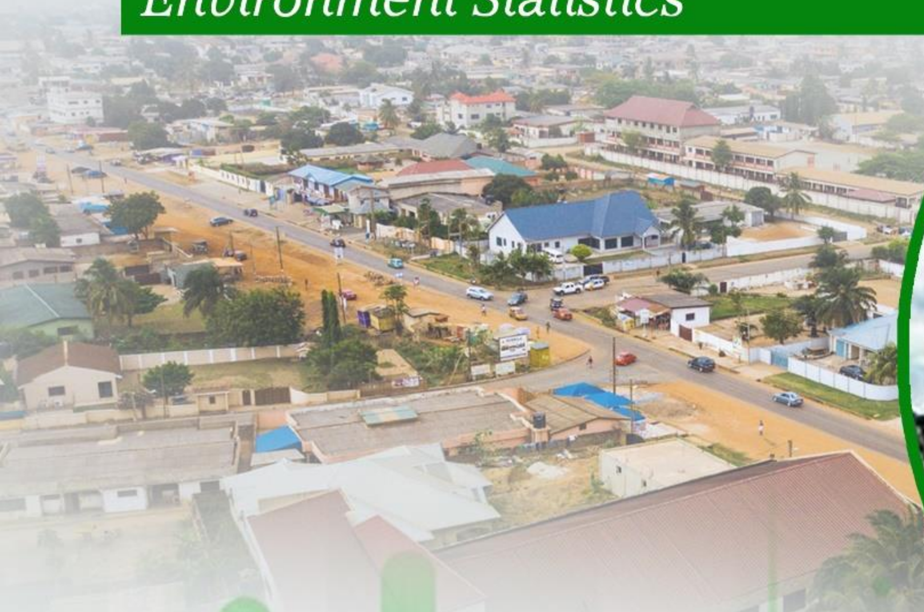
ENVIRONMENT STATISTICS COMPENDIUM

Framework for the Development of Environment Statistics



United Nations Economic Commission for Africa

GHANA STATISTICAL SERVICE
OCTOBER 2020

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[Framework for the Development of Environment Statistics]

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Preface

This is Ghana's first Compendium on Environment Statistics adopting the FDES 2013.The Framework of Environment Statistics (FDES) provides an organised structure to guide the collection and compilation of environment statistics at the national level, bringing together data from the various relevant subject areas and sources. Thus, it is a multipurpose statistical framework that is comprehensive and integrative in nature and defines the scope of environment statistics. The framework is broad and holistic in nature, covering the issues and aspects of the environment that are relevant for policy analysis and decision making.

The 2013 FDES is a flexible framework that provides a standardized structure to guide the collection, compilation and synthesis of data from various subject areas and sources, covering the issues and aspects of the environment that are relevant for analysis, decision-making and policy formulation. It is compatible with other frameworks and systems, both statistical and analytical, such as the System of Environmental-Economic Accounting (SEEA), the Driving force Pressure-State-Impact-Response (DPSIR) framework, and the Sustainable Development Goals (SDGs) framework.

In addition to providing data for planning, data from the FDES will also help policy makers monitor the progress towards the attainment of the Sustainable Development Goals (SDGs), the African Union Agenda 2063, the Coordinated Programme of Economic and Social Development Policies 2017-2024, the National Medium-Term Development Policy Framework and other relevant national policy initiatives.

The development of environment statistics in the past had been uncoordinated and fragmented in its approach. However, in recent times efforts are being made to strengthen and harmonize environment statistics through the implementation of the Framework for the Development of Environment Statistics (FDES). This process began with Ghana's participation in a capacity building programme in the development of environment statistics provided by the African Centre for Statistics under the auspices of the United Nations Economic Commission for Africa (UNECA) in September 2017. As part of the programme, Ghana was selected to receive technical assistance from the ECA to prepare a Compendium of Environment Statistics. The process led to country-wide assessment of the state of environment statistics through the use of the Environment Statistics Self-Assessment Tool (ESSAT) and national stakeholders' consultation. Prior to this technical assistance, the country had also benefited from other capacity development programmes by the United Nations Statistical Division (UNSD) and the Economic Commission of West African States (ECOWAS).

This compendium is the first publication on Environment Statistics to be published in the country as environmental sustainability is at the centre of the SDGs. It will help policy makers understand the interlinkages within and between environment-related goals and targets; promote policy coherence and integration of the environmental dimensions of the SDGs; and help develop indicators to monitor the SDGs, among others. Additionally, it will enhance understanding of the effectiveness of the various environmental interventions initiated by Government and its development partners.

The compendium has been prepared by the National Implementation Team (NIT), a collaboration between Ghana Statistical Service (GSS) and Environmental Protection Agency (EPA) based on the Basic Set of Environment Statistics (BSES) contained in the Framework for the Development of Environment Statistics (FDES 2013). Although there are still some data gaps that need to be addresses going forward, we are satisfied with the results herein.

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Acknowledgements

The Framework for the Development of Environment Statistics (FDES) 2019 of Ghana is an outcome of the active participation of various experts from the institutions in the field of environment. The Ghana Statistical Service (GSS) and the Environment Protection Agency (EPA) would like to acknowledge the invaluable contribution of institutions and individuals to the successful compilation of 2019 Ghana FDES.

We acknowledge with thanks the support of the following Institutions: Ghana Meteorological Agency (GMet), Forestry Commission; the Minerals Commission; Driver and Vehicle Licensing Authority (DVLA), Plant Regulatory Protection Directorate (PRPD), Vertinary Department and the Statistics, Research and Information Directorate (SRID) of Ministry of Food and Agriculture; the Hydrological Services Department; Ghana Geological Survey Authority and the Energy Commission. The others are: the Ghana Water Company Ltd.; the Water Resource Commission; Ghana Irrigation Development Authority (GIDA), CSIR-Soil Research Institute, and the Water Research Institute (WRI). Also, worth mentioning are the Soil Research Institute, Ghana Health Services, Fisheries Commission and National Disaster Management Organization (NADMO).

We are grateful for the exemplary and inspiring leadership provided by the Management of both Institutions (GSS and EPA) and in particular the Government Statistician Prof. Samuel K. Annim, and the Executive Director of EPA, Mr. John A. Pwamang.

Special gratitude goes to the United Nations Economic Commission for Africa (UNECA) for financial and technical support. We further acknowledge the head of the Technical assistance team, Mr David Boko (UNECA) and Mr Manasa Viriri (FDES Consultant) for technical support during the preparations and implementation of Ghana’s FDES. Our appreciation also goes to the Acting Director of Strategic Environmental Assessment (SEA) and Legal Affairs of EPA, Dr Christine O. Asare, the former Head of Agriculture and Environment Statistics Section, Mr Francis Dzah and the Director of Economic Statistics Directorate, Mr Edward Asuo Afram, for their inspiration, technical support and supervisory roles to the National Implementation Team during the programme.

Finally, we wish to acknowledge with gratitude the contribution of all the officers who worked under challenging conditions to collect the required information from institutions across the country, and all the institutions who generously provided the data that are contained in this report.

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Acronyms

AFOLU	Agriculture, Forestry and other Land Use
AMA	Accra Metropolitan Assembly
AU	Africa Union
CSM	Cerebro Spinal Meningitis
DPSIR	Driving Forces-Pressures-State-Impacts-Responses
ECOWAS	Economic Community of West African States
EEZ	Exclusive Economic Zone
EPA	Environnemental Protection Agency
ESSAT	Environment Statistics Self-Assessment Tool
FAO	Food and Agriculture Organization
FDES	Framework for the Development of Environment Statistics
GAMA	Greater Accra Metropolitan Area
GAPS	Ghana Agricultural Production Survey
GAR	Greater Accra Region
GDP	Gross Domestic Product
GHG	Green House Gas
GLSS	Ghana Living Standards Survey
GSS	Ghana Statistical Service
HFC	Hydrofluorocarbon
IPPU	Industrial Processes and Product Use
ISRI	International Soil Reference and Information Centre
ISSS	International Society of Soil Science
IUCN	International Union for Conservation of Nature
KMA	Kumasi Metropolitan Assembly
LFG	Land Fill Gas
MDAs	Ministries, Departments and Agencies
MDG	Millennium Development Goals
MICS	Multiple Indicator Cluster Survey
MMDA	Metropolitan, Municipal and District Assemblies
MoFA	Ministry of Food and Agriculture
MRACLS	Multi Round Annual Crop & Livestock Survey
MTNDPF	Medium-term National Development Policy Framework
NADMO	National Disaster Management Organization

NIT	National Implementation Team
NMVOC	Non-Methane Volatile Organic Compounds
NR	Northern Region
NSO	National Statistical Office
NSS	National Statistical System
PFC	Perfluorocarbons
PM	Particulate Matter
SDGs	Sustainable Development Goals
SDI	Sustainable Development Indicators
SEEA-CF	System of Environmental Economic Accounting – Central Framework
SNA	System of National Accounts
SRID	Statistics, Research and Information Directorate
UER	Upper East Region
UN	United Nations
UNECA	United Nations Economic Commission for Africa
UNSD	United Nations Statistical Division
UWR	Upper West Region
VALCO	Volta Aluminium Company Limited
WRB	World Reference Base for Soil Resources

Glossary

Agro-ecological zones	Geographical areas exhibiting similar soil and climatic conditions that determine their ability to support rain-fed agriculture.
Aquaculture (fish farming)	The farming of aquatic organisms such as fish, molluscs, crustaceans, plants, crocodiles, alligators and other amphibians. In this context, farming refers to some intervention in the rearing process to enhance production, such as regular stocking, feeding and protection from predators.
Arable crops	Crops that mature within a short period of time, usually less than one year. Examples of arable crops are plantain, cocoyam, cassava, yam, etc.
Biomass	Organic material that comes from plants and animals, and it is a renewable source of energy.
Capture fisheries	Fishing from the wild (i.e. from the marine and inland waters)
Forest tree planting	The growing of trees for the purpose of afforestation or production of wood
Fossil fuel	Fuel (such as coal, oil, or natural gas) formed in the earth from plant or animal remains.
Landfill Gas	A complex mix of different gases created by the action of microorganisms within a landfill. Landfill gas is approximately forty to sixty percent methane, with the remainder being mostly carbon dioxide.
Leachate	Liquid that drains or 'leaches' from a landfill. It varies widely in composition regarding the age of the landfill and the type of waste that it contains.
Locality	A locality is classified as urban if it has 5,000 or more inhabitants.
Particulate Matter (PM)	The sum of all solid and liquid particles suspended in air many of which are hazardous. This complex mixture includes both organic and inorganic particles, such as dust, pollen, soot, smoke, and liquid droplets and the particles vary greatly in size, composition, and origin.
Perfluorocarbon (PFC)	A Chemical by product of aluminum smelting and semiconductor manufacturing, it consists of one or two carbon atoms combined with four to six fluorine atoms but no chlorine.

Precursor Gases that are not greenhouse gases at the point of release, but when they get into the atmosphere they can contribute to global warming, and/or local and regional air pollution with its attendant public health challenges.

Wetlands Wetlands are areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters.

Chapter 1

Introduction

1.1 Background

In 2016, Ghana signed onto and adopted the Sustainable Development Goals (SDG) as the Global Agenda for Transformation. The achievement of the SDGs will to a large extent end poverty and hunger, secure education and basic services for all, achieve gender equality and empower the vulnerable in society, protect the environment, fight climate change, foster inclusive economic growth, among others. Ultimately, this will put Ghana on a sustainable development path that ensures that "no-one is left behind". Unlike in the Millennium Development Goals (MDGs), environmental sustainability issues have also been adequately integrated into the Sustainable Development Goals (SDGs). In Ghana, the SDGs have been adequately mainstreamed into the Medium-Term National Development Policy Framework (2018-2021) also referred to as "An Agenda for Jobs: Creating Prosperity and Equal Opportunity for All". This makes quality, reliable, and timely environmental data and statistics vital to better inform policy and decision-making at various level, and to ensure accountability and transparency in environmental management and governance.

1.2 National Medium-Term Development Framework

Within the national development system, environment data are key to the success of monitoring and evaluation of policies, plans and programmes at the national, sector and district levels. Monitoring and evaluation of the national development agenda has been provided for in the National Development Planning System Act, 1994 (Act 480), and all implementing institutions are enjoined by law to undertake monitoring and evaluation of their respective policies, plans, programmes and projects.

1.3 Policy, Legal and Institutional Framework

This section discusses the legal and institutional mandates of relevant institutions as well as the strategy for the development of statistics in Ghana.

1.3.1 National Strategy for the Development of Statistics (2018-2022)

The National Strategy for the Development of Statistics 2018-2022 is a comprehensive strategic document which guides the evolution of the National Statistical System (NSS) to enable it to produce the statistical knowledge the country needs in order to fulfil its development potential. Environment statistics have been identified as very crucial within the national statistical system which calls for continuous capacity building and resourcing of the relevant stakeholders in the NSS.

1.3.2 Statistical Service, Ghana (GSS)

The Statistical Service Act 2019, (Act 1003) mandates Ghana Statistical Service (GSS) as the central statistics producing and coordinating institution for the National Statistical System and to strengthen the production of quality statistics and to provide for related matters quality, relevant, accurate and timely statistical information for the purpose of national development. Vests in it, the responsibility for the collection, compilation, analysis, publication and dissemination of statistical information related to the commercial, industrial, financial, social, demographic, economic and other activities and conditions of the people of this country through the conduct of surveys and national censuses, including population, housing, economic and agricultural censuses in Ghana for general and administrative purposes. The Act also among others prescribes the coordination role of the Service in the developments in statistics outside the GSS.

Clause 24 of the Act gives GSS the mandate to consider statistics produced by public corporation or partner institutions as official statistics if it is accepted to be of standards.

1.3.3 Environmental Protection Agency (EPA)

The Environmental Protection Agency Act, 1994 Act 490 established the EPA to among others, promote studies, research, survey and analyses for the improvement and protection of the environment and the maintenance of sound ecological systems in Ghana. The EPA is also mandated to develop a comprehensive database on the environment and environmental protection for the information of the public.

1.4 Socio-economic Demography

Ghana has a projected population of 30.3 million as of 2019[1] with respect to 2010 Population and Housing Census in 2010 of 24.6 million. Females constitute 50.8 percent, while males 49.2 percent. Urbanization is on the rise with 50.9% of the population living in urban localities in 2010 compared to 43.8% in 2000. The life expectancy for Ghana in 2019 was 63.91 years, a 0.41% increase from 2018. The life expectancy for Ghana in 2018 was 63.65 years.

With the rebase of the Gross Domestic product (GDP)[2] and 2013 as the base year, the GDP of Ghana in 2019[3] was estimated at US$ 66,984 million including oil with a per capita GDP of US$2,212. This put Ghana into the range of low-middle-income countries based on the World Bank per capita GDP threshold[4]

[1] GSS 2019

[2] Gross domestic product (GDP) the total value of goods produced and services provided in a country during one year.

[3] 2019 GDP estimates are provisional and are subject to change

[4] datatopics.worldbank.org/world.../the-classification-of-countries-by-income.html || accessed Wednesday, April 24, 2019 at 10:23hrs.

of countries income classification of US$ 996-3,895. GDP without oil is estimated at US$ 64,138 million. The economy recorded an average growth rate of 3.8% between 2014 and 2019.

Until 2010, Agriculture was considered the most important sector of the economy, with regards to its contribution to GDP and its share of the labor force. Before the rebasing, Agriculture contributes 48.8% to the country's GDP. However, after the rebasing, the Services sector has overtaken the Agriculture sector as its contribution to GDP increased from 41.4% in 2013 to 47.2% in 2019, while the Agriculture sector contributed 21.7% in 2013 and declined to 18.5% in 2019. The country's major exports include gold, diamonds, other metals, and cocoa. Major imports include transport and equipment, machinery and equipment, electrical and electronic equipment, etc.

1.5 Development of Environment Statistics in Ghana

Environmental issues are cross-cutting in nature and therefore requires a multi-faceted approach to effectively address them. According to the Ghana State of Environment 2016 Report, some of the major environmental challenges of the country include; climate change, waste and sanitation, air pollution, land degradation, biodiversity loss, coastal erosion, water pollution, deforestation, among others. This makes it crucial for the availability of the relevant data and statistics to monitor the state of progress in addressing the challenges.

1.5.1 Implementation of the Framework for the Development of Environment Statistics (FDES)

The development of environment statistics in Ghana in the past has been uncoordinated and fragmented in its approach. However, in recent times efforts are being made to strengthen and harmonize environment statistics through the implementation of the Framework for the Development of Environment Statistics (FDES). The process began with the country's participation in a capacity building programme in the development of environment statistics provided by the African Centre for Statistics under the auspices of the United Nations Economic Commission for Africa (UNECA) in September 2017.

As part of the programme, Ghana received technical assistance from the ECA to prepare a Compendium of Environment Statistics in Ghana. The process led to a country-wide assessment of the state of environment statistics through the use of the *Environment Statistics Self-Assessment Tool (ESSAT)* and national stakeholders consultations. Prior to this technical assistance, the country had also participated in capacity development programmes organized by the United Nations Statistical Division (UNSD) and the Economic Commission of West African States (ECOWAS).

1.6 Framework for the Development of Environment Statistics (FDES 2013)[5]

The FDES 2013 is a flexible, multipurpose conceptual and statistical framework that is comprehensive and integrative in nature. It marks out the scope of environment statistics and provides an organizing structure to guide their collection and compilation and to synthesize data from various subject areas and sources, covering the issues and aspects of the environment that are relevant for analysis, policy- and decision-making.

The FDES 2013 targets a broad user community, including environmental statisticians in national statistical offices (NSOs), environmental ministries and agencies, as well as other producers of environment statistics. It helps to mark out the roles of the different data producers, thus facilitating coordination at different levels. It is structured in a way that allows links to economic and social domains. It seeks to be compatible with other frameworks and systems, both statistical and analytical, such as the System of Environmental-Economic Accounting (SEEA), the Driving force Pressure-State-Impact-Response (DPSIR) framework, and the Millennium Development Goals (MDGs), SDGs and the sustainable development indicator (SDI) frameworks. When applicable, it is based on existing statistical classifications. As such, the FDES 2013 facilitates data integration within environment statistics and with economic and social statistics.

The FDES 2013 organizes environment statistics into six (6) components and each of them is broken down into subcomponents and further into statistical topics. The six components cover environmental conditions and quality; the availability and use of environmental resources and related human activities; the use of the environment as a sink for residuals and related human activities; extreme events and disasters; human settlements and environmental health; and social and economic measures to protect and manage the environment. The statistical topics represent the quantifiable aspects of the components and are grouped under subcomponents, taking into account the types and sources of the statistics needed to describe them.
The FDES 2013 sets out a comprehensive, though not exhaustive, list of statistics (the Basic Set of Environment Statistics) that can be used to measure the statistical topics. The Basic Set is organized into three tiers, based on the level of relevance, availability and methodological development of the statistics. Within this scope, a Core Set of Environment Statistics has been identified as Tier 1. The objective of the Core Set is to serve as an agreed, limited set of environment statistics that are of high priority and relevance to most countries.

The FDES 2013 is relevant and recommended for use by countries at all stages of development. However, it is particularly useful for guiding the formulation of environment statistics programmes in countries at the

[5] More information on the FDES can be found on the United Nations Statistical Division (UNSD) website via: https://unstats.un.org/unsd/environment/FDES/FDES-2015-supporting-tools/FDES.pdf

early stages of developing environment statistics such as Ghana as it (i) identifies the scope and constituent components, subcomponents and statistical topics relevant for them; (ii) contributes to the assessment of data requirements, sources, availability and gaps; (iii) guides the development of multipurpose data collection processes and databases; and (iv) assists in the coordination and organization of environment statistics, given the interinstitutional nature of the domain.

1.7 Components of FDES

Using a multilevel approach, the FDES organizes environment statistics into a structure composed of components, subcomponents, statistical topics, and individual statistics. The first level of the structure consists of six (6) fundamental components that follow the FDES conceptual framework. The first component, Environmental Conditions and Quality, brings together statistics related to the conditions and quality of the natural environment and changes in those conditions and quality. The second component, Environmental Resources and their Use, groups statistics related to the availability and use of environmental resources (ecosystem provisioning services, land and subsoil resources). The third component, Residuals, includes statistics related to the use of regulating services of the environment for the discharge of residuals from production and consumption processes. Statistics related to Extreme Events and Disasters (both natural and technological) and their impacts are covered by the fourth component. The fifth component brings together statistics related to Human Settlements and Environmental Health. The sixth component, Environmental Protection, Management and Engagement, group statistics relevant to societal responses and economic measures aimed at protecting the environment and managing environmental resources.

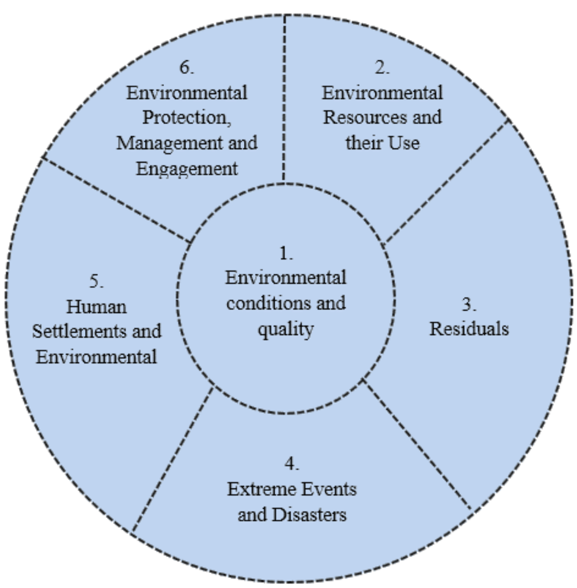


Figure 1.1: Components of the FDES

Environmental Conditions and Quality (Component 1) are central to the FDES. The other five (5) components have been established based on their relationship to the central component. As shown in Figure 1.1, all six (6) components are intrinsically related to each other. The dotted lines separating the components indicate the continuous interactions among them. These interactions exist between and among all the components of the FDES.

1.8 Linkages of FDES with Other Sustainability Frameworks

The FDES is closely related to and supports other systems and frameworks that are frequently used at the national and international levels. Figure 1.2 provides a simplified illustration of the relationship between environmental data, the FDES, the SEEA[6] and indicator frameworks. The FDES is shown here as a tool to bring together and transform primary statistical and non-statistical data into environment statistics. These environment statistics can then be used to produce statistical series and indicators organized according to different analytical or policy frameworks. They may also be used in combination with economic statistics to produce environmental-economic accounts that link environment statistics with the System of National Accounts (SNA[7]).

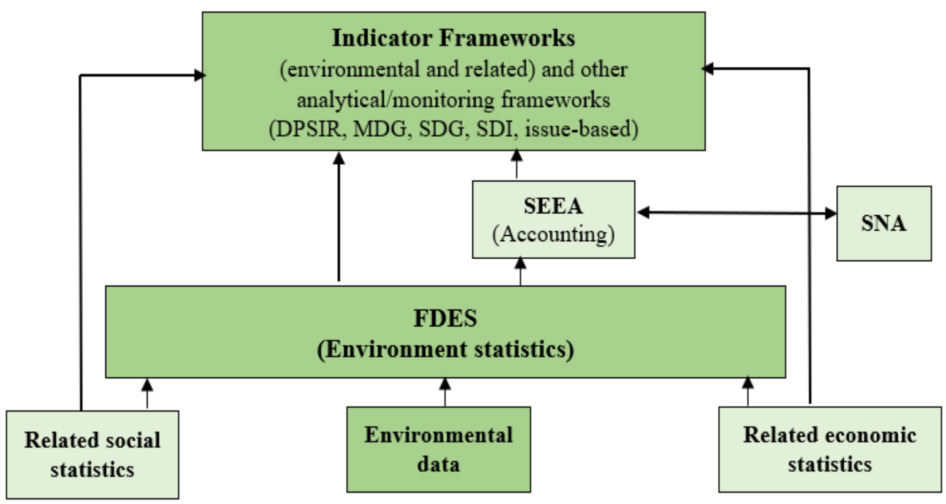


Figure 1.2: Relationship of the FDES to Other Frameworks, Systems and Indicator Sets

[6] The System of Environmental-Economic Accounting (SEEA) is a framework that integrates economic and environmental data to provide a more comprehensive and multipurpose view of the interrelationships between the economy and the environment and the stocks and changes in stocks of environmental assets, as they bring benefits to humanity. For more information access: https://seea.un.org/.

[7] The System of National Accounts (SNA) is the internationally agreed standard set of recommendations on how to compile measures of economic activity. The SNA describes a coherent, consistent and integrated set of macroeconomic accounts in the context of a set of internationally agreed concepts, definitions, classifications and accounting rules.

Chapter 2

Environmental Conditions and Quality

2.1 Introduction

This chapter presents information on physical conditions; land cover, ecosystems and biodiversity; and quality of the environment. The condition of the environment is very important as it directly affects the health and quality of life of people. Poor air quality can lead to health problems such as cancer, and respiratory and cardiovascular diseases and premature death. Sources of data for the computation of this component include remote sensing and monitoring data from environmental, meteorological, hydrological, geological and geographical institutions.

2.2 Physical Conditions

Ghana has a unique global position, lying just above the Equator and also been traversed by the Greenwich meridian. The country is bordered on the East with the Republic of Togo, Côte d'Ivoire to the west, Burkina Faso to the north and north-west, and the Gulf of Guinea (Atlantic Ocean) to the south. The focus areas under the physical conditions of the environment include; the atmosphere, climate, weather, geology, geography and soil characteristics.

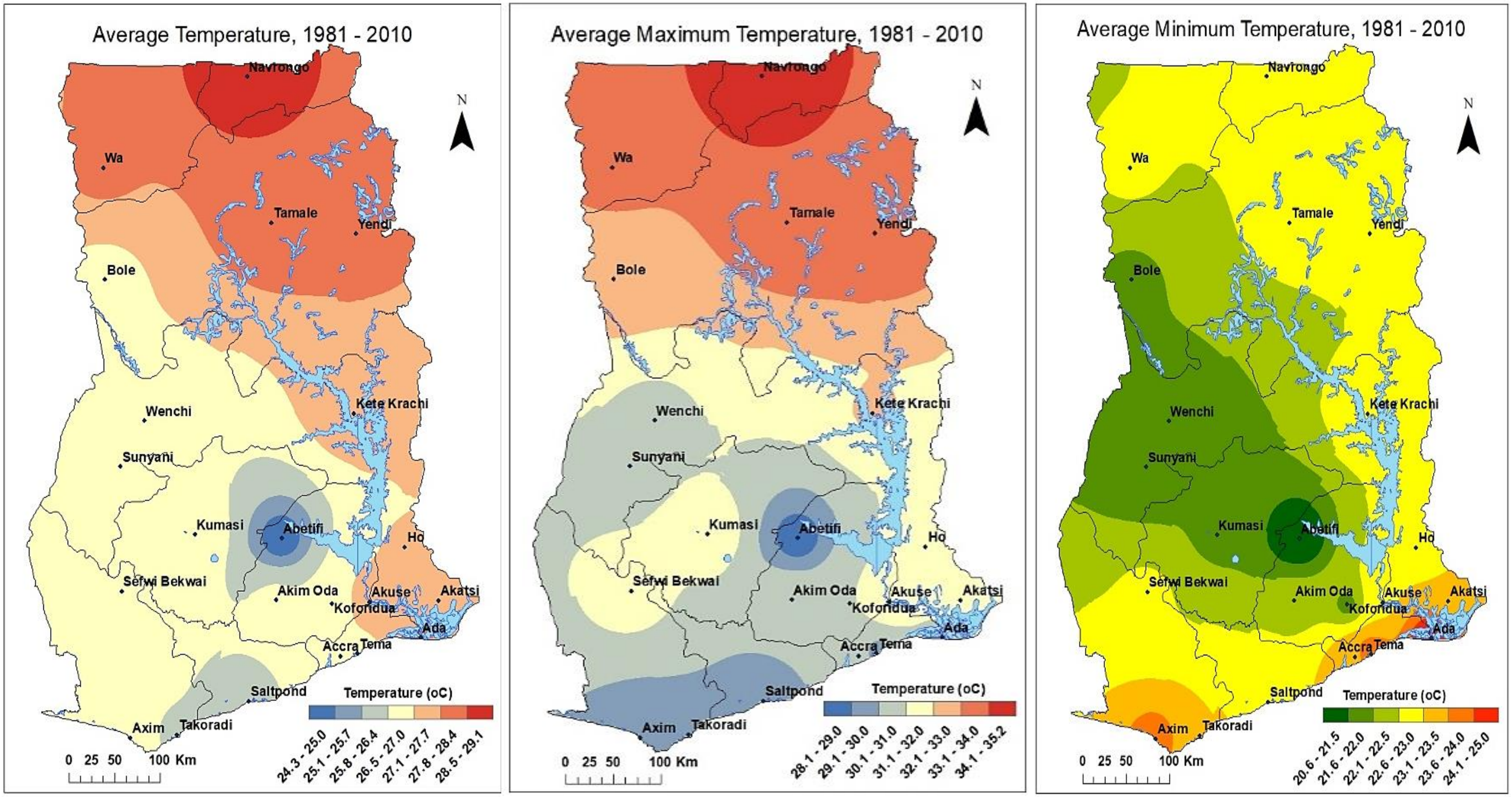
2.2.1 Atmosphere, Climate and Weather

Ghana has two main seasons, the dry and wet seasons. The rainy season begins from April to September. The dry season also referred to as harmattan usually begins from November to March. This section provides data on climatic and weather conditions across the country from 1981 to 2018. Data on climate and weather were recorded from a network of monitoring stations across the country.

2.2.2 Temperature

A maximum monthly average temperature of 31^{o}C. This was recorded throughout the period under review 1981-2010 and a minimum average of 21^{o}C (Table 2.1 and Map 2.1).

