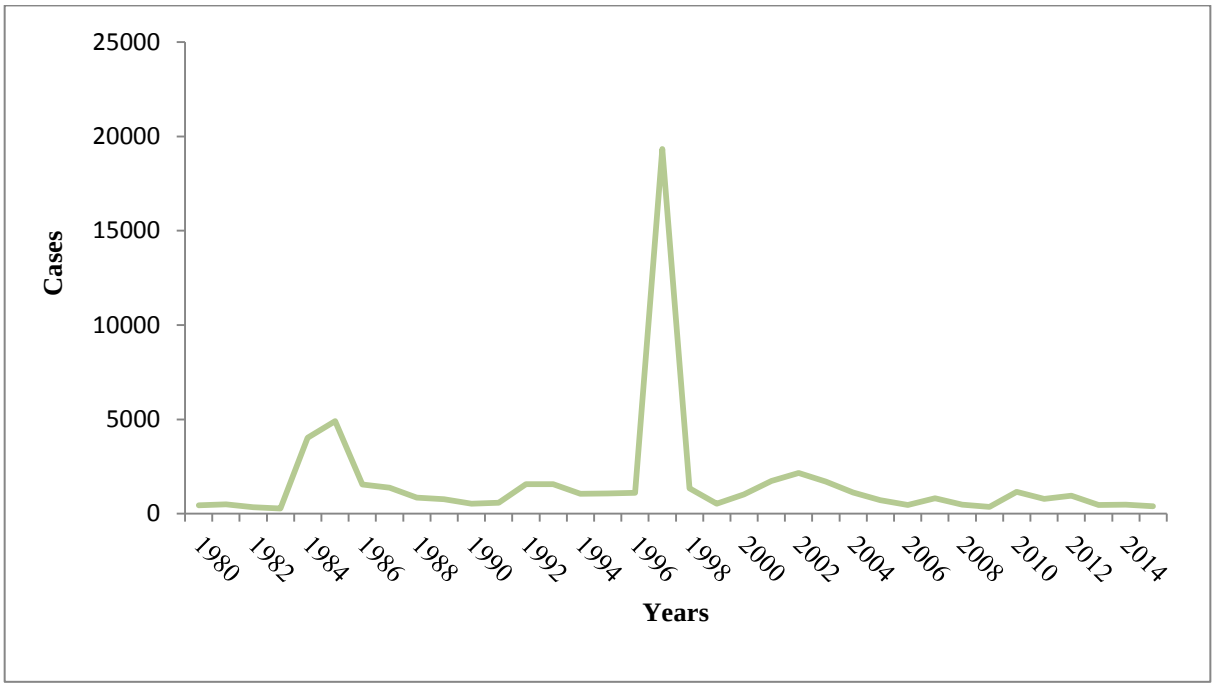
The almost yearly occurrence of the outbreaks and the wide geographical spread in recent times, in particular the 2014 outbreaks affecting all 10 regions and 60% of the districts of the country causing high levels of morbidity and mortality within a short period of time, usually overwhelm the routine capacities of the existing facilities and constitute real public health emergency.

3.4.2.2 Meningitis

Meningitis is inflammation of the meninges, the covering of the brain and spinal cord. It is most often caused by infection (bacterial, viral, or fungal). The meningitis of public health concern is meningitis caused by bacteria. Several different bacteria can cause meningitis. However, three main bacteria are usually responsible for most of the cases - Neisseria meningitides (N. meningitides), Haemophilus influenzae (H. influenzae) and Streptococcus pneumoniae (S. pneumoniae). Meningococcal meningitis is caused by N. meningitides and has the potential to lead to large epidemics. It can cause severe brain damage and is fatal in 50% of cases if untreated. The bacteria are transmitted from person-to-person through droplets of respiratory or throat secretions from carriers. Meningococcal disease epidemics begin in the dry season when the absolute humidity is low especially during the harmattan, often associated with frequent dust storms. The extended meningitis belt of sub-Saharan Africa, stretching from Senegal in the west to Ethiopia in the east (26 countries including Ghana), has the highest rates of the disease (WHO, 2015b).

In Ghana, meningitis cases occur throughout the year in all regions. However, yearly meningococcal epidemics have occurred mostly in the northern savannah zone of the country which lies in the meningitis belt. The meningitis epidemic season begins in November and ends in May with the peak period in February-March. Since 1980, about 400 - 1500 cases have been reported each year with a major epidemic in 1997 which affected over 19,000 people with 1,200 deaths in the three northern regions of the northern savannah zone (Figure 6).

Figure 6: Annual Trend of Meningitis Cases, Ghana, 1980 - 2015



Data Source: Disease Surveillance Department, GHS

Since the year 2000, the districts outside the meningitis belt began experiencing yearly focal outbreaks. The most unexpected was a focal outbreak of meningitis in November 2008 in a community located in the forest zone (Asante-Akim South district of Ashanti region) with unacceptably high case fatality rate of 64.3% (14 cases with 9 deaths). The causative agent was N. meningitides type C. In 2010 there were focal outbreaks from sero-group N. meningitides W135 instead of the classical sero-group of N. meningitides A in Jirapa and Bongo districts of Upper West and Upper East regions respectively. Most of the outbreaks of N. meningitides have been preceded by the occurrence of many cases due to S. pneumoniae.

With the introduction of meningitis A conjugate vaccine in 2010, it appears the disease incidence has reduced considerably but it remains a potential threat (Table 5). In late 2015 to early 2016 outbreaks have been experienced in Brong Ahafo region in the Forest zone due to a mixture of S. pneumoniae and N. meningitides. There were also outbreaks in Upper West and Northern regions.

Meningitis had caused high levels of morbidity and mortality and with S. pneumoniae emerging as one of the pathogens causing outbreaks; the disease will continue to be one of the hazards likely to cause a public health emergency, especially in the northern savannah zone of the country.

Table 5: Meningitis Cases and Deaths by Region, Ghana, 2010 - 2015

Region	2010		2011		2012		2013		2014		2015	
	C	D	C	D	C	D	C	D	C	D	C	D
Ashanti	75	5	81	9	185	1	5	0	16	3	7	0
Brong Ahafo	50	4	42	6	2	1	0	0	18	1	22	8
Central	3	1	2	0	0	0	0	0	0	0	1	0
Eastern	44	4	32	1	17	3	3	0	7	0	25	3
Greater Accra	29	1	23	1	4	0	1	0	18	2	25	1
Northern	181	25	202	25	31	1	23	3	144	5	18	2
Upper East	412	60	216	38	37	6	32	6	86	6	90	10
Upper West	356	26	190	24	17	1	13	5	191	21	198	26
Volta	9	2	1	0	0	0	0	0	0	0	1	0
Western	5	0	1	0	0	0	3	0	2	1	0	0
Total	1,164	128	790	104	293	13	80	14	482	39	387	50

C - Cases D - Deaths

Data Source: Disease Surveillance Department, GHS

3.4.2.3 Yellow Fever

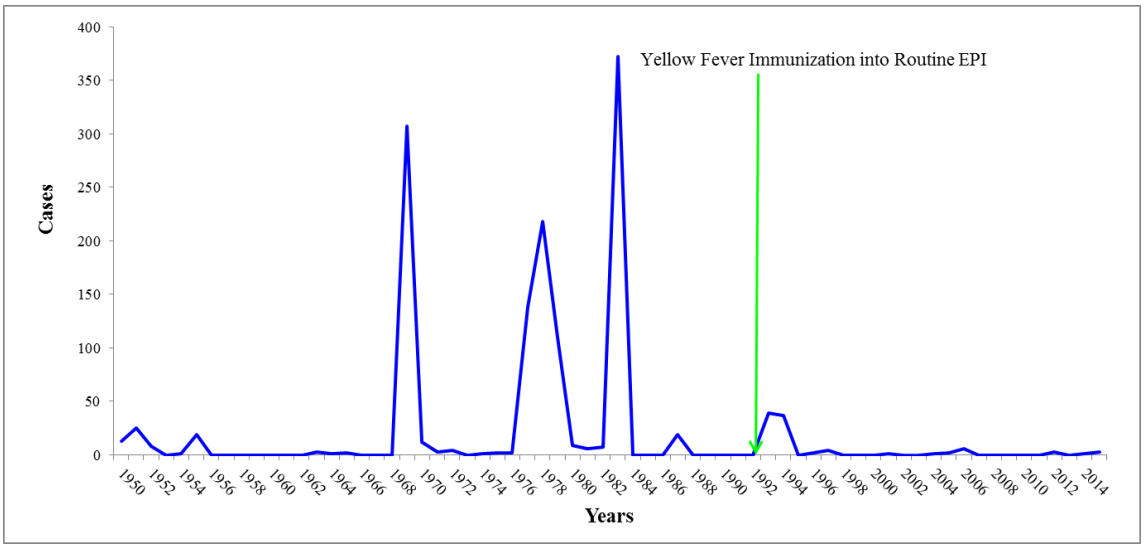
Yellow fever (YF) is a viral disease, found in tropical regions of Africa and the Americas. It principally affects humans and monkeys, and is transmitted via the bite of Aedes mosquitoes. It can produce devastating outbreaks, which can be prevented and controlled by mass vaccination campaigns. The first symptoms of the disease usually appear 3–6 days after infection (incubation period). YF is difficult to diagnose, especially during the early stages. It can be confused with other diseases such as severe malaria, viral hepatitis and haemorrhagic fever, leptospirosis, and Zika virus.

Mosquito is the primary vector. It carries the virus from one host to another, primarily between monkeys, from monkeys to humans, and from humans to humans. The mosquitoes either breed around houses (domestic), in the jungle or sylvatic (wild), or in both habitats (semi-domestic). Conditions favouring yellow fever epidemic include the amount of rainfall and the availability of mosquito breeding sites. Heavy rainfall contributes to the development of large mosquito populations. Conversely, in areas that are continually dry, storing water close to homes may encourage breeding of Aedes aegypti. Mosquito larvae need relatively still water to grow, whether it is in a tree hole, a water storage jar, or a tin can in a garbage dump. For sylvatic transmission, monkeys must be present at least part of the year.

There is no specific treatment for YF, only supportive care to treat dehydration, respiratory failure, and fever. Associated bacterial infections can be treated with antibiotics. Vaccination is the most important preventive measure against YF. The vaccine is safe, affordable, and highly effective. A single dose of yellow fever vaccine is sufficient to confer sustained immunity and life-long protection against YF disease. To prevent outbreaks throughout affected regions, vaccination coverage must reach at least 60% to 80% of a population at risk. In some situations, mosquito control is vital until vaccination takes effect. The risk of yellow fever transmission in urban areas can be reduced by eliminating potential mosquito breeding sites and applying insecticides to water where they develop in their earliest stages.

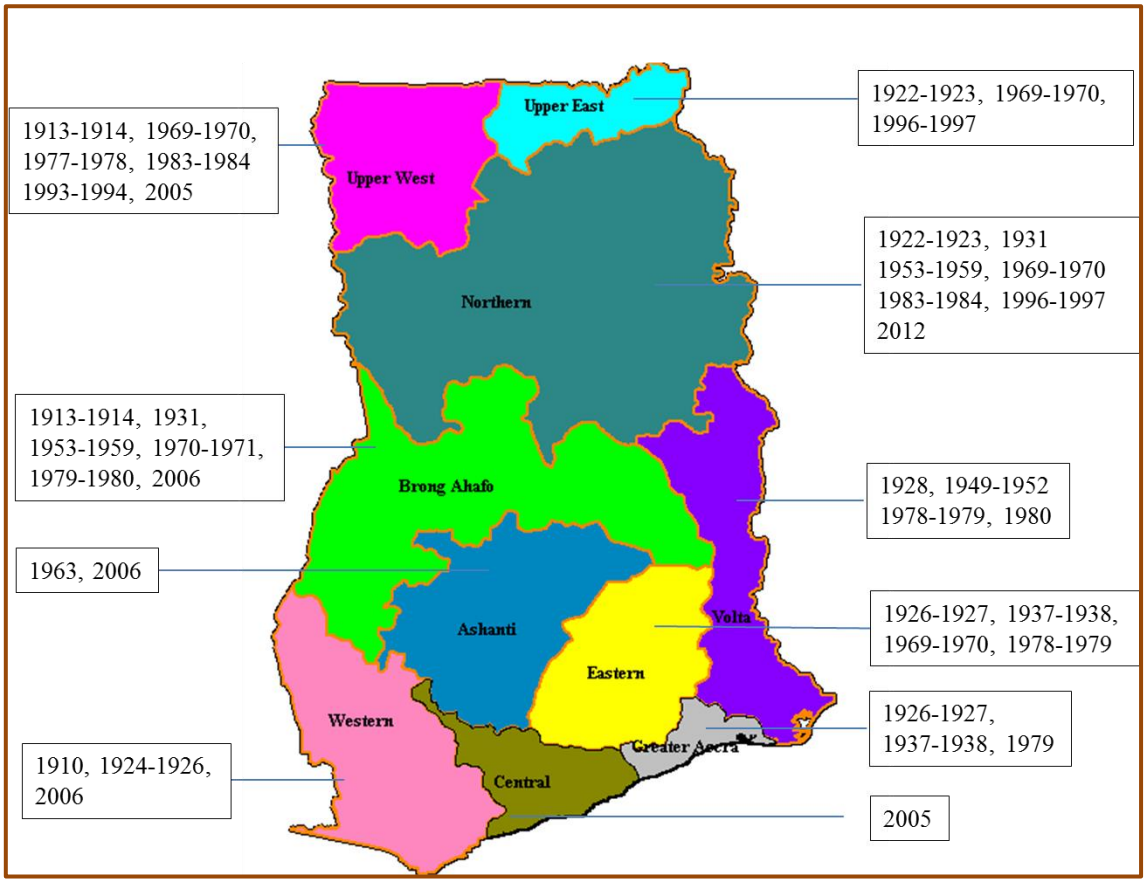
Ghana has had a long history of YF well documented by several authors. David Scott described in detail the sequence of yellow fever epidemics from 1901-1960 in his book entitled "Epidemic diseases in Ghana" (Scott D, 1965). From 1901-1960 the country experienced nearly five major epidemic periods scattered throughout most of the country. YF outbreaks had been experienced from all the three zones of the country in approximately 10-year cycles since 1920 (although no outbreaks were reported from northern savannah zone between 1931 and 1954) leading to high morbidity and mortality. Mass immunization campaigns conducted in southern part of the country in the early 1950s and in the northern part in late 1970 and early 1980s have disrupted these 10-year cycles without completely interrupting transmission of YF virus (Agadzi et al, 1984). The disease is however endemic in the country and of epidemic potential. The most recent severe outbreaks had occurred in 1993/1994 in Upper West region and in 1996/1997 where the Upper East and Northern regions were the regions affected. The inclusion of the YF vaccination into the routine Expanded Programme on Immunization (EPI) since 1992 and the selective mass vaccination campaigns in response to outbreaks have limited YF epidemics from the year 2000 up to date to few sporadic outbreaks with very few cases being recorded during these outbreaks (Figures 7 and 8).

Figure 7: Yearly Trend of Yellow Fever Cases in Ghana, 1950 - 2015



Data Source: Disease Surveillance Department, GHS

Figure 8: Reported Yellow Fever Outbreaks in Ghana by Region by Year, 1901 - 2015



Data Source: Disease Surveillance Department, GHS

3.4.2.4 Avian and Pandemic Influenza

Influenza is a viral infection that affects mainly the nose, throat, bronchi and, occasionally the lungs. Infection usually lasts for about a week, and is characterized by sudden onset of high fever, aching muscles, headache and severe malaise, non-productive cough, sore throat and rhinitis. The virus is transmitted easily from person to person via droplets and small particles produced when infected people cough or sneeze. Influenza tends to spread rapidly in seasonal epidemics. In temperate climates, seasonal epidemics occur mainly during winter while in tropical regions, influenza may occur throughout the year, causing outbreaks more irregularly (WHO, 2014). In Ghana there is increase influenza incidence during the dry months of November to March.

There are 3 types of seasonal influenza viruses – A, B and C. Type A influenza viruses are further classified into subtypes according to the combinations of various virus surface proteins. Among many subtypes of influenza A viruses, influenza A(H1N1) and A(H3N2) subtypes are currently circulating among humans. There are three types of influenza virus circulating in Ghana, namely A(H1N1)pdm09, A(H3N2) and B. (MMIMR, 2016).

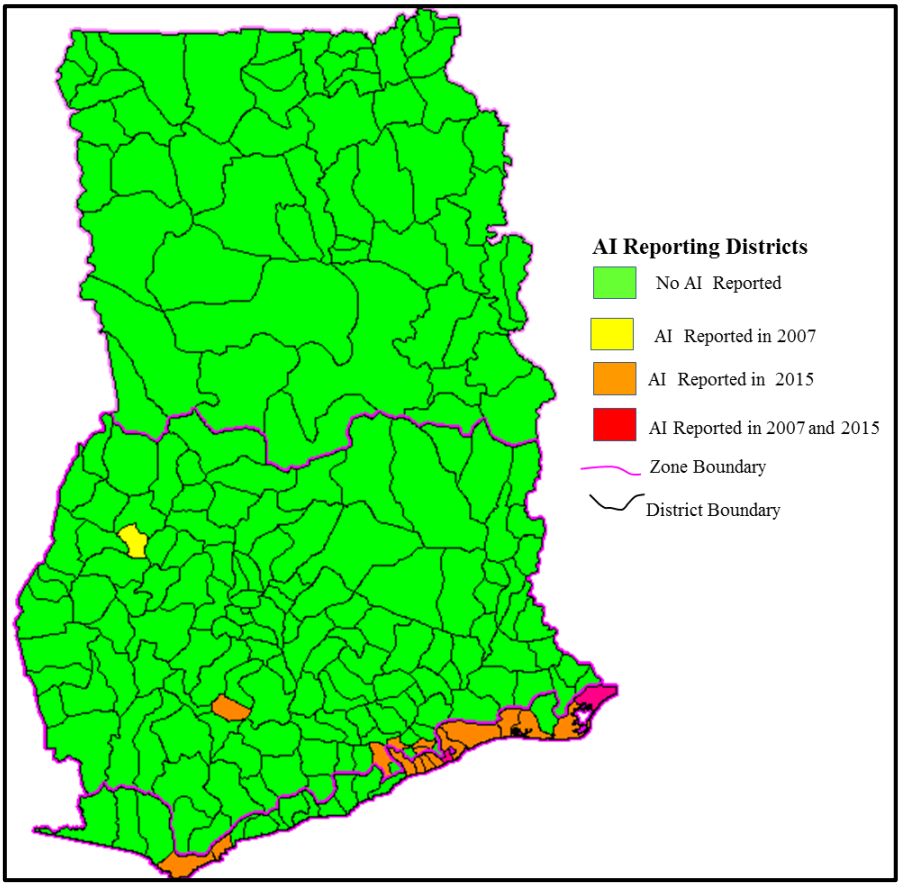
Avian Influenza (AI)

Avian influenza ("bird flu") is an infectious disease of birds caused by type A strains of influenza virus. The infection can cause a wide spectrum of symptoms in birds, ranging from mild illness, which may pass unnoticed, to a rapidly fatal disease that can cause severe epidemics.