Map 2.1: Temperature Maps, 1981- 2010



Source: Ghana Meteorological Authority, 2019

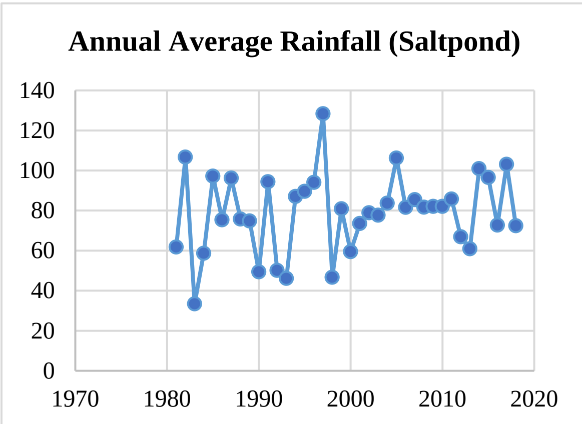
Table 2.1: Temperature Measured in Degree Celsius (Monthly Average)

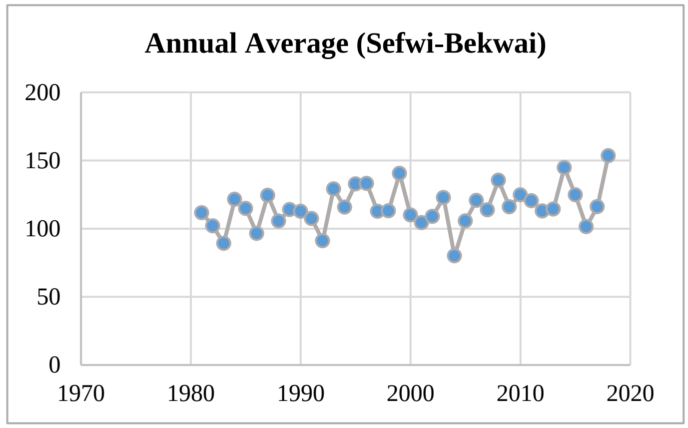
Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average	Min	Max
1981	26.0	27.1	27.2	27.2	27.0	26.9	26.6	26.5	26.5	26.8	26.5	26.6	26.7	21.9	31.6
1982	25.8	26.9	27.1	27.3	27.0	26.9	26.5	26.3	26.3	26.7	26.6	26.3	26.6	21.7	31.6
1983	25.3	26.9	27.5	27.5	27.3	26.8	26.5	26.4	26.4	26.7	26.6	26.4	26.7	21.8	31.6
1984	26.3	26.6	27.1	27.1	26.9	26.6	26.5	26.5	26.5	26.6	26.6	26.0	26.6	21.6	31.6
1985	26.3	26.6	27.1	27.2	27.0	26.7	26.3	26.5	26.5	26.6	26.6	25.9	26.6	21.6	31.6
1986	26.0	27.0	27.0	27.2	26.9	26.7	26.3	26.3	26.3	26.5	26.7	26.0	26.6	21.6	31.6
1987	25.8	26.6	27.0	27.1	26.9	26.5	26.3	26.4	26.4	26.5	26.6	26.0	26.5	21.4	31.6
1988	25.8	26.5	27.0	27.1	26.9	26.5	26.2	26.4	26.4	26.4	26.6	25.9	26.5	21.3	31.6
1989	25.7	26.4	26.9	27.0	26.8	26.4	26.2	26.4	26.4	26.4	26.6	25.9	26.4	21.2	31.6
1990	25.6	26.4	26.9	27.0	26.8	26.4	26.1	26.4	26.4	26.4	26.6	25.8	26.4	21.2	31.6
1991	25.6	26.3	26.8	27.0	26.8	26.3	26.1	26.4	26.4	26.3	26.6	25.8	26.4	21.1	31.6
1992	25.5	26.2	26.8	26.9	26.7	26.3	26.0	26.4	26.4	26.3	26.6	25.7	26.3	21.0	31.6
1993	25.4	26.1	26.7	26.9	26.7	26.2	26.0	26.4	26.4	26.2	26.6	25.7	26.3	20.9	31.6
1994	25.4	26.1	26.7	26.8	26.7	26.2	25.9	26.4	26.4	26.2	26.6	25.6	26.2	20.8	31.6
1995	25.3	26.0	26.6	26.8	26.6	26.1	25.8	26.3	26.4	26.1	26.6	25.6	26.2	20.7	31.6
1996	25.2	25.9	26.6	26.7	26.6	26.0	25.8	26.3	26.3	26.1	26.6	25.5	26.2	20.6	31.6
1997	25.2	25.8	26.5	26.7	26.6	26.0	25.7	26.3	26.3	26.1	26.6	25.5	26.1	20.5	31.6
1998	25.1	25.8	26.5	26.7	26.5	25.9	25.7	26.3	26.3	26.0	26.7	25.4	26.1	20.4	31.6
1999	25.1	25.7	26.4	26.6	26.5	25.9	25.6	26.3	26.3	26.0	26.7	25.4	26.0	20.4	31.6
2000	25.0	25.6	26.4	26.6	26.5	25.8	25.6	26.3	26.3	25.9	26.7	25.3	26.0	20.3	31.6
2001	24.9	25.5	26.3	26.5	26.4	25.8	25.5	26.3	26.3	25.9	26.7	25.3	26.0	20.2	31.6
2002	24.9	25.4	26.3	26.5	26.4	25.7	25.5	26.3	26.3	25.8	26.7	25.2	25.9	20.1	31.6
2003	24.8	25.4	26.2	26.5	26.4	25.6	25.4	26.3	26.3	25.8	26.7	25.2	25.9	20.0	31.6
2004	24.7	25.3	26.2	26.4	26.3	25.6	25.4	26.3	26.3	25.8	26.7	25.1	25.8	19.9	31.6
2005	24.7	25.2	26.1	26.4	26.3	25.5	25.3	26.3	26.3	25.7	26.7	25.1	25.8	20.8	31.6
2006	26.8	27.4	60.3	58.1	26.4	26.8	26.8	26.8	26.8	26.8	26.8	26.8	32.2	22.1	31.6
2007	25.7	27.4	27.6	27.5	27.3	27.0	26.8	26.7	26.7	26.8	26.9	26.6	26.9	22.2	31.6
2008	25.0	26.9	27.3	27.3	27.1	27.0	26.8	26.7	26.7	27.0	27.0	26.8	26.8	22.0	31.6
2009	26.3	27.3	27.7	27.6	27.5	27.2	26.9	26.8	26.8	27.1	26.9	26.8	27.1	22.6	31.6
2010	26.8	27.4	27.8	27.9	27.6	27.2	26.8	26.8	26.9	27.0	26.9	26.5	27.1	22.6	31.6

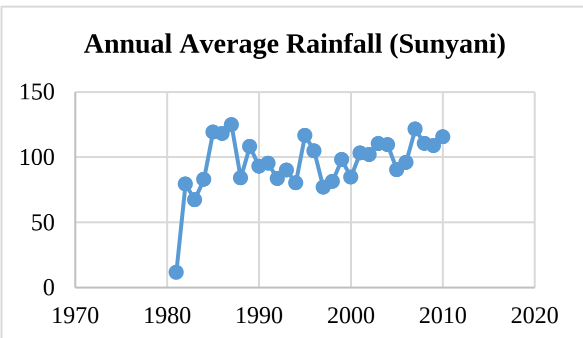
Source: Ghana Meteorological Authority, 2019

2.2.3 Precipitation

The rainfall patterns of Ghana given by the northern and southern zones are presented in Table 2.2 – 2.5.







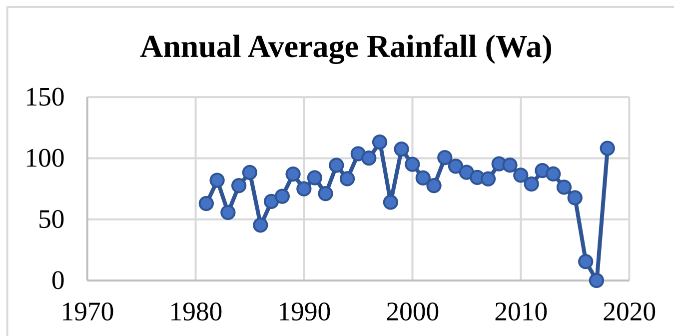
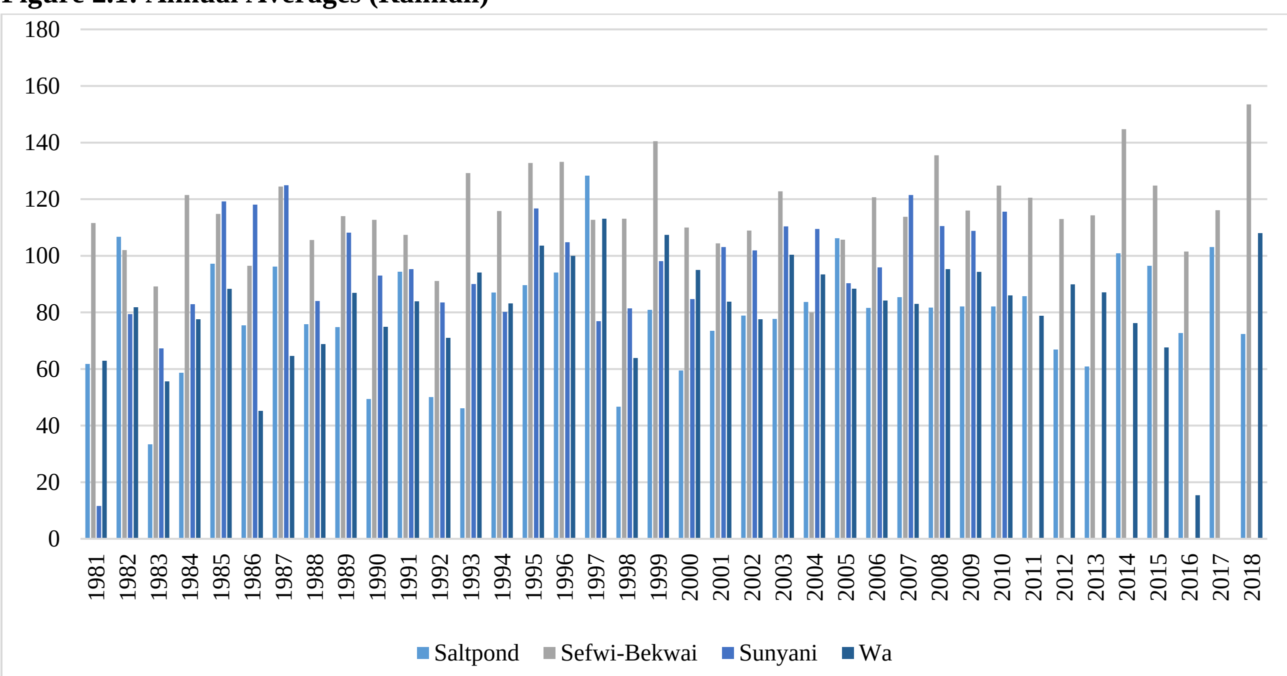


Figure 2.1: Annual Averages (Rainfall)



Source: Ghana Meteorological Authority, 2019

Table 2.2: Rainfall Measured in Milliliters (mm) from 1981-2018 for Saltpond

Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average	Min	Max
1981	0.8	8.9	104.1	93.5	108.9	288.9	87.2	0.8	0.5	48.0	0.0	0.0	61.8	0.0	288.9
1982	10.2	35.5	69.3	157.0	404.1	284.4	116.2	9.3	0.6	175.1	7.3	11.6	106.7	0.6	404.1
1983	0.0	0.0	0.0	18.9	230.8	86.2	3.7	7.0	26.3	9.9	0.0	17.4	33.4	0.0	230.8
1984	35.3	0.0	7.8	94.0	156.7	88.7	33.8	63.4	66.6	120.9	26.1	11.0	58.7	0.0	156.7
1985	54.6	28.1	63.7	175.7	366.4	319.8	37.7	15.8	24.1	45.4	35.5	0.0	97.2	0.0	366.4
1986	4.3	50.6	32.4	78.5	135.3	337.3	30.8	8.3	7.9	87.5	120.4	12.1	75.4	4.3	337.3
1987	9.5	0.0	114.0	47.3	106.8	31.7	68.2	110.2	382.7	207.2	76.7	0.0	96.2	0.0	382.7
1988	0.0	18.7	60.9	30.8	176.6	233.9	35.4	11.8	129.2	167.8	20.5	23.9	75.8	0.0	233.9
1989	10.6	5.2	121.7	88.6	195.7	313.4	46.5	17.4	22.6	73.6	2.2	0.0	74.8	0.0	313.4
1990	7.0	0.6	70.1	43.5	60.3	109.4	23.2	2.8	32.8	124.2	21.7	97.7	49.4	0.6	124.2
1991	51.8	1.0	13.3	104.8	440.0	166.3	199.1	45.7	52.5	57.0	1.0	0.0	94.4	0.0	440.0
1992	0.0	5.6	64.7	80.0	275.3	17.2	21.4	4.8	54.5	28.9	24.0	24.8	50.1	0.0	275.3
1993	17.0	27.0	73.9	45.5	57.5	143.9	1.6	21.5	65.5	41.3	44.2	14.6	46.1	1.6	143.9
1994	30.3	43.8	85.7	48.6	308.7	160.6	13.9	13.3	84.4	172.2	80.0	2.5	87.0	2.5	308.7
1995	0.0	0.8	94.4	223.0	223.4	339.4	61.1	38.8	25.1	56.6	9.4	2.9	89.6	0.0	339.4
1996	5.8	17.2	31.4	120.2	255.8	340.2	37.9	80.3	13.5	66.3	140.5	20.2	94.1	5.8	340.2
1997	8.5	63.9	184.7	123.1	346.0	465.4	41.4	2.3	12.5	156.8	53.0	82.3	128.3	2.3	465.4
1998	22.3	0.0	14.1	57.6	199.4	60.9	32.2	3.0	3.8	156.9	7.2	2.5	46.7	0.0	199.4
1999	43.7	14.7	60.3	155.7	81.1	379.3	65.2	55.7	13.6	32.1	59.6	9.3	80.9	9.3	379.3
2000	14.3	0.0	124.1	88.8	151.5	184.8	31.8	9.4	7.0	33.8	56.8	12.0	59.5	0.0	184.8
2001	0.0	29.3	124.6	90.6	324.1	108.9	51.6	14.5	44.5	38.1	38.6	17.3	73.5	0.0	324.1
2002	31.2	91.0	84.8	188.9	108.8	251.0	79.3	19.0	5.3	39.9	45.3	2.2	78.9	2.2	251.0
2003	3.9	17.0	128.0	119.4	235.0	187.0	13.4	4.6	35.4	129.6	42.8	16.8	77.7	3.9	235.0
2004	27.8	18.7	25.4	46.0	187.9	175.0	126.1	12.0	125.5	204.4	44.9	11.1	83.7	11.1	204.4
2005	30.3	11.1	133.5	90.7	320.4	377.6	33.1	11.4	68.4	144.7	45.7	7.2	106.2	7.2	377.6
2006	2.4	3.0	20.7	72.3	337.9	179.7	49.6	22.0	49.6	183.9	54.4	3.8	81.6	2.4	337.9
2007	0.0	19.3	99.3	85.4	194.6	124.8	84.8	66.9	82.0	214.3	20.5	32.8	85.4	0.0	214.3
2008	2.7	6.6	32.7	135.5	245.6	160.0	38.2	40.4	23.7	65.6	160.5	69.4	81.7	2.7	245.6
2009	20.1	39.2	37.9	125.5	94.0	319.7	286.8	2.3	4.4	10.0	11.8	34.0	82.1	2.3	319.7
2010	4.3	36.9	37.3	41.1	230.6	259.9	49.6	38.4	66.3	61.3	116.5	43.5	82.1	4.3	259.9
2011	0.0	13.7	0.5	204.1	165.5	263.4	129.7	50.6	46.2	99.6	2.3	53.2	85.7	0.0	263.4
2012	1.3	1.8	13.0	45.7	247.5	193.4	36.9	24.5	23.8	184.9	13.5	16.3	66.9	1.3	247.5
2013	31.6	14.3	89.7	52.3	172.5	165.0	40.8	1.9	52.9	63.3	30.6	15.8	60.9	1.9	172.5
2014	56.3	73.0	68.1	82.3	379.2	229.6	69.1	54.4	37.3	64.5	63.0	34.5	100.9	34.5	379.2
2015	13.5	66.0	116.0	59.8	178.3	353.6	43.4	5.3	2.4	203.8	113.1	2.8	96.5	2.4	353.6
2016	0.0	1.3	250.4	58.2	103.1	226.8	39.6	36.7	50.2	99.5	3.3	3.4	72.7	0.0	250.4
2017	73.4	28.1	28.3	114.2	158.3	296.7	52.3	38.5	92.1	131.7	110.4	113.1	103.1	28.1	296.7
2018	0.0	25.2	0.0	40.5	197.0	251.6	6.4	26.1	75.0	160.2	63.1	24.0	72.4	0.0	251.6

Source: Ghana Meteorological Authority, 2019

Table 2.3: Rainfall Measured in Millimeters (mm) from 1981-2018 Sefwi Bekwai

Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average	Min	Max
1981	0.5	151.8	173.5	64.4	321.4	133	134.6	66.2	150.3	98.6	22.8	21.9	111.6	0.5	321.4
1982	0.0	64.8	192.3	50.8	227.6	259.4	152.9	57.6	2.5	138.9	67.1	10.2	102.0	0.0	259.4
1983	0.0	30.1	14.8	123.2	262.7	269.8	15.1	7.9	128.5	128.0	54.3	36.6	89.2	0.0	269.8
1984	15.5	58.2	153.3	60.7	182.7	223.1	74.5	193.3	175.2	214.5	55.1	52.3	121.5	15.5	223.1
1985	69.3	58.9	144.2	159.2	110.6	136.1	202.8	154.4	141.0	132.1	69.0	0.3	114.8	0.3	202.8
1986	0.0	54.9	150.0	120.5	125.0	138.7	108.4	45.5	243.8	88.2	82.9	0.0	96.5	0.0	243.8
1987	8.4	79.3	97.6	46.2	122.5	144.3	184.1	178.2	353.3	233.4	25.7	21.3	124.5	8.4	353.3
1988	0.0	6.8	176.5	93.6	130.3	292.5	132.6	37.1	131.7	173.8	72.2	20.4	105.6	0.0	292.5
1989	0.0	1.8	76.7	154.7	61.1	278.3	178.4	138.5	221.4	198.5	49.3	9.1	114.0	0.0	278.3
1990	24.1	148.1	44.2	127.0	114.9	220.7	37.0	25.1	128.8	193.8	51.5	237.1	112.7	24.1	237.1
1991	32.2	50.3	116.0	158.5	177.1	133.0	160.9	255.1	74.0	63.3	67.4	0.7	107.4	0.7	255.1
1992	0.0	0.0	0.0	205.7	212.7	132.9	80.1	0.0	208.4	177.0	76.2	0.0	91.1	0.0	212.7
1993	0.7	91.4	191.4	75.5	126.1	187.3	174.2	133.6	196.0	233.1	125.1	15.8	129.2	0.7	233.1
1994	15.4	22.5	142.0	151.1	220.5	161.3	74.4	28.5	116.5	396.5	58.5	2.2	115.8	2.2	396.5
1995	0.0	7.9	122.6	369.9	154.9	211.9	135.8	195.6	86.9	123.3	128.6	56.7	132.8	0.0	369.9
1996	13.7	125.8	163.7	188.2	264.7	191.0	189.9	137.5	54.8	159.7	96.9	12.2	133.2	12.2	264.7
1997	16.8	34.5	140.1	236.6	188.1	265.6	48.1	39.5	92.0	169.1	74.3	47.5	112.7	16.8	265.6
1998	52.0	26.7	61.1	88.9	196.4	257.3	55.7	61.3	127.1	231.3	112.4	86.9	113.1	26.7	257.3
1999	21.3	91.5	162.7	179.7	82.0	418.5	312.8	77.0	136.8	130.1	65.7	7.6	140.5	7.6	418.5
2000	19.2	28.5	141.8	200.5	222.6	265.7	83.7	112.3	141.5	24.4	78.1	1.7	110.0	1.7	265.7
2001	0.0	22.5	138.2	234.6	102.0	293.1	101.0	120.8	97.7	83.1	29.2	30.7	104.4	0.0	293.1
2002	15.3	0.9	99.1	138.8	241.3	190.0	223.9	92.1	103.1	103.7	56.4	42.0	108.9	0.9	241.3
2003	57.6	50.8	72.0	132.9	197.8	257.9	41.4	71.2	74.7	296.3	164.8	55.6	122.8	41.4	296.3
2004	0.0	0.0	0.0	42.7	107.0	102.0	194.4	0.0	212.0	223.7	77.8	0.0	80.0	0.0	223.7
2005	8.9	21.5	190.7	116.0	195.7	268.3	5.3	120.0	73.8	158.5	110.2	0.0	105.7	0.0	268.3
2006	43.5	111.5	87.0	169.9	296.4	146.7	131.5	104.0	136.6	159.5	15.3	46.7	120.7	15.3	296.4
2007	0.0	21.6	59.4	172.3	157.6	181.4	210.8	92.6	137.7	259.1	71.3	1.8	113.8	0.0	259.1
2008	0.0	84.3	143.6	146.8	244.7	224.7	132.2	40.7	193.1	251.1	36.5	128.0	135.5	0.0	251.1
2009	3.4	101.2	143.4	129.3	162.1	366.2	88.6	57.3	28.5	94.8	152.3	65.0	116.0	3.4	366.2
2010	40.3	74.4	199.7	189.9	196.7	130.0	150.9	75.6	153.8	182.5	51.0	53.2	124.8	40.3	199.7
2011	0.0	89.5	162.6	165.5	166.3	236.6	117.7	39.2	225.6	164.8	77.9	0.0	120.5	0.0	236.6
2012	55.1	90.0	44.5	93.3	187.3	227.5	141.1	17.9	197.7	178.2	108.9	14.0	113.0	14.0	227.5
2013	0.0	41.0	94.4	215.7	146.8	-	140.1	23.3	230.5	200.1	151.9	13.8	114.3	0.0	230.5
2014	58.4	52.2	159.3	180.2	194.9	244.1	171.9	43.7	278.2	-	153.5	55.7	144.7	43.7	278.2
2015	28.6	92.6	76.9	200.7	180.7	232	79.8	21.1	68	330.9	136.5	49.6	124.8	21.1	330.9
2016	0.0	19.5	172.0	56.5	213.5	143	67.1	35.4	164.1	223.1	71.3	52.1	101.5	0.0	223.1
2017	15.4	36.9	77.4	119.0	140.9	236.2	159.1	67.8	141.6	201	145.6	52.0	116.1	15.4	236.2
2018	2.7	117.3	176.4	202.9	202.0	233.5	160.3	125.2	292.0	197.3	128.2	4.3.0	153.5	2.7	292.0

Source: Ghana Meteorological Authority, 2019

Table 2.4: Rainfall measured in Millimeters (mm) from 1981-2010 for Sunyani

Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average	Min	Max
1981	0	0	0	32.8	38.3	0	1.5	0	11.9	54.9	0	0	11.6	0.0	54.9
1982	0.0	76.5	135.3	151.9	80.0	188.0	82.2	14.7	65.0	141.2	18.8	0.0	79.4	0.0	188.0
1983	0.0	7.1	55.8	166.4	182.4	175.0	11.5	7.4	111.2	42.6	2.8	45.0	67.3	0.0	182.4
1984	0.0	13.5	0.0	83.8	170.2	152.9	187.4	114.9	173.9	88.6	6.6	2.8	82.9	0.0	187.4
1985	17.3	0.0	145.3	102.0	66.6	226.3	184.9	115.8	248.0	262.9	60.9	0.0	119.2	0.0	262.9
1986	0.0	66.3	229.0	67.2	209.8	150.4	122.4	75.4	164.9	319.4	12.5	0.0	118.1	0.0	319.4
1987	7.8	92.3	99.0	78.9	133.3	364.7	96.9	178.2	296.1	138.5	12.7	0.0	124.9	0.0	364.7
1988	0.0	20.7	176.1	86.7	125.4	93.2	248.1	63.2	135.5	51.2	6.4	1.4	84.0	0.0	248.1
1989	0.0	0.2	171.3	155.2	94.7	246.8	106.4	186.3	157.6	157.5	15.6	6.8	108.2	0.0	246.8
1990	0.0	87.3	20.4	185.0	74.3	167.5	48.2	26.9	92.1	133.8	72.9	207.4	93.0	0.0	207.4
1991	20.3	44.5	102.0	143.2	196.3	124.7	99.7	74.5	172.9	126.0	14.2	25.0	95.3	14.2	196.3
1992	0.0	10.2	17.7	188.4	157.2	146.9	83.8	1.5	203.5	138.3	54.2	0.5	83.5	0.0	203.5
1993	0.0	61.0	78.9	112.7	245.7	154.0	19.8	17.9	186.1	151.0	44.3	8.3	90.0	0.0	245.7
1994	14.2	24.6	71.5	100.7	116.6	139.7	16.2	17.0	190.1	223.7	47.6	0.0	80.2	0.0	223.7
1995	0.0	32.0	144.0	268.7	155.5	156.2	108.7	103.2	201.0	150.4	39.4	41.9	116.7	0.0	268.7
1996	0.0	159.7	96.0	135.0	113.3	224.4	128.6	125.5	62.0	186.0	14.8	11.6	104.8	0.0	224.4
1997	24.5	0.0	57.8	59.2	130.1	218.9	94.9	53.7	83.1	164.9	17.6	18.6	76.9	0.0	218.9
1998	5.6	4.9	34.6	136.9	58.4	195.2	57.0	45.1	165.6	243.1	6.5	23.7	81.4	4.9	243.1
1999	20.5	74.1	152.4	139.9	162.9	129.6	34.6	83.6	156.8	136.5	86.3	0.0	98.1	0.0	162.9
2000	27.4	0.0	62.3	243.0	104.6	124.3	101.6	118.4	75.0	59.2	101.1	0.0	84.7	0.0	243.0
2001	0.0	10.1	134.2	398.4	76.3	311.3	56.3	31.5	112.1	70.4	26.1	10.6	103.1	0.0	398.4
2002	30.1	30.2	102.9	262.4	179.1	172.2	97.3	44.7	67.6	152.5	77.1	7.0	101.9	7.0	262.4
2003	22.5	63.8	56.0	204.6	144.7	232.7	31.9	50.7	228.5	211.0	78.6	0.0	110.4	0.0	232.7
2004	14.6	56.9	48.1	137.8	177.1	59.4	94.9	137.7	280.8	253.7	52.8	0.0	109.5	0.0	280.8
2005	1.1	46.9	108.6	123.6	113.8	112.4	73.6	40.6	142.5	233.7	56.9	29.4	90.3	1.1	233.7
2006	47.2	6.3	106.5	64.9	182.7	248.5	84.4	14.9	106.3	266.4	14.9	7.6	95.9	6.3	266.4
2007	0.6	19.0	116.2	161.0	137.6	217.4	146.7	100.4	330.3	140.5	87.8	0.0	121.5	0.0	330.3
2008	0.0	41.4	49.8	204.8	132.7	173.8	81.5	154.2	219.6	188.5	40.0	39.3	110.5	0.0	219.6
2009	0.0	53.7	161.2	154.2	151.0	189.3	172.1	8.5	86.3	112.7	203.1	14.0	108.8	0.0	203.1
2010	0.0	28.6	115.7	203.4	141.2	293.0	158.6	91.1	151.1	139.1	64.8	0.0	115.6	0.0	293.0

Table 2.5: Rainfall Measured in Millimeters (mm) from 1981-2018 for Wa

Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average	Min	Max
1981	0.0	0.0	90.8	29.5	160.2	85.6	109.5	135.9	98.2	45.3	0.0	0.0	62.9	0.0	160.2
1982	0.0	19.4	26.0	119.0	58.7	116.4	221.8	230.9	126.0	29.0	34.8	0.0	81.8	0.0	230.9
1983	0.0	6.8	20.9	83.7	85.8	89.8	116.2	55.7	139.1	68.7	0.5	0.0	55.6	0.0	139.1
1984	0.0	0.0	40.6	64.3	129.1	137.8	166.8	148.5	179.0	63.6	1.8	0.0	77.6	0.0	179.0
1985	0.0	0.0	72.7	77.5	130.4	155.6	186.1	224.7	193.8	0.0	18.9	0.0	88.3	0.0	224.7
1986	0.0	2.3	8.0	33.2	69.2	59.2	107.8	101.2	134.0	24.9	2.2	0.0	45.2	0.0	134.0
1987	0.0	0.0	18.6	30.3	30.4	103.9	96.5	293.9	104.5	97.3	0.0	0.0	64.6	0.0	293.9
1988	0.0	0.9	1.1	74.9	114.1	139.9	230.1	0.0	193.1	64.4	6.9	0.0	68.8	0.0	230.1
1989	0.0	0.0	43.5	41.9	92.8	151.8	114.0	237.5	218.9	105.1	0.0	37.0	86.9	0.0	237.5
1990	0.0	0.0	0.0	83.2	167.6	81.8	175.1	248.2	106.2	15.9	12.6	7.8	74.9	0.0	248.2
1991	0.0	0.4	23.0	115.1	171.5	80.4	236.9	186.1	63.1	130.8	0.0	0.0	83.9	0.0	236.9
1992	0.0	0.0	0.0	28.2	136.6	205.3	124.6	99.2	170.3	66.7	21.4	0.0	71.0	0.0	205.3
1993	0.0	2.5	18.8	152.7	83.9	156.8	183.6	306.5	159.5	64.6	0.7	0.0	94.1	0.0	306.5
1994	0.0	0.0	17.1	38.8	154.1	176.2	132.0	101.1	245.0	130.7	3.8	0.0	83.2	0.0	245.0
1995	0.0	1.9	17.4	101.8	175.5	123.6	188.5	319.3	229.5	68.2	8.6	8.3	103.6	0.0	319.3
1996	0.0	0.0	26.4	34.1	133.1	94.6	135.8	471.4	195.9	108.2	0.0	0.0	100.0	0.0	471.4
1997	0.0	0.0	39.2	98.0	188.4	290.5	124.7	128.7	277.8	191.2	18.4	0.0	113.1	0.0	290.5
1998	0.0	11.4	0.0	66.2	55.0	96.7	117.5	264.7	113.2	42.2	0.0	0.0	63.9	0.0	264.7
1999	5.8	68.9	39.2	60.1	91.9	250.0	150.3	192.7	353.1	75.8	1.1	0.0	107.4	0.0	353.1
2000	67.5	0.0	1.2	76.2	85.0	243.7	150.2	213.6	229.1	73.3	0.0	0.0	95.0	0.0	243.7
2001	0.0	0.0	0.0	85.7	210.9	191.6	84.5	269.8	136.5	26.0	0.0	0.0	83.8	0.0	269.8
2002	0.0	0.0	7.6	95.4	129.9	122.0	240.1	157.5	131.9	41.7	4.6	0.0	77.6	0.0	240.1
2003	0.0	11.7	16.7	99.9	178.8	219.4	91.1	220.8	272.6	76.5	16.9	0.0	100.4	0.0	272.6
2004	26.6	24.7	37.9	84.2	105.0	103.0	177.7	288.6	178.7	87.6	7.3	0.0	93.4	0.0	288.6
2005	0.0	0.0	18.6	186.0	149.2	135.3	121.2	200.3	215.0	34.6	0.0	0.0	88.4	0.0	215.0
2006	35.9	13.8	18.0	50.3	41.0	143.3	100.9	304.5	219.4	83.3	0.0	0.0	84.2	0.0	304.5
2007	0.0	0.0	17.4	156.9	198.0	72.4	121.7	186.5	103.2	113.1	26.9	0.0	83.0	0.0	198.0
2008	0.0	0.0	43.8	80.0	109.3	109.1	219.9	186.5	277.7	117.4	0.0	0.0	95.3	0.0	277.7
2009	0.0	0.0	38.8	78.4	103.9	228.6	162.7	190.7	215.1	111.7	1.5	0.0	94.3	0.0	228.6
2010	0.0	4.0	0.0	186.9	145.4	48.4	123.2	294.8	156.5	70.6	1.8	0.0	86.0	0.0	294.8
2011	0.0	8.8	17.8	58.2	124.2	131.1	104.2	228.5	208.6	63.1	1.5	0.0	78.8	0.0	228.5
2012	0.0	7.1	7.3	67.9	139.1	112.0	138.9	138.8	319.9	145.6	2.2	0.0	89.9	0.0	319.9
2013	0.0	64.1	72.6	112.6	95.5	50.0	120.6	251.5	164.5	103.0	10.2	0.0	87.1	0.0	251.5
2014	0.0	0.0	25.8	113.8	79.1	181.5	71.2	130.3	224.3	51.8	36.6	0.0	76.2	0.0	224.3
2015	0.0	2.0	6.8	24.7	71.2	77.5	80.5	226.5	205.3	117.1	0.0	0.0	67.6	0.0	226.5
2016	0.0	0.0	49.8	11.6	-	-	-	-	-	-	-	-	15.4	0.0	49.8
2017	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2018	0.0	93.7	25.9	80.3	136.4	164.7	122.7	361.0	180.3	130.8	0.0	0.0	108.0	0.0	361.0

Source: Ghana Meteorological Authority, 2019

2.2.4 Watersheds

Ghana is drained by the Volta, South-Western and Coastal Rivers Systems covering 70%, 22% and 8%, respectively, of the total area of the country. The Volta River System comprises the White, Black and Red Volta and Oti Rivers. The South-Western Rivers System comprises the *Bia, Tano, Ankobra and Pra Rivers*. The Coastal Rivers System comprises the *Kakum/Bruku, Ochi-Nakwa, Ayensu, Densu, Odaw and Tordzie/Aka Rivers*. Ghana shares the Volta River basin with Burkina Faso, Togo, Cote d'Ivoire and Mali. It also shares the Bia and Tano River basins with Cote d'Ivoire. The total annual runoff for Ghana is about 54.4 billion m^3 out of which the Volta, South-western and Coastal Rivers Systems contribute a total of 38.3 billion m^3 in the proportions of 64.7%, 29.2% and 6.1%, respectively.

2.2.5 The Black Volta River Basin

The Black Volta River Basin is a trans-national river system that stretches from the north to the south through Mali, Burkina Faso, Ghana and Cote d'Ivoire, and from the west to the east, Burkina Faso, Cote d'Ivoire and Ghana. The basin is drained by the Bougouriba, Gbongbo, Grand Bale, VounHou, Sourou, Wenare, Bambassou, Bondami, Mouhoun (main Black Volta), Tain and Poni rivers as main tributaries. The Ghana portion of the basin covers an area of 18,384 km^2 constituting 14% of the basin and six (6) sub-catchments which are Lerinord, Nwokuy, Bui, Dapola, Noumbiel and Bamboi.

2.2.6 Densu Basin

The Densu Basin is located at the South-Eastern part of Ghana and lies within longitudes 10 30'W -10 45'W and latitudes 50 45'N - 60 15'N. It shares its catchment boundary with the Odaw and Volta Basins to the east and north, the Birim in the northwest and the Ayensu and Okrudu in the west. The Densu River Basin has an area of 2,490 km^2 and spans 11 Local Government Assemblies in three regions (i.e. Central Region, Eastern Region and the Greater Accra Region). There are about 200 settlements in the Basin and the total population is over 600,000, with a density of 240 persons per km^2. The density is higher than the national average of about 100 persons per km^2. The main economic activity is agriculture, which engages about 40% of the economically active population.

The vegetation consists of coastal savannah, thicket and grassland in the south, and moist semi-deciduous forest in the north. The river takes its source from the Atewa Range near Kibi and flows for 116 km into the Weija Reservoir before entering the Gulf of Guinea through the Densu Delta Ramsar Site. The mean annual runoff is 500 x 106 m^3. The Densu River is of specific importance since it includes the Weija Reservoir which supplies water for approximately half of the Accra Metropolitan Area. From the source to the Gulf of Guinea, the Densu River traverses upper Birimian rocks (phyllites, schists, tuffs and grey wackes) in the upper reaches, middle Birimian rocks (granites and granodiorites) in the middle segments and Togo series (quartzites, shale and phyllites) in the lower portions. The Densu Basin is generally low lying with undulating topography and isolated ridges forming the characteristic landscape features in many places.

The soils are mainly well-drained, friable, porous, loamy savanna Ochrosols mostly red or reddish brown in colour. They are generally low in nutrients especially phosphorus and nitrogen. In the northern parts of the Basin are forest Ochrosols, red or reddish-brown, orange-brown or brown in colour with adequate amounts of nutrients. Animals such as deer, African python, alligators, antelopes and crocodiles used to be common in the Basin but all are now extinct. These animal species have been replaced by grasscutters and rats. There are about 18 fish species in the Densu including the Weija Reservoir. However, the most commonly fished species are Tilapia and Mud-fish. The map below shows the topography of the Basin.

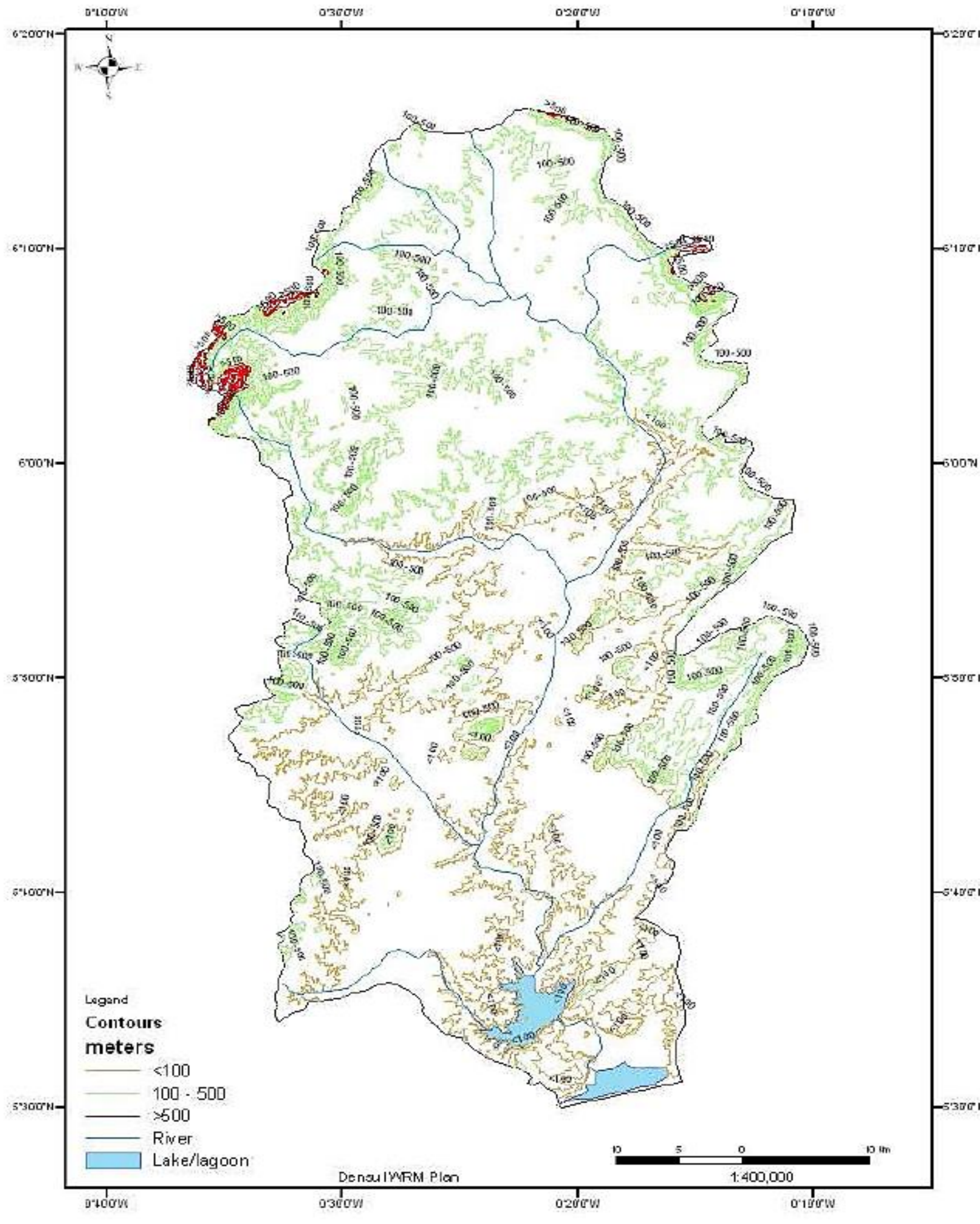
2.2.7 Pra Basin

The Pra Basin is located between Latitudes 50 N and 70 30’ N, and Longitudes 20 30’ W, and 00 30’ W, in south-central Ghana. The drainage network comprises the main Pra and its major tributaries of Birim, Anum, and Offin rivers and their tributaries. The drainage area is about 22,106km2, with an average elevation of about 300m and generally less than 600m above sea level. It features the Lake Bosomtwe, which is a natural lake that stands out as a prominent protected area. It is believed to have been created as a result of a meteoritic impact and is an object of intense interest to both national and international researchers. It is also a significant tourist site.

The Offin sub-basin is the main source of water supply to Kumasi and its environs, through two reservoirs, namely Barekese and Owabi dams. The Birim sub-basin is located predominantly in the Eastern Region and has attractive historic places and nine forest reserves. For instance, the Esen Epan forest reserve near Akim Oda is a tourist site with the biggest tree in West Africa at 12m in circumference and 66.5m tall.

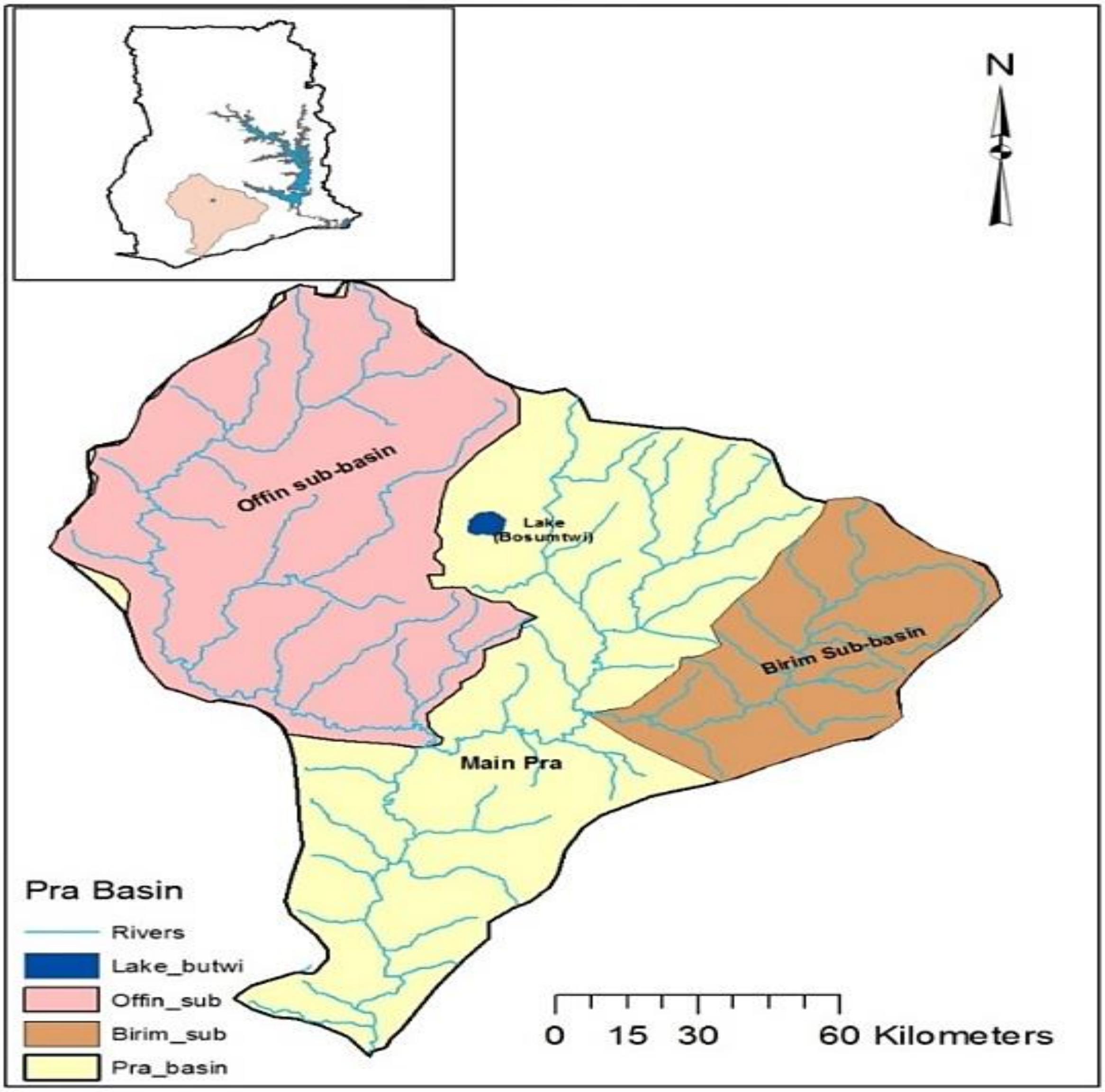
The Pra River and its tributaries constitute a major source of water supply to communities within the basin. The major tributaries are perennial and constitute all-year-round reliable water source. However, human activities such as mining, logging etc. are having adverse impacts and degrading the surface water resources of the basin. The Pra Basin is one of the most extensively and intensively used river basin areas in Ghana in terms of settlement, agriculture, logging and mining. The basin contains most of the large cocoa growing areas in the Eastern, Ashanti, and Central regions.

Map 2.2 Topography of the Densu Basin



Source: WRC, 2007

Map 2.3: Pra and Sub-Basins

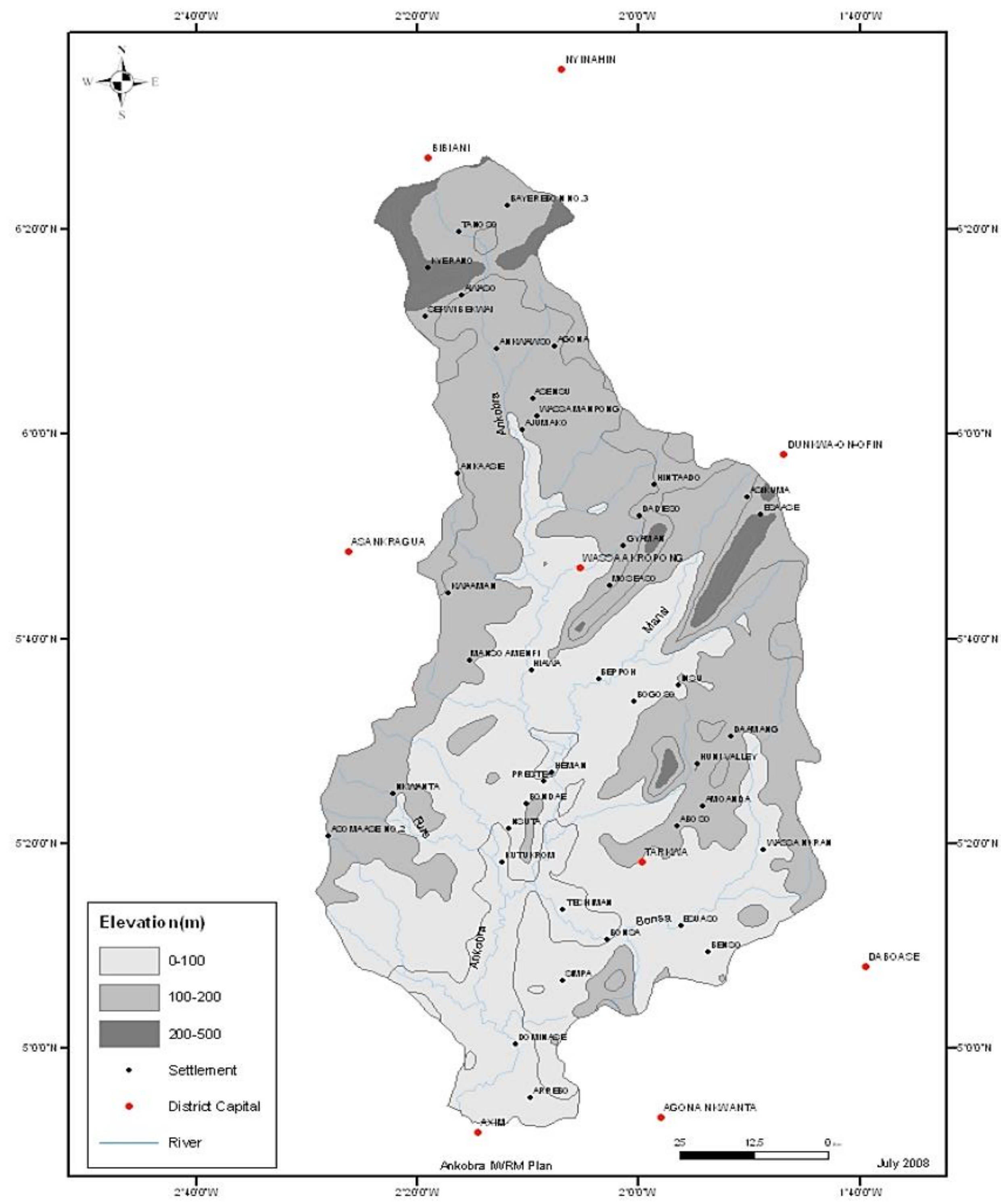


Source: WRC, 2007

2.2.8 Ankobra Basin

The Ankobra Basin is one of the south-western basins of Ghana. It is located within latitudes 4o 52'N and 6o 27'N, and longitudes 1o 42'W and 2o 33'W. It is bounded to the East; West and South by the Pra Basin, Tano Basin and the Gulf of Guinea, respectively. The basin has an area of 8,403 km^2 spanning 11 districts in three regions with Wassa Amenfi, Wassa West and Nzema East Districts making 81% of the total area. The basin falls under the South-Western Equatorial and the Wet Semi-Equatorial climatic regions. The South-Western Equatorial is the wettest climatic region in Ghana with mean annual rainfall above 1900mm. The vegetation of the basin comprises the Rain forest as well as the Moist-semi deciduous forest.

Map 2.4: Topography of Ankobra Basin



Source: WRC, 2007

2.3 Geological and geographical information

Ghana is located along the Gulf of Guinea and the Atlantic Ocean in the sub-region of West Africa. The geology of the country falls mainly within the Precambrian Leo-Man Shield of West Africa. Ghana can be subdivided into four distinct major lithostratigraphic/lithotectonic complexes:

i. Paleoproterozoic supercrustal and intrusive rocks which was formed between 2195 Ma and 2072 Ma;
ii. Neoproterozoic to Early Cambrian, lithologically diverse platform sediments (Voltaian Supergroup), consisting of 1000 Ma to 950 Ma old Kwahu- 'Morago' (Bombouaka) Group at the base, followed after a hiatus of 300 Ma by the Oti-Pendjari Group, which was deposited after 630 Ma, and the late Neoproterozoic to Early Cambrian Obosum Group at the top;
iii. Rocks of the Panafrican Dahomeyide orogenic belt, which include-listed according to increasing degree of deformation and metamorphism - the Buem Structural Unit, the Togo Structural Unit, as well as variety of gneisses of the Dahomeyan Supergroup (peak metamorphism at c.600 Ma) and some interleaved Eburnean protoliths; and
iv. Isolated and spatially restricted coastal sedimentary basins of Ordovician to Cretaceous age, mostly related to the opening of the Atlantic or proto-Atlantic Ocean (Sekondian Group, Accraian Group, Amisian, Apollonian Group).

The Birimian Supergroup comprises belt and basin terrains that are respectively made up of dominantly tholeiitic basalts (Hirdes et al., 1993; Zitzmann et al., 1997), minor andesites (Loh and Hirdes, 1999) and rhyolites, and folded metasediments comprising wacke, argillite, chemical sediments and volcanoclastics (Hirdes et al., 1993). The Tarkwaian Group comprises primarily a sequence of folded, faulted and metamorphosed sandstones, conglomerates and shale (Sestini, 1973; Eisenlohr and Hirdes, 1992).

The intrusive rocks comprise both granitoid and mafic types. The granitoid intrusions are historically divided into the "belt" and "basin" types (Dixcove and Cape Coast granitoids, respectively). The "belt" granitoids are considered more commonly diorite to granodiorite, whilst "basin" types tend to be granodioritic to granitic in composition (Griffis et al., 2002). The Mafic intrusions occur in most of the volcanic belts of Ghana but are particularly abundant in the Ashanti Belt and to a lesser degree in the Sefwi Belt. Compositionally they are mostly gabbroic to pyroxenitic (Loh and Hirdes, 1999). The rocks of the Togo Structural Unit consist of chert, phyllite, quarzitic sandstone, quartzite, mica schist and minor sandstone.

The Dahomeyan Supergroup comprises mafic to felsic schists, gneiss and migmatites considered to have been metamorphosed during the Pan-African tectonothermal event (approximately 500 Ma). The Buem Structural Unit consists of a thick, lower sequence of clastic sediments with some carbonate and tillite units succeeded by clastics and volcanics that include mafic flow units and pyroclastic rocks (Kesse, 1985).

The Voltaian Supergroup consists mainly of flat lying or very gently dipping sediments that apparently defines the eastern margin of a large West African cratonic block and sits on a major Precambrian erosional unconformity. The Voltaian Supergroup is subdivided into the lower Bombouaka Group, the middle Oti-Pendjari Group and the upper Obosum Group. The lower Bombouaka Group is approximately 1000m thick and dominated by mature sandstones and a central section of siliceous and clay-rich units.

The middle Oti-Pendjari Group sediments is about 2500m thick succession and include a distinctive lower sequence with tillite and sandstones, carbonate, and fine-grained cherty sediments (silexite). The upper Obosum Group is only about 500 m thick and consists of a basal section that also includes glacial tillites. These are overlain mainly by cross-bedded quartz sandstones with subordinate shale and mudstones which are now interpreted to represent a foreland molasse basin (Affaton et al., 1980). The rocks of the Accraian Group are composed of sandstone interbedded with shale, finely laminated mudstone and medium grained thickly bedded sandstone. They cover approximately 28 square miles in the vicinity of Accra. The rocks of the Sekondian Group consist of feldspathic sandstones, siltstones and shales. The rocks of the Amisian Group consist of conglomerate, micaceous sandstone, arkose and mudstone. The rocks of the Apollonian Group consist of limestone, marl, mudstone with intercalated sandy beds. Sedimentation in coastal basins continued as evidenced by Tertiary and Quaternary clastic sediments widespread in the Keta and Tano basins.

2.3.1 Geographical Conditions

This section provides information on Ghana's geographical conditions such as the area, elevation and length of marine coastline, among others as presented in Table 2.6.

Ghana's coastal area is a low lying plain rising from the Atlantic coast and the altitude is generally low not more than 200 m above sea level except in the east. It has a narrow continental shelf extending outward to between 20 and 35 km, except off Takoradi where it reaches between 80 and 90 km. The Economic Exclusion Zone (EEZ) of 200 nautical miles has a surface area of nearly 200,000 km^2. The coast consists of low-lying plains and sandy shores which is interspersed with rocky shores, numerous lagoons (92 in total), and estuaries. The area is also intersected by several rivers and streams, most of which are navigable only by canoe. Two large capes (Cape Three Points on the west and Cape St. Paul on the east) are important landmarks along the coast. Each of the four coastal regions has different vegetation cover, western-tropical rain forest, Central and Greater-Accra-coastal savannah, and Volta-guinea savannah.

Table 2.6: Geographical Conditions of Ghana

1	Total Land Area of Ghana	238,535 km^2
2	Length of Coastline	539 kilometers
3	Total Continental Shelf Area	24,300 km^2
4	Mangrove area (2005 est.)	12,400 ha
5	Highest Point of Elevation	Mount Afadjato (885 m)
6	Marine Protected Areas	No record

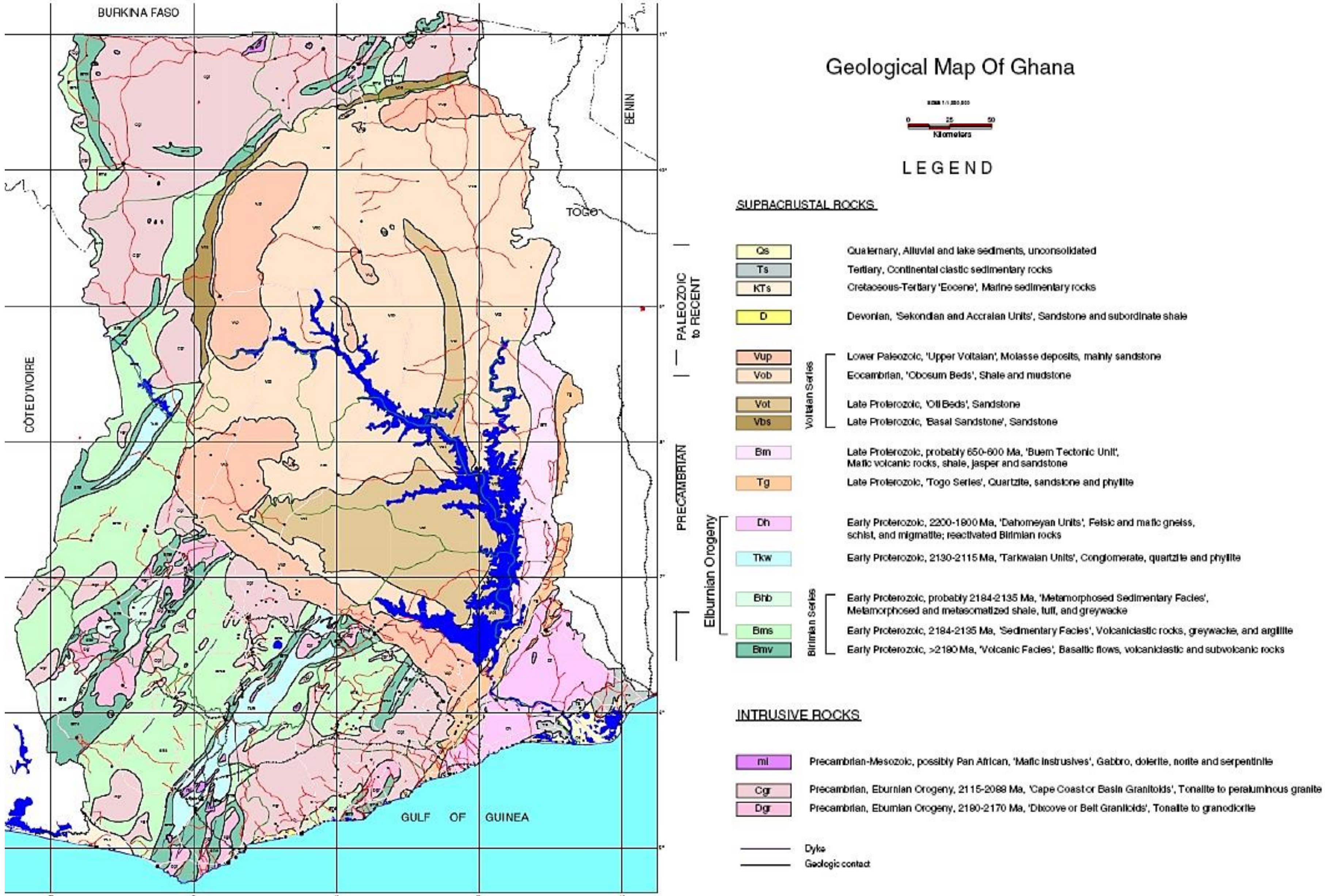
Source: Marine Fisheries Research Division, 2003

2.3.2 Geological Conditions of Ghana

Ghana is located along the Gulf of Guinea and the Atlantic Ocean, in the sub-region of West Africa. Ghana falls mostly within the Precambrian Leoman Shield of West Africa. The main Precambrian rock units existing in Ghana are the metamorphosed and folded Birimian, Tarkwaian, Dahomeyan System, the Togo Series and the Buem Formation. The Precambrian rocks are overlain by late Proterozoic to Paleozoic rocks of the Voltaian System. Rock units, which are younger than the Voltaian System and occur at several places along the coast include the Early or Middle Devonian Accraian series, Mid Devonian-Lower Cretaceous Sekondian Series, Upper Jurassic to Lower Cretaceous Amisian Formation, Upper Cretaceous, Apollonian Formation, Tertiary to Recent unconsolidated marine, coastal, lagoonal, fluviatile sediments and deposits. Intruded into the Birimian rocks are large masses of granitoids known as the Cape Coast and Winneba rock types, Dixcove rock types and Bongo granitoids found mainly in the northern part of the country.

The Country is divided into five geological domains or provinces namely; the Western Unit, the South Eastern Unit, the flat lying Central Unit, the Coastal Basins, and the Tertiary to Recent deposits. These divisions are based on age, tectonics and lithologic characteristics.

Map 2.5: Geological Map of Ghana



Source: Geological Survey Department

2.3.3 Soil Characteristics

The interim Ghana soil classification system (Brammer, 1962) identified forty-two (42) dominant soil groups. The dominant ones include the Forest Ochrosols (Acrisols & Lixisols World Reference Base (WRB)[8], 1998), Savanna Ochrosols (Acrisols, Lixisols, Nitisols & Plinthosols WRB, 1998) and Forest Oxysols (Acrisols & Ferralsols WRB,1998). They are deeply weathered soils belonging to the Latosol soil group family at the preceding higher level. They are similar to the Zonal soils described in the broad soil classification system of Vine (1966), and by Webster and Wilson (1980). Other extensive soils include the Groundwater Laterites (Plinthosols & Lixisols – WRB, 1998), Tropical Black Earths (Vertisols & Cambisols–WRB,1998) and Tropical Grey Earths (Solonetz –WRB,1998), as noted by Adjei-Gyapong and Asiamah (2002). The soils of Ghana have also been studied extensively and correlated to the international soil classification systems, such as the WRB Ahenkorah et al (1994) and Amatekpor and Dowuona (1998).

2.3.3.1 Forest Ochrosols

The soils of the Forest Ochrosols (Acrisols, Lixisols – WRB, 1998) are deeply weathered soils found in the semi-deciduous forest and parts of the forest-savanna transition agro-ecological zones of Ghana. These zones stretch from Wa to the East along the middle portions of the country across the Volta Lake. Together, the soils cover an extensive area of 3,144,575 ha. The soil profiles are matured and often show clay accumulation in the subsoil. They consist of thin (about 20 cm), dark greyish brown, humus-stained, sandy loam and silt loam top soils which are usually moderate fine granular in structure and friable in consistency. The sub soils are thick, often more than 120 cm thick over the weathered substratum. They may be red or brown to yellowish brown showing faint mottles as influenced by physiography and internal drainage. Coarse and prominent mottles occur in plinthic horizons.

The texture of the subsoil is highly variable. It may be sandy clay loam, silty clay loam, sandy clay or silty clay with common to many (10-40%) quartz gravels and stones and hard iron and manganese dioxide concretions. The soils are moderate to strong medium subangular blocky to angular blocky structured with a firm to very firm consistency. Non-gravelly, none-concretionary materials of about 50-120 cm thick from the surface may develop in what is locally termed as drift materials on small hills and upland depressions. Soil colour is an important criterion in grouping these soils at the succeeding lower taxonomic level (Great soil subgroup) under which we have Red and Yellow Forest Ochrosols. These are further subdivided according to parent material and topography with its influence on soil colour (topohydro sequence) into

[8] http://www.fao.org/soils-portal/soil-survey/soil-classification/world-reference-base/en/ | accessed Wednesday 6, 2019 at 20:30hrs

various soils series. These soils are suitable for a wide range of crops especially tree crops such as cocoa, coffee, oil palm, para-rubber, citrus and food crops such as plantain, cocoyam, maize, yam and cassava.

Soil management measures should involve mixed cropping, use of cover crops and mulching to maintain organic matter and surface moisture and check runoff, agroforestry, manuring and inorganic fertilizer application to boost the fertility status of the soil, planting along the contour and minimizing clearing of forest during mechanized cultivation because of the steep slopes and the presence of gravels and ironstone concretions within the plough layer.

2.3.3.2 Forest Oxysols

The Forest Oxysols (Acrisols, Ferralsols – WRB, 1998) cover approximately 647,773 ha land area and are mainly found in the high rainforest zone and consist of moderately shallow to deep, highly weathered, yellowish brown, well-drained, gravelly and concretionary to light or gritty clay upland soils developed over phyllite or biotite granite with silty clay loam textures. In some areas, the soils are very deep, well-drained, gravel-free, yellowish brown sandy clay loams developed from Tertiary sands. All the Forest Oxysols exhibit chemical properties that show little variation from each other. They are severely leached of bases, as a result, the pH values vary from 4.1 to 5.5. The CEC does not exceed 13 cmol(+)kg with kaolinite as the dominant clay mineral. Organic carbon is generally more than 1% in the A horizon decreasing to less than 10g/kg in the subsoil. Total N varies from 0.5% in the A horizon to as low as 0.35 g/kg in the lower horizons. The soils are suitable for the cultivation of both tree crops such as oil palm, rubber, citrus and coconut as we as arable crops which include cassava, pineapple and groundnut.

The soils are susceptible to erosion and hence soil management measures should be adhered to. Topsoil clearance should be kept to the barest minimum because of the heavy rainfall within the High Rain Forest Agroecological Zone, where these soils occur. This will maintain the fragile topsoil structure, check erosion through reduced runoff and maintain the nutrient status. This conservation measure must be rigidly observed for soils on steep slopes. Cultivation of plantation crops with closed canopies must be encouraged to reduce direct impact by raindrops. Mixed cropping systems are also recommended. Liming to bring the pH to appropriate levels and to improve the fertility status is necessary for most arable crops.

2.3.3.3 Savanna Ochrosols

The soils of the Savannah Ochrosols (Acrisols, Lixisols, Nitisols, Plinthosols – WRB, 1998) are similar to the Forest Ochrosols except that they occur in the savanna areas with semi-arid climatic conditions. Together, they cover an area of about 2.35m ha. Though the soils are moderately deep to deep, the solum is relatively thinner than the forest counterparts. Decomposing rock or hard rock may be encountered within 150 cm depth. The topsoils are generally thin.

The Savanna Ochrosols have generally low organic matter due to insufficient accumulation of biomass (less than 2% in the topsoil) under savanna conditions. Soil reaction ranges from near neutral, pH 6.0 – 7.0 in the A horizon, becoming slightly to moderately acid with depth. Cation exchange capacity is generally between 1 and 15 cmol(+)/kg. Morphologically, the soils consist of three major groups namely, the shallow to very shallow, the moderately shallow to moderately deep, and the deep to very deep soils.

The shallow to very shallow phase are susceptible to erosion and are marginal and therefore are best left under the natural vegetation or used as pasture. The moderately shallow to moderately deep, and the deep to very deep soils are suitable for tree crops like cashew and mango, and arable crops like yam, guinea corn, millet, maize, cowpea and groundnut, cassava, pineapple etc., as well as suitable for pasture grazing. The bulk of the country's food crops are grown on these soils. Soil management measures should include manuring, fertilizer application, especially N and P and crop rotation to improve and maintain the fertility status. Mulching, contour ploughing, strip cropping and terracing, especially on the upland members, should also be adopted to check erosion.

2.3.3.4 Groundwater Laterites

The Groundwater Laterites (Plinthosols, Lixisols) cover about 2.7 million hectares of land and occur over Voltaian shales and sandstones, granites and phyllites within the Interior Savanna and Transitional Zone where they constitute almost 50% of the soils in the zone. The soils are mostly found on a level to near level upper and lower slopes and consist of a thin pale-coloured, sandy or silty loam material overlying a vesicular, highly mottled in situ developed ironpan, which is underlain at varying depths by partially weathered or highly mottled material and mudstones or by phyllite or granite. The Groundwater Laterites have pH values similar to the Savanna Ochrosols; the surface layer is near-neutral with the surface being moderate to very acid. Organic and total nitrogen contents are below 20 g/kg and 0.3 g/kg, respectively. Cation exchange capacity (CEC) is generally less than 10 cmol(+)/kg due to presence of high activity clays.

The soils are shallow and very poor in fertility and therefore are unsuitable for large-scale mechanized cultivation of arable crops. However, they can be put under cultivation by using bullock plough or hand implements, given good management practices. However, the deep variants are suitable for mechanized cultivation of arable crops. Suitable crops on the shallow soils include rice and vegetables. Suitable crops on the deep soils include rice, sugar cane, maize, millet, guinea corn and groundnut. Pasture for livestock grazing may be undertaken on both variants. Soil management measures may involve manuring, application of fertilizers, crop rotation, involving especially leguminous crops, and mulching, strip cropping and leaving the residue after harvest.

2.3.3.5 Tropical Black Earths

The most extensive Tropical Black Earths (Vertisols and Cambisols) occur within the Coastal Savanna and the Interior Savanna agro-ecological zones of Ghana. Within the Coastal Savanna Zone where they cover about 70,0000 ha of land. The soils are developed over basic gneiss on low uplands and are associated on the valley flats by the plastic and acid variants. Within the Interior Savanna Zone, the soils are very limited in extent and occur in pockets and are underlain by basic intrusive rocks in the north-west and along the White Volta river to the extreme north-east of the zone. The soil reaction is near-neutral or moderately acid to acid in the topsoil and becomes increasing alkaline with depth because of the accumulation of calcium carbonate concretions. Iron-manganese concretions are also present in the subsoil. Organic matter content is less than 20 g/kg while total nitrogen is less than 1 g/kg. The clay content is more than 30% and CEC is greater than 30 cmol(+)/kg because of the dominance of high activity clays such as smectites and vermiculites.