Avian influenza viruses do not normally infect humans. However, there have been instances of certain highly pathogenic strains, such as A(H5N1) and A(H7N9) having caused severe respiratory disease in humans. In most cases, the people infected had been in close contact with infected poultry or with objects contaminated by their faeces (WHO, 2014). The major public health concern of AI outbreaks in poultry is their effect on poultry populations, the potential of the virus to mutate to become more easily transmissible between humans, raising the possibility of an influenza pandemic.

Ghana experienced a total of three separate Highly Pathogenic Avian Influenza (HPAI) H5N1 outbreaks in poultry in 2007, at approximately one month intervals that commenced in April and affected three districts, Tema, Ketu South and Sunyani (Figure 9). No human cases were detected. How the disease was introduced or why the disease was not more widely disseminated remains to be answered (FAO, WHO, OIE, AU-IBAR 2008). In 2015, there were 34 outbreaks of A(H5N1) in poultry in Ghana with no human case reported. The outbreaks which started in April in Kpone-Katamanso district of Greater Accra region later spread to farms in 18 districts in 5 regions, Greater Accra (12), Ashanti (1), Volta (2), Western (2) and Central (1) (Figure 9), (VSD, 2015 and OIE, 2015).

Figure 9: Districts Reporting Avian Influenza (AI) in Poultry in Ghana, 2007 and 2015



Source of Data: VSD and OIE

Influenza Pandemic

An influenza pandemic is a rare but recurrent event. A pandemic occurs when a new influenza virus emerges and starts spreading as easily as seasonal influenza – by coughing and sneezing. Because the virus is new, the human immune system will have no pre-existing immunity. This makes it likely that people who contract pandemic influenza will experience more serious disease than that caused by normal seasonal influenza. Three pandemics occurred in the previous century: "Spanish influenza" in 1918, "Asian influenza" in 1957, and "Hong Kong influenza" in 1968. The 1918 pandemic killed an estimated 40–50 million people worldwide. That pandemic, which was exceptional, is considered one of the deadliest disease events in human history. Subsequent pandemics were much milder, with estimated 2 million and 1 million deaths in 1957 and 1968 respectively. The latest was the H1N1 (2009) which killed over 18,000. The H1N1 virus that caused that pandemic, A(H1N1)pdm09 is now a regular human flu virus and continues to circulate seasonally worldwide.

3.4.2.5 Viral Haemorrhagic Fevers

Viral haemorrhagic fever (VHF) is a general term for a severe illness or diseases, sometimes associated with bleeding, that may be caused by a number of viruses. These include Ebola Virus Disease, Marburg, Lassa fever, Crimean-Congo haemorrhagic fever, Rift Valley Fever and Dengue. Ebola Virus Disease (EVD) and Lassa Fever (LF) are the VHFs of major public health concern in Ghana following the massive EVD outbreaks in the West African sub region in 2014 and reported LF endemicity in West Africa with 2 cases confirmed in Ghana in 2011.

Ebola Virus Disease

Ebola Virus Disease (EVD), formerly known as Ebola haemorrhagic fever, is a severe, often fatal disease in humans caused by Ebola virus. The average EVD case fatality rate is around 50%. Case fatality rates have varied from 25% to 90% in past outbreaks (WHO, 2016a).

It is thought that fruit bats are natural hosts for Ebola virus. Ebola is introduced into the human population through close contact with blood, secretions, organs or other bodily fluids of infected animals such as chimpanzees, gorillas, fruit bats, monkeys, forest antelope and porcupines found ill or dead in the rainforest. Ebola then spreads through human-to-human transmission via direct contact (through broken skin or mucous membranes) with the blood, secretions, organs or other bodily fluids of infected people, and with surfaces and materials (e.g. bedding, clothing) contaminated with these fluids. Health-care workers have frequently been infected while treating patients with suspected or confirmed EVD. This has occurred through close contact with patients when infection control precautions are not strictly practised.

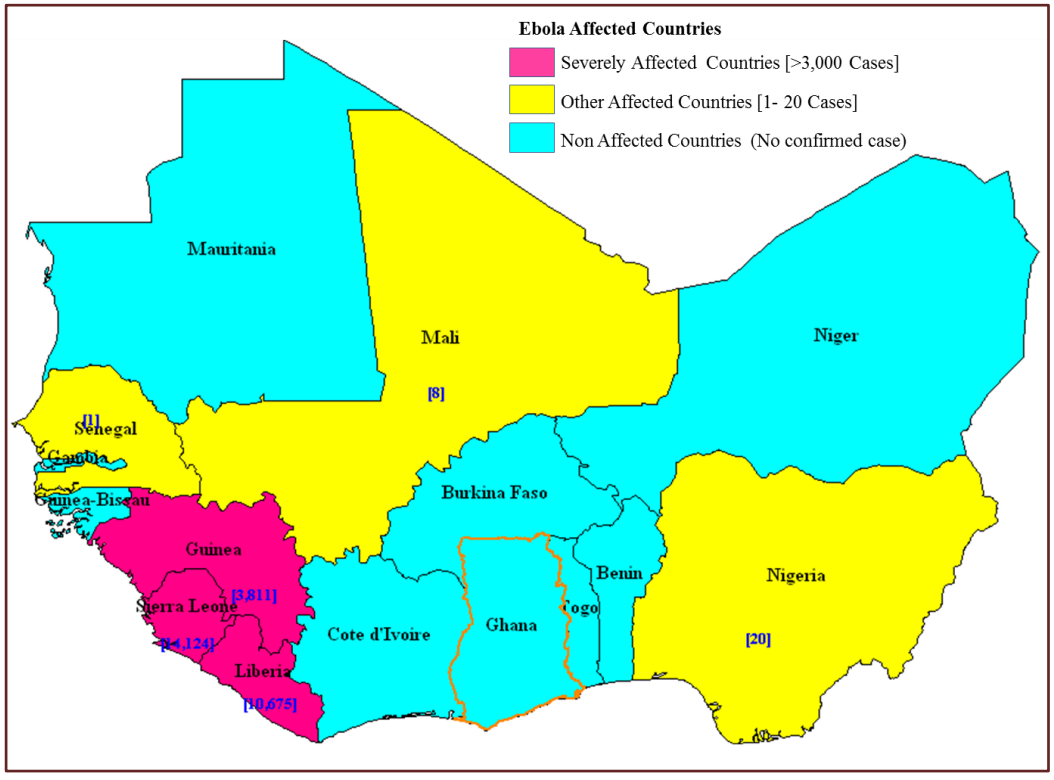
Ebola Virus Disease EVD first appeared in 1976 in 2 simultaneous outbreaks, one in what is now, Nzara, South Sudan, and the other in Yambuku, Democratic Republic of Congo. Between 1976 and 2012 there had been 20 outbreaks recording 2,389 cases and 1570 deaths (case fatality rate of 65.7%).

The outbreak in West Africa which started in Guinea in 2014 is the largest and most complex Ebola outbreak since the Ebola virus was first discovered, with concurrent rural and urban transmission unlike the previous ones which were mainly rural. There have been more cases and deaths in this outbreak than all others combined with unusually high number of health care workers affected. It has

also spread between countries starting in Guinea then spreading across land borders to Sierra Leone and Liberia and also by air to Nigeria and United States of America. On 8 August 2014, the WHO Director-General declared the West Africa outbreak a Public Health Emergency of International Concern (PHEIC) under the International Health Regulations (2005). As of 27 March 2016 a cumulative total of 28,616 cases and 11,310 deaths (CFR 39.5%) have been reported from the three most affected countries, Guinea, Liberia and Sierra Leone (Figure 10). On 29 March 2016, WHO lifted the PHEIC related to EVD in West Africa because all transmission chains have been identified and countries have demonstrated the ability to respond effectively to avert international spread. (WHO, 2016c)

Fortunately, no case of EVD had been confirmed in Ghana although 150 suspected cases were investigated across the country. However, the disease remains a major public health threat to Ghana due to the country's proximity to the recently affected countries; difficulty in recognizing and quickly diagnosing it in its early stages as presenting symptoms are similar to common prevalent infectious conditions like malaria; rapid spread in communities and health facilities with poor infection prevention and control practices; absence of an approved vaccine and effective cure; and high case fatality rate.

Figure 10: Ebola Affected Countries in West Africa, 2014-2015



Source of data: WHO, 2016c

Lass Fever

Lassa Fever (LF) is an acute zoonotic viral haemorrhagic illness that occurs in West Africa. The Lassa virus is transmitted to humans via contact with food or household items contaminated with rodent urine or faeces. The animal reservoir, or host, of Lassa virus is a rodent of the genus Mastomys, commonly known as the "multimammate rat." Mastomys rats infected with Lassa virus do not become ill, but they can shed the virus in their urine and faeces. Person-to-person infections and laboratory transmission can also occur, particularly in hospitals lacking adequate infection prevention and control measures. About 80% of people who become infected with Lassa virus have no symptoms. 1 in 5 infections result in severe disease, where the virus affects several organs such as the liver, spleen and kidneys. The overall case-fatality rate is 1%. Observed case-fatality rate among patients hospitalized with severe cases of Lassa fever is 15%. Early supportive care with rehydration and symptomatic treatment improves survival. The antiviral drug, ribavirin seems to be an effective treatment for Lassa fever if given early in the course of clinical illness.

Lassa fever is known to be endemic in Benin, Ghana, Guinea, Liberia, Mali, Sierra Leone, and Nigeria, but probably exists in other West African countries as well (WHO, 2016b). Ghana diagnosed its first two cases in Amansie West district of Ashanti region in the Forest zone in 2011 (Dzotsi et al, 2012).

The disease is a public health threat due to the fact that it is endemic in the country and other countries in the West African sub-region, difficulty in diagnosis especially early in the course of the disease as presenting symptoms are similar to common prevalent infectious conditions like malaria and typhoid fever and can spread in communities and health facilities with poor infection prevention and control practices and absence of an approved vaccine. As recommended by Dzotsi et al, studies are required to identify the geographical prevalence of the host Mastomys rodent and the presence of LF in the animal to help determine the risk factors and geographical areas at risk for disease transmission in Ghana.

3.4.2.6 Flood

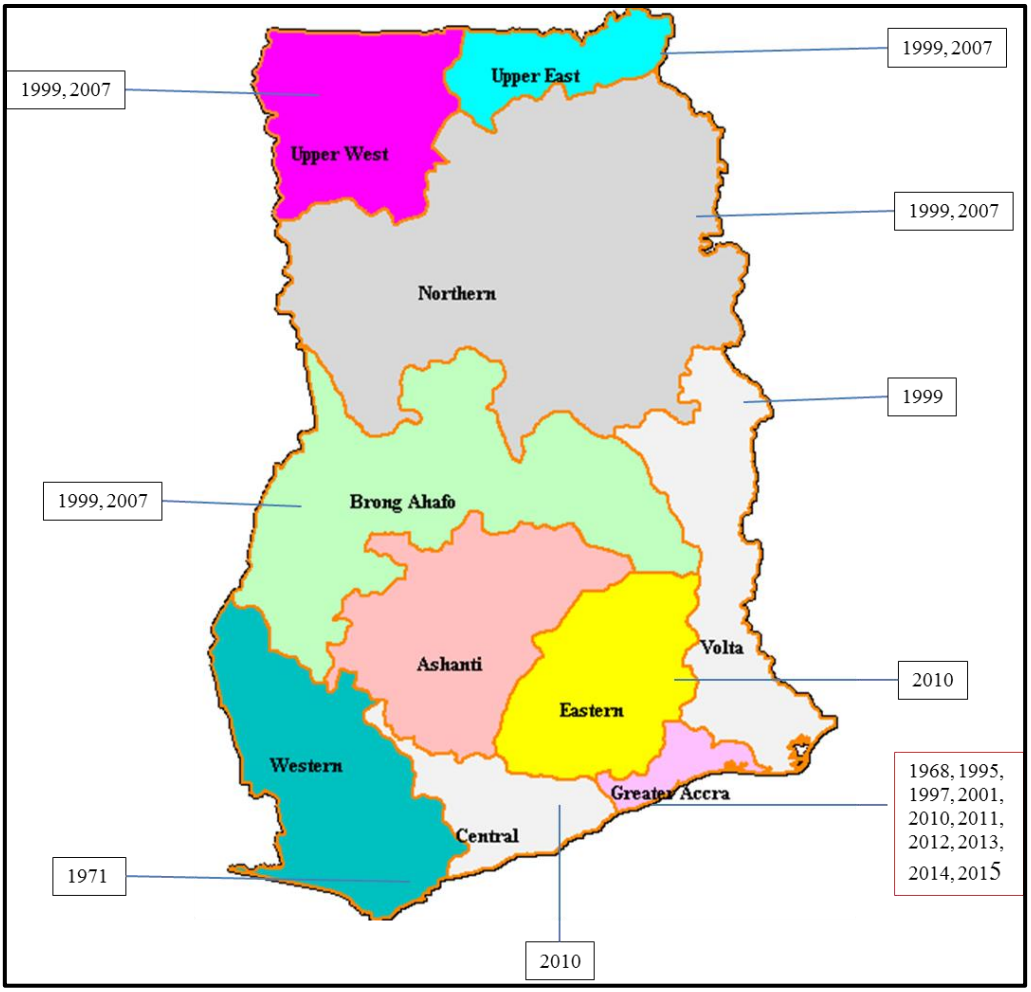
A flood is an overflow of water that submerges land which is usually dry (Flood - Wikipedia).
Floods are dominated by two aspects: the presence of (excessive) water and the topographical characteristics of the area. Water collects in low areas. Flat surfaces close to a river are more prone to flooding and heavy rainstorms can cause sudden floods (flash flood).

Floods often cause damage to homes and businesses if they are in the natural flood plains of rivers. Direct health effect of flood includes loss of life through drowning, trauma from debris, increased risk of electrical shock (in urban areas) and snake bite (in rural areas), Mental and psychosocial problems including post-traumatic stress syndrome. Indirect health effect may result from loss of drinking water or severe water contamination and loss of sewage disposal facilities. The lack of clean water combined with human sewage leads to risk of water borne diseases such as cholera and typhoid fever. The damage to health facilities leads to interruption of health service delivery. Floods can also damage roads and transport infrastructure therefore making it difficult to mobilize aid to those affected or to provide emergency health treatment.

Whether flood hazard really occurs depends on the rainfall, reservoir spills, the surface type and the drainage system. In Ghana there is a high variability of rainfall amounts and intensity; there is also spilling from reservoirs. Two areas in the country are known to suffer from regular flooding due to spilling of upstream reservoirs, the Northern White Volta, threatened by spilling from the Bagre dam in Burkina Faso and the Southern White Volta, due to spilling from the Akosombo dam. In areas where there is hardly any infiltration (e.g. hard rock, paved areas), response times are increased and floods will occur more quickly and frequently compared to areas where infiltration is possible. This is the case for example in Accra.

Almost all regions have experienced flooding in the past 5 decades (Figure 11). In recent times flooding has become a serious phenomenon in Ghana, especially in urban areas. The problems stem from a number of factors such as poor drainage systems and the physical development of flood prone areas. The few existing drains tend to be badly built and clogged by rubbish and silt. Unapproved and haphazard development causes flooding in built–up areas. Since the year 2010 there has been flooding in Accra every year between May and July. Usually if there is continuous heavy rain for more than two hours the capital is flooded.

Figure 11: Floods in Ghana by Region, 1968 - 2015



Source of data: Daily Graphic 5 June 2015

According to hazard mapping done by UNDP in 2010, about a third (35%) of the districts in Ghana is classified as 'high hazard, another third as medium hazard (Table 6) (UNDP, Ghana 2014).

Table 6: Distribution of Districts by Flood Hazard Level

Hazard Level	Number of Districts	%
High	76	35
Medium	69	32
Low	71	33

Data Source: UNDP, Ghana: Risk Assessment and Mapping – Technical Report, 2014

3.4.2.7 Drought

Drought is the naturally occurring phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems" (UNCCD, 1994). Drought is dominantly influenced by the weather, especially rainfall and evapotranspiration. Whether areas suffer from drought depends on the spatial variability of these meteorological variables as well as on the physical properties of the land surface. The most important variable used for mapping is the cumulative rainfall deficit (evapotranspiration minus rainfall). Drought is a slow process as compared to flood.

The health consequences of drought include malnutrition; micronutrient deficiencies caused by food shortage due to decline in soil fertility, disease outbreaks (water-borne diseases) due to decline in water availability and quality. Ghana has experienced drought mainly in the Northern savannah zone of the country.

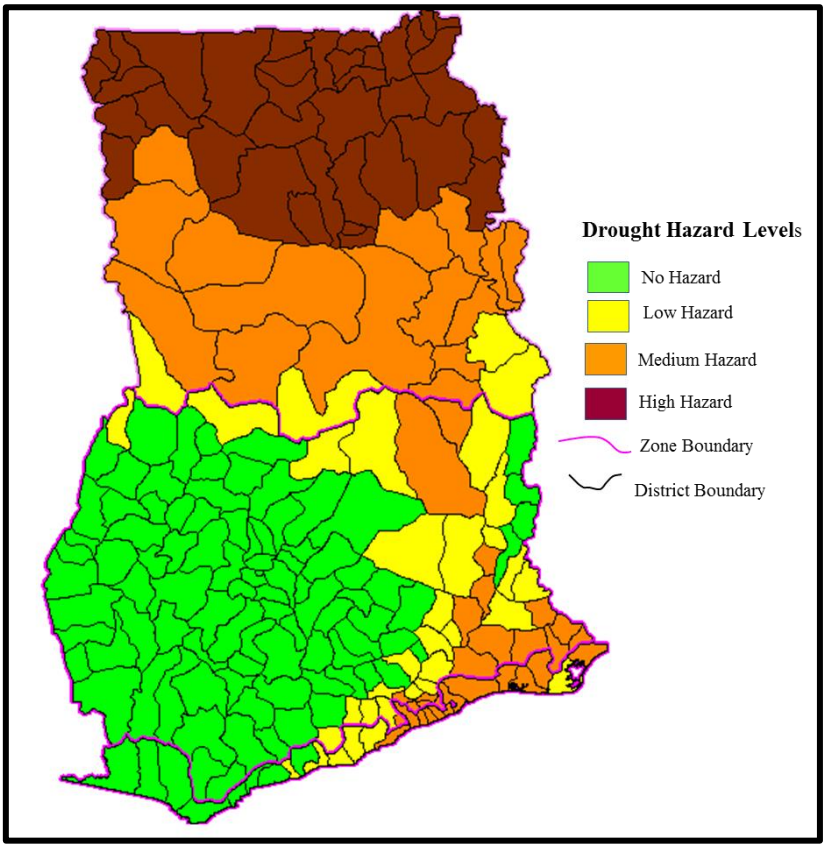
According to the hazard mapping by UNDP, 37 (17%) of districts in Ghana are high level hazard (Table 7). All 37 districts are located in the Northern savannah ecological zone. All the 56 districts in the zone are either high level or medium level for drought hazard (Figure 12) (UNDP, Ghana 2014).