The soils are very productive and can support a wide variety of crops given appropriate machinery and proper management practices. However, because of the presence of high activity clays (Vertisols), the soils become saturated with water during the rainy season and dry out almost completely, developing cracks, during the dry season making their cultivation with simple implements very difficult. The presence of vermiculite causes problems for K availability while the Fe-Mn concretions sorb a large amount of phosphorus. Arable crops like rice, cotton, sugar cane, cowpea and vegetables are suitable on these soils. Soil management measures should involve manuring, application of fertilizers, crop rotation, involving especially leguminous crops, and improved land preparation (such as cambered beds, ridges) to drain excess water and to conserve moisture during the dry season.

2.3.3.6 Tropical Grey Earths

The Tropical Grey Earths (Solonetz) are soils developed from acidic gneisses and schists at very gentle topography mainly within the Coastal Savanna Zone, especially in the South-eastern sections. These soils occur at upland sites and together cover about 150,000 ha of land within the zone. They are low in organic matter, total nitrogen and phosphorus. The pH is near neutral in the topsoils, becoming increasingly alkaline with depth. Exchangeable Na is uniquely high in the subsoil, especially below the clay pan. The CEC varies from 5 cmol(+)/kg in the topsoil to more than 20 cmol(+)/kg in the subsoil. Both kaolinite and smectites are present in these soils. They have a distinctive profile: the dark grey to greyish brown, porous sand or sandy loam topsoil of about 30 cm thickness is underlain by approximately 30 cm compact, hard claypan.

Below this layer, the soil is less than compact and contains calcium carbonate concretions and soluble salts. A stone-line at the base overlies a moderately to highly weathered gneiss or schist. Soils of the Tropical Grey Earths are not suitable for both tree and arable crops and therefore are to be left under pasture for grazing.

However, the Ghana classification system was designed in the 1950s and early 1960s (Brammer,1962). Only limited data on the soils of Ghana were available at that time. This could not support a comprehensive soil taxonomic system like the Soil Taxonomy (Soil Survey Staff, 1975; ISSS/ISRI/FAO, 1998). These later classification systems were based on the pedological processes to soil formation, which involves taking inventory of the soil morphological characteristics that may be observed in the field (ISSS/ISRI/FAO, 1998). Further details of the various types of soils in Ghana are provided in Table 2.7 and Annex 2.

Table 2.7: Types of Soils

No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/Extent (Ha)**	**Depth[1] (cm)**
1	**Central**	Acrisols			
			Abonku-eja/awuaya-nkansaku	29,623.6	>100
			Achimfu-kuntu/asokwa-suprudu	587.2	>100
		Acrisols			
			Asikuma-atewa/ansum-oda	522.8	>100
			Atukrom	14,284.2	>100
			Edina-bronyibima/benya-udu	10,375.3	>100
			Kumasi-asuansi/nta-ofin	339,639.8	>100
			Nzima-bekwai/oda	104,296.9	>100
		Arenosols			
			Keta-goi	1,563.9	55
		Cambisols			
			Apeosika-pershi	490.5	>100
		Fluvisols			
			Ayensu-chichiwere	7,090.2	>100
			Chichiwere-kakum	25,141.1	>100
		Leptosols			
			Adzintam-yenku	14,745.2	23
			Fete-bediesi	5629.088	90
			Nyanao-tinkong/opimo	7159.245	30
		Lixisols			
			Adawso-bawjiasi/nta-ofin	2,0997.3	>100
		Solonchaks			
			Oyibi-muni	3,912.7	>100
			Oyibi-muni/keta	1,940.8	>100
		Vertisols			
			Osibi-bumbi	8,779.8	>100
			Lagoon	1,665.5	>100

No.	Regions	Soil Order	Soil Group Family	Coverage/Extent (Ha)	Depth[1] (cm)
			Nsaba-swedru/nta-ofin	46,082.7	>100
2	Greater Accra	Acrisols			>100
			Manfe	168.1	>100
			Nyigbenya	2,052.6	>100
			Nyigbenya-agawtaw	4,776.7	>100
			Nyigbenya-haacho	32,865.6	>100
			Oyarifa-manfe	17,514.5	>100
		Arenosols			
			Goi	845.5	>100
			Keta	1,235.9	55
			Keta-oyibi	1,451.2	>100
		Cambisols			
			Amo-tefle	39,721.9	>100
			Ashaiman	77.7	>100
			Beraku-krabo	1,747.0	>100
			Toje	6,422.8	>100
			Toje-agawtaw	22,693.1	>100
		Fluvisols			
			Ayensu-chichiwere	11,452.4	>100
		Gleysols			
			Ada	502.9	>100
			Ada-oyibi	62,484.2	>100
		Leptosols			>100
			Fete	32,978.4	>100
			Fete-bediesi	29,344.2	90
			Kloyo	2,096.3	50
			Korle	4,323.2	>100
			Nyanao-tinkong/opimo	4,484.5	30
		Luvisols			
			Adawso-bawjiasi/nta-ofin	185,820.2	>100
		Luvisols			
			Aveime-ada	112,66.8	>100
			Aveime-zipa	2,568.7	>100
			Danfa-dome	1,776.9	>100
			Doyum-agawtaw	15,448.1	>100
			Simpa-agawtaw	51,899.9	>100
		Plinthosols			>100
			Chuim-gbegbe	911.7	>100
		Solonchaks			>100
			Oyibi-muni	9,997.2	>100
		Solonetz			>100
			Agawtaw	33,242.3	>100
			Songaw	2,176.7	>100
		Vertisols			>100
			Akuse	70,610.9	>100
			Alajo	467.4	>100
			Lupu	5,100.1	>100
			Tachem	4,285.0	>100
		N/A			
			Lagoon	15,264.6	
			Volta Lake	884,796.7	
				1866,138.7	
3	Oti	Acrisols			
			Nyankpala	11,060.7	>100
			Osumbi-didinla	8,028.7	>100
			Oyarifa-krabo	7,777.0	>100

No.	Regions	Soil Order	Soil Group Family	Coverage/Extent (Ha)	Depth[1] (cm)
			Techiman	5126.2	>100
		Arenosols			
			Ketre-sangebi/banda-chaiso	16,252.1	>100
		Cambisols		12,649.5	>100
			Amo-chichiwere/dayi-angela	12,649.5	>100
		Fluvisols			
			Adankpa	2,463.7	>100
			Nterso-zaw	3,408.0	>100
		Leptosols			
			Adomi-kpeyi	50,741.7	>100
			Agramma-nyanfo/torkor	7,160.9	>100
			Domanbin-denteso	54,777.8	>100
			Fete-salom	37,714.7	>100
			Fete-salom/abotakyi-kitasi	4,161.2	>100
			Kadjebi-wawa/ketre-konsu	3,739.2	>100
			Kintampo	50,56.9	20
			Salom-mate/banda-chaiso	18,650.9	>100
		Luvisols			
			Kpelesawgu	266,116.7	>100
		Luvisols			
			Dadiekro-lima	8,583.5	>100
			Ejura-amantin/denteso	59,248.8	>100
		Planosols			>100
			Blengo-botoku/kudzra-edo	101,477.5	>100
			Lima-volta	4,600.1	>100
		N/A		9,127.9	>100
			No data		
			Pegi-agu	1,850.8	>100
4	**Eastern**	Acrisols			
			Adujansu-bechem/nta-ofin	9,386.7	>100
			Atewa-ansum	44,333.3	>100
			Kumasi-asuansi/nta-ofin	12,082.5	>100
			Manfe-fete	11,769.0	>100
			Nzima-bekwai/oda	821.3	>100
			Oyarifa-krabo	11,644.4	>100
			Oyarifa-manfe	1,118.6	>100
			Wiawso-shi	716.4	>100
		Arenosols			
			Atewiredu	275.8	>100
			Atewiredu-katie	2,215.6	>100
			Bediesi-sikaben	53,452.9	>100
		Cambisols			
			Amo-chichiwere/dayi-angela	386.0	>100
			Amo-tefle	268.4	>100
		Fluvisols			
			Birim-awaham/kakum-chichiwere	142.8	>100
			Denteso-sene	13,432.5	>100
			Dewasi-wayo	16,839.5	>100
		Leptosols			
			Adomi-kpeyi	15,715.5	>100
			Fete-salom	9,260.3	90
			Kintampo	2,902.7	20
			Korle-okwe	1,567.2	>100
			Kowani-techiman-santaboma/bediesi	29,953.4	58
			Nyanao-tinkong/opimo	17,545.7	>100

No.	Regions	Soil Order	Soil Group Family	Coverage/Extent (Ha)	Depth[1] (cm)
			Wenchi-kumayili	17,730.6	>100
			Yaya	3,274.9	>100
			Yaya-bediesi-/bejua	94,629.3	>100
			Yaya-otrokpe	19,140.4	>100
			Yaya-pimpimso/bejua	11,129.1	80
		Lixisols			
			Adawso-bawjiasi/nta-ofin	40,00.8	>100
			Bediesi-sutawa/bejua	62,311.4	>100
			Bediesi-yaya/asuansi-atewa	11,860.9	>100
			Damongo-murugu-techiman	20,137.8	>100
			Damongo-techiman/ejura-sene	4,217.3	>100
			Kpelesawgu-changnalili/amantin	1,963.0	30
			Nankese-akroso/nta-ofin	2,064.9	>100
			Pimpimso-sutawa/bejua	14,592.0	>100
			Somusie-denteso	52,604.3	>100
		Luvisols			
			Ejura-amantin/denteso	1,076.4	>100
			Ejura-kpelesawgu/denteso	1,764.4	>100
			Nankese-koforidua/ nta-ofin	30,093.5	>100
			Simpa-agawtaw	1,232.5	>100
		Planosols			
			Ablade-kpelesawgu	5,449.2	>100
			Blengo-botoku/kudzra-edo	486.2	>100
		Regosols			
			Kungwani	403.3	>100
		Vertisols			
			Akuse	12,44.7	>100
		N/A			
			No data	52,125.8	
			Nsaba-swedru/nta-ofin	3,500.5	>100
			Pegi-agu	1,284.4	>100
5	**Ashanti**	Acrisols			
			Adujansu-bechem/nta-ofin	12,006.4	>100
			Akumadan-afrancho	4,058.1	>100
			Akumadan-bekwai/oda	39,736.0	>100
			Asikuma-atewa/ansum-oda	23,925.4	>100
			Asuansi-kumasi	19,406.4	>100
			Asuansi-wacri/suko	13,795.8	>100
			Atukrom	68,895.7	>100
			Atukrom-asikuma/ansum	72,608.9	>100
			Bekwai-zongo/Oda	26,764.6	>100
			Boamang-suko	44,344.1	>100
			Bomso-asuansi/nta-ofin	44,662.2	>100
			Juaso-bompata/asuboa-pamasua	352,830.4	>100
			Kotei	1,224.9	>100
			Kumasi-asuansi/nta-ofin	217,899.9	>100
			Mim/Oda	108,553.4	>100
			Nzima-bekwai	3,745.5	>100
			Nzima-bekwai/Oda	824,040.7	>100
			Nzima-boi	184,332.9	>100
			Wiawso-shi	1,376.9	20
		Arenosols			
			Aya-yenahin/bepo	16,277.6	>100
			Kobeda	16,867.4	10
		Fluvisols			

No.	Regions	Soil Order	Soil Group Family	Coverage/Extent (Ha)	Depth[1] (cm)
			Birim-awaham/kakum-chichiwere	75,108.1	>100
			Denteso-sene	46,573.9	>100
		Gleysols			>100
			Bejua-pakpe	137.4	>100
			Oda	483.1	>100
			Tanoso	16,399.4	>100
		Leptosols			
			Jamasi	4,165.8	5
			Kasele-kowani	5,920.2	>100
			Kintampo	2,222.0	20
			Kobeda-amuni/bekwai	22,831.4	>100
			Nyanao-tinkong/opimo	1,844.6	30
			Yaya	4,595.1	10
			Yaya-pimpimso/bejua	55,747.9	80
		Lixisols			
			Bediesi-sutawa/bejua	14,963.5	>100
			Birem-cheriase	4,639.6	>100
			Damongo-ejura	38,953.9	>100
			Damongo-murugu-techiman	19,483.2	>100
			Damongo-techiman/ejura-sene	69,990.7	>100
		Luvisols			
			Ejura-amantin/denteso	2,793.5	>100
			Ejura-kpelesawgu/denteso	109,550.7	>100
		Planosols			
			Ablade-kpelesawgu	98,194.0	>100
		N/A			
			Lagoon	4,778.0	>100
			No data	1,294.5	
			Nsaba-swedru/nta-ofin	549,493.6	>100
			Nta-ofin	3,429.9	>100
6	**Brong Ahafo**	Acrisols			
			Batia	16,121.3	>100
			Besua	13,105.3	>100
			Kumasi-asuansi/nta-ofin	108,794.5	>100
			Nkrankwanta	71,694.8	>100
			Nzima-bekwai/oda	905,229.5	>100
			Yakasi	8,336.5	>100
		Fluvisols			
			Birim-awaham/kakum-chichiwere	38,038.6	>100
		Gleysols			
			Tanoso	16,072.7	>100
		Leptosols			
			Banda (hill)	4,215.2	>100
			Murugu-kintampo	5,685.2	>100
		Lixisols			
			Banda	110,068.6	30
			Damongo-murugu	20,200.9	>100
			Damongo-murugu-techiman	52,826.2	>100
			Debibi	125,802.8	>100
			Drobo	65,461.7	>100
			Dumboli	4,788.5	>100
			Farmang	2,829.3	>100
		Luvisols			>100

No.	Regions	Soil Order	Soil Group Family	Coverage/Extent (Ha)	Depth[1] (cm)
			Botokrom	2,959.6	>100
		N/A			>100
			Gyapekrom	7,312.4	20
7	**Ahafo**	Acrisols			
			Adujansu-bechem/nta-ofin	132,102.1	>100
			Asuansi-kumasi	13,704.6	>100
			Atukrom	109,843.8	>100
			Atukrom-subin-adujansu	67,264.4	>100
			Hwidiem	29,508.7	>100
			Kumasi-asuansi/nta-ofin	8,462.9	>100
			Nzima-bekwai	3,449.5	>100
			Nzima-bekwai/oda	16,876.6	>100
		Fluvisols			
			Alluvial	9,447.5	>100
		Gleysols			
			Oda	178.8	>100
		Nitisols			
			Susan	134,429.8	>100
		N/A			
			Nta-ofin	892.8	>100
8	**Bono East**	Fluvisols			
			Denteso-sene	155,136.6	>100
			Sene	7,765.8	>100
		Gleysols			
			Bejua-pakpe	8,692.8	>100
			Tanoso	59,263.5	>100
		Leptosols			
			Kowani-kasele/kpelesawgu	13,117.3	58
			Kowani-santaboma/kete-krachi	2,298.1	58
			Kowani-techiman-santaboma/bediesi	27,754.4	58
			Murugu-kintampo	2,171.9	>100
			Wenchi (boval)	9,158.0	5
			Wenchi-kumayili	5,411.8	10
		Lixisols			
			Bediesi-sutawa	78,870.3	>100
			Bediesi-sutawa/bejua	270,614.3	>100
			Damongo-murugu	233,513.3	>100
			Damongo-murugu-techiman	95,495.2	>100
			Damongo-techiman/ejura-sene	60,447.4	>100
			Kowani-santaboma/denteso-sene	1,438.6	>100
			Kowani-santaboma/kete-krachi	5,600.1	>100
			Kpelesawgu-changnalili	302,113.2	30
			Kpelesawgu-changnalili-kungawni	23,626.2	30
			Kpelesawgu-kumayili-wenchi	65,034.6	50
			Somusie-denteso	88,132.9	>100
		Luvisols			
			Ejura-amantin/denteso	430,747.7	>100
		Planosols			
			Lima	52,710.2	>100
			Lima-volta	119,334.7	>100
		N/A			

No.	Regions	Soil Order	Soil Group Family	Coverage/Extent (Ha)	Depth[1] (cm)
			No data	133,524.0	>100
9	Northern	Planosols	Lima-volta Association		>100 cm
		Lixisols	Mimi-techiman		>100 cm
		Planosols	Lima		>100 cm
		Lixisols	Kpelesawgu-kumayili-wenchi		>30 cm
		-	Changnalili-lima-kpelesawgu		
		Lixisols	Tanina		
		Plinthosol	Sambu-pasga		>87cm
		Leptosols	Kintampo		>20 cm
		Lixisols	Kpelesawgu		>100 cm
		Acrisols			
			Nyankpala	206,681.2	>100
		Fluvisols			
			Denteso-sene	276.2	>100
			Nterso-zaw	803.9	>100
		Leptosols			>100
			Adomi	4,062.3	>100
			Adomi-kpeyi	10,662.3	>100
			Gushiagu-kasele	22,076.2	20
			Jagogo	813.2	8
			Kintampo	530.9	20
			Nyankpala	869.7	>100
			Pigu	1,412.8	8
			Pigu-kpelesawgu	1,010.9	>100
			Walewale	868.1	5
			Wenchi	9,969.6	10
			Wenchi-kintampo	2,606.0	10
			Wenchi-lumo	475.0	10
			Wenchi-sambu	8,297.1	20
		Luvisols			
			Damongo-murugu/tanoso	14,534.5	>100
			Kpelesawgu	101,119.7	>100
			Kpelesawgu-changnalili	73,768.6	30
			Lapliki	8,691.2	>100
		Luvisols			
			Bimbila	62,348.2	>100
		Planosols		266,263.3	>100
			Blengo-botoku/kudzra-edo	28,146.4	>100
			Lima-Volta	238,116.9	>100
		Plinthosol			
			Sambu-pasga	68,304.7	>100
			Sirru	10,502.0	>100
		Plinthosols			
			Lumo	667.5	>100
			Pumpu	46,765.8	55
		N/A			
			Changnalili	9,180.5	30
			Changnalili-lima-kpelesawgu	16,751.6	30
10	North East	Cambisols			
			Bombi-yaroyiri	6,346.8	>100
		Fluvisols			
			Dagare	13,939.3	>100
			Nterso-zaw	1,140.8	>100

No.	Regions	Soil Order	Soil Group Family	Coverage/Extent (Ha)	Depth[1] (cm)
			Siare-dagare	109,388.9	>100
			Siare-pani	5,588.8	>100
		Gleysols			>100
			Berenyasi-kupela	657.5	>100
		Leptosols			
			Chereponi	360.7	>100
			Chuchuliga	39.0	20
			Jagogo	6,256.1	>100
			Kagu	170,801.1	42
			Kintampo	23,380.2	20
			Kintampo-mimi	110,190.7	>100
			Klopu	4,462.7	>100
			Kpea	6,702.3	>100
			Mogo	219.4	>100
			Pigu	476.5	8
			Pigu-kpelesawgu	7,070.9	8
			Walewale	6,805.6	>100
			Wenchi	969.0	>100
			Wenchi (boval)	2,463.1	5
			Wenchi-lumo	1,372.2	>100
			Wenchi-sambu	1,090.2	20
			Wenchi-techiman	7,386.0	20
			Yagha	10,807.9	>100
		Luvisols			
			Bianya	2,798.0	>100
			Kpelesawgu	504,028.1	>100
			Lapliki	72,583.0	>100
			Mimi	179,194.5	>100
			Mimi-techiman	38,479.6	>100
			Nambari	10,092.3	>100
			Sanda	4,696.1	80
			Tanchera	17,856.6	>100
		Luvisols			>100
			Nangodi	662.6	30
		Planosols			>100
			Lima-volta	257,990.8	>100
		Plinthosol			>100
			Nalerigu-kintampo	59,515.6	75
			Sirru	12,840.3	>100
		Plinthosols		110,068.6	>100
			Lumo	20,200.9	>100
			Pumpu	52,826.2	55
			Pusiga	125,802.8	>100
		Vertisols		65,461.7	
			Pani-kupela	4,788.5	>100
		N/A		2,829.3	
			Changnalili		30
			Changnalili-lima-kpelesawgu	2,959.6	30
			Kolingu	7,312.4	60
11	**Savannah**	Acrisols			
			Techiman-tampu		>100
		Arenosols		132,102.1	
			Kunkwa	13,704.6	>100
		Fluvisols		109,843.8	

No.	Regions	Soil Order	Soil Group Family	Coverage/Extent (Ha)	Depth[1] (cm)
			Dagare-kunkwa	67,264.4	>100
			Nterso-zaw	29,508.7	>100
			Siare-dagare	8,462.9	>100
			Siare-lapliki	3,449.5	>100
		Leptosols		16,876.6	
			Kagu		42
			Kintampo	9,447.5	20
12	**Upper East**	Planosols	Lima-Volta Association	-	>100 cm
		Lixisols	Lapliki	-	>100 cm
		Lixisols	Tanchera	-	>100 cm
		Plinthosols	Pusiga	-	>30 cm
		Leptosols	Wenchi-kintampo	-	>10 cm
		Gleysols	Berenyasi-kupela	-	>100 cm
		Leptosols	Kintampo-mimi	-	>100 cm
		Luvisols	Nangodi	-	>30 cm
		Leptosols	Yagha	-	>100 cm
		Leptosols	Tongo	-	>10 cm
		Leptosols	Chuchuliga	-	>20 cm
		Leptosols	Bongo	-	>40 cm
		Lixisols	Bianya	-	>100 cm
		Lixisols	Varempere-tafali	-	>100 cm
		Fluvisols	Dagare	-	>100 cm
		Lixisols	Mimi	-	>100 cm
13	Upper West	Arenosols	Kunkwa Consociation	-	>100 cm
		Fluvisols	Siare-dagare Association	-	>100 cm
		Vertisols	Pani-kupela Association	-	>100 cm
		Leptosols	Kagu Consociation	-	>100 cm
		Lixisols	Tanina Consociation	-	>100 cm
			Kolingu Consociation	-	>60 cm

Source: Council for Scientific and Industrial Research (CSIR) – Soil Research Institute

2.4 Land Cover

Between 2000 and 2010, forest increased from 8.9million hectors to almost 9.2 million hectors, land used for cropping also increased from 3.9 million to 5.2 million hectares. There was an increase in wetlands area from 792,678.80 to 878,783.90 hectares as well as land used for settlement from 203844.20 hectares to 345,048.30. In the case of grassland and other land types categories there was a reduction in grassland area from 9.95 million to almost 8.2 million hectares and other land cover types from 156,683.00 to 109,724,10 hectares (Table 2.8).

Table 2.8: Land Use by Type of Ecosystem in Hectares

No.	Ecosystem Type	Location	2000	2010
1	Forests	-	8,911,425.6	9,195,136.6
2	Cropland	-	3,904,571.6	5,221,448.5
3	Grassland	-	9,954,340.0	8,173,402.6
4	Settlements	-	203,844.2	345,048.3
5	Wetlands	-	792,678.8	878,783.9
6	Other	-	156,683.0	109,724.1
Total			**23,923,543.2**	**23,923,544.0**

Source: Forestry Commission, 2010

2.5 Ecosystems and Biodiversity

The section provides information on wetlands, known flora and fauna.

2.5.1 Wetlands

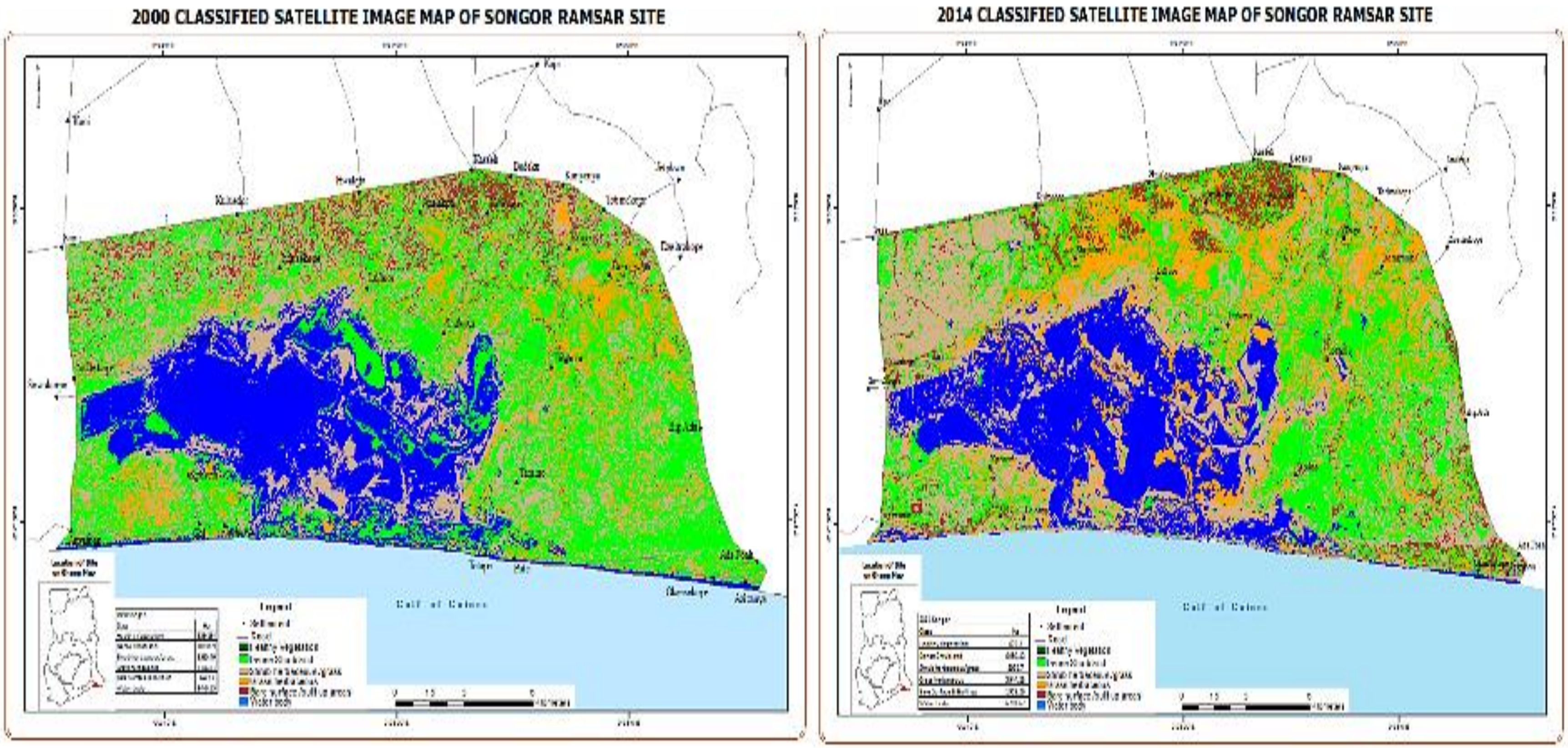
Wetlands are important ecosystems that contribute significantly to human well-being, local and national economies, as well as environmental health and sustainability. Wetland functions (e.g. groundwater re-charge, sediment trapping, water filtration and purification through sediment trapping, nutrient recycling, flood control and storm protection) and values (e.g. food and protein sources, fibre, fuelwood) make wetlands some of the most productive and dynamic habitats in the world and great examples of ecosystem services. Wetlands are recognized also as vital for biodiversity conservation. Wetlands on the coast of Ghana include, estuaries and lagoon habitats (e.g. Amansure, Narkwa, Amisa, Songor and Keta Lagoons), open and closed lagoon systems (e.g. Muni, Korle, Sakumo), estuarine and salt pan complexes (e.g. Densu delta). Information on extent of inland wetlands remain scanty (Table 2.9).

Table 2.9: Changes in Habitat of Coastal Ramsar Sites in Hectares (Ha)

Type/Year	Songor		Densu delta		Sakumo		Muni	
	2000	2014	2000	2014	2000	2014	2000	2015
Healthy Vegetation	839.25	673.2	466.52	271.80	0	0	1335.34	538.65
Dense Shrubland	10138.94	6959.43	2959.21	1957.05	4467.80	2580.66	1960.66	1640.52
Shrub herbaceous/grass	8585.49	8991.70	1329.76	647.82	4018.97	2882.34	2504.98	3098.52
Grass herbaceous	3166.81	5353.48	2059.03	676.62	6735.72	2030.49	746.46	1399.32
Bare Surface & Built up	1422.10	1918.26	8853.61	12237.20	9744.79	17787.10	256.86	167.58
Water body	6445.15	6701.67	2996.33	2873.97	959.42	646.11	152.42	112.14

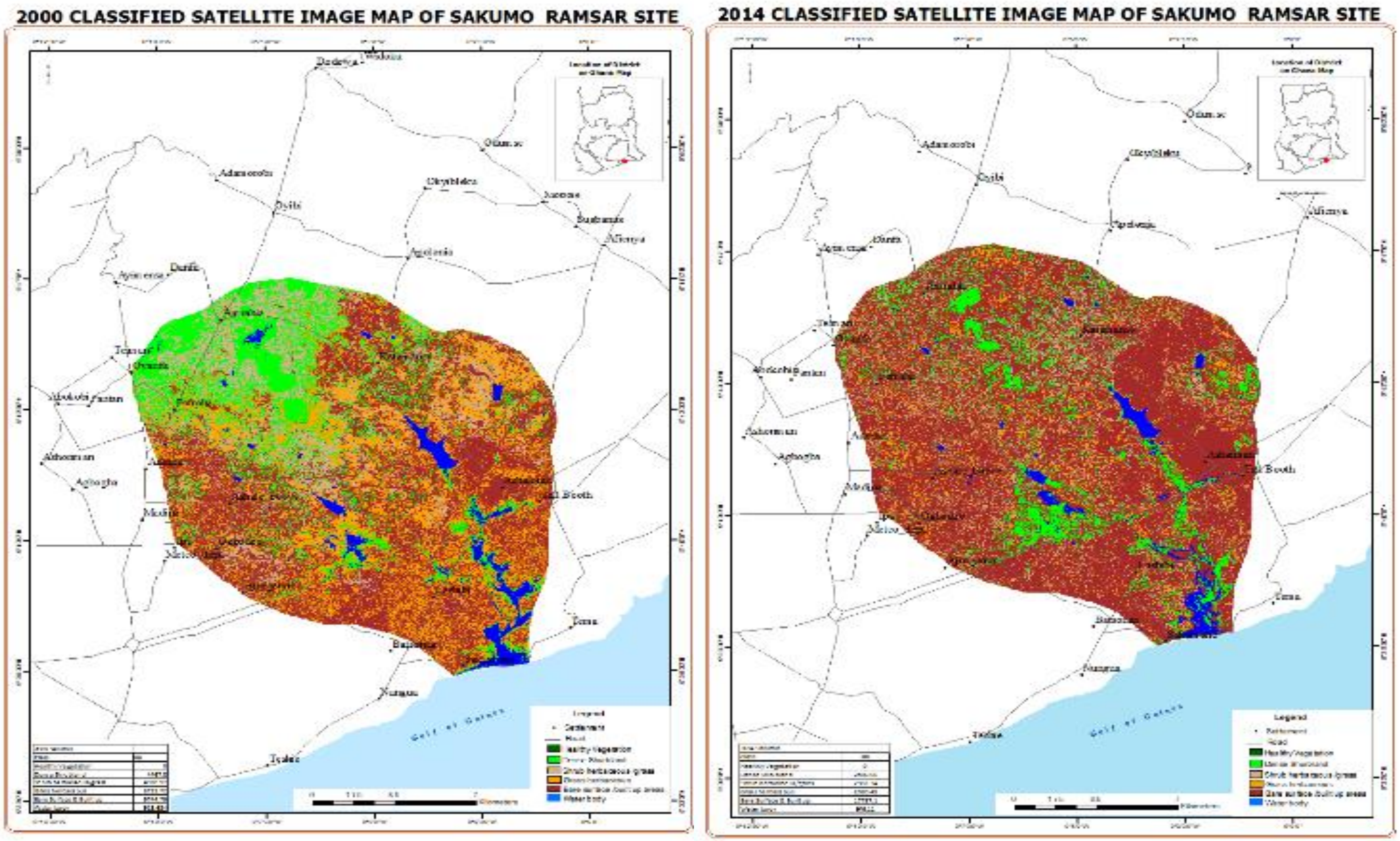
Source: Ghana State of Environment 2016 Report

Map 2.6: Satellite Imagery of Songor Ramsar Site in 2000 and 2014



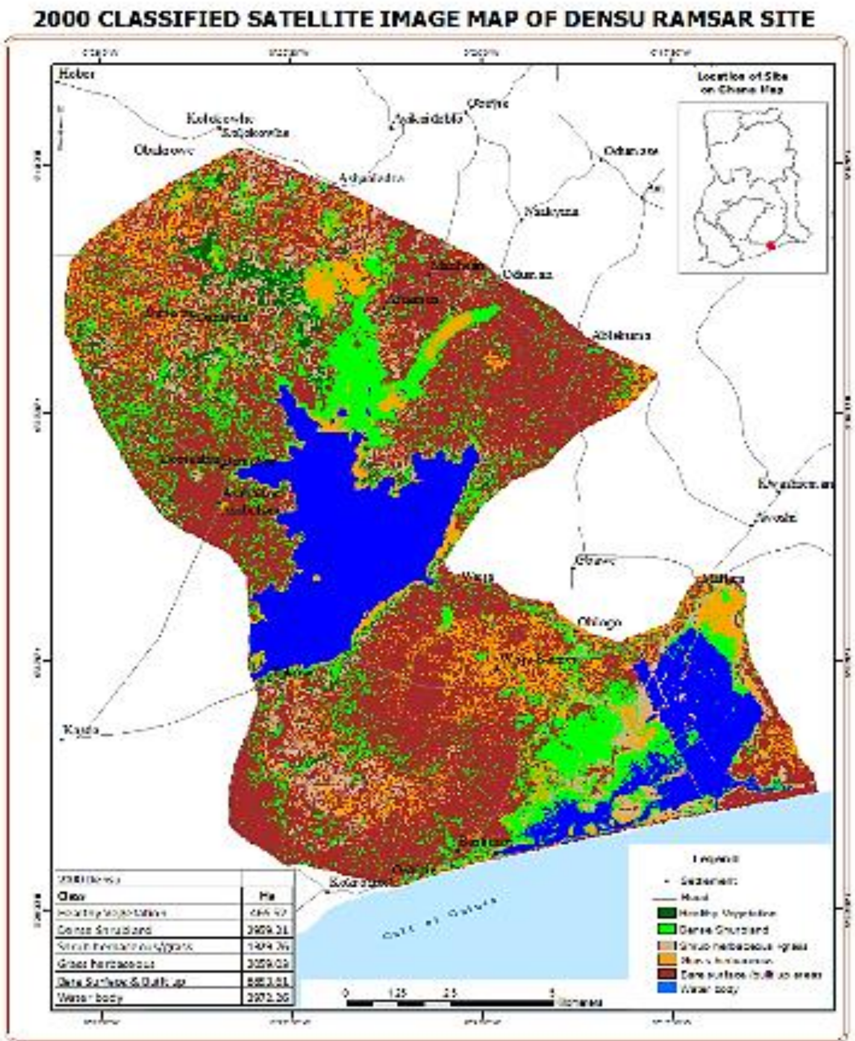
Source: Ghana State of Environment 2016 Report

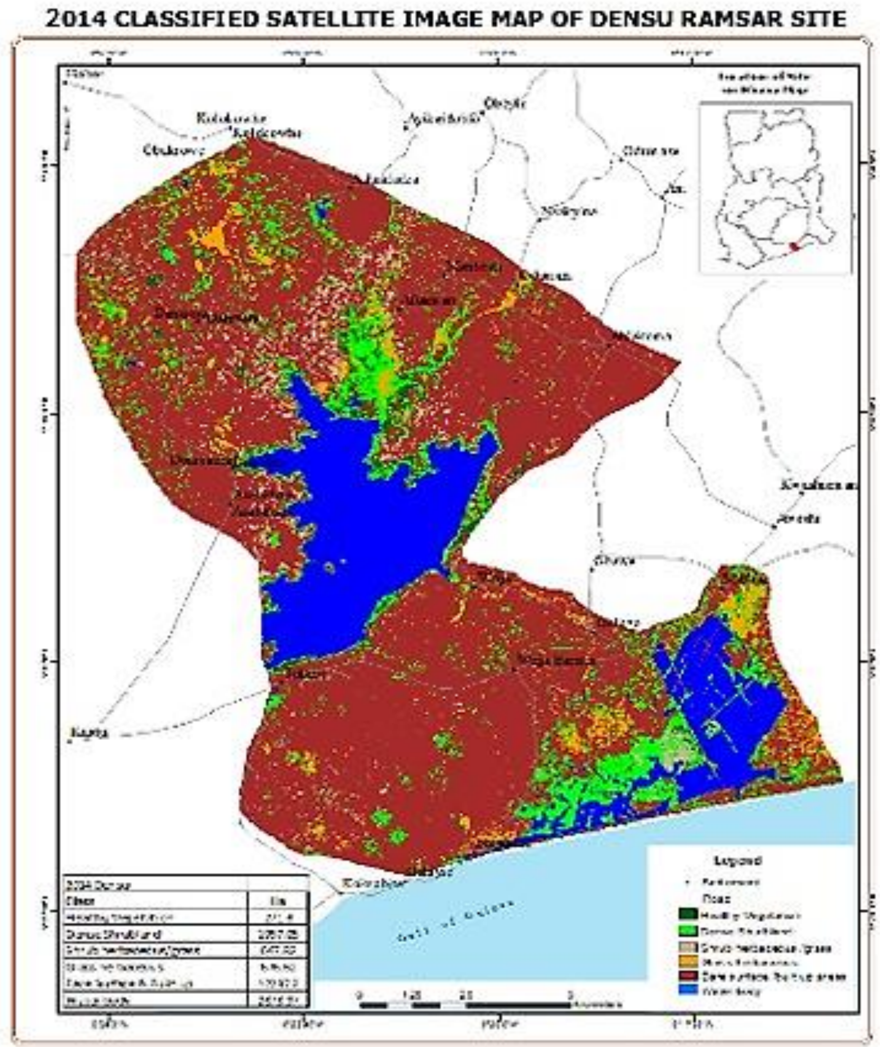
Map 2.7: Satellite Imagery of Sakumo Ramsar Site in 2000 and 2014



Source: Ghana State of Environment 2016 Report

Map 2.8: Satellite Imagery of Densu delta in 2000 and 2014





Source: Ghana State of Environment 2016 Report

2.5.2 Flora species

The dominant flora species in Ghana is the Angiosperms which stands at a population of 5,217. The Gymnosperms are the least whose population stands at seven (7) as shown in Table 2.10.

Table 2.10.: Known Flora Species by Number (Indigenous)

No.	Group name	Number
1	Angiosperms	5,217
2	Bryophytes	46
3	Lycophytes	12
4	Gymnosperms	7
	Total	**5,282**

Source: IUCN (2017)

2.5.2.1 Threatened species of Flora

Ghana has rich floral diversity, with the tropical forest, in particular the wet evergreen forest in the southwestern part of Ghana, exhibiting the highest level of endemism and species numbers. The three taxonomic groups adds to a total number of 3227 angiosperms (comprising 2974 indigenous and 253 introduced species); a single gymnosperm (one known indigenous species and a few others introduced) and 124 pteridophytes. The IUCN threatened species information includes a list of threatened flora in Ghana, as well as information on threat categories, which provides a useful indicator for monitoring the status of floral diversity in the country. 119 plant species occurring in Ghana are listed on the IUCN Red Data List comprising three species that are critically endangered (CR), 20 that are endangered (EN) and 96 Vulnerable (VU). Refer to Annex 1 for threatened plant species and threat categories of Ghanaian plant species listed on the IUCN Red Data.

2.5.3 Fauna species

Butterflies were the dominant Fauna species in 2017, (925) followed by 794 birds, 377 Amphibian and Reptiles and 327 Mammals (Table 2.11).

Table 2.11: Known Fauna Species by Numbers in 2017 (Indigenous)

No.	Name of Species	Status category	Class	Number
1	Mammals	-	-	327
2	Birds	-	-	794
3	Amphibians and Reptiles	-	-	377
4	butterflies	-	-	925
	Total			**2423**

Source: Forestry Commission, 2017

2.5.3.1 Threatened species of Fauna

Terrestrial fauna is better known than the marine and aquatic fauna. The 2016-2020 National Biodiversity Strategy and Action Plan reports 221 species of amphibians and reptiles, 724 species of birds and 225 species of mammals. Marine and aquatic biodiversity amount to 392 marine species including 347 fish species and 157 freshwater fish species. Table 2.12 provides a summary of the status of threatened species listed in the IUCN Red Data List for the various taxonomic groups. The threatened species of fauna recorded for Ghana includes 56 species of fish, 11 species of amphibians, 7 species of Reptiles, 22 species of birds and 20 species of mammals.

Table 2.12: Summary of Threatened Vertebrate Species

Taxonomic Group[9]	Critically Endangered (CR)	Endangered (EN)	Vulnerable (VU)	Total
Fishes*	2	18	36	56
Amphibians	2	5	4	11
Reptiles*	2	0	5	7
Birds	4	1	17	22
Mammals	1	6	13	20
Total	**11**	**30**	**75**	**116**

Source: Forestry Commission, 2017

2.6 Forests Area

The Ashanti, Western North and the Western regions have the most forest areas as at 2015. Ashanti, 353,655.54 hectares, Western North, 351,000.63 hectares and Western, 316,119.60 hectares. The region with the least forest area as at 2015 is the Greater Accra Region with a forest area of 5,211.09 hectares. Apart from Ahafo, Bono, Central, Eastern, Western and Western North Regions, all the other regions have their forest areas in 2017 being higher than what existed in the year 1990. Table 2.13 shows the extent of forest by region.

[9] *Groups not fully assessed; data comprises number of species known to be threatened within groups assessed to date.

Table 2.13A: Total Forest Areas by Region (Hectares, ha)

	1990			**2000**		
Region	**Close forest**	**Open forest**	**Total**	**Close forest**	**Open forest**	**Total**
Ahafo	122,217.9	10,334.1	132,552.0	122,784.5	8,264.6	131,049.1
Ashanti	213,278.9	116,481.4	329,760.4	219,696.0	102,929.5	322,625.5
Bono	93,065.4	50,346.4	143,411.8	56,482.7	78,268.4	134,751.2
Bono East	977.2	143,870.9	144,848.1	1,881.7	159,543.6	161,425.4
Central	81,277.9	4,299.1	85,577.0	80,680.5	3,219.5	83,900.0
Eastern	100,967.0	37,292.9	138,260.0	102,868.9	24,275.3	127,144.3
Greater Accra	191.4	1,104.7	1,296.1	5.5	269.1	274.6
Northern	587.7	21,206.6	21,794.3	635.7	26,318.3	26,953.9
North East	545.9	3,916.9	4,462.7	588.0	4,386.3	4,974.3
Oti	11,551.7	46,801.2	58,352.9	16,178.0	38,748.0	54,925.9
Savannah	5,402.1	119,782.8	125,184.9	10,978.1	122,806.9	133,785.0
Upper East	2,006.9	13,559.1	15,566.0	3,051.9	24,886.3	27,938.2
Upper West	320.2	17,734.6	18,054.8	1,962.7	22,947.4	24,910.1
Volta	575.1	5,212.4	5,787.5	2,195.5	5,171.8	7,367.2
Western	308,635.2	18,914.4	327,549.6	313,898.2	13,210.1	327,108.3
Western North	326,668.1	51,011.9	377,680.1	288,099.6	84,716.3	372,815.9
Total	**1,268,268.8**	**661,869.4**	**1,930,138.1**	**1,221,987.5**	**719,961.3**	**1,941,948.8**

Source: Forestry Commission, 2000

Table 2.13B: Total Forest Areas by Region (Hectares, ha)

	2010			2012			2015		
Region	**Close forest**	**Open forest**	**Total**	**Close forest**	**Open forest**	**Total**	**Close forest**	**Open forest**	**Total**
Ahafo	120,546.9	9,104.2	129,651.1	119,055.2	10,036.9	129,092.1	108,828.5	22,186.9	131,015.4
Ashanti	206,850.0	84,781.6	291,631.6	204,711.5	89,264.0	293,975.5	166,379.0	187,276.5	353,655.5
Bono	42,987.3	77,384.3	120,371.6	37,622.3	93,347.5	130,969.8	35,073.3	86,310.3	121,383.5
Bono East	1,296.7	196,430.2	197,726.9	5,876.7	126,028.2	131,904.9	134.1	217,288.1	217,422.2
Central	73,557.5	8,704.5	82,262.1	71,219.4	10,676.0	81,895.4	66,554.3	15,006.7	81,561.0
Eastern	73,557.5	8,704.5	82,262.1	80,241.8	48,205.0	128,446.7	78,036.3	57,031.1	135,067.4
Greater Accra	25.0	1,524.0	1,549.0	50.9	1,431.3	1,482.2	-	5,211.1	5,211.1
Northern	589.2	35,202.8	35,792.0	1,279.9	36,093.5	37,373.4	0.1	53,732.3	53,732.3
North East	536.9	4,119.8	4,656.8	784.4	5,728.0	6,512.3	837.7	13,812.0	14,649.8
Oti	13,782.2	47,092.1	60,874.4	15,463.8	43,574.6	59,038.4	25,693.9	50,853.3	76,547.3
Savannah	10,170.4	189,565.4	199,735.7	13,179.9	222,119.4	235,299.2	2,401.4	212,481.5	214,882.9
Upper East	1,813.9	16,733.9	18,547.7	3,587.8	32,586.5	36,174.2	50.1	57,117.6	57,167.7
Upper West	1,741.6	23,741.3	25,482.9	3,189.0	40,980.2	44,169.2	349.8	66,371.1	66,721.0
Volta	1,982.6	5,518.3	7,500.9	2,415.9	5,173.3	7,589.2	369.3	11,604.1	11,973.3
Western	297,033.4	23,123.0	320,156.4	291,103.7	27,194.9	318,298.7	266,136.5	49,983.1	316,119.6
Western North	311,468.4	51,849.4	363,317.8	308,614.3	51,170.0	359,784.3	258,664.7	92,336.0	351,000.6
Total	**1,157,939.6**	**783,579.2**	**1,941,518.9**	**1,158,396.5**	**843,609.1**	**2,002,005.5**	**1,009,509.0**	**1,198,601.6**	**2,208,110.7**

Source: Forestry Commission, 2015

2.6.1 Forest Protected Areas

In Ghana, about 1.76 million ha, constituting 21% of High Forest Zone (HFZ), are permanently protected forest areas. Other protected areas include, national parks, resource reserves, wildlife sanctuaries and Ramsar sites. Community dedicated forests and sacred groves are mainly the protected forest in the off reserves. Timber logging operations take place within timber utilization contract areas in both on reserve and off forest reserves (FAO, 2015).

Currently, around 2,555,900 ha of Ghana's forests are under some form of protection either as forest reserves of wildlife protected areas. There are 266 gazetted forest reserves of which 204 in the HFZ, occupy 1,634,100 hectares and 62 in the savannah zone cover 0.6 million hectares. Only 16% of the HFZ may be categorized as being in good state, while the rest are in various stages of degradation. Unreserved closed canopy forests in the HFZ currently cover about 0.4 million hectares. The reserves in the HFZ have been classified according to four (4) management categories namely timber production area, permanent protection, convalescence and conversion.

Table 2.14 indicates that timber production area represents about 47% of the forest reserves in the HFZ whereas the area under permanent protection occupies about 22%. Furthermore, convalescence currently occupies 7% whilst areas that have undergone conversion occupy about 24% of the total HFZ under forest reservation.

Table 2.14: Area of Forest Reserves in the High Forest Zone

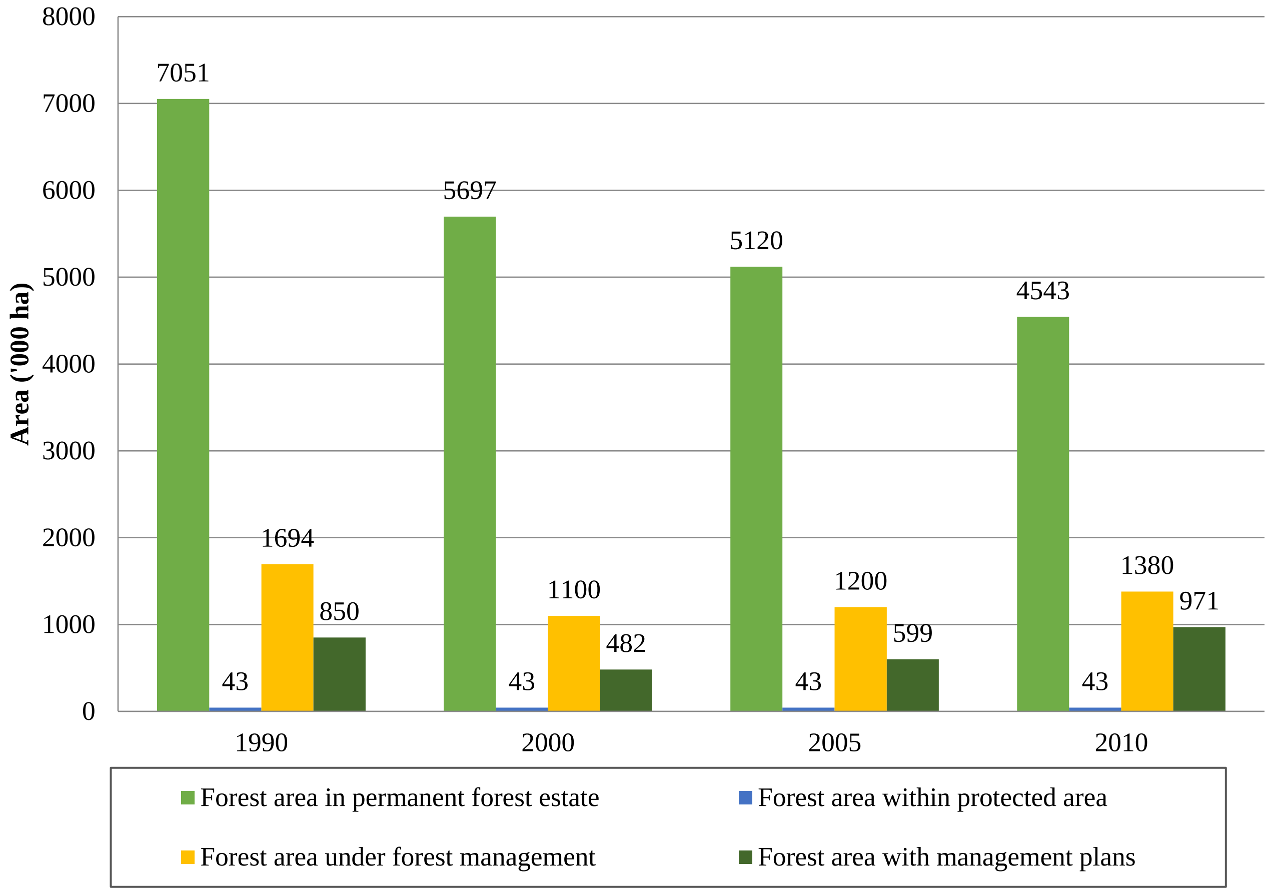
Forest management category	Area (ha)	Percentage
Timber Production Area	762,400	47.0%
Permanent Protection	352,500	22.0%
Convalescence	122,000	7.0%
Conversion	397,000	24.0%
Total Reserve	**1,633,900**	**100.0%**

Source: Forestry Commission, 2016: Ghana Forest Plantation Strategy, 2016 - 2040

2.6.2 Forest Management

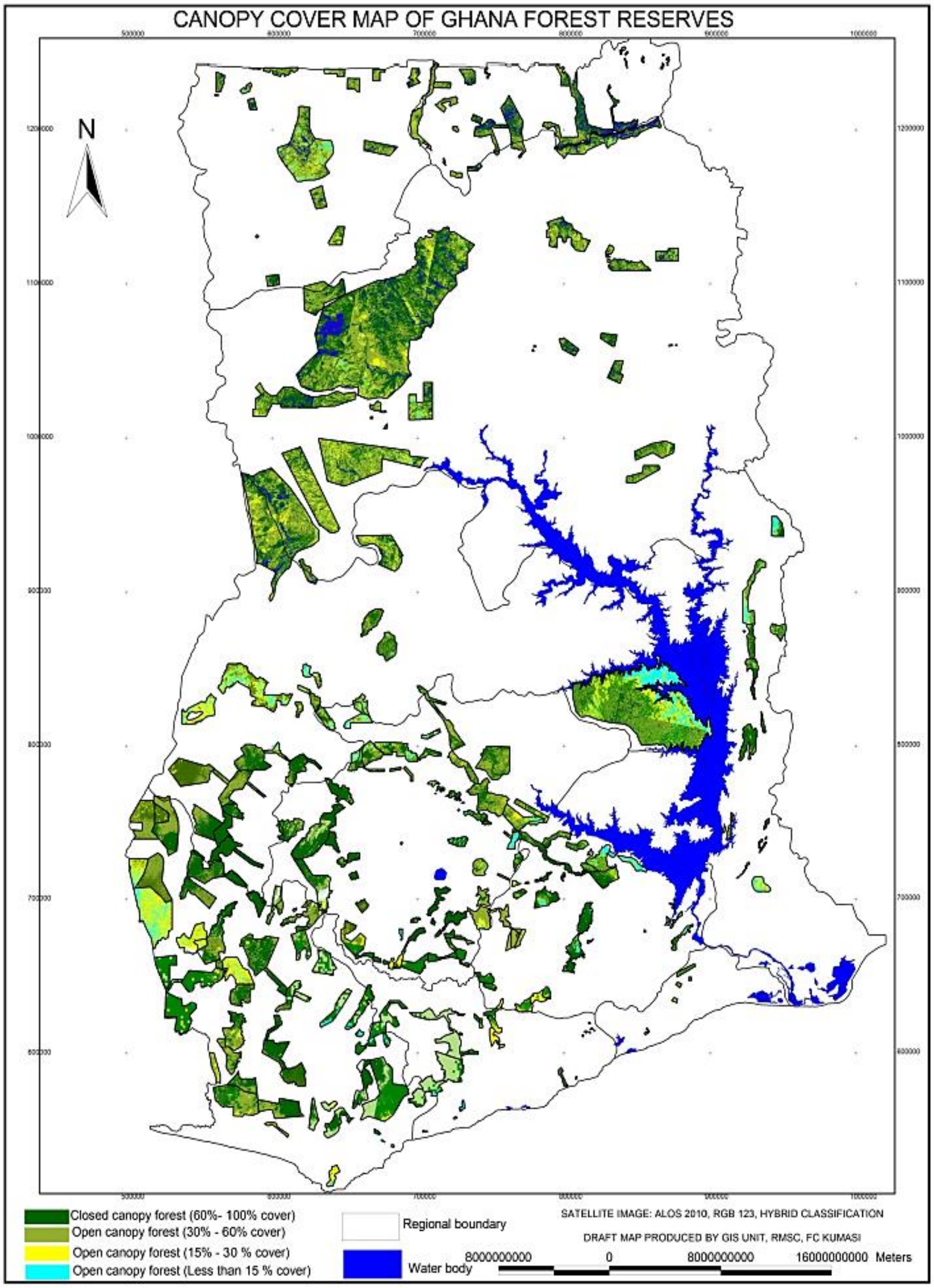
Between 1990 and 2010, the total forest area under reservation decreased from 1.8 million ha to 0.7 million ha partly as a result of the categorisation of the area into protection and production functions. The categories include forest areas in permanent forest estate, forest areas within permanent protection, forest area under forest management and forest area with management plans. Figure 2.2 shows that whereas forest areas in permanent protection had remained constant, forest areas in permanent forest estate had reduced consistently over the years. On the other hand, forest area under forest management and forest area with management plans have both experienced negative and positive changes.

Figure 2.2: Forest Management Categories



Source: Forestry Commission (2012)

Map 2.9: Canopy Cover Map of Forest Reserves in Ghana



Source: Forestry Commission, 2014

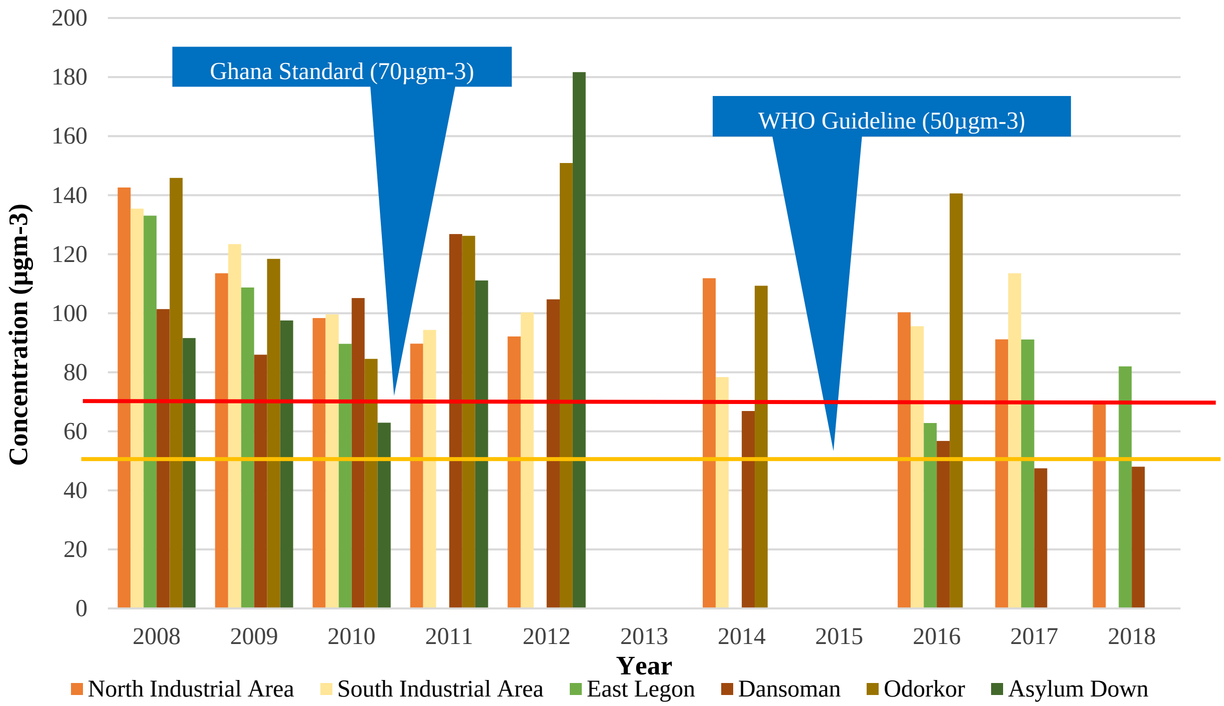
2.7 Air Quality

The EPA, Ghana operates an air quality monitoring network that collects PM_{10} and limited $PM_{2.5}$ data from sixteen (16) locations throughout the city of Accra and its environs. The network is made up of 6 monitoring locations in selected Residential, Commercial and Industrial Areas in Accra and 10 roadside monitoring locations.

2.7.1 PM_{10} Permanent Monitoring Locations

Annual mean PM_{10} concentrations (μgm^{-3}) for permanent monitoring locations between 2008 and 2018 are illustrated in Figure 2.3. The concentrations ranged from 47-182 μgm^{-3}, with the minimum and maximum at Dansoman in 2017 and 2012 in Asylum Down respectively. With the exception of North Industrial Area (2018), East Legon (2016), Dansoman (2014, 2016, 2017 and 2018), and Asylum Down (2010)[10] all the annual PM_{10} concentrations recorded between 2008 and 2018 were above the 70 μgm^{-3} Ghana Standard for ambient PM_{10} (Figure 2.3). Similarly, apart from the Dansoman (2017, 2018)[11] all annual mean PM_{10} concentrations recorded over the same period were above the 50μgm^{-3} World Health Organization (WHO) guideline.

Figure 2.3. Annual Mean PM_{10} Concentrations for Permanent Monitoring Locations (2008-2018)



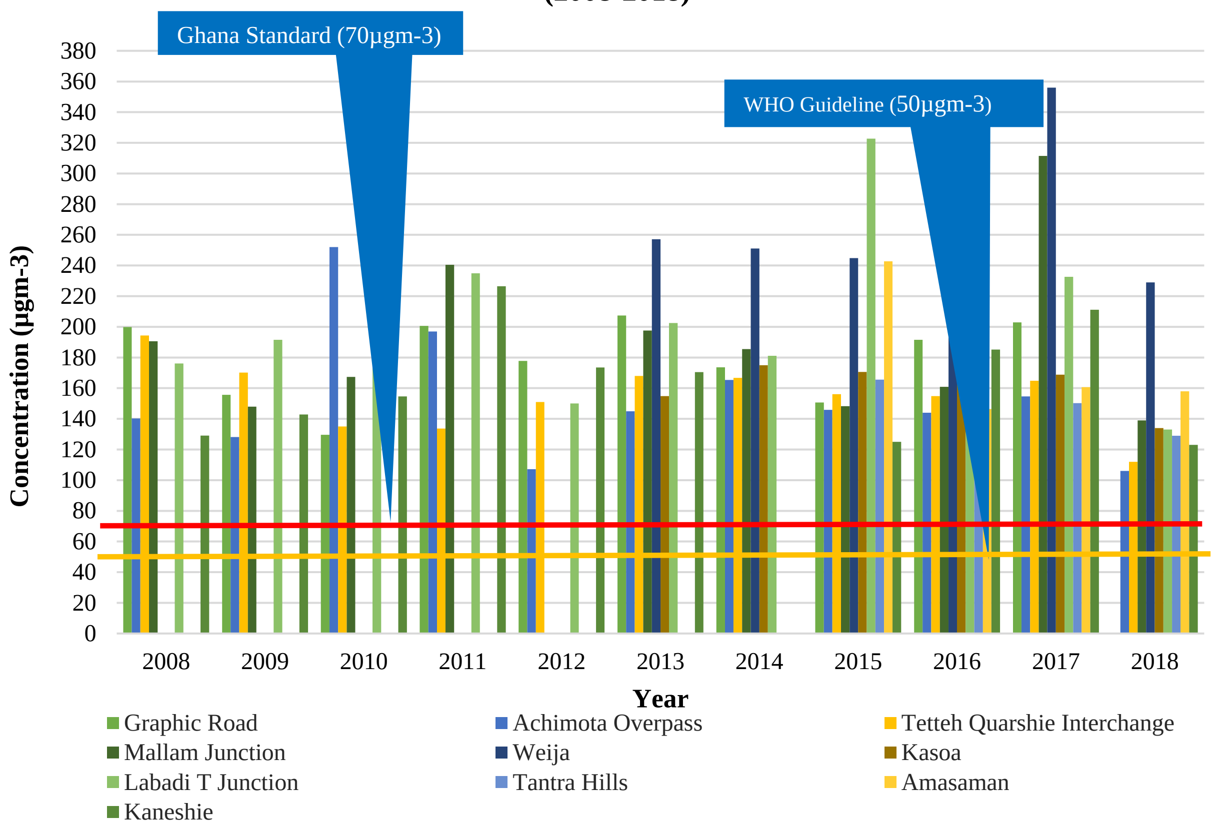
Source: Environmental Protection Agency (EPA), 2019

2.7.2 PM_{10} Roadside Monitoring Locations

[10] Environmental Protection Agency (EPA), 2019
[11] Environmental Protection Agency (EPA), 2019

Figure 2.4 shows the annual mean PM_{10} concentrations (μgm^{-3}) for the Roadside monitoring locations between 2008 and 2018. The concentrations recorded for the period ranged from106 -356 μgm^{-3}, with the minimum and maximum at Achimota in 2018 and 2017 in Weija respectively. All the annual PM_{10} concentrations recorded over the period were above both the Ghana standard and WHO Guideline for ambient PM_{10} (Figure 2.4).

Figure 2.4 Annual Mean PM_{10} Concentrations (µgm-3) for the Roadside Monitoring Locations (2008-2018)



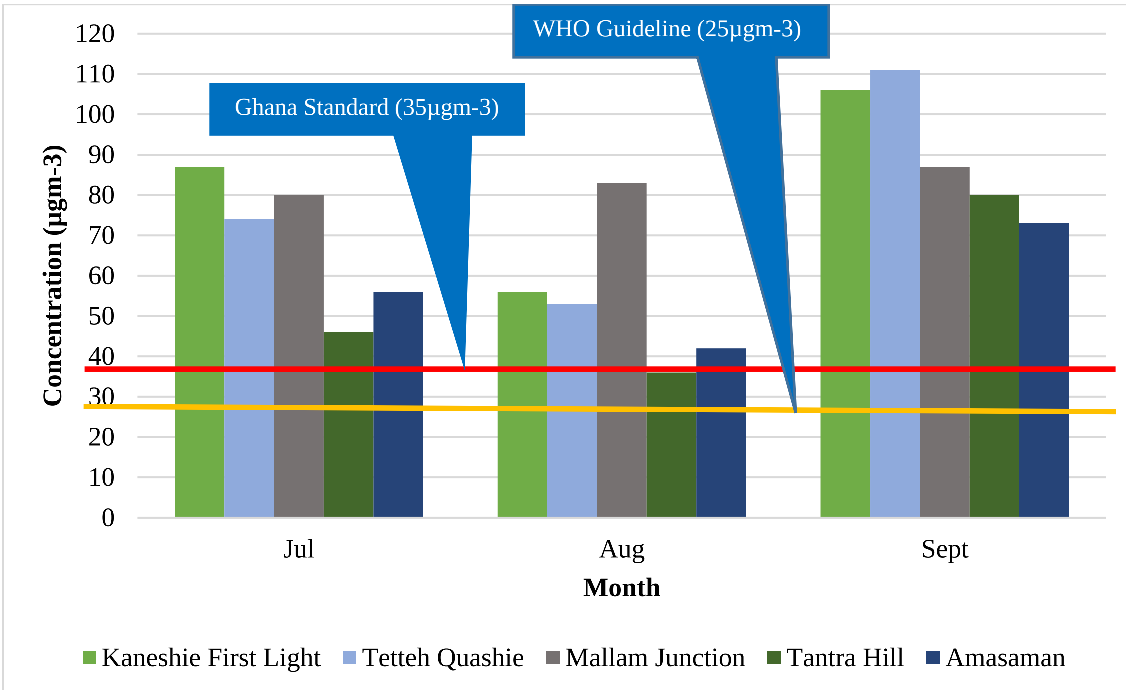
Source: Environmental Protection Agency (EPA), 2019

2.7.3 $PM_{2.5}$ Roadside Monitoring Locations

Monitoring data on the concentration levels of $PM_{2.5}$ were limited in nature and scope during the preparation of this compendium. Figure 2.5 shows the annual mean $PM_{2.5}$ concentrations (μgm^{-3}) for the Roadside monitoring locations between July and September 2019. The concentrations recorded for the period ranged from 36 - 111 μgm^{-3}, with the minimum recorded at Tantra Hill (Aug. 2019)[12] and the maximum recorded at Tetteh Quarshie (Sep. 2019). All the PM_{10} concentrations recorded over the period were above both the Ghana standard and WHO Guideline for $PM_{2.5}$.