Table 7: Distribution of Districts by Drought Hazard Level

Hazard Level	Number of Districts	%
High	37	17
Medium	46	21
Low	34	16
No	99	46

Data Source: UNDP, Ghana: Risk Assessment and Mapping – Technical Report, 2014

Figure 12: District Drought hazard map, Ghana



Data source: UNDP, Ghana: Risk Assessment and Mapping – Technical Report, 2014

3.4.2.8 Earthquake

Earthquake is a shaking or trembling of the earth that is volcanic or tectonic in origin causing any type of damage or negative effect on communities or properties (GLIDE). An earthquake occurs when there is slip along a fault in the earth. Energy is released during an earthquake in several forms as heat, and as seismic waves that radiate out from the "source" in all directions and cause the ground to shake, sometimes hundreds of kilometres away (Natural Resources Canada, 2009). Earthquakes are caused by the movement and deformation of the tectonic plates caused by the heating and cooling of rock underneath them. The stress on the rocks accumulates until it is suddenly released in a rapid burst of movement. Although most earthquakes are natural, human activities have caused small earthquakes. These include mining activities (such as underground collapses and rock bursts), oil recovery and the filling of reservoirs behind large dams. Underground nuclear explosions are also known to have caused minor earthquakes near the test site.

Earthquakes are measured by their consequence, ‘a measure of the amount of energy released during an earthquake’. While the first magnitude scale was the Richter scale, currently there are several different regional magnitude scales, of which the most universal today is the moment magnitude scale, which assesses the amount of energy released by an earthquake.

The amount and type of damage depends on the magnitude of the earthquake, the distance from the earthquake epicentre (the origin point of the earthquake), the depth of the earthquake, the frequency of the ground motion, the kind of faulting and the soil and rock type of an area (Natural Resources Canada, 2009). A powerful earthquake could cause buildings and structures such as bridges to collapse, trapping people in the debris. People can also be killed or injured by falling debris such as glass, chimneys, book cases and roof tiles. Further fatalities and injuries may occur during aftershocks if buildings compromised by the original earthquake are re-entered. Fires caused by ruptured gas mains etc., may also pose a risk.

Although Ghana is far away from the major earthquake zones that mark the present day lithospheric plate boundaries, the country has been struck by damaging earthquakes in the past (Table 8), and recently has been experiencing minor tremors regularly. The tremors that occurred on 14 February and 6 March 1997 and other recent microseismic activities were very threatening registering more than 4.0 on the Richter scale. Accra, the capital city, with a growing number of large industrial activities is located in the earthquake-prone zone. Microseismic studies in the country indicate that the seismic activity is associated with active faulting, particularly near the intersection of the two major fault zones, the coastal boundary fault and Akwapim fault zone. Most of the located earthquakes have their epicentres near the junction of these faults (Paulina Amponsah, 2004).

Table 8: Earthquakes in Ghana, 1615 - 2002

Year	Type	Areas	Magnitude	Impact
1615	Earthquake	Elmina		First earthquake in Ghana. Fortress of Sao Jorge at Elmina was destroyed.
1636	Earthquake	Axim	5.7 MS	Earliest recorded earthquake in Ghana. Buildings and underground workings of a gold mine at Aboasi, northeast of Axim collapsed burying many of the miners
1858	Minor tremor	Accra		No damage
1862	Earthquake	Accra	6.5ML	3 deaths, considerable infrastructure damage. Osu Castle was destroyed. Effects also in Togo and Benin
1871	Minor tremor	Accra	4.6 ML	No damage
1872	Minor tremor	Accra	4.9 ML	No damage
1883	Minor tremor			No damage
1906	Earthquake	Ho	6.2 ML	Severe damage - collapsed buildings, no casualties were reported. Event also felt in Togo and Benin
1907	Minor tremor	Accra		No damage
1911	Minor tremor	Accra		No damage
1939	Earthquake	Accra	6.5 MR	Most destructive earthquake in Ghana's history. The event lasted about thirty seconds and killed 17 and injured 133.
1964	Minor tremor	Accra		No damage
1969	Minor tremor	Accra		No damage
1997	Minor tremors	All regional capitals	4.8 MR	No damage
1998-2002	Minor tremors		1.0–3.0 MR	No damage

MS – Surface wave magnitude, ML – Local magnitude, MR – Richter scale magnitude

Data Source: Paulina Amponsah. Seismic activity in Ghana: Past, present and future Annals of Geophysics, Vol 47, 2004

3.4.2.9 Land (Road) Transport Accidents

Road traffic emergency is a crash, collision or incident, of large scale, involving land or road transportation. An increase in average speed is directly related both to the likelihood of a crash occurring and to the severity of the consequences of the crash. Drinking and driving increase both the risk of a crash and the likelihood that death or serious injury will result. There are many types of distractions that can lead to impaired driving, but recently there has been a marked increase around the world in the use of mobile phones by drivers that is becoming a growing concern for road safety. Text messaging also results in considerably reduced driving performance, with young drivers at particular risk of the effects of distraction resulting from this use. In Ghana, over speeding, over loading and disregard to road signs or regulations have been identified as the first-three main road traffic accidents (RTA) causing factors (Nyamuame et al, 2015). Wearing a motorcycle helmet correctly can reduce the risk of death by almost 40% and the risk of severe injury by over 70%. Wearing a seat-belt reduces the risk of a fatality among front-seat passengers by 40–50% and of rear-seat passengers by between 25–75% (WHO, 2015c).

Road traffic crashes are the leading cause of death globally and the main cause of death in those aged 15 - 29 years. Road traffic injuries cause considerable economic losses to victims, their families, and to nations as a whole. One of the new Sustainable Development Goals (SDG) targets is to halve the global number of deaths and injuries from road traffic crashes by 2020 (WHO 2015). Ninety percent of the world's fatalities on the roads occur in low- and middle-income countries, even though these countries have approximately half of the world's vehicles. Even within high-income countries, people from lower socioeconomic backgrounds are more likely to be involved in road traffic crashes. Half of those dying on the world's roads are "vulnerable road users": pedestrians, cyclists and motorcyclists. Thousands of small-scale road accidents occur annually, although, large-scale road transportation emergencies are uncommon. Few are severe enough that they exceed routine local emergency capacity.

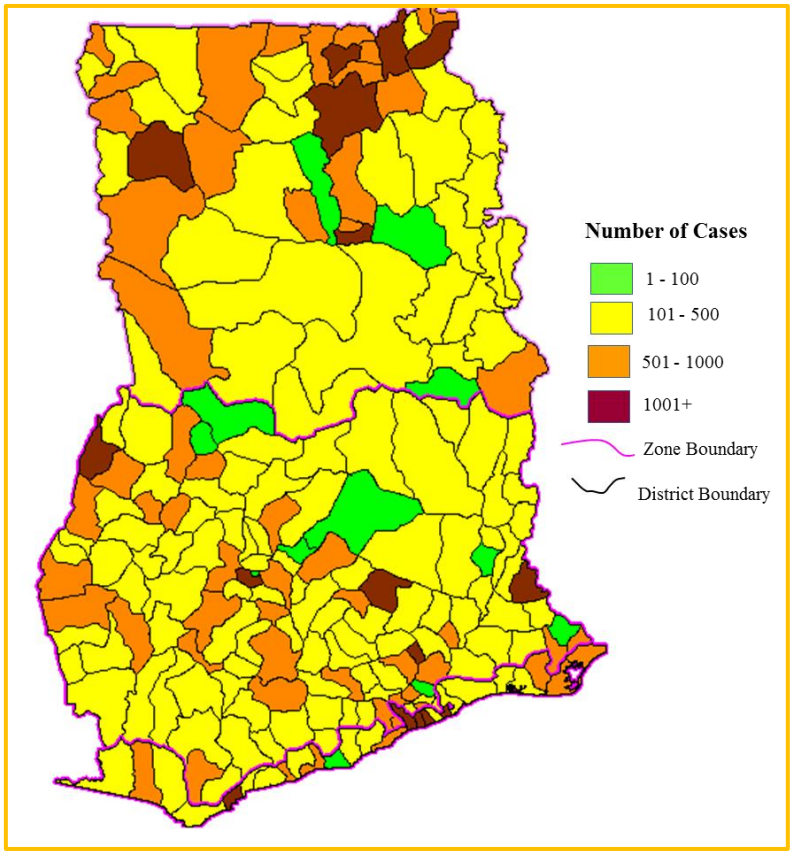
In Ghana, available data from the Ghana Health Service indicate that overall the number of reported road traffic injuries increase from 2011 to 2013 and then start to decrease with the highest average annual incidence recorded for the period in Ashanti and Greater Accra regions (Table 9). Nyamuame et al (2015) in their study of road traffic accident trends in Ghana reported that road traffic accidents and fatalities are on the increase with progression in the year and population growth with highest incidence of accidents and fatalities being recorded in Greater Accra and Ashanti regions respectively, the two most populous regions and with the most economic activities. The study also showed that the three regions in the northern savannah zone (Northern, Upper East and Upper West) recorded the lowest number of RTA cases. This could be attributed to their remote location relative to Accra where most economic activities occur and low number of vehicles in these regions. The high hazards areas for road transport accidents are the major towns including the regional capitals and big commercial towns (Figure 13). The number of accidents tends to increase during periods of festivities such as Christmas and Easter when most people travel to their home towns and drivers tend to over speed to make so many trips to accommodate the increase in volume of passengers.

Table 9: Average Annual Incidence of Road Traffic Injuries by Region, Ghana, 2011 - 2015

Region	2011	2012	2013	2014	2015	Total
Ashanti	14,450	15,261	14,366	12,221	11,046	67,344
Brong Ahafo	10,686	13,598	13,315	11,783	10,739	60,121
Central	7,965	9,590	9,518	7,485	7,943	42,501
Eastern	13,159	15,200	13,061	11,873	8,950	62,243
Greater Accra	13,055	14,380	16,702	14,187	12,775	71,099
Northern	10,622	12,932	15,023	11,565	8,360	58,502
Upper East	7,439	9,577	11,708	12,586	10,493	51,803
Upper West	5,501	5,869	6,764	5,655	5,901	29,690
Volta	12,114	14,323	14,366	9,966	6,464	57,233
Western	10,274	11,394	11,216	8,645	8,651	50,180
Ghana	105,265	122,124	126,039	105,966	91,322	550,716

Source of Data: DHIMS, CHIM, GHS

Figure 13: Hazard Map for Road Traffic Accidents



Road traffic injuries can be prevented. Action is needed to address road safety in a holistic manner, that requires involvement from multiple sectors (transport, police, health, education) and that addresses the safety of roads, vehicles, and road users themselves. Effective interventions include designing safer infrastructure and incorporating road safety features into land-use and transport planning; improving the safety features of vehicles; and improving post-crash care for victims of road crashes. Interventions that target road user behaviour are equally important, such as setting and enforcing laws relating to key risk factors, and raising public awareness.

3.4.2.10 Air Transport (Aviation) Accidents

Transportation emergencies involving aircrafts may arise from the following circumstances: an aircraft colliding with another aircraft in the air; an aircraft crashing or being in imminent danger due to mechanical problems, or human error; an aircraft crashing while in the take-off, cruising or landing phases of a flight; an aircraft colliding with an object on the ground or at any stage during the flight, two or more aircraft colliding on the ground during staging or taxi operations. A transportation emergency involving aircraft may result in secondary hazards such as fires and explosions. If a structure is impacted, it may result in building/structural collapse.
Despite the high volume of air traffic, serious air transportation incidents involving large numbers of people are fairly rare. However, when they do occur, they can result in a large number of injuries and even fatalities. The number of people affected depends on the size of the aircraft, the number of passengers and crew, the speed at which it is travelling and the area (and the population) in which the incident occurs. Serious property damage can occur if the incident occurs in an area with a large number of buildings and/or structures. Damage can be very severe, resulting in the complete destruction of the building/structure. Critical infrastructure may also be damaged. However, due to the size of aircraft and the amount of fuel aboard, air transportation incidents are usually localized.

Ghana has experienced very few aviation accidents in the past. On 5 June 2000, a Ghana Airlink Fokker F-27 from Tamale to Accra crashed on approaching Kotoka International Airport. Six people were killed. On 2 June 2012, an Allied Air Boeing 727 cargo aircraft operating from Lagos to Accra on behalf of DHL with 4 crew members overshot the runway while landing in heavy rain. At least 12 people on the ground (passengers on a minivan on the 37 Military Hospital-Burma Camp road at El-Wak) were killed. All the 4 crew members survived (KIA-Wikipedia).

3.4.2.11 Water Transport Accidents

Transportation emergencies involving marine vehicles may arise from the following circumstances: a collision with another marine vehicle or object, the marine vehicle capsizing, floundering, sinking, a marine vehicle encounters severe weather which causes damage or flooding, a fire and/or explosion aboard the marine vehicle; the marine vehicle striking land, rocks and becoming damaged or grounded, a marine vehicle suffers structural damage that compromises its safety, flooding of a marine vehicle. Therefore water transport accident areas are along the sea and rivers where most people use water transportation as their main means of transport.

Ghana has experienced boat accidents, particularly on the Volta Lake in recent years, the latest of which was the one that occurred on 29 May 2016 in which 25 people, including children, died when a boat carrying about 60 people capsized on the lake in Yeji in the Pru district of Brong Ahafo region.

3.4.2.12 Structural Collapse

Structure collapse is the loss of integrity in a structure that results in the structure losing shape, caving in, flattened or reduced to debris. Structures, such as buildings and bridges collapse if the load-carrying capacity within the structure or of the structure as a whole is exceeded and the building material is stressed beyond its limit. Structures may exceed their load-carrying capacity due to the stresses of different causes. These include design and construction flaws, material flaw, high wind, earthquake, fire, explosion, deterioration, the lack of strict building codes and the non-availability of proper construction materials. Structures may experience a complete or partial collapse; and the collapse may be sudden or delayed. Collapse usually begins with fractures and deformations of the structure but may occur quickly so that these are not noticeable in time to evacuate.

A building/structural collapse is usually an isolated occurrence, unless it occurs as a secondary hazard due to an event such as an earthquake. The immediate building is affected, as well as any other structures that are within the collapse zone that is likely to experience falling debris.

In Ghana, between 2012 and 2014, Accra officially recorded four major building collapses that claimed a total of 19, the most serious one being the Melcom supermarket building near Achimota that collapsed in 2012 and claimed 14 lives (Mark Bediako 2015).

3.4.2.13 Nuclear and Radiological Emergency

Nuclear accident

Nuclear hazard results from ionizing radiation whose source is a major nuclear installation. Nuclear generating stations produce electricity created by nuclear fission. Nuclear fission generates heat which is used to boil water to produce steam which can then be used to power turbines which generates electricity (OPG, 2010). A nuclear facility emergency could occur if a substantial amount of radioactive material is released into the environment. Advances in technology and safety procedures have decreased the probability of a nuclear facility emergency significantly. A nuclear facility emergency could be triggered by fire or explosion, technological malfunction, intentional or unintentional human activity (EMO, 2005). The release of radioactive materials depends on the characteristics of the event and the type and response of the containment system. These systems are designed to prevent the release of radioactive materials in the event of an accident. Sudden releases (i.e. within a few hours) can only occur if the system malfunctions or it is bypassed. In the extremely unlikely event of a nuclear facility emergency that results in the release of high levels of radioactive material, the most likely ways in which people can be exposed to radiation are: external contamination – the contamination of the skin and/or clothing; direct Exposure – exposure to the source of the radiation and internal contamination – the inhalation of radioactive material or the ingestion of contaminated food or water (EMO, 2009).

Exposure and contamination can be minimized in the event of a nuclear facility emergency through the use of specific protective measures. The type of protective measures that should be used depends on the type of radioactive material, the amount released, the size of the affected area, land use and the population. The protective measures include restricting access to the affected area to essential personnel, ingestion of Potassium Iodide (KI) – this blocks radioactive iodine from entering the

thyroid (it is only useful in an emergency that involves the release or potential release of iodine-131); and remaining indoors, with windows and doors closed and external ventilation systems turned off.

Radiological accident

A radiological emergency occurs when ionizing radiation from radioactive material is unintentionally emitted outside of protective spaces, at levels high enough that it presents a threat to people or the environment. There are three basic types of ionizing radiation: Alpha particles, Beta particles, Gamma rays. A device that contains radioactive material and could result in exposure is referred to as a 'source'. Radiation sources are commonly used in universities, industry and government facilities. A source can be classified as being dangerous if uncontrolled exposure could result in severe health effects. A source may be considered to be uncontrolled if it is abandoned, lost, stolen or otherwise outside of regulatory control. Radiological emergencies may also arise from the misuse or malfunctioning of industrial and medical sources and transportation accidents carrying radioactive materials and from unknown origins. While radiological incidents may occur from time to time, (these are usually small and are cleaned up very quickly without any negative effects) radiological emergencies are rare.

There are several different ways in which people and animals can be exposed to radiation. These include direct exposure (being near or in contact with an uncontrolled source); inhalation of radioactive particles; ingestion of foods or liquids contaminated with radiation.

Health effects may not appear for days, weeks or even years depending on the length, type of radioactive material and form of exposure. Negative health effects can be divided into two categories: chronic and acute. Chronic health effects are related to long-term exposure to radiation. The energy level of the radioactive material is not sufficient to cause immediate health effects. Negative health effects may not show up until months or years after exposure. The primary chronic health effect related to radiation exposure is cancer. Teratogenic mutations of foetuses are also possible if pregnant women are exposed to radiation sources over the long-term (EPA, 2010). Acute health effects are caused by exposure to high levels of radiation. These effects may appear quickly, within a matter of hours or days. The principal acute health effect is radiation sickness. Radiation sickness can induce symptoms such as weakness, hair loss, nausea, damage to the organs and skin burns. If the dose of radiation received from exposure is high enough, radiation sickness can be lethal with death usually occurring within two months of exposure (EPA, 2010). Another potential negative effect of a radiological emergency involving a dangerous source could be ground contamination. Depending on the level of contamination, clean-up of the site may be necessary. If the contamination is severe, any inhabitants of that site may require relocation.