[12] Environmental Protection Agency (EPA), 2019

Figure 2.5: Monthly Mean $PM_{2.5}$ Concentrations for Roadside Monitoring Locations (Jul-Sep, 2019)



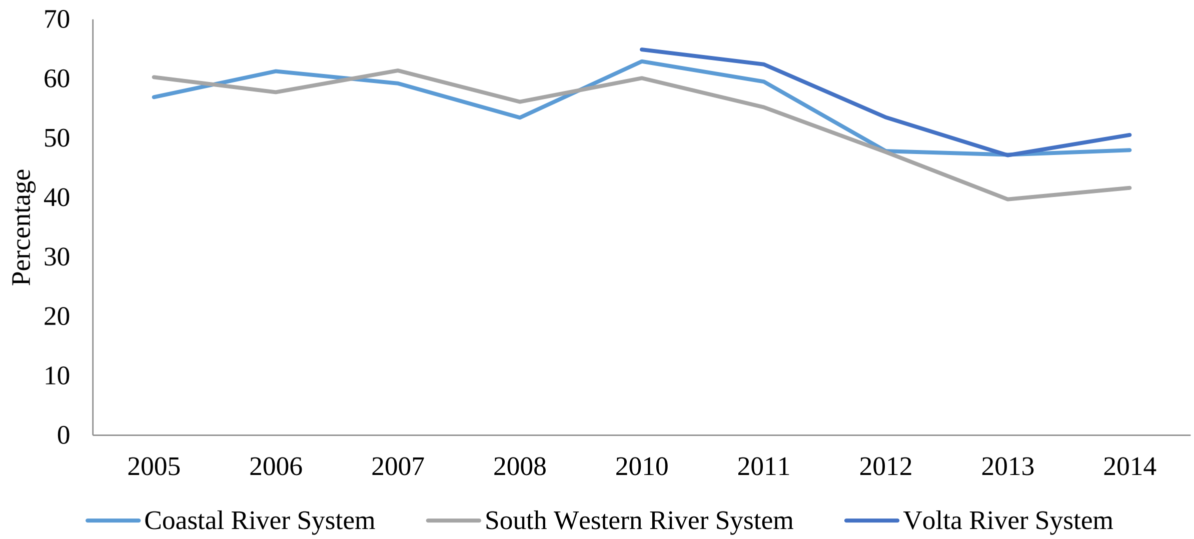
Source: Environmental Protection Agency (EPA), 2019

2.8 Freshwater Quality

The distribution of water within the country is not uniform, the south-western part (rain forest ecological zone) are better watered than the coastal and northern regions (savannah ecological zones). Seasonal variability is also observed for raw water availability. Surface water coverage is 5% of total land area of the country. There are three major basin systems, the Volta Basin, South Western Rivers and Coastal Basins. The Volta Basin system is composed of the White, Black, Main Volta, Oti and Dayi. The South-Western rivers are composed of the Pra (main river), Offin, Birim, Ankobra, Tano and Bia rivers and Lake Bosomtwe. The coastal rivers are the, Densu, Ayensu, Kakum, Butre, Ochie-Amissa and the Ochi-Nakwa rivers.

Surface water quality is below drinking water quality standards as compared to ground water. This is mainly attributed to anthropogenic activities such as discharge of untreated waste materials into water bodies, farming along water systems and illegal artisanal mining (‘Galamsey’). The quality of groundwater resources in Ghana is generally within standards for abstraction and use. The principal groundwater-quality problem observed in Ghana is high iron concentrations, seen in many groundwater supplies. The most serious direct health problems related to drinking water are considered to be from fluoride excess and iodine deficiency which have been noted in parts of the Upper Regions of northern Ghana. The water quality in many of Ghana's surface water system has been declining since 2004. Water quality analyses between 2005 and 2014 showed a decreasing water quality over the period (Figure 2.6).

Figure 2.6: Water Quality Index in the Major Water Systems in Ghana



Source: Ghana State of Environment 2016 Report

2.9 Marine Water Quality

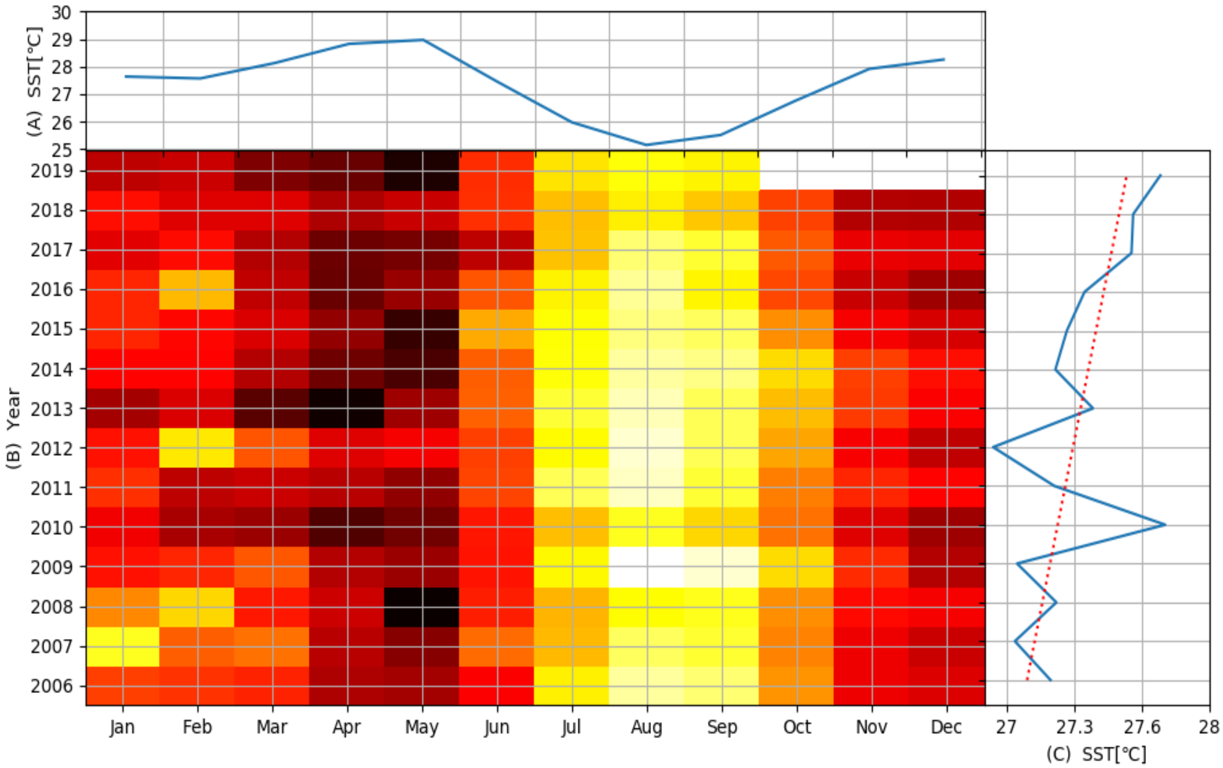
The rich marine biodiversity within Ghana's Exclusive Economic Zone (EEZ) is influenced on the larger scale by changes in air-sea interactions that drive key oceanographic processes such as changes in the direction and speeds of wind-induced currents, fronts and upwelling. These processes generate the needed nutrients for primary production in the sun-lit column of the upper ocean through photosynthesis and feeding during secondary and tertiary production. The duration, intensity and spatial stretch of upwelling is an important process for assessing the productivity of marine ecosystem, and is monitored with sea surface temperature measurements.

Figure 2.7 shows monthly average of sea surface temperature measurements from the space-borne sensor MODIS. It captures the seasonal and inter-annual variability patterns that are associated with the changing intensity of the upwelling off the coast of Ghana and the warm/cool years from 2006 to 2019. It depicts the seasonal variation in surface temperatures and the resulting intensity and duration of stratification (warm) and upwelling (cold) periods. Details of the variations for the different months and years shows that 2012 was a relatively cool year with a short-lived intense minor upwelling in February and relatively cool period of stratification from March to June.

These suggest the EEZ of Ghana may have had high nutrient levels to promote phytoplankton growth and secondary production. Very warm sea surface temperatures were measured in 2010 and from 2016 to 2019. During these years, the minor upwelling was absent and the major upwelling from July to September was relatively warm and short-lived. There was reduced upsurge and mixing of nutrient-rich bottom water required for increased biological production.

The trend line in shows that there is a steady rise of 0.04°C/year in sea surface temperature within Ghana's EEZ. The continuous warming of the ocean of the coast of Ghana is expected to adversely affect fish catch especially among the artisanal and semi-industrial sector who target pelagic fishes (fishes that occupy the shallow depths of the ocean).

Figure 2.7: Analysis of sea surface temperature variability off the coast of Ghana



Source: Ghana State of Environment 2016 Report

Chapter 3

Environmental Resources and their Use

3.1 Introduction

The focus of the chapter is on statistical information on environmental resources and their use. This includes measurement of stocks and changes in stocks of these resources and their use for production and consumption. Changes in the stocks of environmental resources include additions and reductions, from both anthropogenic and natural activities. In the case of non-renewable resources, unsustainable exploitation leads to the depletion[13] of the resource. For renewable resources, if extraction (e.g., abstraction, removal and harvesting) exceeds natural regeneration and human made replenishment, the resource is depleted.

3.2 Mineral Resources

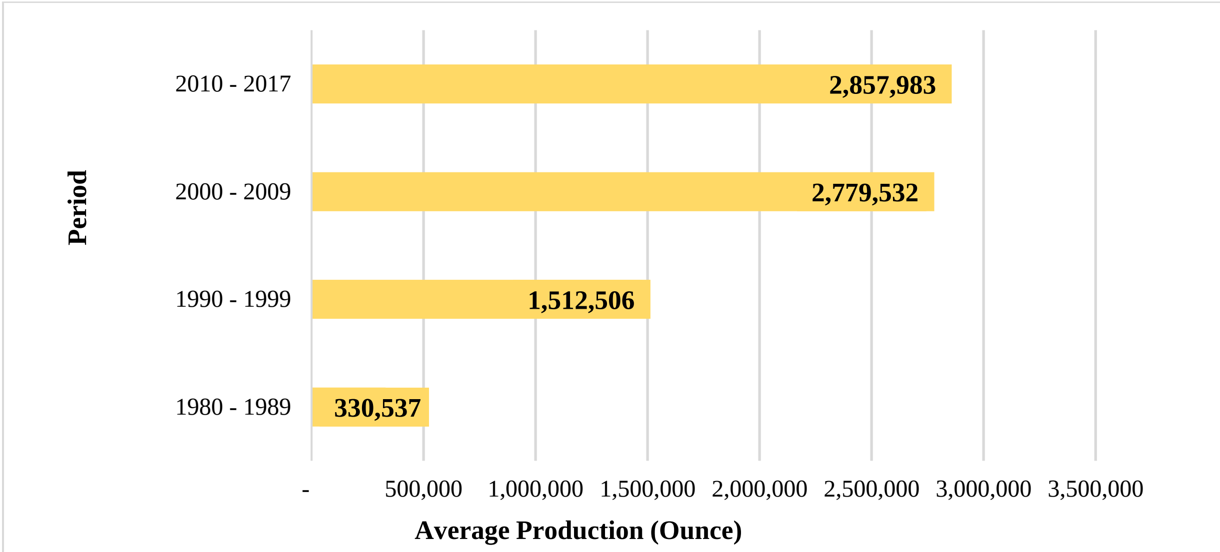
Minerals[14] include metal ores (including precious metals and rare earths); non-metallic minerals such as coal, oil, gas, stone, sand and clay; chemical and fertilizer minerals; salt; and various other minerals such as gemstones, abrasive minerals, graphite, asphalt, natural solid bitumen, quartz and mica. Classes of known mineral deposits include commercially recoverable deposits; potential commercially recoverable deposits; and non-commercial and other known deposits.

3.2.1 Extraction of Gold

The extraction of gold has been increasing consistently from the lowest average of 330,537 ounces through (1980-1989) to a peak of 2,857,983 ounces during (2010- 2017). During 1980-1989, an average of 330,537 ounces were produced annually and it increased 5 times to an average of 1,512,506 ounces within the period (1990-1999). Average Gold production increased from 2,779,532 ounces to 2,857,983 ounces, respectively, during the period (2000 -2009) and (2010 - 2017). The favorable gold prices on the international market coupled with new technologies and new mines contributed to the increase in gold production in Ghana over the three-decade period (Table 3.1).

[13] Depletion, in physical terms, is the decrease in the quantity of the stock of a natural resource over an accounting period that is due to the extraction of the natural resource by economic units occurring at a level greater than that of regeneration.
[14] Minerals are elements or compounds composed of a concentration of naturally occurring solid, liquid or gaseous materials in or on the earth’s crust

Figure 3.1: Average Gold Production, 1980 - 2017

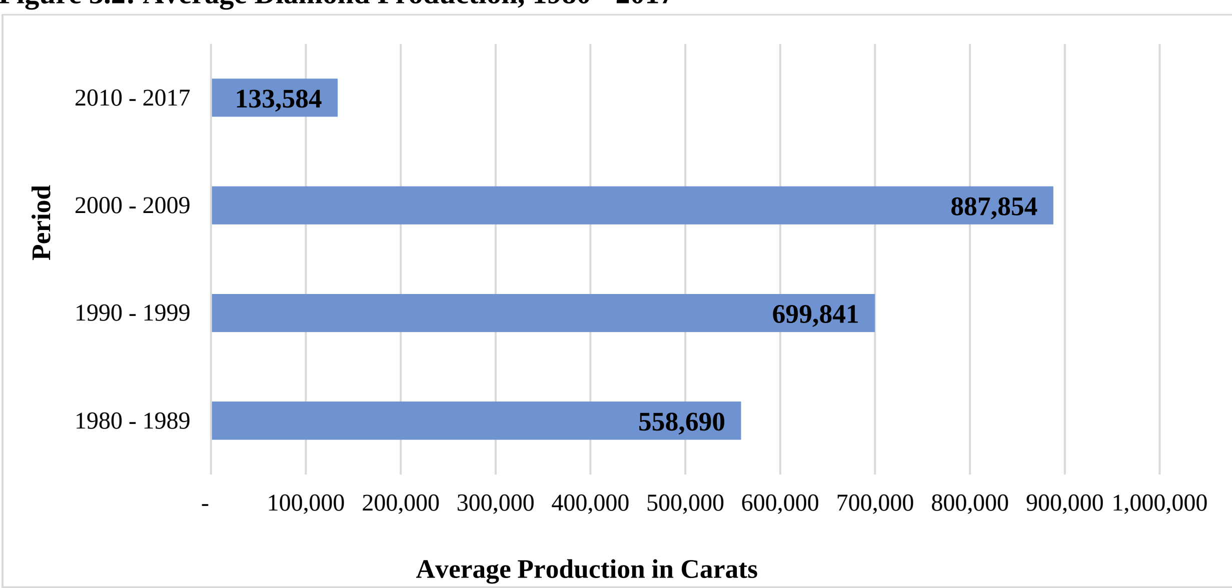


Source: Minerals Commission, 2017

3.2. Extraction of Diamond

Production of average diamonds has been increasing from 558,690 carats during the period (1980-1989) to 699,841 carats through (1990-1999). The period (2000-2009), saw the average diamond production reaching a record high of 887,854 carats. It declined considerably to 133,584 metric tonnes during the period (2010-2017) .The only diamond mine in Ghana is on divestiture, due to challenges in attracting financial assistance to revamp its operations. It's currently under care and maintenance (Table 3.1).

Figure 3.2: Average Diamond Production, 1980 - 2017

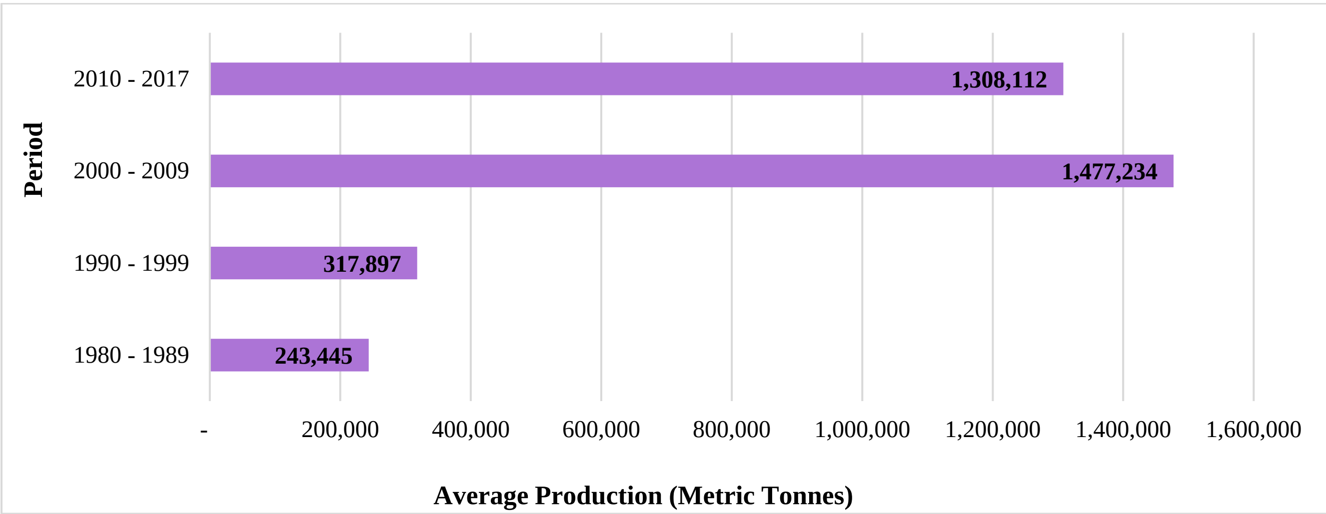


Source: Minerals Commission, 2017

3.2.3 Manganese

The best average production period of Manganese was through 2000-2009 as it recorded all time high of 1,477,234 Metric Tonnes (MT) whiles 243,445 metric tonnes were recorded as the lowest during the period 1980-198).The acquisition of new machinery and trucks coupled with increasing shift time has contributed to growth in the operations of Ghana manganese over the period Source: Minerals Commission (Table 3.1).

Figure 3.3: Average Manganese Production, 1980 - 2017

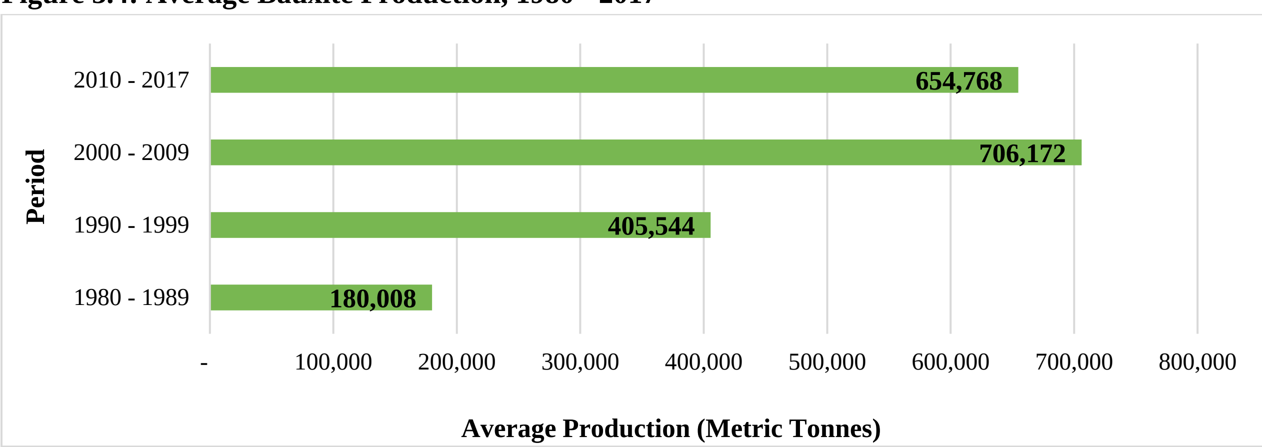


Source: Minerals Commission, 2017

3.2.4 Bauxite

Bauxite reached its average peak at 706,172 MT during the period 2000-2009. Average production increased from 180,008 metric tonnes through the period (1980-1988) to 405,544 MT during 1990-1999. The injection of millions of dollars into the operations of Ghana Bauxite Company Limited accounted for the significant increase in bauxite production over the period (Table 3.1).

Figure 3.4: Average Bauxite Production, 1980 - 2017



Source: Minerals Commission, 2017

Table 3.1: Extraction of Selected Minerals, 1980 - 2017

Year	Gold (Oz)	Diamonds (Carats)	Bauxite (Mt)	Manganese (Mt)	Salt (NaCl) Mt
1980	342,904	1,150,042	196,892	240,006	
1981	338,042	836,491	156,769	197,439	
1982	337,754	683,585	92,954	132,232	
1983	285,291	388,771	82,310	175,288	
1984	282,299	345,675	44,169	267,996	
1985	299,615	636,127	124,453	357,270	
1986	287,124	560,538	226,461	262,900	
1987	328,926	440,681	201,483	242,410	
1988	373,937	259,358	299,939	284,911	
1989	429,476	285,636	374,646	273,993	
1990	541,147	636,503	368,659	246,869	
1991	847,559	687,736	324,313	311,824	
1992	1,004,625	656,421	399,155	276,019	
1993	1,261,890	590,842	364,641	295,296	
1994	1,438,483	746,797	451,802	238,544	
1995	1,715,867	631,708	530,389	187,548	
1996	1,583,830	714,738	383,370	266,765	
1997	1,752,452	829,524	536,723	332,703	
1998	2,371,108	822,563	341,120	384,463	
1999	2,608,102	681,576	355,263	638,937	
2000	2,457,152	878,011	503,825	895,749	
2001	2,381,345	1,090,072	678,449	1,076,666	
2002	2,236,833	963,493	683,654	1,135,828	
2003	2,274,627	904,089	494,716	1,509,432	
2004	2,031,971	905,344	498,060	1,597,085	
2005	2,138,944	1,065,923	606,700	1,719,589	
2006	2,337,784	972,992	972,991	1,699,546	123,162
2007	2,628,290	836,488	1,033,368	1,305,809	124,072
2008	2,796,955	599,007	574,389	1,261,000	184,550
2009	3,119,832	354,443	420,477	1,007,010	
2010	3,391,587	308,679	595,092	1,564,628	
2011	3,676,222	283,369	407,918	1,705,314	
2012	4,337,913	215,118	662,925	1,501,033	
2013	4,397,241	160,821	908,586	1,724,417	
2014	4,471,573	241,235	798,114	1,531,394	
2015	3,623,741	174,364	1,014,605	1,562,769	
2016	3,841,763	173,863	1,278,561	2,034,560	
2017	4,231,376	87,065	1,476,966	3,021,633	

Source: Minerals Commission, 2017

3.3 Energy Resources

Energy can be produced from non-renewable or renewable sources. Non-renewable energy resources are hydrocarbons used for energy production. Statistics on the magnitude of their stocks through time are required for sustainable management of the resources. Stocks of non-renewable energy resources are defined as the amount of known deposits of energy resources. They include fossil fuels such as natural gas and crude oil. Classes of known energy resource deposits include commercially recoverable deposits, potential commercially recoverable deposits, and non-commercial and other known deposits. Extraction of non-renewable energy resources reflects the quantity of the resource physically removed from the deposit during a period.

3.3.1 Extraction of Energy Resources

The extraction of natural gas peaked in 2018 with a value of 86.7mmscf per day after it has started slowly from 5.2 mmscf per day at the inception in 2015. On the other hand, extraction of crude oil recorded its highest output in 2018, with 58.66 mmbo and the lowest in 2010 with 0.17mmbo. Output of natural gas declined from 2016 to 2018. However, output of crude oil increased from 2012 to 2016, but decreased slightly in 2017. Table 3.2 provides additional details on the extraction of natural gas and crude oil.

Table 3.2: Extraction of Energy Resources from 2008-2018

Year	Natural Gas (mmscf / day)	Crude Oil (mmbo)
2008	-	0.19
2009	-	0.21
2010	-	0.17
2011	-	1.37
2012	-	23.83
2013	-	28.94
2014	-	36.86
2015	5.2	37.30
2016	67.8	37.46
2017	60.3	32.30
2018	86.7	58.66

Source: Energy Commission, 2018

3.4 Production, Trade and Consumption of Energy

Energy production refers to the capture, extraction or manufacture of fuels or other energy products in forms which are ready for general use. Energy products are produced in a number of ways, depending on the energy source. Energy production, transformation, distribution and use are processes characterized by different efficiency rates, which cause distinct environmental impacts (including land use change, air pollution, GHG emissions and waste). Total energy production originates from sources that can be classified as non-renewable or renewable. These constitute key environment statistics that can assist when analyzing the sustainability of the energy mix at the national level. Energy production includes the production of primary and secondary energy. Energy imports and exports refer to the amount of fuels, electricity and heat obtained from or supplied to other countries. Total energy supply is intended to show flows that represent energy entering the national territory for the first time, energy removed from the national territory and stock changes. It represents the amount of energy available on the national territory during the reference period. Final energy consumption refers to the consumption of primary and secondary energy by households and through economic activities. Therefore, producing statistics to describe these activities are key to informing environmental sustainability policy.

3.4.1 Primary Energy Production

Production of energy from oil increased from 9.0 ktoe at its inception in 2002 to 5351.0 ktoe in 2015. It slowed in 2016 to 4614.0 ktoe and then increased to 887l.0 ktoe in 2018. Production of natural gas increased sharply from 51.4 ktoe in 2014 to 665.1 ktoe in 2015. However, it declined slightly to 591.5 ktoe in 2016 but increase to 850.5 ktoe in 2017. It declined to 820.8 ktoe in 2018. The highest production of Hydro energy was recorded in the year 2014 with 721.2 ktoe. It decreased between the year 2001 and 2003 but resumed an upward trend until 2005.

It further decreased until 2007 and then resumed an upward trend again until 2014 where it peaked. It declined consistently to the year 2017 (Table 3.3). Solar energy production has been constant since its inception in 2017 producing 2.0ktoe. Primary energy production of Biomass has declined consistently from 2000 to 2007 (3890.6ktoe to 3068.1ktoe). It increased steadily to 3903.3ktoe in 2017 but declined to 3881.3 ktoe.

Table 3.3: Primary Energy Production by Primary Energy Resources (ktoe)

Year	Non-Renewable		Renewable		
	Crude Oil	Natural Gas	Hydro	Solar	Biomass
2000	0.0	-	568.4	-	3890.6
2001	0.0	-	568.3	-	3705.2
2002	9.0	-	433.1	-	3541.2
2003	10.0	-	334.1	-	3398.0
2004	23.0	-	454.1	-	3276.7
2005	12.0	-	484.1	-	3178.4
2006	23.0	-	483.2	-	3102.5
2007	27.0	-	320.5	-	3068.1
2008	31.0	-	532.9	-	3070.4
2009	25.0	0.0	591.4	-	3127.0
2010	195.0	0.0	601.6	-	3207.0
2011	3405.0	0.0	650.2	-	3370.7
2012	4134.0	0.0	694.1	-	3409.2
2013	5266.0	0.0	708.0	-	3553.9
2014	5328.0	51.4	721.2	0.0	3629.0
2015	5351.0	665.1	502.6	0.0	3618.0
2016	4614.0	591.5	478.3	0.0	3602.4
2017	8380	850.5	482.9	2	3903.3
2018	8876	820.8	517.5	2	3881.3

Source: Energy Commission, 2018

3.4.2 Secondary Energy Production

The secondary energy production of electricity recorded its maximum in 2018 (1387.1ktoe) and lowest in 2003 (505.8 ktoe). Generally, it has had increasing trend from 2000 to 2018. LPG has had a generally very fluctuating trend, recording low productions in 2001 (7.5ktoe), 2006 (38.7 ktoe), 2009 (15.1 ktoe) and 2015 (2.2ktoe). LPG's highest productions was recorded in 2016 (123.4ktoe) while the lowest was in 2015 (2.2 ktoe). In addition, Kerosene recorded its maximum in the year 2011 (173.6 ktoe) and the lowest in the year 2000 (0.1 ktoe).

Also, ATK peaked in the year 2005 (121.4ktoe) with the lowest in the year 2017 (0.1ktoe). Furthermore, Gas oil recorded its highest in the year 2004 (613.8ktoe) and the lowest in 2017 (6.6ktoe). Also, Fuel oils recorded its maximum in the year 2000 (254.1) with the lowest in the year 2017 (1.2ktoe) as indicated in Table 3.4.

Table 3.4: Secondary Energy Production (ktoe), 2000-2018

Year	Electricity	LPG	Gasoline	Kerosene	ATK	Gas Oil	Fuel Oils
2000	621.2	10.4	250.6	0.1	110.5	386.7	254.1
2001	675.8	7.5	300.6	88	65.3	381.8	253.2
2002	625.5	26.3	363.5	115.3	83.2	482.3	189.8
2003	505.8	56.8	455.5	53.3	87.3	547.1	158.6
2004	519.2	70.8	580.7	101	109	613.8	193.1
2005	583.7	81.3	595.4	62.9	121.4	525.2	199.3
2006	724.9	38.7	309.1	112.9	47.2	317.7	150.9
2007	623.8	72.7	517.6	114.4	67.1	430	47.2
2008	728.5	58.9	410.8	90.4	21.7	389.4	218.7
2009	770.4	15.1	141.8	67.1	1.3	111	24.6
2010	874.3	34.1	354.6	125.6	119	316	93.9
2011	963.2	48.1	361.5	173.6	118.4	334.6	87.9
2012	1,034.00	28.9	165.6	50.2	48.6	131.3	76.8
2013	1,106.80	27.7	175.7	73.1	61	122.4	42.1
2014	1,114.80	3.5	42.4	54.2	9.6	30.1	42.4
2015	988.3	2.2	33.4	21.8	18.5	30.3	8.7
2016	1,120.00	123.4	256.2	15	38.3	275.1	62.1
2017	1,209.80	123.1	6.8	4.7	0.1	6.6	1.2
2018	1,397.10	94.9	106.7	34.1	22.1	115.3	30.6

Source: Energy Commission, 2018

3.4.3 Total Energy supply

Crude oil recorded its highest supply in 2007 (2094.8ktoe) with its lowest supply of energy in 2017 (169.2 ktoe). There was a constant increase from 2000 to 2006. During the years 2006, 2013, 2015 and 2018, the supply of crude oil fluctuated. In the year 2018 natural gas sector recorded the highest supply of energy (1458.8ktoe) with its lowest in 2009 (5.0ktoe). The supply of natural gas varied during the decade (2009 –

2019). Petroleum products recorded the maximum supply of energy in 2018 (4233.9 ktoe) with its lowest supply in 2001 (1375.2 ktoe).

A gradual increase in the supply of this energy occurred from 2001 to 2004 and 2011 to 2018 while 2005-2010 saw its supply fluctuating. In comparison to the other sectors, this sector recorded the highest energy supply. Biomass had its highest supply in 2017 (3903.3 ktoe) and the lowest supply in the year 2007 (3068.1 ktoe). The supply of biomass decreased from 2000 to 2008 and increased from 2009 to 2014. Fluctuation occurred during the years 2015-2018. This type of energy supply recorded the highest from 2000 to 2014 compared to the other energy products (Table 3.5).

Solar energy recorded highest supply in 2018 (2.8 ktoe) and the lowest in 2013 - 2015 with a steady figure of 0.3. There was an increase in supply from 2016 to 2018. This sector recorded the overall lowest supply. Also, hydro energy recorded its maximum supply in 2014 (721.1 ktoe) with its lowest supply in 2003 (334.1ktoe). From 2000 to 2003, the supply decreased and increased from 2009 to 2014. There were fluctuations in supply from 2004 to 2008.

Table 3.5: Total Energy Supply by Energy Product (ktoe), 2000-2018

Year/Energy Product	Crude Oil	Natural Gas	Petroleum Products	Biomass	Solar	Hydro
2000	1310.6	-	1415.1	3890.6	-	568.4
2001	1569.6	-	1375.2	3705.2	-	568.3
2002	1816.7	-	1466.5	3541.2	-	433.1
2003	1972.5	-	1522.8	3398.0	-	334.1
2004	2016.5	-	1664.7	3276.7	-	454.1
2005	2006.8	-	1596.9	3178.4	-	484.1
2006	1747.1	-	1838.3	3102.5	-	483.2
2007	2094.8	-	1970.7	3068.1	-	320.5
2008	2015.3	-	1738.4	3070.4	-	532.9
2009	1002.1	5.0	1539.0	3127.0	-	591.4
2010	1880.5	393.5	1990.8	3207.0	-	601.6
2011	1431.4	769.2	2323.2	3370.7	-	650.2
2012	1598.8	389.3	2600.2	3409.2	-	694.1
2013	1446.4	291.6	3203.7	3553.9	0.3	708.0
2014	648.2	619.4	3515.1	3629.0	0.3	721.2
2015	462.2	1184.8	3742.8	3618.0	0.3	502.6
2016	1823.2	692.4	3799.7	3602.4	2.3	478.3
2017	169.2	1145.6	3924.6	3903.3	2.4	482.9
2018	415.8	1458.8	4233.9	3881.3	2.8	517.5

Source: Energy Commission, 2018

3.4.4 Final Consumption of Energy

Under Grid electricity energy consumption, residential consumption of energy recorded it highest in 2018 (555ktoe), with its lowest in 2000 (196.5ktoe). It increased consistently from 2000 to 2018. Commerce & Service recorded its highest consumption in 2017 (242.5ktoe), whiles 2007 turned out to be its lowest (33.9ktoe), and thereafter, there was a continuous increase from 2007 to 2014 with fluctuations from 2014 to 2018. The Industry recorded its maximum in 2001 (363.4ktoe) and lowest in 2004 (166ktoe) and fluctuated from 2005 to 2011.

Residential consumption of petroleum peaked in the year 2009 (204ktoe) and recorded its lowest consumption in 2000 (88ktoe) with a continuous increase from 2000 to 2006. The Industry recorded the highest consumption of petroleum in 2011 (434ktoe) whiles Commerce and Service also recorded the lowest (5 ktoe) consumption of petroleum in 2000, 2001, and 2005.

Residential consumption of Biomass recorded the highest consumption of energy from 2000 to 2011. Agriculture and transport for grid electricity recorded the lowest consumption of energy as compared to the other sectors. For the petroleum sector, transport recorded the highest on yearly basis. The overall highest and lowest consumption of energy recorded for Biomass and grid electricity were residential, agriculture and fisheries (Table 3.6).

Table 3.6: Final Consumption of Energy (ktoe)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Grid Electricity																			
Residential	196.5	209.0	219.8	231.4	244.4	273.5	252.2	222.4	250.6	328.6	351.7	380.6	419.8	448.6	453.5	429.6	502.8	533.7	555.0
Commerce & Service	38.8	40.0	41.1	42.4	43.5	47.9	40.9	33.9	36.3	48.5	124.2	138.4	159.4	178.8	185.0	181.8	221.0	242.5	228.6
Industry	356.6	363.4	320.8	170.7	166.0	187.3	326.8	281.2	309.1	236.6	197.5	252.0	271.7	280.5	280.6	220.6	256.5	264.7	349.4
Agriculture & Fisheries	0.2	0.3	0.4	0.5	0.6	0.7	0.7	0.7	0.8	1.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3
Transport	0.3	0.3	0.3	1.0	1.2	0.8	0.8	1.0	0.9	0.6	0.7	0.9	0.7	0.3	0.5	0.8	1.0	0.5	0.7
Total	**592**	**613**	**582**	**446**	**456**	**510**	**621**	**539**	**598**	**615**	**674**	**772**	**852**	**908**	**920**	**833**	**982**	**1,042**	**1,134**
Petroleum (Oil & Gas)																			
Residential	88	90	100	100	106	112	121	110	99	204	144	176	198	173	153	174	177	176	181.6
Industry	131	142	148	157	180	198	287	334	334	384	384	434	402	412	384	396	356	337	406.6
Commerce & Service	5	5	6	7	5	6	7	8	7	13	8	11	12	12	11	14	15	15	16.6
Agriculture & Fisheries	58	55	58	54	60	58	57	64	60	71	70	77	88	91	89	92	83	142	94.8
Transport	1148	1163	1220	1161	1337	1319	1392	1603	1567	1913	1877	2118	2467	2611	2633	2868	2642	2449	2847.2
Total	**1,430**	**1,455**	**1,532**	**1,479**	**1,689**	**1,692**	**1,863**	**2,118**	**2,066**	**2,585**	**2,484**	**2,817**	**3,167**	**3,299**	**3,271**	**3,544**	**3,273**	**3,119**	**3,547**
Biomass																			
Residential	3127	2941	2792	2642	2560	2470	2398	2322	2247	2218	2183	2285	2291	2363	2461	2448	2440	2471	2451.6
Commerce & Service	75	75	77	77	80	83	87	89	90	93	95	93	98	106	117	119	122	130	116.3
Industry	230	222	214	206	199	192	186	183	181	183	186	197	200	207	214	217	221	228	226.6
Agriculture & Fisheries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
Total	**3,432**	**3,238**	**3,082**	**2,925**	**2,839**	**2,745**	**2,671**	**2,594**	**2,518**	**2,493**	**2,464**	**2,576**	**2,589**	**2,676**	**2,792**	**2,785**	**2,783**	**2,828**	**2,795**

Source: Energy Commission, 2018

3.5 Land Use

Land use reflects both the activities undertaken and the institutional arrangements put in place for a given area for the purposes of economic production, or the maintenance and restoration of environmental functions[15].

3.5.1 Use of Forest Land

Changes in forest area in the different categories resulted from economic activities (afforestation or deforestation), reclassifications among the categories, or natural processes (expansion or regression). FAO defines afforestation as the establishment of forests through planting and/or deliberate seeding on land that, until then, was not classified as forest. It implies a transformation from non-forest to a forest. FAO defines deforestation, in turn, as the conversion of forest to another land use or the long-term reduction of the tree canopy cover below the minimum 10 per cent threshold.

Reforestation, which is the re-establishment of forest through planting and/or deliberate seeding on land classified as forest, is also included here. Not all forest land is used primarily to produce wood. The primary designated functions of forests are production, protection of soil and water, conservation of biodiversity, social services, multiple use and other. To better understand the uses of forest land, statistics on forest land should be classified according to its primary designated function.

Table 3.7: Land Use (National Data)

	2000	**2010**
Type of land use	**Area (Ha)**	**Area (Ha)**
Forest land	8,911,425.6	9,195,136.6
Cropland	3,904,571.6	5,221,448.5
Grassland	9,954,340.0	8,173,402.6
Settlements	203,844.2	345,048.3
Wetlands	792,678.8	878,783.9
Other land	156,683.0	109,724.1
Total	**23,923,543.2**	**23,923,544.0**

Source: Forestry Commission, 2010

[15] 2013 FDES

3.6 Timber Resources

Timber resources can be natural or cultivated and are important environmental resources in many countries. They provide inputs for construction and the production of furniture, cardboard, cellulose, paper and other products, and are also a fuel source. Timber resources are defined by the volume of trees, living and dead, which can still be used for timber or fuel. This includes all trees regardless of diameter or tops of stems.

3.6.1 Export of Timber

The year 2012 recorded the smallest amount of timber exports (251,245.6m^3), whiles the year 2008 (545,915.1m^3) recorded the largest amount of timber exports (Table 3.8). There was a continuous increase in the volume of timber exported from 2006 to 2008, and from 2013 to 2016, and conversely 2008 to 2012 recorded a continuous decrease volumes of timber exported.

Table 3.8: Export of Timber Products (Wood & Wood Products)

Year	Volume (m^3)	Value (US$M)	Year	Volume (m^3)	Value (US$M)
1997	442,078.2	308.0	2008	545,915.1	214.6
1998	415,700.8	171.0	2009	426,221.9	147.5
1999	433,125.1	173.8	2010	403,254.1	158.5
2000	498,843.3	175.2	2011	319,842.9	123.5
2001	476,500.5	169.0	2012	251,245.6	114.8
2002	472,426.6	210.9	2013	271,722.2	137.2
2003	444,388.3	187.4	2014	356,036.0	158.9
2004	455,180.4	196.1	2015	267,379.5	155.3
2005	466,155.3	211.6	2016	396,991.5	258.7
2006	451,608.0	195.6	2017	339,226.6	218.4
2007	528,570.1	211.8	2018	332,927.0	216.1

Source: Forestry Commission, 2018

3.6.2 Fertilizers

In 2006, Muriate of potash was the minimum fertilizer used with a record of 19Mt whiles 2,692,580 MT of NPK liquid (Lt) was used in 2012. The most commonly used fertilizer from 2004 to 2018 was NPK with a total sum of 1,852,325.15 MT, because NPK had the highest usage in 2005, 2006, 2007, 2009, 2016, 2017, and 2018. On the contrary, Potassium Sulphate had the lowest total usage of 76,784 MT.

Table 3.9 : Fertilizers and Pesticides Use

No.	Type of Input	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	NPK (Mt)	18,223	38,978	84,907	87,388	18,873	197,631	30,560	70,359	230,723	227,571	89332	121509.83	258290.19	153767.13	224202
2	NPK Liquid (Lt)							11,521	844,543	2,692,580	264,649	1,345,562	71,800	127,565	14,351.00	
3	Urea (Mt)	250	4,540	9,072	4,962	13,773	25,028	16,079	48,552	31,950	51,044	3,864	23,594.27	16,353.40	78,590.56	42,149
4	Muriate of Potash (Mt)	822	1,000	19	109	8853	15,007	12077	62,338	43384	43,441	28642	25,572.81	14,267.82	26,018.00	16495
5	Sulphate of Ammonia (Mt)	7,688	15,000	19090	17,458	4172	4,616	52117	20,140	83840	68,979	7551	59,676.16	14,417.39	36,833.10	10429
6	Phosphates (Mt)	1,850	1000	99	504	15,440	66501	236,547	108862	78,355	63700	17182	43,040.11	109,960.87	23,279.53	3239
7	Nitrates (Mt)	95,312	157	52,601	52823	64,085	110		157	267	407	49,319	49,491.79	3,450.04	2,203.41	90022
8	Potassium Sulphate (Mt)	72,000	135	103	321	371								3,626.52		227
9	Insecticides (Mt)	610	5,982	6,921	9,979	5,121	5,078	8,735	832,810	543,000	1,539	6,513	3,695	5,742.20	1,619.50	
10	Fungicides (Mt)	770	1,713	2,148	2,575	2,767	1,248	4,955	596,000	180,000	4,599	1,167	1,328	4,706.90	4,482.00	
11	Herbicides (Mt)	1096	5,340	8,780	8,932	10,835	4,555		854,400	991,300	4,723	7,889	294,009	32,947.10	19,112.50	

Source: Plant Protection & Regulatory Services Directorate, MoFA

3.7 Water Resources

Water resources consist of freshwater and brackish water, regardless of their quality, in inland water bodies, including surface water, groundwater and soil water. Inland water stocks are the volume of water contained in surface water and groundwater bodies and the soil at a point in time. Water resources are also measured in terms of flows to and out of the inland water resources during a period of time. Surface water comprises all water that flows over or is stored on the ground's surface, regardless of its salinity levels. Surface water includes water in artificial reservoirs, lakes, rivers and streams, snow, ice and glaciers. Groundwater comprises water that collects in porous layers of underground formations known as aquifers.

Statistics on water resources include the volume of water generated within the country or territory as the result of precipitation, the volume of water lost to evapotranspiration, the inflow of water from neighboring countries, and the outflow of water to neighboring countries or the sea.

3.7.1 Abstraction, Use and Returns of Water

Abstraction, use and returns of water are the flows of water between the environment and the human subsystem and within the human subsystem. Water abstraction is the amount of water that is removed from any source, either permanently or temporarily, in a given period of time. Water is abstracted from surface water and groundwater resources by economic activities and households. It can be abstracted for own use or distribution to other users.

The freshwater abstraction data provided is for the formal irrigation schemes which are under the management of the Ghana Irrigation Development Authority (GIDA). This data is exclusive of water abstraction by informal irrigation sector both the smallholder and large-scale commercial farms. There are 56 formal irrigation schemes currently under the management of GIDA contributing about 6% of irrigated lands. Most irrigated lands fall under the informal irrigated sectors as shown in Table 3.11.

The water abstraction data as summarized in Table 3.10 was compiled from 29 of the formal irrigation schemes between the period of 2009 and 2017. These irrigation schemes use fresh surface water, no groundwater data were included. The rest of the 56 formal irrigation schemes are not captured because of non-availability of data or the scheme being nonoperational or under rehabilitation. The abstraction data was estimated from the annual Crop Production figures and the net irrigation requirement for the crops under production. Further details on fresh surface water abstraction for irrigation is provide in Annex 3.

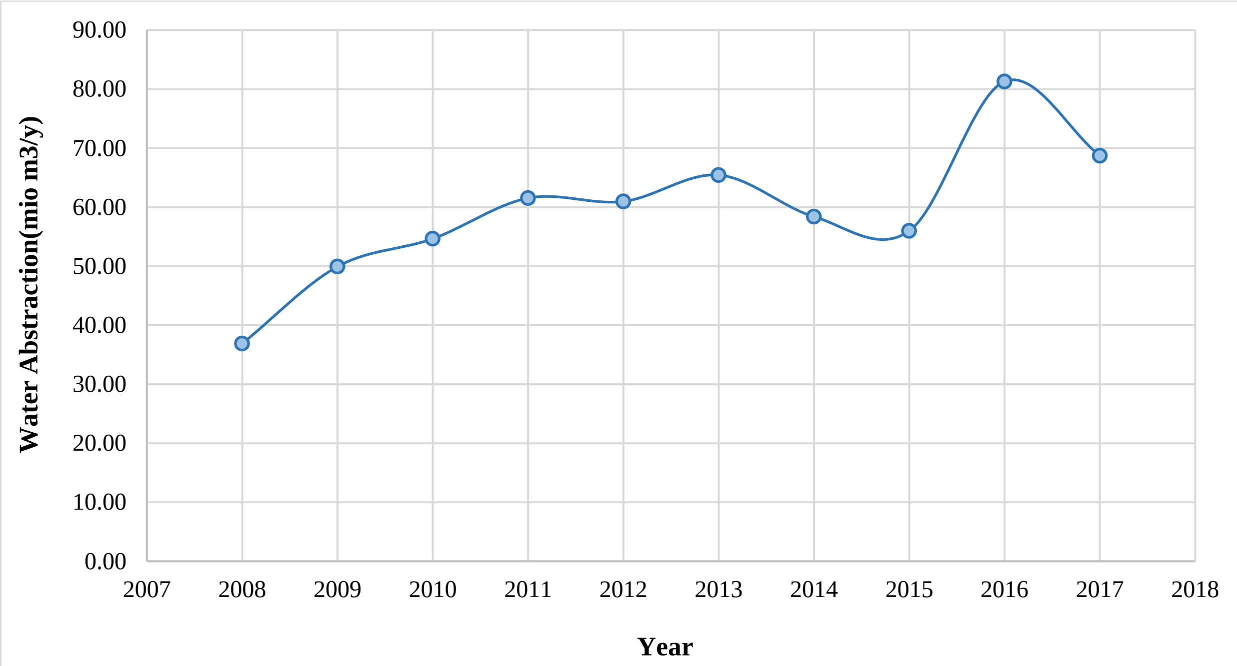
From Figure 3.5, irrigation development has been growing steadily over the years. It declined in 2014, 2015 but rose rapidly in 2016. This trend is expected to continue with more investment in the sector. The Authority has also taken steps to address the challenges in managing the informal sector. It must however be noted that the large-scale informal sectors are located on the GIDA schemes.

Table 3.10: Summary of Fresh Surface Water Abstraction Data for Irrigation

Regions	Fresh Surface Water Abstraction for Irrigation in Agriculture (mio m^3)									
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Western	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Central	0.000	0.320	0.796	0.348	0.530	0.790	0.050	0.605	0.963	0.101
Greater Accra	16.218	20.362	25.390	25.550	27.210	31.400	22.160	32.050	33.709	22.170
Eastern	0.000	0.191	0.078	0.122	0.000	0.000	0.000	0.000	0.000	0.000
Volta	8.670	12.776	10.020	12.716	13.931	13.763	14.783	12.918	10.785	18.871
Ashanti	0.297	0.166	0.978	0.839	1.163	0.862	0.811	0.697	0.827	0.946
Brong Ahafo	0.446	0.417	0.448	0.485	0.412	0.323	0.329	0.309	0.135	0.083
Northern	2.405	3.581	3.524	4.071	3.933	4.452	4.798	3.472	5.613	3.911
Upper East	8.836	12.115	13.418	17.403	13.782	13.846	15.459	5.932	29.265	22.634
Total Surface Water Abstraction for Irrigation (mio m3/y)	**36.87**	**49.93**	**54.65**	**61.54**	**60.96**	**65.44**	**58.39**	**55.98**	**81.30**	**68.72**

Source: Ghana Irrigation Development Authority (GIDA), 2019

Figure 3.5: Annual Fresh Surface Water Abstraction for Irrigation



Source: Ghana Irrigation Development Authority (GIDA), 2019

Table 3.11: Irrigated Agricultural Lands per Year

Year	Irrigation Type			Total
	Formal Irrigation	Informal Irrigation (Smallholder)	Informal Irrigation (Large Scale Commercial)	
2009	12,168	-	17,636	29,804
2010	12,633	-	17,636	30,269
2011	11,709	-	17,636	29,345
2012	11,709	-	17,636	29,345
2013	10,668	-	17,636	28,304
2014	10,668	-	17,636	28,304
2015	11,000	189,000	21,000	221,000
2016	11,000	189,000	21,000	221,000
2017	12,003	189,000	21,000	222,003
2018	12,978	189,000	21,000	222,978

Source: Ghana Irrigation Development Authority (GIDA), 2019

Chapter 4

Residuals

4.1 Introduction

This chapter contains statistics on the amount and characteristics of residuals generated by human production and consumption processes, their management, and their final release to the environment. Residuals are flows of solid, liquid and gaseous materials, and energy that are discarded, discharged or emitted by establishments and households through processes of production, consumption or accumulation. Residuals may be discarded, discharged or emitted directly to the environment or be captured, collected, treated, recycled or reused.

4.2 Emissions of Greenhouse Gases (GHG)

Behind the struggle to address global warming and climate change lies the increase in greenhouse gases in our atmosphere. A greenhouse gas is any gaseous compound in the atmosphere that is capable of absorbing infrared radiation, thereby trapping and holding heat in the atmosphere. By increasing the heat in the atmosphere, greenhouse gases are responsible for the greenhouse effect, which ultimately leads to global warming. Greenhouse gas concentrations have increased rapidly, and human activities are the primary cause. The result is a worldwide, unnatural warming that's driving other changes in our environment. Hence, the need to monitor the rate at which these gases are emitted into the atmosphere. Below are the data that depicts the quantity of Greenhouse gas emission in Ghana.

4.2.1 Total National Greenhouse Gas Emission

The country recorded a total national greenhouse gas emission of 42.2 MtCO2e (million tonnes carbon dioxide equivalent) in 2016 compared to 25.3 MtCO2e in 1990, 27.6 MtCO2e in 2012. The 2016 emissions are 66.4%, 53% and 7.1% more than the previously reported net emission levels for 1990, 2000 and 2012, respectively, thus a significant increase in emissions between 1990 and 2016. In all, the national emissions increased at 2.1% annual growth rate during 1990-2016. The visible drop in the emissions between 2004 and 2005 was as a result of the reductions in fuel consumption in the transport and electricity categories.

All sectors have recorded emission increases over the 26-year inventory period. But for the emissions that occurred between 2012 and 2016, the waste sector saw the highest increase of 17% followed by the energy sector (14.2%) and then by the Agriculture, Forestry and other Land Use (AFOLU) sector (4.0%).

On the other hand, emissions from the IPPU sector notably decreased from 1.52 $MtCO_2e$ to 1.04 $MtCO_2e$ representing a 31.3% reduction. Stationary and mobile combustions were the main sources of emissions in the energy sector, so in terms of the trends, they both recorded 22.7% and 7.2% increases, respectively, within the same timeframe. The fugitive emissions have also increased over the period 2012-2016 largely due to the increased oil and gas production.

4.2.2 Net Carbon dioxide (CO_2) Emissions by sectors in Mt

The total CO_2 emissions grew from 16.84 Mt in 1990 to 27.29 Mt in 2016 representing a 62% increase. The Energy and Agriculture, Forestry and other Land Use (AFOLU) sectors were the key sources of CO_2 emissions mainly from fossil fuel combustion and land-use change. While CO_2 in the energy sector saw a 454% increment (from 2.52 Mt to 13.97 Mt) that of the AFOLU sector dropped by 7.9% from 14.02 Mt in 1990 to 12.91 Mt in 2016.

The energy sector CO_2 emissions increased by 15% for the period 2012-2016 and AFOLU CO_2 slightly declined by nearly 1% in the same period. CO_2 emissions from industrial processes and product use also increased from 0.29Mt to 0.3 between 1990 to 1995 saw some declined and appreciation from 1996 to 2016. CO_2 emissions from the waste sector was consistent with a value of 0.003Mt from 1990 to 2000, appreciated to 0.004 from 2001 to 2006, 0.005 in 2007 and gradually increased to 0.009 in 2016. Carbon dioxide per sector (Figure 4.1).

Although, agriculture, forestry and other land use generated the highest record of net carbon dioxide emission for the years being reported, except for years 2015 and 2016 where the energy sector recorded the highest. Also, there were fluctuations from year 2000 to 2016. Industrial processes & product use was the second lowest contributor in the generation of carbon dioxide emission. It also experienced constant fluctuation and with year 2012 recording the highest (0.54) with the least (0.005) being 2003 and 2004 (Table 4.1).

Figure 4.1: Annual Carbon Dioxide (CO_2) Emissions Per Sector in Mt

Source: Environmental Protection Agency (EPA), 2019

Table 4.1: Net Carbon dioxide (CO2) Emissions by sectors in Mt

Year	Energy	Industrial Processes & Product Use (IPPU)	Agriculture, Forestry and Other Land Use (AFOLU)	Waste	Total
1990	2.52	0.29	14.02	0.003	16.839
1991	2.03	0.3	14.07	0.003	16.402
1992	2.29	0.3	14.13	0.003	16.73
1993	2.34	0.32	14.18	0.003	16.842
1994	2.89	0.3	14.24	0.003	17.427
1995	2.69	0.3	14.3	0.003	17.292
1996	3.21	0.29	14.36	0.003	17.859
1997	3.16	0.29	14.43	0.003	17.872
1998	5.33	0.13	14.43	0.003	19.889
1999	4.81	0.19	14.59	0.003	19.598
2000	4.83	0.29	12.74	0.003	17.865
2001	5.22	0.31	13.31	0.004	18.848
2002	6.6	0.24	13.53	0.004	20.37
2003	5.98	0.05	13.17	0.004	19.205
2004	5.76	0.05	12.63	0.004	18.45
2005	5.67	0.14	12.71	0.004	18.521
2006	7.82	0.3	12.89	0.004	21.019
2007	8.98	0.29	12.93	0.005	22.206
2008	7.94	0.4	12.97	0.006	21.309
2009	9.03	0.34	12.72	0.006	22.101
2010	9.29	0.4	13.02	0.007	22.713
2011	10.79	0.52	12.89	0.007	24.208
2012	12.15	0.54	13.01	0.007	25.71
2013	12.24	0.27	13.34	0.009	25.853
2014	12.54	0.38	13.2	0.008	26.128
2015	13.14	0.4	12.86	0.008	26.413
2016	13.97	0.39	12.91	0.009	27.285

Source: Environmental Protection Agency (EPA), 2019

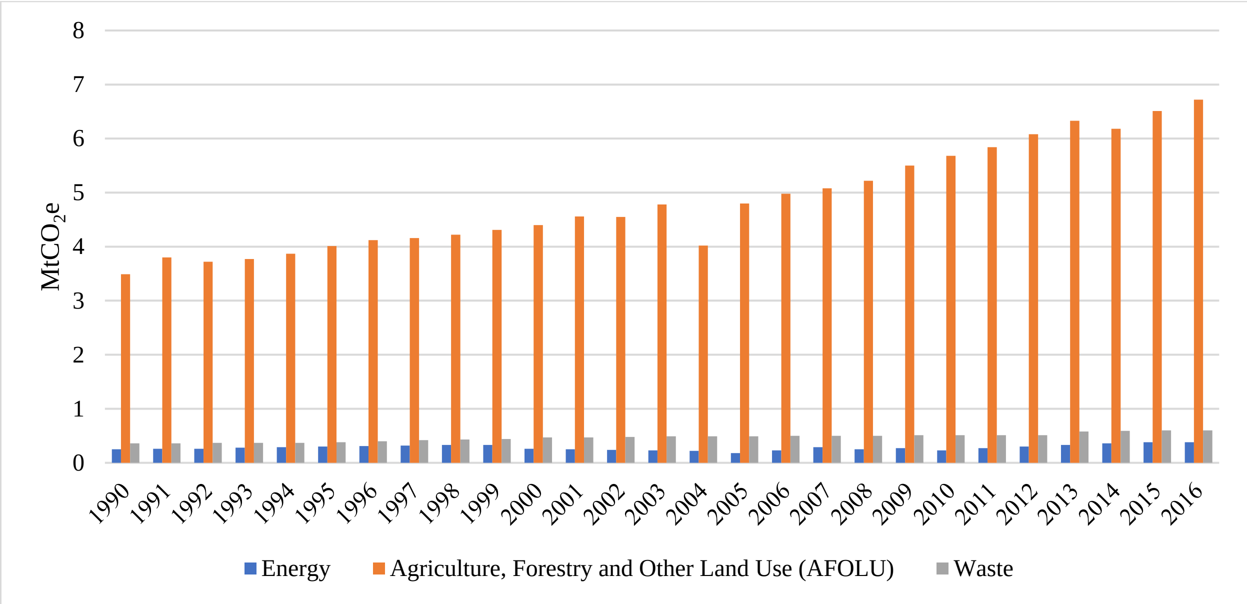
4.2.3 Nitrous Oxide (N_2O) Emissions per sector in $MtCO_2e$

Nitrous oxide emissions occurred in AFOLU, waste, and the energy sectors as indicate in Figure 4.2. The country's total N_2O emissions saw notable increment from 4.09 $MtCO_2e$ in 1990 to 7.1 $MtCO_2e$ in 2016 with the AFOLU sector being the dominant source followed by the waste sector. Within the AFOLU sector, direct and indirect N_2O emissions from managed soils accounted for 86% of the N_2O emissions in 2016. The remaining 14% came from livestock rearing. Besides the AFOLU sector, relatively smaller quantities of N_2O emissions were from the waste and energy sectors. In the waste sector, open burning was a major source of N_2O while for the Energy sector and road transport accounted for the majority of the emissions.

Agriculture, forestry and other land use (AFOLU) sector recorded the highest emission of nitrous oxide among all the sectors. The sector recorded a rising trend from 3.49 in 1990 to 6.72 in 2016 with only a drop in the year 2003 and 2004 (Figure 4.2).

On the contrary the energy sector recorded the lowest emission of this gas in comparison to the other sectors. It recorded its highest emission of 0.38 in 2015 and 2016 and 0.18 as the lowest in 2005. Also, this sector experienced a steady increase of emissions from 1990 to 1999, and fell from 2001 to 2005 and fluctuated from 2006 to 2011 and started rising again from 2012. Another contributing sector to the emission of nitrous oxide is the waste sector. There was also a steady increase throughout the period of reporting from 0.36 to 0.6 (Table 4.2).

Figure 4.2: Annual Nitrous Oxide (N_2O) Emissions Per Sector



Source: Environmental Protection Agency (EPA), 2019

Table 4.2: Nitrous Oxide (N_2O) Emissions per sector in $MtCO_2e$

Year	Energy	Industrial Processes & Product Use (IPPU)	Agriculture, Forestry and Other Land Use (AFOLU)	Waste	Total
1990	0.25	-	3.49	0.36	4.09
1991	0.26	-	3.8	0.36	4.42
1992	0.26	-	3.72	0.37	4.35
1993	0.28	-	3.77	0.37	4.41
1994	0.29	-	3.87	0.37	4.53
1995	0.3	-	4.01	0.38	4.69
1996	0.31	-	4.12	0.4	4.82
1997	0.32	-	4.16	0.42	4.91
1998	0.33	-	4.22	0.43	4.98
1999	0.33	-	4.31	0.44	5.09
2000	0.26	-	4.4	0.47	5.13
2001	0.25	-	4.56	0.47	5.28
2002	0.24	-	4.55	0.48	5.27
2003	0.23	-	4.78	0.49	5.49
2004	0.22	-	4.02	0.49	4.73
2005	0.18	-	4.8	0.49	5.48
2006	0.23	-	4.98	0.5	5.71
2007	0.29	-	5.08	0.5	5.87
2008	0.25	-	5.22	0.5	5.98
2009	0.27	-	5.5	0.51	6.28
2010	0.23	-	5.68	0.51	6.42
2011	0.27	-	5.84	0.51	6.62
2012	0.3	-	6.08	0.51	6.89
2013	0.33	-	6.33	0.58	7.25
2014	0.36	-	6.18	0.59	7.13
2015	0.38	-	6.51	0.6	7.49
2016	0.38	-	6.72	0.6	7.71

Source: Environmental Protection Agency (EPA), 2019

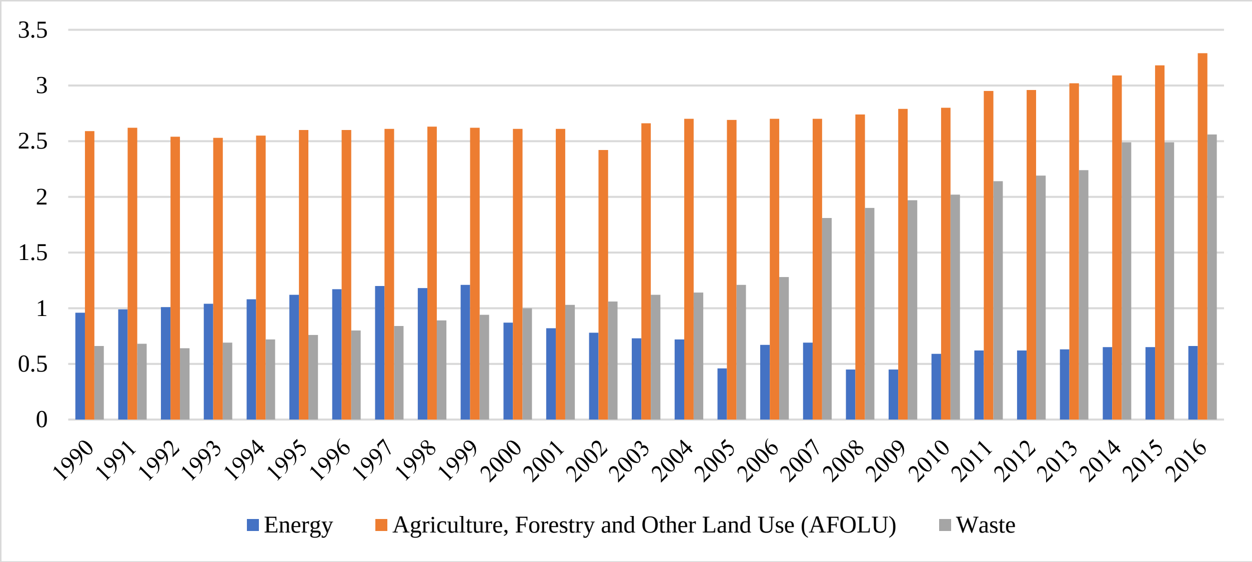
4.2.4 Methane emissions by sectors in MtCo2e

The energy sector experienced increment in the emission of methane from 1990 to 1997 with oscillations occurring from 1998 to 2016. Also, an all-time highest emission from this sector was observed in the year 1999 with the lowest in 2008 and 2009. In comparison to the other sectors, this sector recorded the least level of emissions of methane in 2008 and 2009.

From 1990 to 2016, methane emissions increased by 55% as indicated in Figure 3 with the highest proportion coming from the AFOLU and Waste sectors. Methane emissions for the period 2012-2016 rose up by 13%. The AFOLU and Waste sectors were the two dominant sources of methane and they both correspondingly accounted for 50.6% and 39.3% of the total methane emissions. In the AFOLU sector, the emissions from enteric fermentation and manure management were the main sources of methane. For the waste sector, most of the methane emissions were from wastewater treatment and discharge and solid waste disposal. Emissions from unmanaged waste disposal sites and the domestic wastewater treatment and discharge determined the waste sector emission trends. The increases in the net emissions from waste were due to growing populations, operational and management challenges at most landfill sites and the poor state of domestic wastewater treatment facilities in the country.

Agriculture, Forestry and other Land use sectors recorded the highest values for the years 1990 to 2016 in comparison to the other sectors, yet it experienced fluctuations during the years. Furthermore, the highest percentage recorded in this sector was in 2016 with the lowest being 1993. It recorded the overall highest percentage in relation to the other sectors in 2016. Waste sector saw a progressive increase in the emission of methane gas from 1992 to 2016 with the highest record being in 2016 and its lowest in 1992 (Figure 4.3). There were fluctuations from 1990 to 1992. For more details see Table 4.3.