Ghana, for the past three decades, has been using various types of radiation emitting devices and radioactive sources. The practices in Ghana cover the following main areas: medicine, industry and research and teaching. There are 158 authorised facilities in Ghana that use radiation emitting devices and/or radioactive sources. Major practices in Ghana are research reactor, Co-60 gamma irradiator, Co-60 radiotherapy source and Ir-192 source for non-destructive material testing. (NADMO and GAEC, 2010)

According to the International Atomic Energy Agency (IAEA) emergency planning categorization of radio-nuclear practices in Ghana fall into Category III and IV.

Emergency Planning Category III: Facilities without significant off-site risk but with the potential for accidents resulting in deterministic health effects on-site. According to the Ghana Atomic Energy Commission (GAEC), the following practices fall in this category:

- 30kw Research Reactor at the Ghana Atomic Energy Commission
- 18.5 PBq Co-60 Gamma source for radiation Processing centre
- 18.5 PBq Co-60 gamma source for radiation therapy at Korle-Bu Hospital Radiotherapy Centre
- 22.2PBq therapy at Komfo Anokye Hospital Radiotherapy Centre
- 18.5TBq Cs-137 Gamma source for brachytherapy at Korle Bu Radiotherapy Centre
- 22.2TBq Gamma Source for brachytherapy at Komfo Anokye Hospital Radiotherapy Centre
- 27TBq Ir-192 source for non-destructive material testing
- 37TBq Co-60 gamma source for destination inspection at Tema port
- 37TBq Co-60 gamma source for destination inspection at Takoradi port

Emergency Planning Category IV: Areas with little or no known threat. This is the minimum for all countries because accidents involving lost or stolen sources or the transportation of radioactive material are possible anywhere. All the rest of practices in Ghana fall into that category.

Emergency Planning Category V: Is less likely for Ghana since at present the nearest nuclear power plant, Koeberg, near Cape Town, South Africa, is situated more than 4000 km from Ghana's borders.

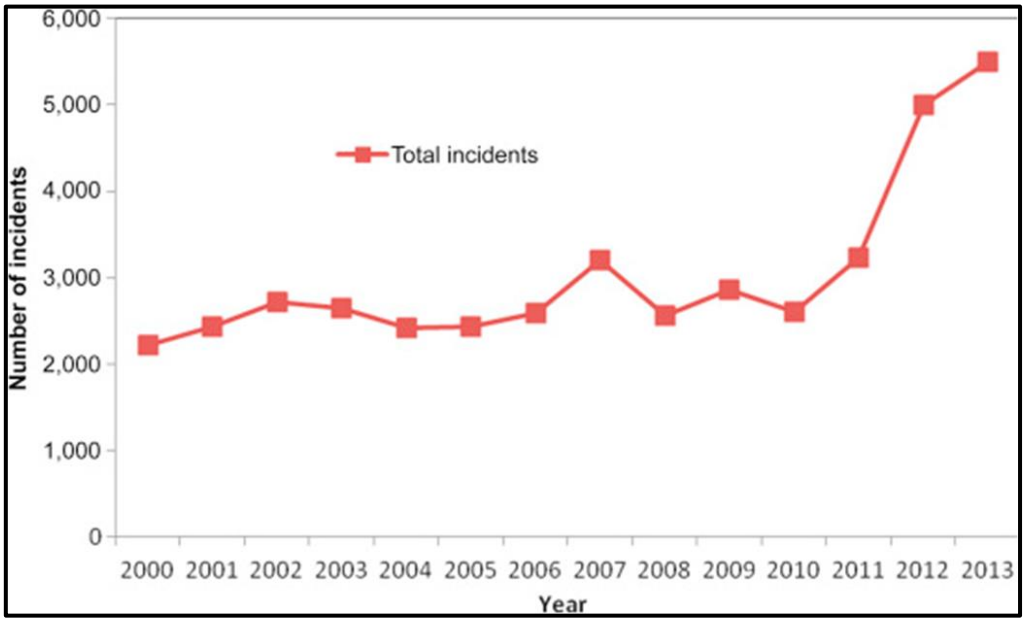
3.4.2.14 Fire

Fire is uncontrolled and/or potentially destructive burning caused by the ignition of a fuel or material, combined with oxygen, which gives off heat and light, with or without an open flame.
Fires require three elements in order to propagate, a fuel source (e.g. bedding, wood), oxygen and a source of ignition. Sources of ignition include: heat, static electricity and chemical reactions (IRP, 2006). The persistent and spread of a fire depends on the type of fuel source, the amount of fuel source, the source, type and location of initial ignition, the size and layout of the building/surroundings, air turbulence caused by the interaction of fire and/or burning gases with obstacles, the type of vents and their locations, additional fuel sources, the presence of prevention and mitigation systems.
Fires can occur outdoors or within structures such as houses. The most common type of fire is outdoor fires. Structure fires can have one of several causes including heating/cooling, cooking, cigarette/lighters, faulty electricity wiring and arson. Different types of buildings are more likely to experience fires resulting from different causes.

Structure fires can result in fatalities, injuries and significant property damage. Fire fatalities result from direct effect of the fire (e.g. burns), secondary complications from fire injuries (e.g. pulmonary oedema), damage caused by the fire (e.g. roof collapse), being involved in fire control (e.g. a rescue attempt). Fire prevention measures include use of smoke alarms, use of fire resistant building materials, sprinkler systems, fire extinguishers and improvement in fire-fighting technology.

In Ghana, Addai et al reported in their study on trend of fire outbreaks in Ghana from 200 to 2013 that the rate of fire incidence increased each year (Figure 14). This increase was attributed to several factors: rate of population growth and industrialization, unstable electricity, urbanization, negligence, illegal electrical connection, etc. The cause of fire was categorized into domestic, industrial, vehicular, institutional, electrical, commercial, bush, and others. Among these causes, domestic fire accounted for 41% of the total number of fire incidents in the country. Most of the fire incidents occurred in the populated cities of Ghana. Most of the recent fire outbreaks have taken place in state facilities that are of great strategic value, thereby making fires an issue of public concern. For example, the Kumasi Central Market suffered fire outbreaks on 28 May 2009, 2 January 2010 and on 30 December 2012. Other important places that were destroyed by fire include the Ministry of Information, the loading gantry of Tema Oil Refinery, offices of the Electoral Commission, and the Ridge residence of former President Rawlings (Addai E. K et al, 2016)

Figure 14: Pattern of Yearly Incidence of Fire in Ghana, 2000 - 2013



Source: Addai E. K. et al - Trend of Fire Outbreaks in Ghana and Ways to Prevent These Incidents, 2016

However, the fire (secondary hazard) that occurred in Accra on 3 June 2015 following heavy rain and flooding and fuel leakage from a petrol filling station on to the top of flood waters that was ignited by a naked flame nearby was a typical example of public health emergency. Many people were burnt to death beyond recognition and others sustained various degrees of severe burns.

3.4.2.15 Oil and Natural Gas Emergency

Oil and gas emergency is an event that poses a threat to public safety, property, the environment, critical infrastructure or the economy from the uncontrolled release of oil and/or natural gas from: 1) a pipeline; 2) oil/natural gas wells; 3) storage facilities and/or distribution systems.

Oil and natural gas are natural resources that were produced from the carbon and hydrogen molecules of decayed organic matter. Decayed organic matter built up in layers over millions of years within geological formations. Over time, heat, pressure and anaerobic bacteria altered the organic matter into oil and gas. Oil and natural gas can be found in many different geologic formations. They can be retrieved by drilling wells to the deposit. Oil has many uses including gasoline, diesel fuel, synthetic rubber and fibres, plastic and pesticides whilst natural gas is used for heating, plastics and fertilizers.

The term 'natural gas' refers primarily to methane and other gas types such as ethane, propane, butane, pentanes and heavier hydrocarbons. It does not naturally have an odour, so the odorant, mercaptan is added (during processing) in order to give it a distinct smell and make it easier to detect. Some of the hazards associated with natural gas are: asphyxiation, ignition and explosion. Natural gas containing high levels of hydrogen sulphide is referred to as 'sour gas'. Hydrogen sulphide is very toxic to humans.

Oil or liquid petroleum is made up of a mixture of liquid hydrocarbons. It is referred to as 'crude oil' if it has not been refined. Some of the hazards associated with oil are: spills contaminating land and waterways and have severe impacts on wildlife and natural ecosystems; fire – oil fires in oil wells, pipeline or storage facilities can be extremely difficult to extinguish due to the abundance of fuel. The smoke produced by these fires may contain many chemicals and particulates that are harmful to human health if proper safety precautions are not taken. If it is ignited and explosions occur can result in fatalities, injuries, property damage, critical infrastructure failure and environmental damage. Perhaps the greatest risk is environmental contamination.

There has not been major oil and gas spillage in Ghana. However with the discovery of oil and its exploration, the establishment of the gas plant and the oil refinery, the likelihood of occurrence of oil and gas spillage accidents in the country cannot be ignored.

3.4.2.16 Chemical

A chemical can be considered a hazard if by virtue of its intrinsic properties it can cause harm or danger to humans, property, or the environment. Some harmful chemicals occur naturally in certain geological formations, such as radon gas or arsenic. Other sources of chemical pollution include agriculture, manufacturing and chemical industries.

Studies have shown that exposure to agro-chemicals (notably pesticides and fertilizers) is as a result of practices such as non-adherence to re-entry intervals of these chemicals, inappropriate handling of chemicals during mixing, application, the practice of tasting to ascertain potency, storage of chemicals at home, indoor locations like bedroom and kitchen where inhalation is likely to be pronounced, and lastly the practice of non-utilization of personal protective equipment (Jeyaratuam J, 1992).
In the manufacturing sector, a wide range of chemicals pose health hazards. These include aromatic solvents like benzene which can cause cardiac arrest, burns in acute exposure situations while chronic effects like leukaemia occur much later. Chemicals like isocyanates used in the plastics industry are potent sensitizing agents and may evoke asthmatic attacks. Acids and alkalis important in manufacturing have the potential of causing serious burns.

Wastes from industries are potential sources of pollution. A number of small to medium scale industries are located within unplanned areas including residential neighbourhoods and even in houses. Many of these industries dispose of their wastes into drains which are subsequently transported to water bodies during heavy rains. Activities of small-scale and illegal artisanal mining (popularly called Galamsey) have polluted several communities' water sources with arsenic and mercury. Significant cyanide spills which occurred in 2001, 2002 and 2003 in the Tarkwa mining areas resulted in high pollution of rivers and wetlands. There is also seepage from indiscriminate dumping of waste as a result of deficient urban services such as well engineered landfill and proper chemical treatment facilities.
Chemicals can also contaminate food. There are reported cases of use of chemicals and pesticides for fishing and game hunting in Ghana. Available evidence shows that there are high amounts of chemicals and pesticides residues in food (including meat) sold on the local market (Adu-Kumi et al., 2010) and even certain imported food substances.

3.4.2.17 Civil Disorder

A group or groups of people intentionally not observing a law, regulation or rule in order to disrupt a business, organization or community to bring attention to their cause, concern or agenda.
Some of the potential causes include: resource shortages, a victory or defeat of a sports team, hostile labour disputes, local, national or international events, the implementation of controversial laws polices or court rulings, disagreements between special interest groups over a particular issue or cause e.g. chieftaincy disputes and ethnic conflicts. Civil disorder can take many forms including, small or large groups that cause the disruption of normal public services and activities, groups that intentionally block or impede access to buildings, roads or other sites, assaults on public figures, police or security personnel, a riot in which property is destroyed and the public threatened.

Civil disorder incidents can have significant impacts on the health sector. Hospitals and clinics may be inaccessible if the civil disorder incident is nearby or they may be overwhelmed by a sudden increase in people requiring medical care. As a result, the health sector requires significant contingency planning for civil disorders.

In Ghana, the May 2001 stadium disaster and the numerous chieftaincy disputes, notably the murder of Dagbon chief and 40 others in 2002 are some of the civil disorders with grave consequences the country has encountered in the recent past.

3.4.2.18 Terrorism

Terrorism is the intentional poisoning, infecting or otherwise targeting through means such as planned explosions of an individual or small group for non-political reasons. This involves the use of materials such as chemical, biological, radiological, nuclear and explosive (CBRNE) intentionally released with the intent to cause harm to humans, property, business or the environment. These materials can be weaponized or non-weaponized. The impact includes risk of mass casualties or fatalities and illnesses, chronic health, psychosocial problems, and creation of a hazardous environment.

The impact of the incident depends on the type of material used, amount of material used, dispersal method, number of different materials used, the location (open or closed), the weather conditions, the population density, the length of exposure, the length of time in which symptoms appear, the length of time in which the material is identified. (CDC, 2010)

The most likely type of CBRNE incident is explosive. Explosive devices do not have to be particularly sophisticated in order to cause a significant amount of damage. Instructions for building explosive devices can be found on the internet. Many ingredients for an explosive device have common, daily uses and are easy to obtain. High volume purchases of these ingredients may raise suspicion. However, numerous purchases at different locations and over a period of time may go undetected.

Cities with a high volume and high reliance on public transportation may have their transportation infrastructure at risk. An attack against a public transportation system which a large number of the local population relies on for transit may paralyze a city.

Although Ghana has not experienced any terrorist act, the recent attacks in Mali (November 2015), neighbouring Burkina Faso (January, 2016) and La Cote d'Ivoire (March 2016) must put the country on high alert.

3.5. Risk Analysis

The results of analysis of various contributing factors including the extent of exposure to the hazard, the vulnerability of the population and their coping capacities that help to determine the likelihood and adverse health consequences resulting in a public health emergency are presented in this section.

3.5.1 Cholera

The occurrence of Cholera is influenced by the presence of the causative agent and its ability to cause the disease in the host and the ease of spread of the disease. The risk factors for spread of the disease include inadequate supply of safe water, poor food and personal hygiene, poor liquid and solid waste disposal, urban slums characterized by poor sanitation and open defaecation, floods leading to contamination of domestic water sources.
The parameters used for the categorization of cholera hazard level is the number of years the area has experienced outbreaks in the past 5 years (2011 – 2015) and the impact of the outbreak (average annual incidence and the fatality)

Variables for cholera vulnerability assessment include

- Populations with unsafe water supply and poor sanitation
- Living in slums (urban and peri-urban)
- Living in flood prone areas

Coping capacity variables include

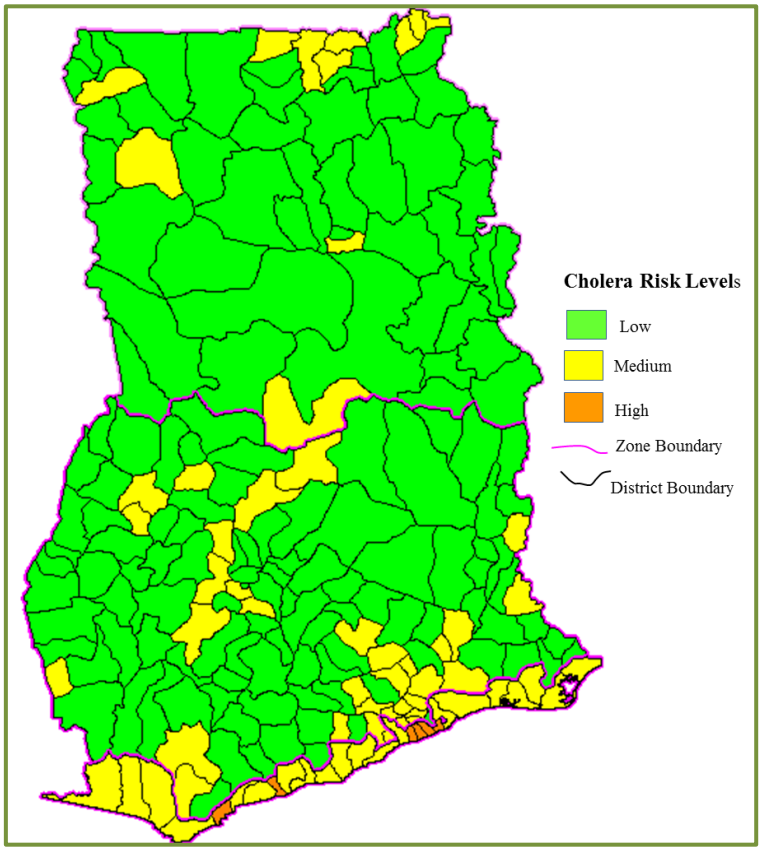
- Ability to detect cases early
- Availability of rapid response team to provide community interventions
- Awareness of public about the prevention and control measures
- Availability of case management facilities

Analysis by district shows that 7 (3%) of the districts in the country are at high risk of cholera outbreak, whilst 65 (30%) are medium risk and the remaining 144 (67%) are at low risk. Six (86%) of the high risks districts are located in the coastal zone. All the districts in the coastal zone are either at high risk or medium risk of the cholera disease (Table 10 and Figure 15). Analysis by zone indicates that the coastal zone is at high risk whilst the forest and northern savannah zones are at medium risk for cholera.

Table 10: Cholera Risk Level, Ghana, 2016

Ecological Zone	Number of Districts			
	Low Risk	Medium Risk	High Risk	Total
Northern Savannah	45	11	0	61
Forest	99	34	1	129
Coastal	0	20	6	26
Ghana	144	65	7	216

Figure 15: Cholera Risk Level by District



In the coastal zone, the location of the national capital (Accra) and regional capitals, Sekondi and Cape Coast, and points of entry (Tema and Takoradi seaport, Aflao and Elubo border crossings) with large daily population movements in this zone puts more pressure on the already existing poor water, sanitation and hygiene (WASH) facilities and thereby increasing vulnerability to cholera outbreaks. In addition, internal rural-urban migration had created slums in these areas with poor WASH facilities which facilitate the spread of cholera. The coastal zone is also low lying, and compounded by poor drainage systems, is prone to flooding which may destroy sanitary facilities resulting in contamination of water sources and consequently leading to cholera outbreaks.

Accra metropolis and the two districts carved out of it in 2008, Ledzokuku-Krowor and La-Dade-Kotopon, are considered hotspots for cholera (regular high attack rate, often coinciding with the rainy season, persistence of cholera cases beyond the usual seasonal peak and high case fatality rate) and tend to serve as the epicentre of most cholera outbreaks.

The institution of enhanced acute watery diarrhoea (AWD) surveillance including the introduction of cholera rapid diagnostic tests has improved early detection of cholera outbreaks. Recently the GHS has adopted the strategy of training rapid multidisciplinary response teams and deploying them to investigate cholera cases and provide WASH interventions in households and communities where cases occur. There has also been an increase in education and awareness creation by the media on cholera prevention and control. Efforts are being made to build more treatments centres, supplementing permanent structures with tents, particularly in Accra. In May 2016 one of such treatment centres was commissioned in Accra. Cholera treatment logistics are also being prepositioned at treatment centres. These increased coping capacities will reduce the risk of cholera in the country as a whole.

3.5.2 Meningitis

Risk factors for Meningococcal meningitis epidemics include immunological susceptibility of the population (loss of herd immunity, prevalent strain etc.), dry season when the absolute humidity is low, as during the harmattan, often associated with frequent dust storms, crowded living conditions, low socioeconomic status, concurrent upper respiratory infections, and poor nutritional status.

The vulnerability variables used in the risk analysis include

- Location - being in the African meningitis belt
- The prevalent strain of meningitis causing bacteria
- Crowded living conditions
- Area(s) with important population movements (border, market hub, etc.)

The coping capacities include

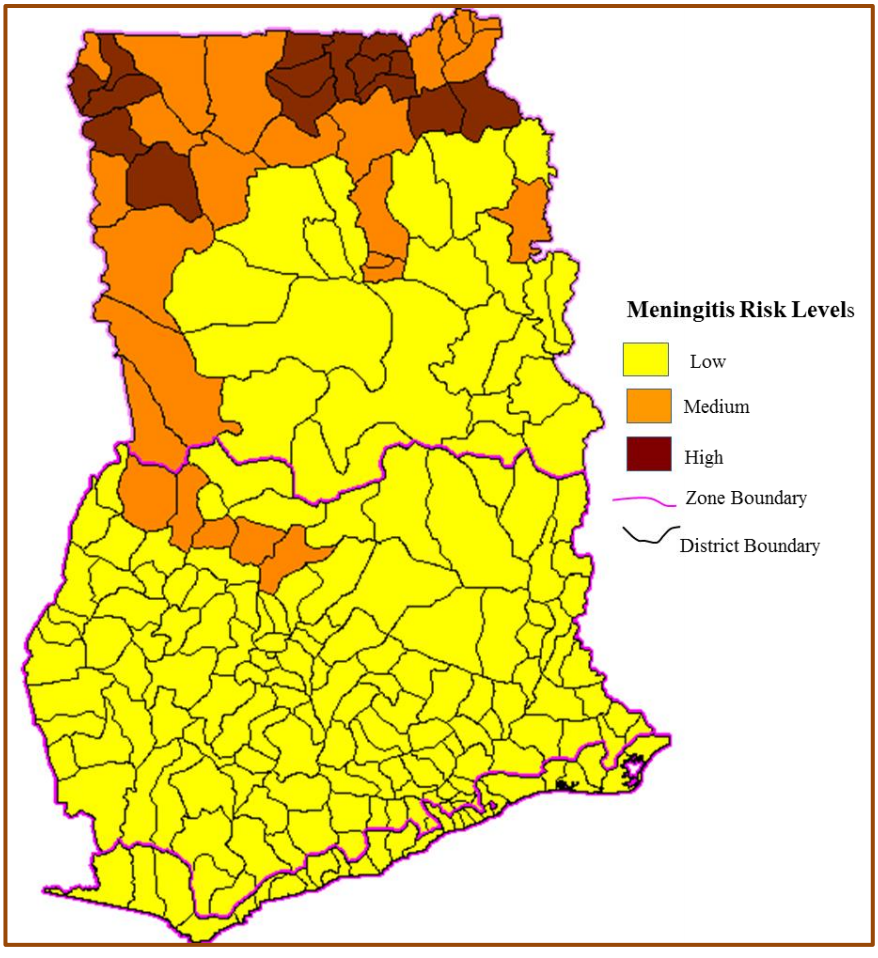
- Ability to detect outbreaks early (Enhanced surveillance)
- Easy access to vaccine
- Access to treatment
- Awareness about disease and health seeking behaviour

The frequency of outbreaks, the impact in terms of annual incidence and fatality from 2011 to 2015 were used to define the hazard level. Risk analysis showed that 15 (7%) of 216 districts are classified as high risk for meningitis while 25 (12%) are at medium risk, and 176 (81%) are at low risk. All the 15 high risk level districts are located in the northern savannah zone (Table 11 and Figure 16). By zone the northern savannah zone is classified as being at high risk whist the forest zone is at medium risk and the coastal zone is at low risk for meningitis.

Table 11: Meningitis Risk Level by District by Zone, Ghana, 2016

Ecological Zone	Number of Districts			
	Low Risk	Medium Risk	High Risk	Total
Northern Savannah	21	20	15	56
Forest	129	5	0	134
Coastal	26	0	0	26
Ghana	176	25	15	216

Figure 16: Meningitis Risk Map



The northern part of the northern savannah zone comprising the districts in the Upper East, Upper West and some districts in Northern region lies in the meningitis belt which has one rainfall season (May to September) and continues to experience long dry weather condition. As a result of climate change the meningitis belt is extending southwards with the districts in the upper part of the forest zone also experiencing focal outbreaks e.g. Tain, Wenchi, Nkoranza South, Techiman and Jaman North districts of Brong Ahafo region experienced outbreaks from latter part of 2015 to early part of 2016.

In the past the pathogen responsible for meningitis outbreak is N. meningitides for which there are vaccines for prevention and for response. However, the emergence of S. pneumonae, for which there are no vaccines yet available for mass vaccination response, increases the risk of meningitis outbreaks in and outside the meningitis belt. Although Northern and Upper West regions which are the most sparsely populated regions in the country are in this zone most of the population live in crowded households which promote spread of the disease. In addition, the zone has the poorest nutritional indicators in the country (GSS, GHS and ICF, 2015).

3.5.3 Yellow Fever

Risk factors for Yellow fever include low level population immunity, presence of the vector, and failure of local surveillance systems to detect cases early. An area is considered at risk for an epidemic of yellow fever if it has experienced yellow fever epidemics in the past; people visit or work in large forested areas with monkeys where sylvatic yellow fever is likely to occur.

The vulnerability variables used to assess YF risk are

- Visiting or working in forested areas with monkeys
- Presence of mosquitoes which transmit YF
- A long rainy season or long dry season
- Large proportion of the population not vaccinated.

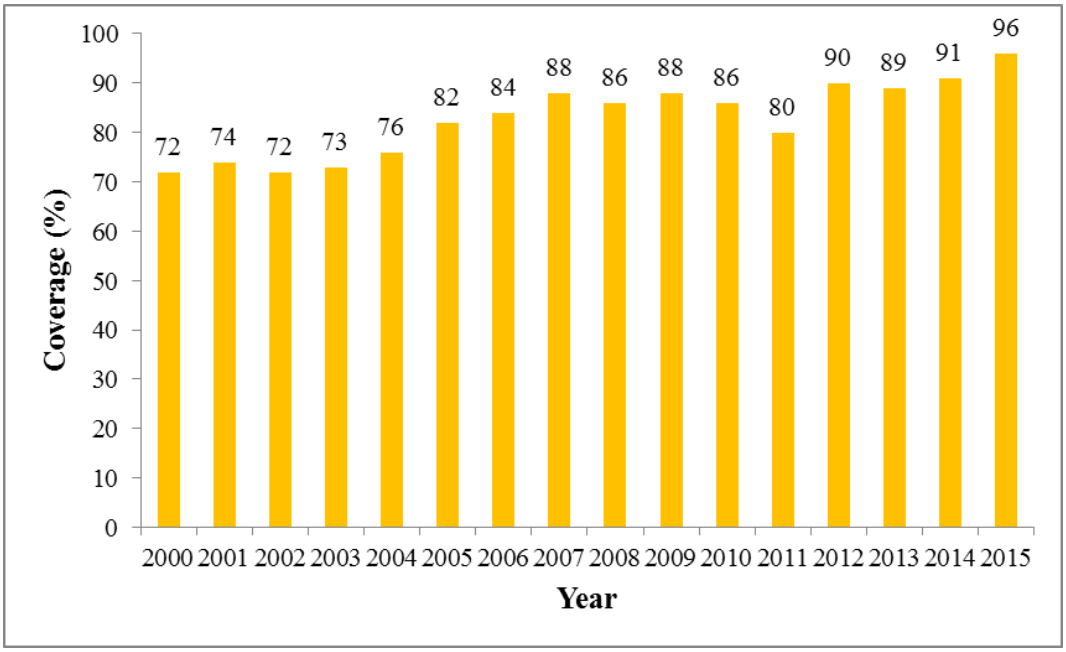
The coping capacity variables include

- Ability to detect epidemics promptly
- Availability of YF vaccine stock for an immediate response
- Capacity to organise an immunization campaign within a very short time.

The whole country is situated in the YF ecological risk zone (latitudes 15N and 10S) with districts in the forest zone in particular having large forested areas with monkeys. People still visit these forests to hunt and for other economic activities. The rainfall pattern in the country favours epidemic of YF. The 2010 population and housing census indicate that there is increasing urbanization with more people living in the cities (GSS, 2012). On the edge of these cities, shanty towns and slums with no access to basic sanitation (running water and waste disposal) are also developing rapidly. The living environment of these new urban populations promotes widespread contact between people and A. aegypti, the YF vector. Domestic water containers and all manner of refuse littering the streets (tin cans, old tyres, etc.) favour the multiplication of breeding sites for mosquito larvae. Also the phenomenon of new urban dwellers returning regularly to their rural communities of origin increases the risk of infection of non-immune persons travelling in areas where infected

vectors persist and, conversely, favours the introduction of the disease into previously YF-free zones. Although the above mentioned vulnerability factors exist, the increasing high YF vaccination coverage since YF was incorporated into the EPI in 1992 (Figure 17), and the many preventive mass YF response campaign over the years has led to a decrease in the proportion of non-immunized population in the country and ultimately decreasing vulnerability to YF.

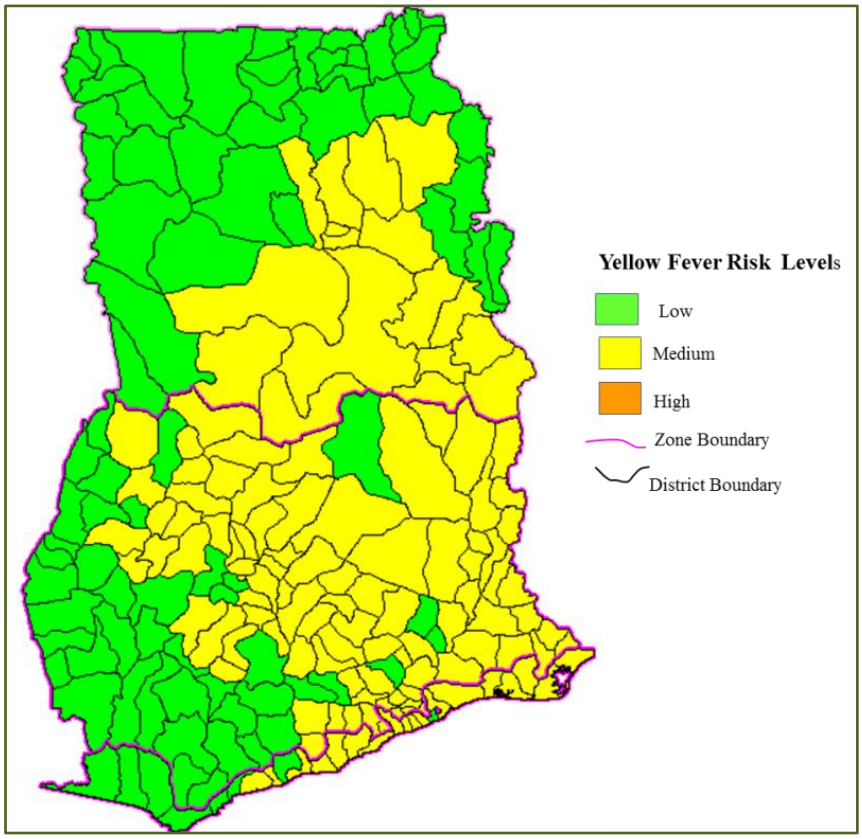
Figure 17: Yellow Fever Immunization Coverage, Ghana, 2000 – 2015



Data Source: EPI, GHS

The institution of an enhanced surveillance system since 2002 by which each district in the country is expected to detect and investigate with blood specimen collected for laboratory confirmation of at least one suspected case of YF in a year coupled with immediate response with mass immunization of a whole district and neighbouring districts if a case is confirmed has reduced the risk of YF considerably. Risk categorization by zone showed that all the zones are at medium risk of YF outbreaks.

Figure 18: Yellow fever District Risk Map, Ghana, 2016



3.5.4 Avian and Pandemic Influenza

The risk factors for Pandemic Influenza include the emergence of new virus strain, underlying chronic conditions, crowded living conditions, poor nutritional status, areas with important population movements (e.g. at the borders, markets).

The vulnerability variables used to assess avian and pandemic influenza risk are

- intrinsic mutability of influenza virus leading to emergence of new strain
- Poor biosecurity in poultry farms and free range poultry
- Staging posts for Migratory birds for Avian Influenza (AI)
- Live bird markets

Coping capacities include

- Ability to detect cases early
- Access to influenza vaccines
- Access to medicines including antibiotics and Tamiflu
- Compliance with infection prevention and control practices

Wild waterfowls are considered the natural reservoir of all influenza A viruses and usually carry the low pathogenic form. Migratory birds can introduce low pathogenic viruses to poultry flocks, which then change to the highly pathogenic form. There are a number of staging posts for migratory birds in

Ghana such as: Keta Lagoon complex, Songor, Sakumo, Densu Delta, Muni-Pomadze, Amuzuri and Owabi Ramsar Sites. The areas around the ramsar sites are vulnerable to AI outbreaks. Majority of the ramsar sites are located along the coast and this makes the districts in the coastal zone high risk of avian influenza outbreaks. Out of the 19 districts that have reported AI in the country (in 2007 and 2015), 17 (89%) are in the coastal zone where almost all the ramsar sites (staging posts) for migratory birds are located. The other 2 districts are in the forest zone. Although avian influenza viruses do not normally infect humans, one of the highly pathogenic strains, A(H5N1) which has been noted to cause severe disease in humans is the one responsible for all the outbreaks in poultry in Ghana. Therefore avian influenza A(H5N1) can be regarded as a strain with pandemic potential, since it might ultimately adapt into a strain that is contagious among humans. The coastal zone of the country is at medium risk for avian influenza in humans while the risk level is low in the forest and northern savannah zones.

With regard to pandemic influenza, once a fully contagious virus emerges anywhere in the world, its global spread is considered inevitable. Given the speed and volume of international air travel today, the virus could spread more rapidly, possibly reaching all continents and countries including Ghana in less than 3 months. Because most people will have no immunity to the pandemic virus, infection and illness rates are expected to be higher than during seasonal epidemics of normal influenza. Supplies of vaccines and antiviral drugs – the two most important medical interventions for reducing illness and deaths during a pandemic – will be inadequate at the start of a pandemic especially access to vaccines since it will take some time to develop vaccine for the new strain of the virus. Death rates are largely determined by four factors: the number of people who become infected, the virulence of the virus, the underlying characteristics and vulnerability of affected populations, and the effectiveness of preventive measures. Accurate predictions of mortality cannot be made before the pandemic virus emerges and begins to spread. Therefore the risk level for pandemic influenza is high across the three zones of the country.

3.5.5 Ebola Virus Disease and Other Viral Haemorrhagic Fevers

According to Paulo Francesconi et al (2003) the important risk factor for EVD is direct repeated contact with a sick person's body fluids, as occurs during the provision of care. The risk is higher when the exposure took place during the late stage of the disease at home. The risk is reduced when the patient stayed in a hospital, probably because of the use of gloves, even before strict barrier nursing was implemented. The risk tended to increase with the increasing number of different types of direct contact. The risk is higher among persons who were exposed through two or three different types of direct contact compared with the risk for those who had no direct contact. Other risk factors include sleeping in the same room and sleeping on the same bed apparently transmission through contaminated fomites.

Vulnerabilities variables for EVD and other haemorrhagic fevers include

- People visit or work in large forested areas with bats, monkeys and other primates,
- Cultural practices including practices at funerals and other social gatherings
- Mobile populations within densely populated urban areas
- Non-adherence to routine standard IPC practices in health care facilities

Coping Capacity variables include

- Capacity for early detection of outbreaks
- Awareness of general public about the disease
- Functional health system - isolation wards, well trained staff with adequate supply of Personal Protective Equipment (PPE) and other logistics, strict adherence to standard IPC practices in health care settings

There has not been any confirmed EVD case reported in Ghana though there were suspected cases investigated in the wake of the epidemic that ravaged the West African sub-region in 2014. However, the country is still vulnerable. The intense traffic between Ghana and neighbouring countries as well as other countries far from Ghana's borders could facilitate the importation of the virus and trigger an outbreak in the country. It is estimated that an average of 30 flights land at and depart from the Kotoka International Airport (KIA) on a daily basis, transporting between 4,000 and 10,000 passengers on a daily basis. Land and sea border crossings are frequent. An estimated 56 approved entry points are used daily, and the number of unauthorized crossing points is estimated to be higher than the approved ones. There are numerous bus terminals that transport people from within and outside Ghana on a daily basis. Swift cross travel around the world further complicates surveillance of passengers' from original country of departure. Initial symptoms of EVD are similar to common endemic diseases in Ghana, such as malaria. Health workers are at risk if caring for viral haemorrhagic fever patients in the absence of adherence to proper barrier nursing and standard infection prevention and control practices.

All zones of the country are at high risk of EVD especially in urban areas where the population density is high with many economic activities, high population movement and in health facilities that do not adhere to routine standard infection prevention and control practices.

3.5.6 Flood

Two parameters are used to determine flood vulnerability. These are land use and population density. Urban areas are classified as highly vulnerable to flood. Forest, shrub land and grassland represent natural environments with hardly any housing or economic activity, the impact of flooding is very low and therefore vulnerability of these areas to flooding is low. Areas with high population density are more vulnerable to flooding. Flood vulnerability is likely to increase in future due to the continuous increase in built up areas, together with the increase of the population density.

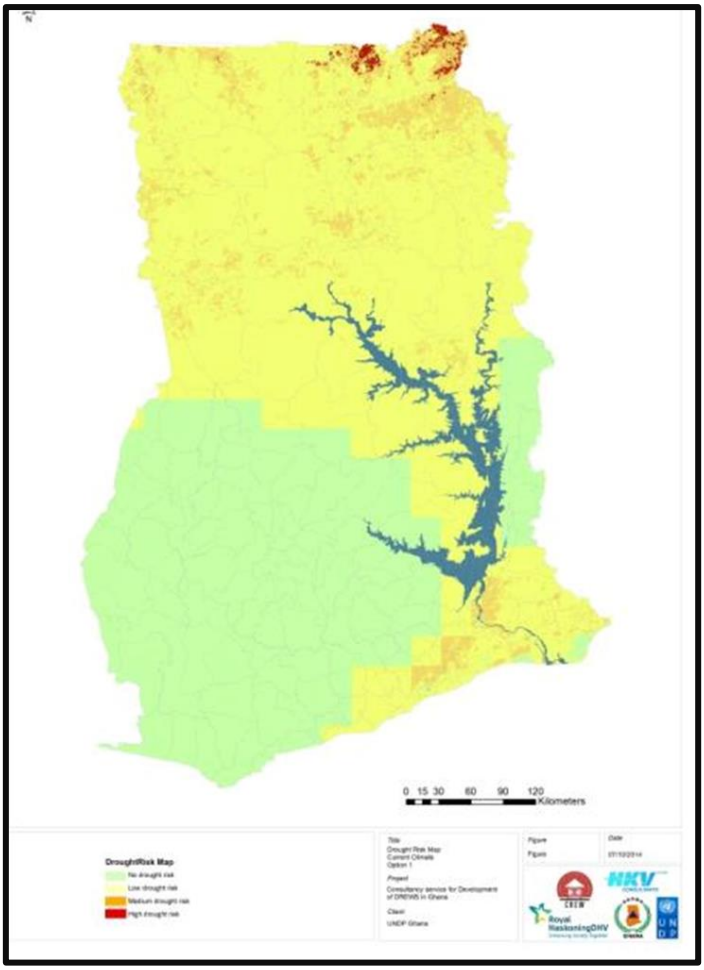
Accra and other urban areas where buildings are springing up with concrete floors and poor drainage facility with people building in water ways thus preventing the free flow of water are at high risk of flooding. By zone, the coastal zone is at high risk, the northern savannah at moderate risk whilst the forest zone is at low risk.

3.5.7 Drought

Drought vulnerability is determined solely by land use. However, increase in population affects the rate of land use. Areas that are close to surface water bodies (rivers, lakes) are less vulnerable to drought. The same applies to areas with a shallow groundwater level. Drought vulnerability will increase in the future, mainly due to the increase in land used for agricultural purposes (UNDP Ghana, 2014).

As per the drought hazard and risk mapping done by UNDP, Ghana's high and medium level drought risk districts are located in the northern savannah zone especially in the Upper East region (Figure 19). By zone, the northern savannah is at high risk with the coastal and forest at low risk.

Figure 19: Drought Risk Map - 2010

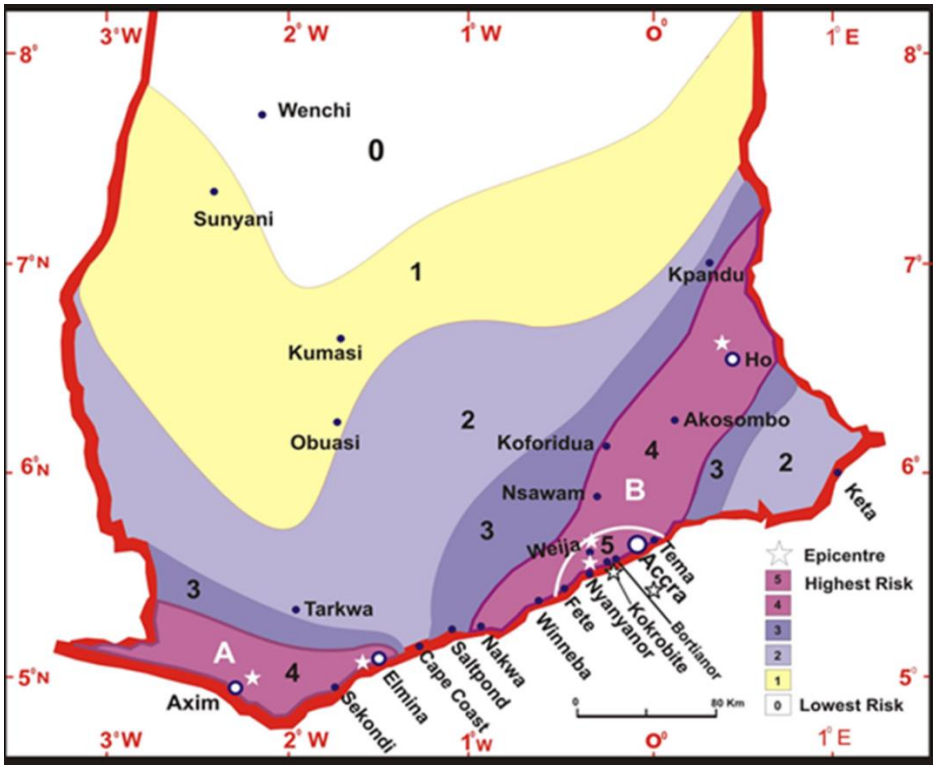


Source: UNDP, Ghana: Risk Assessment and Mapping – Technical Report, 2014

3.5.8 Earthquake

Earth quake vulnerable areas are in the coastal and forest zones in the Western, Central, Greater Accra, Eastern, and Volta Regions (Figure 20). The epicentres of the earthquake zones are located in Axim, Elmina, Nyanyanor, Weija, Accra and Ho (Jacob M. Kutu, 2013). The coastal zone is at high risk whilst the forest and northern savannah zones are medium and low risk respectively for earthquake hazard.

Figure 20: Earthquake Risk zones in Ghana



Source: Jacob M Kutu, 2013

3.5.9 Road Traffic Injuries

The high hazards areas for road transport accidents are the major towns including the regional capitals and big commercial towns. The risk factors include drink driving, over speeding, and not wearing seat belts, and travelling during periods of festivities such as Christmas and Easter. The vulnerability variables are travelling long distances along the roads linking major commercial towns in the country especially at night. The drivers feel tired and sleepy during their journeys. Most of the vehicles also do not have seat belts and therefore when accidents do occur the fatalities are high. All the zones of the country are at high risk of road traffic accidents. The risk can be reduced by the driver stopping and resting for some time (for at least one hour) during long distance journeys, and having two drivers to alternate the driving. The enforcement of the law on installation and wearing of seatbelts in all vehicles and all other traffic regulations will help further reduce the risk of road traffic emergencies in the country.

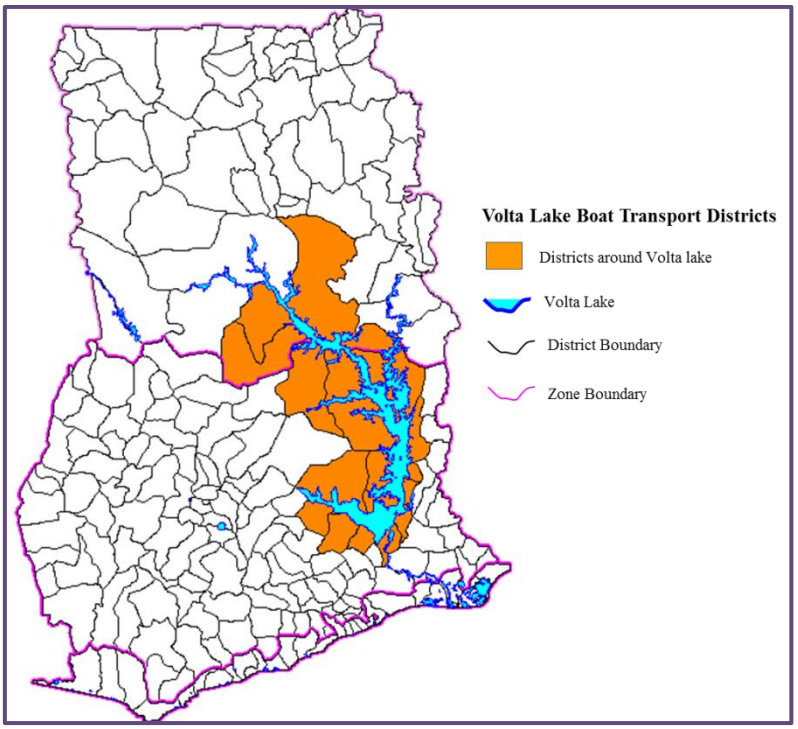
3.5.10 Aviation or Air Transport Accident

Risk factors for air transport accidents include bad weather conditions such as rainstorm, and terror attacks. Since the take-off and landing phases account for a high percentage of airline crashes, developed areas adjacent to major airports and in airport flight paths are more vulnerable to this hazard (EMO, 2005). In Ghana apart from the Kotoka International Airport (KIA) the other major domestic airports at risk are the Kumasi and Tamale airports which have seen increase in domestic traffic in recent times. The plan to upgrade these airports to international status makes them likely to see increase in volume of air traffic and also the risk of terror attacks. The coastal zone in which the KIA is located is at high risk whilst the forest and northern savannah zones in which the Kumasi and Tamale airports respectively are located are at medium risk.

3.5.11 Water Transport Accident

Vulnerability to water transport accidents include non-availability of alternative means of transport, bad weather condition such as rainstorm, night travels, travelling in small boats, long distance across the lake. High risk areas for water transport accidents in Ghana are areas along the Volta Lake where there are no alternatives to water transport and the use of small boats (Figure 21). Traders and market women are particularly at risk especially on market days when they have to travel across the lake to transact their trading activities. The boats are likely to be overloaded on these days, especially in the evening when it is getting dark and most people want to reach their destinations before night fall. For water transport accidents, the high risk zones are the northern savannah and forest whilst the coastal zone is at moderate risk.

Figure 21: Volta Lake Boat Accident Risk Districts



3.5.12 Structure Collapse

Factors leading to collapse of structures include use of inferior building materials, non-adherence to building codes, and exposure of structures to loads far exceeding what they were designed. In Ghana, storey buildings which were designed for offices but converted into commercial outlets are particularly vulnerable to collapse. They have not been designed to carry such loads as heavy machinery put on second or third floor of the buildings. These heavy loads of equipment coupled with the weight of the large number of people who patronize the commercial activities in these buildings at a time put a lot of strain on these structures and with time start developing cracks and eventually collapse. These buildings are usually located in big commercial towns. The coastal and forest zones where most of these buildings are located are at high risk of structure collapse whilst the northern savannah zone is at moderate risk.

3.5.13 Nuclear and Radiological

The likely nuclear and radiological risk Ghana faces is ionizing radiation from an unshielded radioactive material source either lost, stolen or uncontrolled resulting in lethal doses and considerable contamination above the intervention levels. The country is not at risk from severe nuclear accident emanating from a nuclear power plant since at present the nearest nuclear power plant is near Cape Town, South Africa, which is more than 4000 km from Ghana's borders. On the whole all the zones are at low risk of nuclear and radiological hazard. Risk levels will increase when Ghana acquire a nuclear plant.

3.5.14 Fire

Urbanization and population density are key vulnerability factors for fires. The fires that can lead to public health emergency are usually industrial or commercial fires where many people are involved. However, most of the fires that occur in the country are domestic fires. In the study by Addae et al, domestic fires accounted for 41% of the total number of fire incidents in the country. The areas of greatest risk are the capital Accra, Tema and Takoradi where most of the industries are located. In all the zones the likelihood of fires is very high and the impact will be very severe. All the zones are at high risk for fire disasters.

3.5.15 Oil and Gas Spillage

With the discovery of oil and its exploration in Ghana, the establishment of the gas plant and the oil refinery, the likelihood of oil and gas spillage is high. The leakage may come from oil/natural gas wells, a pipeline or storage facilities and/or distribution systems. The areas of greatest risk are Western region coast districts of Jomoro, Ellembele and Axim where the oil wells are located; Tema district where the oil refinery is located; and the route along the West African gas pipeline from

Nigeria to Ghana. The proliferation of many filling stations in highly populated urban centres, some located close to very busy commercial houses are also high risk areas for oil spillage.
The coastal zone is at high risk whilst the forest and northern savannah zones are at medium risk of public health emergency resulting from oil or gas spillage.

3.5.16 Chemical

Most of the medium and small scale industries that discharge their industrial waste into drains are located in the major urban towns, especially in the coastal zone. These industrial wastes and the seepage from indiscriminate dumping of chemical waste are subsequently transported to pollute water bodies during heavy rains. The activities of small-scale and illegal artisanal mining (popularly called Galamsey) have been polluting communities' water sources with chemicals such as arsenic and mercury. These activities are on the increase in all the three zones of the country, especially the forest and northern savannah zones. All the three zones are classified as being at medium risk of adverse health effects from chemical hazards.

3.5.17 Civil Disorder

The vulnerable areas for civil disorders are where many chieftaincy and ethnic conflicts frequently occur in the country leading to loss of life and property. These areas include the Dagbon and Bunkpurugu traditional areas in the Northern region and the Alavanyo-Nkonya conflict areas of the Volta region. All the three zones are at medium risk of health emergencies emanating from civil disorder hazards.

3.5.18 Terrorism

In Ghana terrorist attacks are not likely to be aimed at Ghanaians in particular but the fact that the country collaborates in fighting terror, the terrorists my attack the interests of western countries (the main targets of terrorists) in Ghana. The vulnerable areas include embassies, international airport, five-star hotels and large shopping malls where expatriates are likely to patronize. Most of these places are located in Accra, in the coastal zone. The coastal zone is therefore at high risk for terrorism hazard whilst the forest and the northern savannah zone are at moderate risk.

Below (Table 12) is the summary of the Public Health Risk level of the identified hazards by the three ecological zones.

Table 12: Public Health Risk Level by Hazard by Zone in Ghana, 2016

Northern Savannah		
High Risk	**Medium Risk**	**Low Risk**
Meningitis	Cholera	Avian Influenza
EVD	YF	Earthquake
Drought	Flooding	Nuclear and Radiological Accidents
Pandemic Influenza	Air Transport Accidents	
Road Transport Accidents	Failure of Structures	
Water Transport Accident	Oil/Gas spillage	
Fire	Terrorism	
Civil Disorders	Chemical	

Forest Zone		
High Risk	**Medium Risk**	**Low Risk**
EVD	Cholera	Avian Influenza
Pandemic Influenza	Meningitis	Drought
Road Transport Accidents	YF	Nuclear and Radiological Accidents
Water Transport Accident	Flooding	
Failure of Structures	Earthquake	
Fire	Air Transport Accidents	
Civil Disorders	Oil/Gas spillage	
	Chemical	
	Terrorism	

Coastal		
High Risk	**Medium Risk**	**Low Risk**
Cholera	Avian Influenza	Meningitis
EVD	Earthquake	YF
Pandemic Influenza	Water Transport Accident	Drought
Flooding	Chemical	Nuclear and Radiological Accidents
Road Transport Accidents		
Air Transport Accidents		
Failure of Structures		
Oil/Gas spillage		
Fire		
Civil Disorders		
Terrorism		

3.6 Ranking of Risks

In order to guide prioritization of the response interventions to public health risks, hazards were ranked (Table 13) by the level of risk they pose in causing public health emergencies using the SMAUG criteria: seriousness, manageability, acceptability, urgency and growth (Detail scores in Annex 2).

Table 13: Ranking of Hazards by Risk in Ghana, 2016

Rank	Hazards			
	National	Northern Savannah Zone	Forest Zone	Coastal Zone
1	EVD	EVD	EVD	EVD
2	Cholera	Meningitis	Road Traffic Accidents	Cholera
3	Meningitis	Pandemic Influenza	Pandemic Influenza	Flooding
4	Pandemic Influenza	Drought	Fire	Pandemic Influenza
5	Road Traffic Accidents	Road Traffic Accidents	Water Transport Accident	Terrorism
6	Flood	Water Transport Accident	Failure of Structures	Road Traffic Accidents
7	Terrorism	Fire	Civil Disorders	Aviation Accidents
8	Yellow Fever	Civil Disorders	Cholera	Failure of Structures
9	Fire	Cholera	Meningitis	Oil/Gas spillage
10	Avian Influenza	YF	YF	Fire
11	Aviation Accidents	Flooding	Flooding	Civil Disorders
12	Water Transport Accident	Aviation Accidents	Earthquake	Avian Influenza
13	Structure Failures	Failure of Structures	Aviation Accidents	Earthquake
14	Drought	Oil/Gas spillage	Oil/Gas spillage	Water Transport Accident
15	Earthquake	Terrorism	Chemical	Chemical
16	Oil/Gas spillage	Avian Influenza	Terrorism	Meningitis
17	Civil Disorders	Earthquake	Avian Influenza	YF
18	Chemical	Chemical	Drought	Drought
19	Radio nuclear Accidents	Radio nuclear Accidents	Radio nuclear Accidents	Radio nuclear Accidents

The top three hazards are biological hazards. Although confirmed cases of EVD and other viral haemorrhagic fevers (except Lassa fever) have not been reported in Ghana, they ranked highest because of the propensity to cause devastating outbreaks with high case fatality rate due to difficulty in recognizing and quickly diagnosing it in its early stages as presenting symptoms are similar to common prevalent infectious conditions like malaria; rapid spread; vulnerability of health care workers and absence of an approved vaccine and effective cure. In addition to EVD, the top three public health risk hazards in northern savannah zone are meningitis, pandemic influenza and drought whilst those for the forest zone are road traffic accidents, pandemic influenza and fire, and for coastal zone are cholera, flood and pandemic influenza.

3.7 Conclusion

Ghana has experienced significant impacts from various types of hazards in the past and this will continue to be impacted in the future. The risk mapping document is important in enhancing the focus of public health emergency management in determining prevention, preparedness, and mitigation, response and recovery activities based on risk. The risk levels are not static. Increasing vulnerability in future will increase the risk while strengthening the coping capacities will reduce the risk level.

The goal of the risk analysis in public health emergency management is to reduce risk level by targeting interventions aimed at reducing vulnerability and increasing the coping capacities. The hazards listed as posing high risk are those that must be very high priority for prevention, preparedness, and mitigation, response and recovery programmes in the country and in the specific zones; attempts should be made to minimize the risks of those hazards. The hazards that are listed as medium are those that should be addressed after the hazards with high risk.

The main vulnerability factors cutting across all the ecological zones are geographical location, poor access to water, sanitation and hygiene (WASH) facilities, and climate change. Not much can be done about some of the factors such as geographic location and climate change. The focus should be on reducing the other vulnerabilities and increasing the coping capacities.

3.8 Recommendations

The following **recommendations** are made to reduce the risks posed by the identified hazards:

Reducing vulnerabilities

1. Increase access to WASH facilities
2. Enforce all laws relating public health and safety of the populace.

Increasing Coping Capacity

1. Establish early warning systems for all identified hazards likely to lead to public health emergency
2. Strengthen surveillance to ensure early detection of events
3. Intensify risk communication and social mobilization to ensure that the population is adequately informed about various hazards and action to prevent or mitigate the risks at personal, household and community levels
4. Strengthen and enforce good infection prevention and control practices in the health facilities
5. Build and equip isolation wards, treatment centres for infectious diseases across the country

Overall Recommendation

Since occurrences of hazards vary depending on factors such as location, scale and topography, it is necessary for the various regions and districts to conduct regional and district level risk mapping tailored to their own location to determine the hotspots for identified hazards for targeted local preparedness and response interventions.

CHAPTER FOUR - CAPACITIES ASSESSMENT

4.1 Introduction

Capacities assessment was undertaken to determine the existing capacities available to respond to public health emergencies and other health threats as part of efforts in strengthening public health emergency management (PHEM) in the country. Certain minimum capacities are required to ensure adequate response to public health emergencies. These core capacities are well defined in the International Health Regulations (2005).

The main objective of the capacities assessment is to determine the ability of existing structures and resources to respond to public health emergencies and other health threats.

Specific objectives are to

1. determine the strength of each core capacity
2. determine the weaknesses of each capacity
3. recommend appropriate interventions to strengthen the core capacities

4.2 Methodology

Desktop review of documents and key informant interviews at selected national, regional and district level institutions, laboratories and health facilities were undertaken using structures questionnaire to assess the capacities, summarizing the strength and weaknesses of each core capacity. The following capacities were assessed: legislation and policy; coordination and partnership; surveillance; laboratory; preparedness and response; risk communication; points of entry; human resources; and special events including food safety, zoonotic, chemical, nuclear and radiological events.

4.3 Findings and Discussions

4.3.1 Legislation, policy and financing

There are a number of legal frameworks and policies which provide guidance for Public Health Emergency Preparedness and Response (PHEPR) in Ghana.

Constitution of Ghana

Article 35 (2) of the directive principles of state policy in the 1992 constitution of the Republic of Ghana states that **"**The State shall protect and safeguard the independence, unity and territorial integrity of Ghana, and shall seek the wellbeing of all her citizens." Seeking the wellbeing of its citizens includes protecting them from all hazards including those leading to public health emergencies (GoG, 1992).

National Disaster Management Organization (NADMO)

NADMO which was established by ACT 517 of 1996 with the responsibility to manage disasters and similar emergencies in the country has its mission "to manage disasters by coordinating the resources of government institutions and non-governmental agencies, develop the capacity of voluntary community-based organisations to respond effectively to similar emergencies and improve livelihood through social mobilisation, employment generation and poverty reduction projects (NADMO, 2010).

IHR (2005)

IHR (2005) which entered into force in 2007 are international laws which help countries working together to save lives and livelihoods caused by the international spread of diseases and other health risks. It is a legally binding text with rights, obligations and procedures that Ghana and other member countries of the World Health Organization (WHO) must comply with. The purpose of IHR (2005) is ''to prevent, protect against, control and provide a public health response to the international spread of disease in ways that are commensurate with and restricted to public health risks, and which avoid unnecessary interference with international traffic and trade'' (WHO, 2008). IHR (2005) provides the legal and policy framework for notification, verification and containment at source internationally.

IDSR Technical Guidelines

The second edition guidelines (2011) of the Integrated Disease Surveillance and Response (IDSR) strategy proposed by WHO which was adopted by Ghana in 1998, provides policy direction for early detection and response to public health threats (GHS, 2011)

Radiation and Protection Instrument and Nuclear and Radiological Plan

The Radiation and Protection Instrument, LI 1559 of 1993 and the national nuclear and radiological emergency response plan prepared by NADMO and the Ghana Atomic Energy Commission (GAEC) in 2010 provides legal and policy direction for preparedness and response to nuclear and radiological emergencies (GoG, 1993), (NADMO and GAEC, 2010).

Food and Drug Authority

The Food and Drugs Authority (FDA), formerly the Food and Drugs Board (FDB), was established in August 1997. It is the National Regulatory Authority mandated by the Public Health Act, 2012 (Act 851) to regulate food, drugs, food supplements, herbal and homeopathic medicines, veterinary medicines, cosmetics, medical devices, household chemical substances, tobacco and tobacco products.

Public Health Act, 2012

The Public Health Act (PHA), 2012 (Act 851) enacted by the Parliament of Ghana consolidates the laws relating to public health and provides the policy and legal framework to prevent disease, promote, safeguard, maintain and protect the health of humans and animals. It makes provision for the declaration of emergencies of infectious nature in humans and animals and the management of such public health emergencies. It includes emergency powers in respect to such situations (GoG, 2012). However, the development of the legislative instrument (LI) which serves as the standard operation procedures is still in progress.

The weaknesses in this core capacity include

- Development of the LI to support the implementation of the PHA is yet to be completed
- There is no policy defining the implementing structure and roles and responsibilities of various administrative levels and stakeholders in IHR implementation.

- Legal status and arrangements to support the activities of IHR focal person are not well developed.
- No budget line has been allocated to support the implementation of IHR activities
- No policy or strategic plan to strengthen surveillance and response to public health emergencies due to chemical events.
- There are no dedicated funds to finance public health emergencies, especially funds to support preparedness activities and Rapid Response Teams (RRTs) for immediate investigation and response to emergencies.

4.3.2 Coordination and partnership

There is a high level Inter-Ministerial Committee (IMC) made up of sector Ministries whose mandates have bearing on health and chaired by the Minister of Health. This committee was established in the wake of the Ebola Virus Disease (EVD) that ravaged the West African sub-region in 2014, initially to provide high level political support for the development and implementation of the national EVD preparedness and response plan. The committee has been transformed to be the highest national body, with the support of development partners, to provide policy direction and ensure involvement of all sectors, coordinate and provide the enabling environment and resources for effective and efficient implementation of all public health emergency plans. Corresponding committees, the Regional Public Health Emergency Management Committee (RPHEMC) and the District Public Health Emergency Management Committee (DPHEMC) exist at regional and district levels chaired by the Regional Ministers and the District Chief Executives respectively. There is also the National Technical Coordination Committee (NTCC) to provide technical support to the Inter-ministerial committee. The NTCC has 4 subcommittees, namely surveillance (epidemiological and laboratory); case management; risk communication; and finance and logistics. The response to all public health emergencies is coordinated by the Emergency Operation Centre (EOC). There also exits the International Health Regulations Steering Committee (IHRSC), made up of various institutions responsible for ensuring that the core capacities as spelt out in the IHR 2005 for State Parties are being met.

The weaknesses of this core capacity include the inadequate representation at the highest level of other sectors in IMC; irregular meetings of the NTCC and its technical sub-committees to collate information and provide technical input to guide the IMC, especially during the period when there are no running emergencies. The terms of reference (ToR) for some of the committees are not well defined in terms of mandate, composition, and frequency of meetings, relationship and linkages with other committees within and outside the health sector to guide the activities of these committees. The line of communication, reporting and exchange of information and engagement between the health sections of NADMO and the PHE coordination structures in the MoH is not clear and therefore there is lack of clarity in harmonization of response between the health sector and NADMO. It is necessary to develop and formally approve ToRs at the highest level of the health sector to guide the EOC, NTCC, technical sub-committees, RPHEMC, DPHEMC activities to avoid duplication of efforts and maximize potentials to synergy and efficiency. The ToRs should detail the linkages between the MoH structures and NADMO in public health emergency preparedness and response. The power and mandate of EOC including control over resources and accountability also need to be well defined.

4.3.3 Surveillance

Ghana has a relatively efficient surveillance system in place. In 1998 the country adopted the Integrated Disease Surveillance and Response (IDSR) strategy proposed by WHO AFRO to strengthen disease surveillance in the WHO African region (WHO, 2000). The goal of IDSR is to improve the ability of districts to detect and respond to diseases, conditions and events that cause high levels of morbidity, mortality and disability in the district's catchment areas. The surveillance system involves both indicator-based surveillance (IBS) and event-based surveillance (EBS).

As part of the IBS system, if an immediately reportable disease, condition or other public health event is suspected, an initial report is made by the fastest possible means (e.g. telephone) to provide information about the patient through the hierarchical system to the national level. The initial verbal report is followed by a written report on the case-based report form. After immediately notifying the next level about instances of immediately reportable diseases, conditions or events, weekly summary information about the priority events are then collated and reported, including zero reporting, to the next higher level. If necessary, specimens are taken for laboratory confirmation of cases using appropriate specimen collection containers. There are guidelines, manuals and standard operating procedures available for infectious surveillance events including action thresholds.

EBS system is the organized and rapid capture of information about events that are potential risk to public health. This information can be rumours and other ad-hoc reports transmitted through formal channels (i.e. established routine reporting systems as in IBS) and informal channels including the media, health workers and non-governmental organizations. The EBS system involves events related to the occurrence of disease in humans, such as clustered cases of a disease or syndromes, unusual disease patterns or unexpected deaths as recognized by health workers and other key informants in the country; and events related to potential exposure for humans, such as events related to diseases and deaths in animals, contaminated food products or water, and environmental hazards including chemical and radio-nuclear events.

An important component of the surveillance system in Ghana is the community-based surveillance where community trained agents (including volunteers, community health workers) report the occurrence of selected health events using very sensitive community case definitions and also report unusual health events to the health authorities at the sub-district and district levels.

There is also sentinel surveillance system to monitor the influenza virus circulating in the country under the auspices of Noguchi Memorial Institute for Medical Research (NMIMR) in collaboration with the Ghana Health Service and the Ghana Armed Forces. There are currently 24 sentinel sites in the country, but about 10 of these sites are inactive. Reagents for laboratory confirmation of influenza virus are provided from the US Naval Army Medical Research Unit (NAMRU) to NMIMR.

A contact tracing software for EVD has been developed but is yet to be rolled out for use in the districts. It is anticipated that the software would be adapted for use in the investigation and contact tracing of other infectious diseases such as cholera and meningitis.

A weekly epidemiological bulleting (GWEB) for dissemination of surveillance information to the regions and districts within the Ghana Health Service and partners has been in existence since 2003.

Since 2015 the recipients of the bulletin have been expanded to include the Veterinary Services Directorate. Some regions are also producing weekly bulletins to disseminate surveillance information.

Cross-border collaboration had been vibrant with regular meetings held in the past, especially between Upper East regional and district teams with their counterparts from Burkina Faso to discuss issues relating to disease outbreaks and other public health events of national and international concern but has not been in operation recently due to lack of funds and commitment. Since the outbreak of EVD in West Africa in 2014 efforts are being made by the GHS with support from WHO to revive this important activity.

The major challenge identified in the surveillance system is late detection of cases. Case detection usually starts in the health facilities where the clinicians are the key stakeholders. However, the involvement of clinicians in detection of public health emergencies is very minimal. Case definitions are not applied and scanty clinical notes are written making record reviews very difficult. A strategy of establishing public health units in all major health facilities to facilitate this process has not been successfully implemented. This strategy needs to be aggressively pursued with regular clinician sensitisation on surveillance issues to ensure their involvement and participation in public health surveillance. The other weaknesses include non-application of the IHR Decision Instrument to determine whether an event is a potential PHEIC and inadequate documentation of surveillance activities.

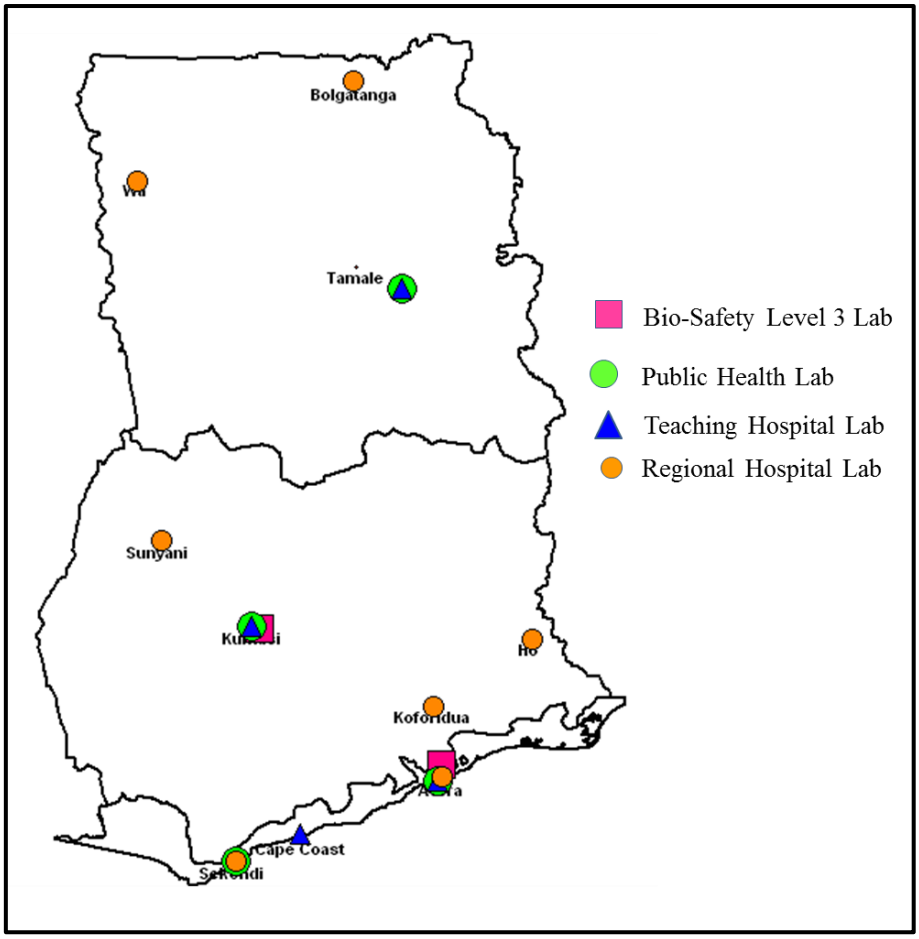
4.3.4 Laboratory

Laboratory support is one of the pillars of surveillance and response system. The laboratory is essential for confirmation of pathogens and other causative agents causing public health emergencies and also to monitor the response interventions. Ghana has a network of laboratories from district hospitals to the national level for these functions. District hospitals can perform rapid tests using rapid diagnostic kits, and regional and teaching hospitals can culture for confirmation of key bacterial organisms. The introduction of cholera rapid diagnostic test kits will help in early detection of cholera outbreaks. The National Public Health & Reference Laboratory (NPHRL) located in Accra (Korle-bu) has oversight responsibility over zonal Public Health Laboratories (PHL) strategically located in each of the three zones (Takoradi in Coastal, Kumasi in Forest and Tamale in Northern Savannah) of the country (Figure 22).

The NPHRL and PHLs support IDSR in the diagnosis and confirmation of infectious agents causing disease outbreaks. Currently the three PHLs have the capacity to perform Polymerase Chain Reaction (PCR) diagnostic test. The NPHRL supports capacity building of laboratory staff, conducts research including evaluation of new test kits. The NPHRL and the PHLs are supported by the Noguchi Memorial Institute for Medical Research, (NMIMR) based at the University of Ghana, Legon near Accra, an internationally recognized laboratory (Biosecurity level 3) that has capacity and accreditation to perform diagnosis and confirmation of highly infectious pathogens like Polio, Influenza, Ebola and other Viral Haemorrhagic Fevers (VHFs). The NMIMR has highly qualified staff and also provide training for laboratory scientists from other countries in the West African sub-region. The recent commissioning of a Bio-Safety Level 3 laboratory at the Kumasi Centre for

Collaborative Research in Tropical Medicine (KCCR) provides an additional support for the diagnosis of highly infectious pathogens.

Figure 22: Location of Laboratories* Supporting Public Health Emergency Response in Ghana



*Excluding district hospital laboratories

The biggest challenge facing the laboratories is irregular and untimely availability of diagnostic test kits including reagents, especially in the PHRL and PHL. There is also no national regulatory legislation or policy that defines the role and responsibilities of laboratories at different levels in the health sector. Though a draft National Health Laboratory Strategic Plan (2013-2017) has been developed, this has not been adopted yet for implementation **(**Gyampomah 2015) and there is no policy for national laboratory to monitor antimicrobial resistance for priority pathogens. Laboratory protocols, although produced by the national level, are not generally available at the district and health facility levels for use.

4.3.5 Preparedness and Response

All levels of the health sector have developed emergency preparedness and response plans for public health emergencies. However, most of these plans are targeted at infectious diseases, such as cholera, meningitis, yellow fever, avian and pandemic influenza and recently EVD. Some of these plans have

been tested through actual response to outbreaks that had occurred or through simulation exercises e.g. for EVD following the outbreak of EVD in the West African sub-region. Laboratory protocols for specimen collection and shipment have been produced. Case management guidelines are available for infectious diseases hazards. National stockpiling exists for infectious diseases. Rapid Response teams (RRT) have been formed to investigate and conduct initial response to public health emergencies.

The emergence of EVD in the West African sub-region has strengthened emergency preparedness planning. There is capacity to gather, analyse and interpret information to coordinate surveillance activities. Some levels have prepositioned essential response supplies at vantage points. There is also capacity to procure equipment (such as PPE, drugs etc.) during a public health emergency. The completed and the planned EVD treatment centres are now to serve as isolation centres for all highly infectious diseases. IPC has been recognized as the cornerstone of the control of infectious hazards. IPC policy and guidelines have been developed. Training of trainers haven been conducted and IPC training is being rolled out to all health facilities.

The key challenges or weaknesses in preparedness and response include preparedness and response plans largely focus on infectious disease hazards and do not cover other potential health threats; there is no approved PHE strategic plan for use by all partners and agencies that would guide response in a coordinated manner and with strategic focus. As a result the focus has been on event specific response.

Mapping of available resources and their location has not been conducted. There is no inventory of chemical hazard sites or facilities which could be the source of public health emergencies. A directory or roster of experts for potential hazards has not been compiled at any of the levels. Although members of RRTs have been brought together as individual technical experts to respond to public health emergencies, they have not been trained or oriented as teams to be able to effectively complement each other as team members. Rapid communication systems are in place for alert and rapid deployment of the RRTs as evidenced by some cases investigated, but these are not documented. The non-availability of checklist of materials required for rapid response hampers adequate preparation by RRTs before going to the field. There are no facilities to quarantine humans exposed to infections. Most of the health facilities do not have adequately equipped isolation wards. Out of the three EVD treatment centres planned to be constructed in the wake of the EVD outbreak in the West African sub-region, only the Tema one in the coastal zone has been completed and ready for use. The one in Tamale in the Northern Savannah zone is almost complete. However, the one to be located in Kumasi, in the forest zone, is yet to start. Each health facility, especially the regional hospitals is expected to have isolation wards and holding rooms. It must be noted that a holding room is more or less a mini isolation ward and therefore must have the minimum IPC structures but most facilities currently do not meet such specifications.

There are no guidelines for mass casualty management. There are also no case management guidelines for food borne diseases, chemical, nuclear & radiological events. National stockpiling exists only for infectious diseases and not for other hazards.

4.3.6 Risk communication

Risk communication is an important integral part of public health emergency management. Effective risk communicant is aimed at equipping the public with knowledge to understand the characteristics of a hazard or event and appreciate why particular behaviour is required for the prevention and mitigation and response to the event. Communication plans were developed for avian influenza, H1N1 and EVD and cholera. There is the need to develop a communication plan using the all-hazard approach. The designated unit for risk communication for Public Health Emergency is the Health Promotion Department (HPD) of the Ghana Health Service. The HPD is leading the efforts in communication activities, supported by the other members of the communication sub-committee of the National Technical Coordination Committee, made up of communication representatives from the Ministry of Food and Agriculture (MoFA), National Disaster Management Organization (NADMO), UNICEF, WHO, Office for the Coordination of Humanitarian Affairs (OCHA), and Information Services Department under the Ministry of Communication. The HPD has focal persons at the regional level. There is an ongoing process to have focal persons at the district level.

As part of the pandemic preparedness and response plan for H1N1 outbreak, a needs assessment for risk communication was undertaken in Ghana in November 2011 to develop effective tools for information exchange at entry-points during pandemics/epidemics **(GIZ, 2011)**. Some of the findings include most of the information received come from the media, notably television and FM radio. Respondents wanted to receive all the information from only one reliable source which most of them mentioned as the Health Authorities through the Ministry of Health.

Weaknesses in this capacity include no public awareness, information, education, and communication materials on chemical, food safety, and radiological/nuclear events; unavailability of written and agreed protocols or standard operating procedures (SOPs) defining the roles and responsibilities of various partners and stakeholders including a clearing house for risk communication messages. There are no guidelines for designated spokespersons for communication during emergencies.

4.3.7 Points of entry

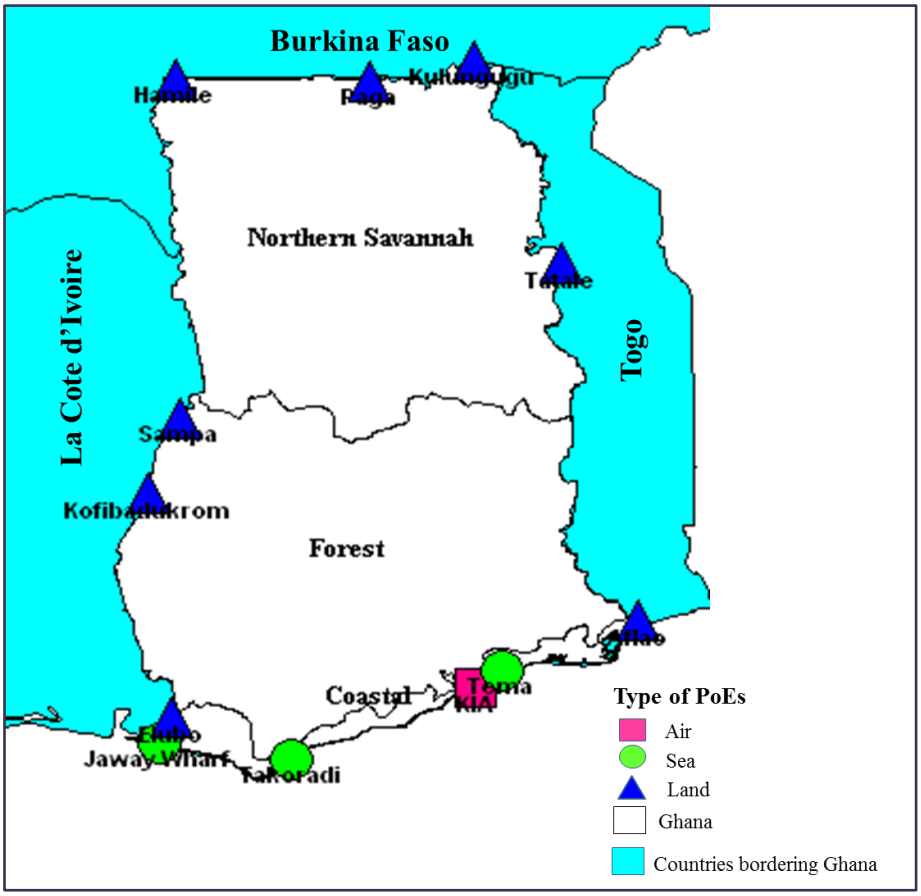
There are numerous points of entry (PoEs) into Ghana of which 56 are approved but only 22 are manned by Port Health (PH) staff. Thirteen (13) of these are designated as per International Health Regulations (IHR) requirements. The following are the main PoEs: Kotoka International Airport (KIA) in Accra, the sea ports of Tema and Takoradi in the Greater Accra and Western Region respectively; the land borders of Aflao (Volta region) to the east with Republic of Togo, and Elubo (Western region) to the west with La Cote d'Ivoire, Hamile (Upper West region) to the north west with Burkina Faso; Paga and Kulungugu (Upper East Region) to the north and north east respectively with Burkina Faso. Other land-crossing PoEs include Sampa (Brong Ahafo Region) to the west with La Cote d'Ivoire (Figure 23).

The PoEs have contingency plans although some have not been tested. One of the key health activities at the PoEs is screening for early detection of public health events. There are several methods through which a suspected case passing through the points of entry may be identified. There is the temperature screening and filling of health screening forms in which symptoms and potential

exposures of arriving passengers are recorded. Additionally, at the Kotoka International Airport (KIA), there is the early warning system where the airplane crew reports a sick individual on board an arriving aircraft to the control tower. Ghana Airport Company Limited had procured 5 walk-through scanners for KIA. Three additional ones were procured by JICA for the KIA. JICA also installed one scanner each for Elubo and Aflao PoEs. International Organization for Migration (IOM) has provided tremendous support in terms of training and logistics to 8 of the 13 designated PoEs, namely KIA, Tema, Takoradi, Elubo, Aflao, Sampa, Paga and Hamile. IOM has also donated a prefabricated holding unit to Elubo, Sampa, Paga and Hamile PoEs.

There is good collaboration among key stakeholders (Port Health staff, Immigration and Customs staff) at the PoEs. Communication has also been established between PoEs and identified first referral health facilities where ill travellers could be further investigated and treated.

Figure 23: Designated Points of Entry, Ghana



It must be noted that the Ebola threat has helped in strengthening capacity at the PoEs. As noted by the Collaborative Arrangement for the Prevention and Management of Public Health Events in Civil Aviation (CAPSCA) project assistance visit to the KIA, 25-26 June 2015, the Port Health staff at the Kotoka International Airport are well informed of the WHO IHR (2005) requirements for management of public health emergencies at the PoE, but the personnel are not aware of procedures to be followed in case of public health emergency other than Ebola (CAPSCA 2015).

The key challenges facing the PoEs include inadequate staff, equipment and premises for port health staff. There is lack of quarantine facilities, inadequate IPC logistics (gloves, sanitizers etc.); and also there are no vehicles to transport ill travellers to health facilities. Apart from the KIA which has a stand-by ambulance, the other PoEs would have to call for ambulance stationed at locations far from the PoEs. There are no written protocols or memoranda of understanding among agencies at border crossing internally and with the counterparts of the neighbouring countries.

In general the ability to secure the border and prevent the entry of live animals from adjacent countries is lacking, especially in the north. The borders are porous and in many areas the same ethnic groups occupy both sides of the borders making the control of movement across the borders ineffective. The flow of trade from Lagos, Nigeria in the east to Abidjan, Cote d'Ivoire in the west forms the major corridor of the West African trade and passes through four regions in the coastal zone of Ghana. The nature of this trade pathway has the potential to spread disease.

4.3.8 Human resources

The College of Health and Well-Being (formerly the Rural Health Training School), Kintampo and the Master of Public Health (MPH) programme of the School of Public Health (SPH), University of Ghana have over the years produced public health personnel who have been supporting surveillance and response to public health emergencies in the country. SPH has also since 2007 been offering Field Epidemiology and Laboratory Training (FELTP) at Master of Philosophy (MPhil) level to produce highly qualified personnel for disease surveillance, outbreak investigations and response in the country. In 2015 the school initiated basic FELTP course aimed at building capacity for disease surveillance at the district level where 200 field officers at the district level are expected to be trained with financial support from the World Health Organization. This was building on the training of 30 of such category of staff in the Greater Accra region in 2014. These efforts are being complemented by Centers for Disease Control and Prevention (CDC), Atlanta who are also supporting the Ghana Health Service in training district staff in basic field epidemiology. In addition, the Centre for International Cooperation in Health and Development based in Canada is currently supporting capacity building in disease surveillance through the West Africa Regional Disease Surveillance Capacity Strengthening (WARDS) Project in 12 districts in Ghana. A number of private schools or colleges of public health have also sprung up. Their programmes have not been reviewed to determine the extent to which these institutions can contribute in building the critical mass of human resources to support response to public health emergencies.

The key challenge in the human resource for health is the maldistribution of health professionals with most of doctors and nurses based in the urban area, especially in Accra and Kumasi. Other weaknesses include no training needs assessment to support the development of health care workers and other professionals in line with IHR requirements and no training plan in line with IHR requirements has been developed.

4.3.9 Zoonotic Events

The Veterinary Services Directorate (VSD) of MoFA has been involved in surveillance and outbreak response of zoonotic diseases in animals, such as Avian Influenza, Anthrax and rabies. There has also been increasing collaboration between human and animal health sectors since the emergence of Avian Influenza in the country in 2007 but the process is slow.

Zoonotic diseases pose problem in Ghana, particularly because of uncontrolled movement of animals from neighbouring countries and the importation of animal products. The problem is compounded by lack of adequate training of both human and animal health practitioners on zoonotic conditions and slow pace of collaboration between the MoH and the Ministry of Food and Agriculture (MoFA).

There are inadequate human resources in the VSD. Currently there are only 68 Veterinary officers in the country. However with the opening of two Veterinary Medical Schools in the country, at the University of Ghana and the University of Science and Technology with the first batch currently doing their internship, the human resources challenges will be addressed.

4.3.10 Food Safety Events

The Food Safety Division (FSD) of the Food and Drugs Authority's (FDA) executes the mandate of the Authority provided in Part Seven of the Public Health Act 2012 to protect public health and safety through the regulation of the food service industry, the control of meat production as well as assuring the safety of genetically modified organisms for food, feed and processing. It also provides technical support to the food industry to promote the production of safe and quality food through the application of contemporary food safety management systems.

Ghana adopted a Food Safety Policy on 27 April, 2015. The goal of the policy is to bring coordination into the regulation of food safety and define the role of stakeholders to ensure public health and facilitate trade in food. The policy outlines the policy objectives and measures and strategies to achieve the objectives. The policy also states the institutional arrangements for implementing the policy, among them the national coordination mechanism and clearly defines the role of all relevant stakeholders. There is not much risk communication on food safety.

4.3.11 Chemical Events

The Environmental Protection Agency (EPA) has adopted various measures to deal with hazardous wastes including but not limited to generation, source treatment, recycling and reuse practices. Within the health sector, based on the 'polluter pays' principle, the Ministry of Health has put in place a Health Care Waste Management policy and guidelines, to facilitate effective and safe management of wastes in the sector (MoH, 2006)

Currently, there is a pilot programme on-going in the Ashanti and Brong-Ahafo regions aimed at identification of severely hazardous pesticides formulations under the Rotterdam Convention on Prior Informed Consent (PIC) procedures for certain chemicals and pesticides in international trade. It is envisaged that this project would create awareness among farming communities on how to identify and report on incidents associated with hazardous pesticides under normal conditions of use.

The GHS has been working hand in hand with the environment and agricultural sectors to train health workers, farm workers and agricultural extension officers in safe handling of chemicals, prevention and recognition of poisoning.

The weaknesses include no surveillance system for chemical events and there is virtually no or very little risk communication on chemical events.

4.3.12 Radiological and Nuclear Events

According to the Ghana Atomic Energy Commission (GAEC), due to socio-economic development in Ghana, there has been widespread use of radiation sources in medicine, industry, research and teaching. GAEC has identified major installations which can give rise to potential radiation exposure likely to lead to deterministic health effects. In response to the potential hazards the existence of these facilities pose, GAEC and NADMO developed the National Nuclear and Radiological Emergency Response Plan (NNRERP) to cope with nuclear radiological emergencies. The NNRERP outlines the roles and responsibilities of ministries, other organisations and facilities involved in a response and summarized competencies, responsibilities, scope of co-operation and relation of different state organizations as well as emergency organizations, resources and response missions at national level (NADMO and GAEC, 2010). Drills were conducted in 2015 on handling of radiological and nuclear events.

There is little or no risk communication for nuclear and radiological events.

4.4 Conclusion

The assessment has documented strengths and weaknesses of each of the core capacities. Currently, adequate policy and legal framework for the preparedness and response to public health emergencies exist, but what is needed is translation of these policies into guidelines, protocols, standard operating procedures and job aids to guide those who are actually involved in the implementation of the public health emergency preparedness and response activities, supported by regular updating of their knowledge and the necessary logistics.

4.5 Recommendations

The following recommendations are made to strengthen the core capacities to ensure early detection and prompt and effective response to public health emergencies.

Legislation, Policy and Financing

1. Expedite action on completion of the LI for the Public Health Act.
2. Set up Ghana Public Health Emergency Fund (GPHEF) similar to the Africa Public Health Emergency Fund (APHEF).

Surveillance

3. Strengthen surveillance at all levels
    a. Sensitize clinicians and involve them in surveillance activities.
    b. Institutionalize Public Health Units in Hospitals.
    c. Institute induction courses on surveillance for new staff and regular refresher courses for health staff at all levels.
4. Establish/ strengthen early warning systems for all hazards.

Laboratory

5. Ensure adequate, timely supply of diagnostic kits and reagents to all laboratories in the laboratory network for public health emergencies.

Preparedness and Response

6. Compile and distribute to all stakeholders a roster of experts for all hazards.
7. Develop guidelines, SOPs, protocols and job aids for preparedness and response on all prioritized hazards, particularly for mass casualty management.
8. Stockpile adequate and appropriate logistics for response to identified hazards and prioritize their prepositioning based on level of risk.
9. Make Infection Prevention and Control (IPC) the cornerstone of preparedness and response to public health emergencies.
    a. Roll out the planned IPC trainings and enforce compliance with standard IPC practices in health facilities.
    b. Accelerate the building and equipping of isolation wards or treatment centres for infectious diseases.
10. Institutionalize regular update of skills of health staff in public health emergency response

Risk Communication

11. Develop communication plans for all identified hazards
12. Develop protocols and SOPs defining the roles and responsibilities of various stakeholders in risk communication including clearing house for risk communication messages.
13. Develop guidelines for designated spokesperson for communication during public health emergencies.
14. Increase risk communication activities on IPC practices at personal, household and community levels.

Points of Entry

15. Provide adequate staff and premises at the designated PoEs.
16. Sign memorandum of understanding between MoH and other agencies at the PoEs to enhance collaboration and facilitate the work of Port Health staff

Coordination and Partnership

17. Strengthen all coordinating structures and ensure their functionality.
    a. Review and formally approve the terms of reference (ToRs) of all coordinating committees and technical sub-committees at the highest level of the health sector to guide the activities of these committees to avoid duplication of efforts and maximize their potentials to synergy and efficiency.
    b. Define the power and mandate of EOC including control over resources and accountability.
    c. Clarify the line of communication, reporting and exchange of information and engagement between the health sections of NADMO and the public health emergency coordination structures in the MoH.
    d. Reconstitute various coordinating committees based on ToRs.
    e. Orientate all members of committees on their ToRs.
    f. Establish linkages with other relevant stakeholder committees outside the MoH.
    g. Provide adequate resources to support the committees.
18. Establish institutional structures for one-health concept - steering committee and secretariat
19. Develop a strategic plan for public health emergencies, and incorporating it within the Health Sector Medium Term Development Plan (HSMTDP). This would ensure in-built mechanisms for implementation, monitoring, evaluation and building the systems and capacities. If this starts with the next HSMTDP (2018 onwards), it would be a very big step to institutionalize public health emergency preparedness and response in Ghana.

Furthermore, since the recommended actions are meant to strengthen the core capacities to ensure early detection and prompt and effective response to **public health emergencies**, it is suggested that the following under listed recommended activities should be implemented within a short-term period of three months whilst the remaining are implemented within a period of 18 months (medium-term) from the receipt of this report; and where an activity has an end point it should completed during the suggested time period.

1. Expedite action on completion of the LI for the Public Health Act
2. Ensure adequate, timely supply of diagnostic kits and reagents to all laboratories in the laboratory network for public health emergencies
3. Stockpile adequate and appropriate logistics for response to identified hazards and prioritize their prepositioning based on level of risk
4. Review the terms of reference of all coordinating committees
5. Define the power and mandate of EOC including control over resources and accountability.
6. Reconstitute various coordinating and technical committees based on terms of reference
7. Orientate all members of committees on their terms of reference

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ANNEXES

Annex 1: Scoring chart for Potential to cause Public Health Emergency

Hazard	Scale	Timing	Unpredict-ability	Likely to overwhelm routine capabilities	Total Score	Score Potential for PHE*
Cholera	3	2	1	2	8	++
Meningitis	3	2	1	2	8	++
Yellow Fever	3	2	1	1	7	++
Avian Influenza	1	2	2	2	7	++
Pandemic Influenza	3	2	2	3	10	+++
Viral haemorrhagic fevers e.g. Ebola, Lassa Fever	3	2	3	3	11	+++
Floods	2	3	2	1	8	++
Drought	2	1	2	2	7	++
Earthquake	2	3	3	3	11	+++
Transport Accidents (Road, Aviation, Maritime)	1	3	3	2	9	++
Failure of structures	1	2	2	2	7	++
Fires	1	3	3	2	9	++
Chemicals	1	2	2	2	7	++
Oil/Gas spillage	1	2	2	2	7	++
Nuclear and radiological accidents	1	2	2	2	7	++
Civil Disorders	1	2	1	1	5	+
Terrorism	2	2	2	3	9	++

* Potential for resulting in public health emergency +++ = High, ++ = Medium, + = Low

Annex 2: Ranking Scores of Hazards Risk using SMAUG Criteria

Hazard	Rank	Seriousness	Manageability	Acceptability	Urgency	Growth	Total Scores
Ebola Virus Disease	1	8	6	5	4	3	26
Cholera	2	8	3	4	6	3	24
Meningitis	2	8	4	4	6	2	24
Pandemic Influenza	4	8	4	4	4	3	23
Road Accidents	5	6	5	4	6	1	22
Floods	5	5	5	4	6	2	22
Terrorism	5	6	5	5	5	1	22
Yellow Fever	8	6	2	5	6	2	21
Fires	8	4	5	5	6	1	21
Avian Influenza	10	6	4	3	4	3	20
Aviation Accidents	10	6	5	4	4	1	20
Water Transport Accidents	10	5	4	4	6	1	20
Structure Failures	10	4	4	5	6	1	20
Drought	14	5	4	4	4	2	19
Earthquake	14	4	6	3	4	2	19
Oil/Gas spillage	16	4	4	5	4	1	18
Civil Disorders	16	4	3	5	5	1	18
Chemical	18	3	4	5	4	1	17
Radio nuclear accidents	18	3	4	5	4	1	17