Figure 4.3: Annual Methane emissions per sector in $MtCO_2e$



Source: Environmental Protection Agency (EPA), 2019

Table 4.3: Methane emissions by sectors (MtCo2e)

Year	Energy	Industrial Processes & Product Use (IPPU)	Agriculture, Forestry and Other Land Use (AFOLU)	Waste	Total
1990	0.96	-	2.59	0.66	4.2
1991	0.99	-	2.62	0.68	4.29
1992	1.01	-	2.54	0.64	4.2
1993	1.04	-	2.53	0.69	4.26
1994	1.08	-	2.55	0.72	4.34
1995	1.12	-	2.6	0.76	4.48
1996	1.17	-	2.6	0.8	4.56
1997	1.2	-	2.61	0.84	4.65
1998	1.18	-	2.63	0.89	4.7
1999	1.21	-	2.62	0.94	4.77
2000	0.87	-	2.61	1	4.48
2001	0.82	-	2.61	1.03	4.46
2002	0.78	-	2.42	1.06	4.26
2003	0.73	-	2.66	1.12	4.52
2004	0.72	-	2.7	1.14	4.56
2005	0.46	-	2.69	1.21	4.35
2006	0.67	-	2.7	1.28	4.66
2007	0.69	-	2.7	1.81	5.2
2008	0.45	-	2.74	1.9	5.1
2009	0.45	-	2.79	1.97	5.21
2010	0.59	-	2.8	2.02	5.41
2011	0.62	-	2.95	2.14	5.71
2012	0.62	-	2.96	2.19	5.77
2013	0.63	-	3.02	2.24	5.89
2014	0.65	-	3.09	2.49	6.24
2015	0.65	-	3.18	2.49	6.32
2016	0.66	-	3.29	2.56	6.51

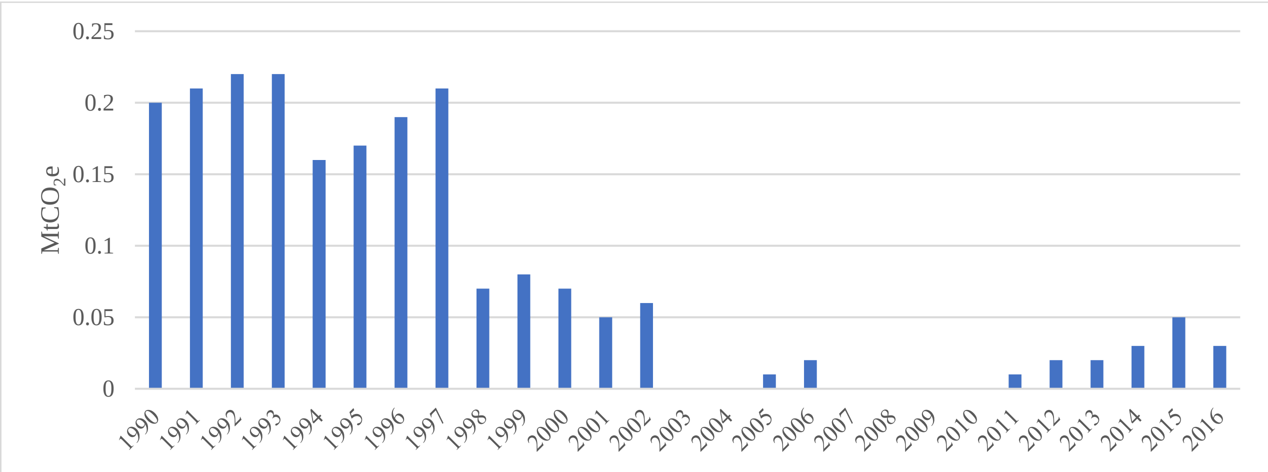
Source: Environmental Protection Agency (EPA), 2019

4.2.5 Perfluorocarbon (PFC) Emissions per Sector

There was a slight increase, a steady rate and variability in the emission of per fluorocarbon by the Industrial Processes and Product Use (IPPU) sector from 1990 to 1991, 1992 to 1993 and 1998 to 2016, respectively. Notwithstanding, this same sector saw slight increases in the emission of the gas occurring from 1994 to 1997. 0.22 was the highest value of emission recorded in 1992 and 1993 with the least (0) in 2007 and 2008 (Table 4.4).

Perfluorocarbons are industrial emissions from technology used in the primary aluminum production by Volta Aluminum Company (VALCO) during anode effects. Apart from the fact that PFCs emissions generally depict a declining trend of -85% between 1999-2016, there were years (2002, 2003, 2009, and 2010) that the emissions were completely missing because the aluminum plant (VALCO) was not operating at all. Since VALCO's operations have been consistent, though, on a limited capacity (running a single pot), PFC emissions have increased by 100% between 2011 and 2016 as indicated in Figure 4.4.

Figure 4.4: Perfluorocarbon Emissions in $MtCO_2e$



Source: Environmental Protection Agency (EPA), 2019

Table 4.4: Per fluorocarbon (PFC) Emissions Per Sector

Year	Energy	Industrial Processes & Product Use (IPPU)	Agriculture, Forestry and Other Land Use (AFOLU)	Waste	Total
1990	-	0.2	-	-	0.2
1991	-	0.21	-	-	0.21
1992	-	0.22	-	-	0.22
1993	-	0.22	-	-	0.22
1994	-	0.16	-	-	0.16
1995	-	0.17	-	-	0.17
1996	-	0.19	-	-	0.19
1997	-	0.21	-	-	0.21
1998	-	0.07	-	-	0.07
1999	-	0.08	-	-	0.08
2000	-	0.07	-	-	0.07
2001	-	0.05	-	-	0.05
2002	-	0.06	-	-	0.06
2003	-	-	-	-	-
2004	-	-	-	-	-
2005	-	0.01	-	-	0.01
2006	-	0.02	-	-	0.02
2007	-	0	-	-	0
2008	-	0	-	-	0
2009	-	-	-	-	-
2010	-	-	-	-	-
2011	-	0.01	-	-	0.01
2012	-	0.02	-	-	0.02
2013	-	0.02	-	-	0.02
2014	-	0.03	-	-	0.03
2015	-	0.05	-	-	0.05
2016	-	0.03	-	-	0.03

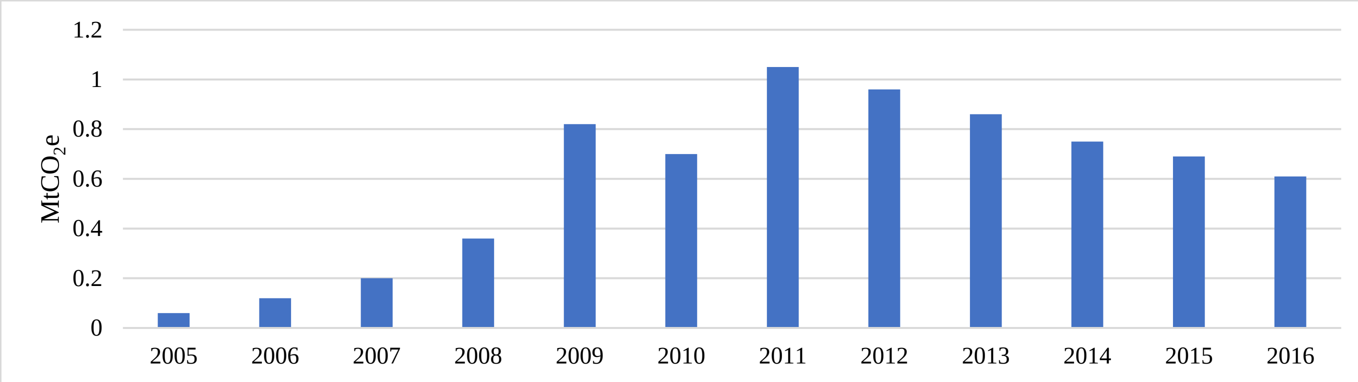
Source: Environmental Protection Agency (EPA), 2019

4.2.6 Hydrofluorocarbon (HFC) Emission per Sector expressed in $MtCO_2e$

Hydro fluorocarbon experienced a continuous increase in its emission from the Industrial Processes and Product Use (IPPU) sector from 2005 to 2009. During the period of 2010 to 2012, there were fluctuations in the emission of this gas from this same sector. In addition, the emission of the gas faced a state of diminishing from 2012 to 2016 by negligible values. All the above said and done, this sector saw its highest percentage of 1.05 in 2011 while the least (0.06%) which cannot be disputed was seen in 2005 (Table 4.5).

The HFC emissions increased from 0.06 $MtCO_2e$ in 2005 until it peaked by 1.05 $MtCO_2e$ in 2011 and started dipping afterwards to 0.6 $MtCO_2e$ in 2016 (Figure 4.5). The decline in HFC emissions correspond to the influence for phase down of high-Global Warming Potential HFCs in the country.

Figure 4.5: Annual Hydro fluorocarbon emission in $MtCO_2e$



Source: Environmental Protection Agency (EPA), 2019

Table 4.5: Hydro Fluorocarbon (HFC) Emission per Sector expressed ($MtCO_2e$)

Year	Energy	Industrial Processes & Product Use (IPPU)	Agriculture, Forestry and Other Land Use (AFOLU)	Waste	Total
2005	-	0.06	-	-	0.06
2006	-	0.12	-	-	0.12
2007	-	0.20	-	-	0.20
2008	-	0.36	-	-	0.36
2009	-	0.82	-	-	0.82
2010	-	0.70	-	-	0.70
2011	-	1.05	-	-	1.05
2012	-	0.96	-	-	0.96
2013	-	0.86	-	-	0.86
2014	-	0.75	-	-	0.75
2015	-	0.69	-	-	0.69
2016	-	0.61	-	-	0.61

Source: Environmental Protection Agency (EPA), 2019

4.2.7 Precursors and Local Air Pollutants Gg/Year

Carbon monoxide (CO) contributed the highest gas emission compared to other gases. Also, in the year 1997 Carbon monoxide recorded the highest (2334.33Gg) with it lowest (1707.92Gg) in 2008. Furthermore, there was a consistent increase from 1992 to 1997 with a gradual decrease from 1998 to 2005 and fluctuations from 2006 to 2016 (Table 4.6).

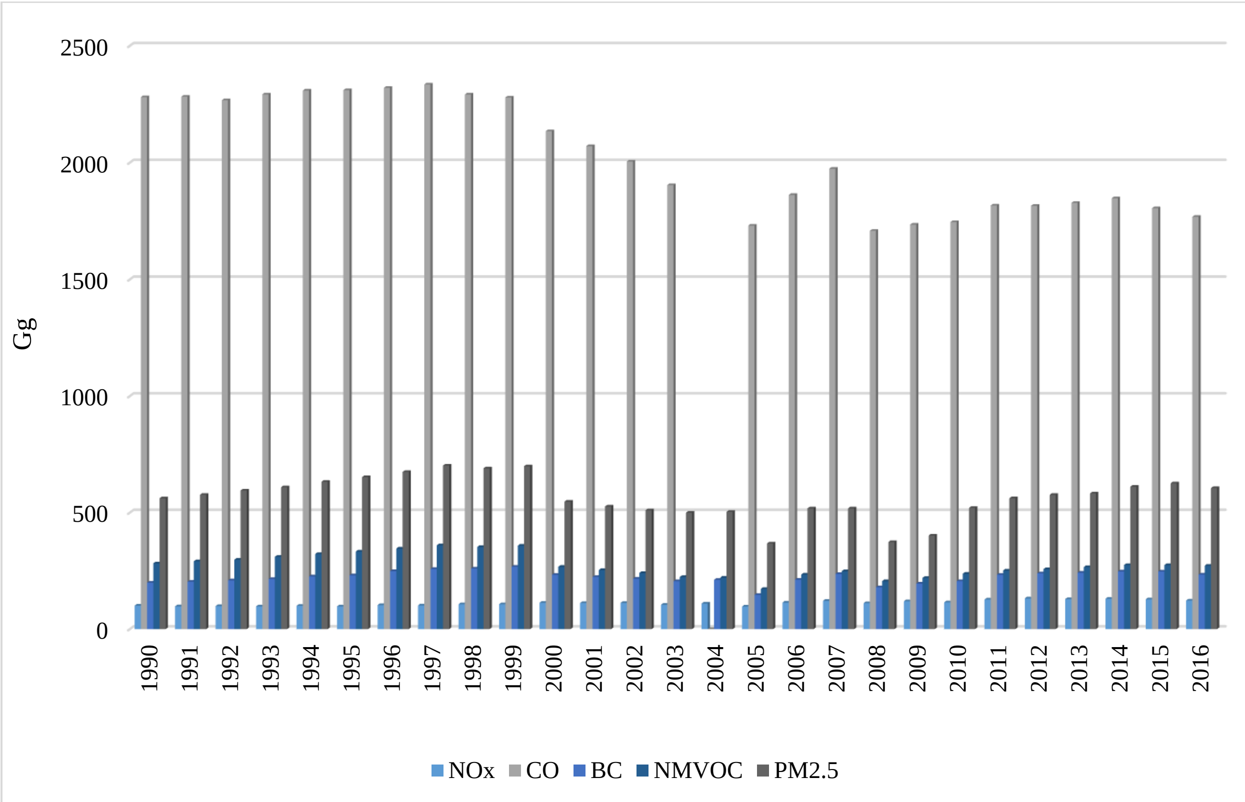
Particulate Matter$_{2.5}$ ($PM_{2.5}$) and Non-methane volatile organic compounds (NMVOC) recorded a continuous increase from 1990 to 1997, the latter year recorded the highest for each of the gases. Non-methane volatile organic compounds (NMVOC) had a gradual decrease from 1999 to 2005 and slight fluctuations from 2006 to 2016. In 2005, $PM_{2.5}$ decreased largely by 135.29 compared to the 2004 record.

Nitrogen Oxide (NO_x) recorded the lowest (97.24) emission of gas as compared to the other gas emission, with a rise and fall in NO_x from 1990 to 2016 by small margin. Black carbon (BC) had a continuous increase from 1990 to 1999, with 1999 being the highest (267.66) and the lowest (146.64) in 2005. The trends of NOx, CO, BC, NMVOCs and $PM_{2.5}$ emissions for the period 1990-2016. Except CO that saw a decline, the rest of the pollutants showed a rising pattern. Nitrogen oxides are a group of poisonous, highly reactive gases. NO_x gases form when burned at high temperatures. Between 1990 and 2016, NO_x emission levels increased by 21.6%.

Carbon monoxide (CO) is a common industrial hazard resulting from the incomplete burning of natural gas and any other material containing carbon such as gasoline, kerosene or wood etc. (Figure 4.6). In 2016, most (80.4%) of the NOx emissions came from the energy sector through the burning of fossil fuels. The remaining 19.6% were from the burning activities in the AFOLU (18%) and waste (1.7%) sectors respectively. Most of the CO emissions were from the energy sector (69.2%) and followed by the AFOLU (29.9%) and waste (0.9%) sectors. The patterns of CO emissions indicated a steady decline by 22.5% between 1990 and 2016.

Black carbon is a constituent of $PM_{2.5}$ and is produced from the incomplete burning of fossil fuels and biomass. The data figure shows a total black carbon emission in Ghana to be 234.3 Gg in 2016, mainly from road transport and residential cooking activities under the sector. The 2016 BC emission was 17.6% higher than the 1990 levels and increased at 0.6% annual growth

Figure 4.6: Precursors and Local Air Pollutants Gg/Year



Source: Environmental Protection Agency (EPA), 2019

Table 4.6: Precursors and Local Air Pollutants Gg/Year

Year	NOx	CO	BC	NMVOC	$PM_{2.5}$
1990	100.64	2,279.92	199.29	282.05	561.10
1991	97.54	2,281.99	203.43	291.18	576.20
1992	98.67	2,267.03	209.21	297.60	594.60
1993	97.24	2,291.83	215.24	310.25	608.57
1994	99.89	2,308.31	226.28	322.26	632.13
1995	97.50	2,310.02	230.89	332.81	652.13
1996	102.80	2,319.93	248.88	345.55	674.32
1997	101.57	2,334.33	258.41	359.58	701.82
1998	106.66	2,291.51	259.77	352.33	689.57
1999	106.76	2,278.42	267.66	357.98	698.62
2000	112.78	2,134.15	233.03	267.32	546.71
2001	111.64	2,070.30	223.94	253.37	526.07
2002	111.98	2,004.48	216.39	240.64	509.61
2003	104.36	1,903.41	205.64	223.73	499.30
2004	109.42	1.891.82	211.28	220.76	502.79
2005	96.87	1,730.13	146.64	172.58	367.50
2006	113.58	1,861.65	212.20	234.05	517.89
2007	121.23	1,973.53	236.60	248.32	517.74
2008	111.11	1,707.92	179.76	205.72	373.44
2009	119.37	1,734.54	195.38	219.73	401.44
2010	114.79	1,745.38	205.79	237.53	519.99
2011	127.09	1,816.14	233.10	250.94	561.45
2012	131.59	1,815.05	239.18	257.11	575.90
2013	128.51	1,827.43	242.05	265.92	582.34
2014	130.38	1,847.26	247.37	274.91	610.98
2015	127.83	1,804.80	246.90	274.63	625.47
2016	122.42	1,767.67	234.28	271.84	605.20

Source: Environmental Protection Agency (EPA), 2019

Chemical Formula/ Measurement Unit

Carbon dioxide	CO_2
Methane	CH_4
Nitrous oxide	N_2O
Nitrogen Oxides	NOx
Carbon monoxide	CO
Black carbon	BC
Non-methane volatile organic compounds	NMVOC
Particulate Matter 2.5	$PM_{2.5}$
Gigagram per year	Gg/Year
Metric tonne of Carbon Dioxide Equivalent	$MtCO_2e$

4.3 Generation and Management of Waste

The focus of this section is to provide information on the generation and management of waste (solid and liquid) in the country.

4.3.1 Generation of Solid Waste

Solid waste generation in Ghana currently ranges between 0.2 and 0.8 kg/person/day (Miezah *et al*., 2015), with an estimated volume of 13,500 tonnes of solid waste being produced daily nationwide, based on an estimated 2015 population of 27 million (GSS, 2012). Per capita waste generation has increased over the last decade, with average per capita generation per day in Accra, for instance, increasing from 0.4kg/person/day in 2005 to 0.7kg/person/day in 2015 (Miezah *et al*., 2015). The two largest cities, Accra and Kumasi, together, generate over 4000 tonnes of solid waste daily, with per capita generation estimated at 0.75 kg/person/day. Figure 4.7 shows the trend in daily solid waste generation in Accra and Kumasi from 2000 to 2015. There was a general increase in rates of waste generation in Accra and Kumasi, with estimated daily generated volumes of 1500, 1800 and 2500 tonnes per day, for Accra, in 2005, 2010 and 2013, respectively, to a current generation rate of 2800 tonnes per day.

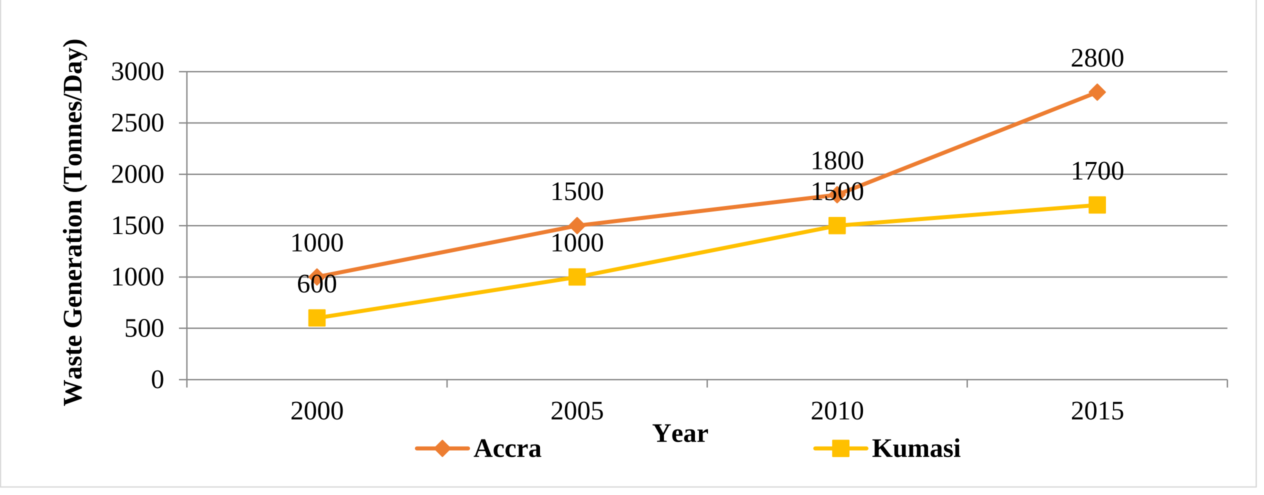
Accra a major city in Ghana generates nearly 900,000 metric tons of solid waste per year, approximately 67% of which is organic matter. The rate of waste generation is approximately 0.5 kilograms per person per day. Solid waste collection in Accra is mostly privatized. The city contracts with 10 waste collection firms that are responsible for all residential, commercial, and industrial waste generated in their respective collection districts. The firms recover their costs by collecting city-regulated fees from waste generators. The city estimates that 88% of waste generated in areas where it provides collection services is collected. However, waste collection services are only provided in a limited area; only 40% of households in the city have waste collection bins. Accra is working to increase its waste collection coverage, especially in low-income areas of the city.

Accra's waste disposal sites are currently closed; the city has no waste disposal site of its own. Collected waste is currently transported from Accra to a landfill in Tema, approximately 37 kilometers outside Accra. The landfill was constructed to accept 700 tons per day, but currently receives more than double that amount (more than two-thirds comes from Accra). The city recently entered into a contract for the construction of a new landfill, but a site has not been determined and financing is not certain. It is unknown whether the new landfill will include leachate and LFG collection systems. Accra generates a large amount of organic waste that is high in moisture content. There is no formal dedicated organics collection service provided by the city, but there are two innovative models currently in place in Accra: a community-based, small-scale composting project and a large-scale, and open-windrow facility with a materials recovery unit.

The small-scale composting project involves collecting approximately 2-tons of organic waste per day from 60 companies, mainly hotels and restaurants in the tourist area of Osu. These companies receive a 5–10% collection discount depending on volume. The diverted organic waste is sent to neighborhood composting centers where it is converted to compost. The large-scale Accra Composting and Recycling Plant receives approximately 500 tons of municipal solid waste per day (organic and non-organic). The plant is owned and operated by a private company through a public-private partnership with the city. Since its commissioning in 2012, the facility has processed a total of 16,000 tons.

Informal waste disposal occurs in areas of Accra where there are no waste collection services. Informal solid waste disposal sites include abandoned stone quarry sites, gouged natural depressions in the ground, old mining areas, or man-made holes in the ground. Open burning occurs at some of the open dumps, particularly during the dry season.

Figure 4.7: Trend in Daily Solid Waste Generation in Accra and Kumasi (2000 - 2015)



Source: Waste Management Department, AMA & KMA

4.3.2 Composition of Solid Waste

Solid waste generated in the country is dominated by organic materials, paper, and plastic wastes, with organic materials currently constituting an average of about 60 percent of total solid waste. However, the composition ratio of the various components of solid waste streams seems to be gradually changing with time. Whereas the urbanized areas like Kumasi and Accra, have recorded decreases in organic waste content. The composition dynamics of waste in selected cities and towns of Ghana is presented in Table 4.7. Waste from metropolitan areas and municipalities are dominated by the organics while waste from the smaller districts is dominated by plastics. The northern regions of the country generate more plastic waste than organic waste, in contrast to observed trends in the south.

Table 4.7: Percentage Composition of Solid Waste (2005 – 2015)[16]

Waste Component	Accra		Kumasi		Tamale	
	2005-2009	2010-2015	2005-2009	2010-2015	2005-2009	2010-2015
Organic	69	60.7	64	40.2	20	27
Paper	4	8.3	3	7.0	5	6
Plastics and rubber	12	18.0	4	19.9	57	46
Metal	2	4.3	1	2.2	10	6
Glass	3	2.7	-	1.2	5	7
Others	10	6.0	19	29.4	3	8

Source: Waste Management Department, AMA & KMA

4.3.3 Generation of Waste by Sector

Generally, total waste generation at the national level has increased from a total of 8.28 mil tons from 1999 to 19.5 mil tons in 2015. Data on waste generation from sources such as mining and quarrying, manufacturing, construction, oil and gas, among others were difficult to obtain. Table 4.8 illustrates waste generated from different sectors in the country.

Table 4.8: Waste Generated by Sectors

Year	Unit	Agriculture, forestry and fishing	Mining and quarrying	Manufacturing	Other economic activities [17]	Households	Total Waste Generation
1999	1000 t	6,772.57	-	-	300.77	1203.08	8,276.42
2000	1000 t	6,784.24	-	-	331.34	1325.36	8,440.94
2001	1000 t	7,032.57	-	-	345.96	1383.83	8,762.36
2002	1000 t	8,249.63	-	-	361.12	1444.49	10,055.24
2003	1000 t	8,244.81	-	-	370.87	1483.49	10,099.18
2004	1000 t	6,772.57	-	-	387.03	1548.12	8,707.72
2005	1000 t	8,060.92	-	-	454.26	1817.05	10,332.23
2006	1000 t	8,224.60	-	-	473.82	1895.27	10,593.68
2007	1000 t	10,833.10	-	-	516.56	2066.22	13,415.88
2008	1000 t	10,954.26	-	-	561.26	2245.02	13,760.54
2009	1000 t	13,625.67	-	-	600.10	2400.39	16,626.16
2010	1000 t	12,422.40	-	-	662.61	2650.46	15,735.48
2011	1000 t	14,157.82	-	-	679.18	2716.72	17,553.72

[16] Sources of data include; Fobil et al., 2010; Miezah et al., 2015; Asase et al., 2009; Zoomlion Ghana, 2010; WMD/TaMA, 2010; Amoah & Kosoe, 2014

[17] This includes Water collection treatment and supply, sewerage, waste collection, treatment and disposal activities, remediation and other waste management services, services.

Year	Unit	Agriculture, forestry and fishing	Mining and quarrying	Manufacturing	Other economic activities [17]	Households	Total Waste Generation
2012	1000 t	14,953.13	-	-	696.16	2784.64	18,433.93
2013	1000 t	15,107.61	-	-	713.56	2854.25	18,675.43
2014	1000 t	15,516.54	-	-	731.40	2925.61	19,173.56
2015	1000 t	15,834.55	-	-	783.01	3132.03	19,749.59
2016	1000 t	-	-	-	802.58	3210.33	4,012.91
2017	1000 t	-	-	-	822.65	3290.59	4,113.23

4.3.4 Solid Waste Disposal

Waste management companies, operating under public-private partnership arrangements with government through the MMDA's, dispose of municipal solid waste, from communal containers and door-to-door collection services, at landfills and dumpsites under the supervision of the Waste Management Department of the MMDAs. These disposal sites include both engineered-sanitary landfills and open dump sites. As at 2015, there were 5 operational engineered sanitary landfills in Ghana, located in Tema, Takoradi, Kumasi, New Abirem, and Tamale, as well as 172 official dumpsites (Zoomlion, 2016) as in tables 4.9 and 4.10.

Table 4.9: Regional Breakdown of Disposal Sites in Ghana, 2015

Region	Dumpsites	Engineered Landfills
Brong Ahafo	27	0
Upper West	11	0
Central	13	0
Ashanti	21	1
Volta	21	0
Western	23	1
Eastern	28	1
Upper East	7	0
Northern	17	1
Greater Accra	4	1
Total	172	**5**

Source: Zoomlion Ghana Limited, 2016.

Table 4.10: Engineered Landfills in Ghana as of 2015

Landfill	Commission Date	Planned Operational Capacity/Day (Tonnes)	Current level of operation/ Day (Tonnes)	*Estimated Lifespan
Kpone (Tema)	2013	500	2000	10 years
Tamale	2004			
Takoradi				
Kumasi	2004		1300	15 years
New Abirem	2014	10	-	-

**Estimated lifespan was based on planned operational capacity*

Chapter 5

Extreme Events and Disasters

5.1 Introduction

This chapter organizes statistics on the occurrence of extreme events and disasters and their impacts on human well-being and infrastructure in Ghana. Extreme events, such as widespread flooding, or very strong storms, have the potential to cause extensive damage and impacts on people, infrastructure, and the environment.

5.2. Ghana's Disaster Profile

The National Disaster Management Organization (NADMO) is the foremost institution in Ghana by ACT 517 of 1996 to manage disasters and similar emergencies in the country. Table 5.1 indicates the types of disaster which been identified for redress in Ghana.

Table 5.1: Types of Hazards/Disasters and Coverage Area

Types of Hazards/Disasters	Coverage Area
Hydro-meteorological Disasters	Flood, Windstorm, Rainstorm, Drought and Tidal waves.
Pest and Insect Infestation Disasters	Armyworm, Anthrax, Blackfly, Locust, Larger Grain Borer etc.
Geological/ Nuclear Radiological Disasters	Earthquakes, Tsunamis, Gas Emission and Landslide etc.
Fires and Lightning Disasters	Bush/Wild fires, Domestic and Industrial fires and Lightening.
Disease Epidemics Disasters	Cholera, Yellow Fever, Cerebro -Spinal Meningitis (CSM), Pandemic Influenza etc.
Man-Made Disasters	Social conflicts, Collapse of Building, Vehicular and Aviation Accidents, Lake/ Boat Accidents Marine and Railway Disasters, etc.

Source: National Disaster Management Organisation (NADMO), 2019

5.2.1 Major Disasters in Ghana[18]

Ghana has had major disasters over the years. Notably among them include the following:

i. Outbreak of Cerebro-Spinal Meningitis (CSM): The outbreak affected the three Northern Regions which claimed 1,356 lives in 1997. The breakdown is as follows (UER-852, UWR-73, NR-431) – 1997.

ii. Cholera Outbreak: This happened in Greater Accra and Central Regions (GAR-38, CR-79): a total of 117 people died. An amount of fifty thousand Ghana Cedis (GH¢15,000) was spent on the management and control of the epidemic and the procurement of tents.

iii. Armyworm Invasion: There was an armyworm invasion in the three Northern Regions, Ejura in Ashanti and Dawhenya in the Greater Accra Region. Relief provided included seeds, chemicals, protective clothing etc, amounted to seventy thousand Ghana Cedis (GH¢70,000).

iv. Northern Floods: The 1999 Northern floods swept through the Upper West, Upper East, Northern and the Northern parts of the Brong Ahafo and Volta Regions affected over three hundred thousand (300,000) persons. There were secondary disasters of water-borne and water related diseases to contend with. It cost GH¢280,000 to manage the disaster

v. Black Flies Invasion: It affected the three Northern Regions. An amount of thirty thousand Ghana Cedis (GH¢30,000) was spent on relief and public education programme through workshops and seminars.

vi. Operation Okumkom" I: As result of insufficient and erratic rainfall in the three Northern Regions, the government had to provide subsidized food to the people in the affected regions to the tune of two hundred Thousand Ghana Cedis (GH¢200,000) in the early part of 1997.

vii. Operation "Okumkom" II: Just as above, the government provided three hundred Thousand Ghana Cedis (GH¢300,000) to purchase food for the people in Dangme East and West in the Greater Accra region, and for Keta, South and North Tongu Districts in the Volta Region. – 1998.

viii. The 2nd northern Floods: This swept through Upper West, Upper East and Northern Regions affected over three hundred thousand (307,127) persons. There were some deaths recorded in the three regions (31 in Upper East; 10 in Upper West). There were secondary disasters of water-borne and water related diseases to contend with – 2007.

5.3 Occurrence of Natural Extreme Events and Disasters

Ghana experienced the highest number of flooding during the period 2011-2015 with a total of five hundred and eight (508) flooding situations experienced nationwide. Again, heavy rainstorm with flooding occurred over the same periods with a total of four hundred and ten (410) heavy storms being experienced within the country.

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[18] Source: Source: National Disaster Management Organisation (NADMO) website

This is quite significant and has direct and negative repercussions on human lives and infrastructure. Over the thirty (30) year period, one (1) earth quake was recorded during the period 2011-2015 and one (1) sea erosion during the period 2006-2010. Between 2006 and 2010, Ghana had a total of fifty-three (53) outbreak of diseases compared to eight (8) between 1985 to 1990.The highest numbers of droughts and water shortages were experienced over the years 1991 -1995 and between 2011 and 2015 with a total of 5 records.

Extreme natural disasters occur at extreme temperature and weather conditions most of them caused by anthropogenic activities. Over the years, there have been the occurrence of extreme disasters and this has been recorded by the National Disaster Management Organization (NADMO). The number of disasters during the years 1985 to 2015 and recorded by NADMO are shown in Table 5.2.

Table 5.2: Number of Disasters Recorded

	1985-1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015
Disease Epidemics	8	9	34	12	53	14
Drought/Water Shortage	4	5	2	4	4	5
Fire	17	27	29	37	82	70
Flood	27	28	43	46	207	508
Flood/Rainstorm	0	0	0	0	1	410
Storm	20	33	19	20	37	19
Wild Fire	10	17	6	2	6	6
Agric Diseases/Pest	8	3	3	2	3	2
Thunder/Lightening	0	0	0	0	0	2
Earth Quake	0	0	0	0	0	1
Sea Erosion	0	0	0	0	1	0

Source: National Disaster Management Organisation (NADMO)

5.4 Impact of Natural Extreme Events and Disasters

The impact of Natural disasters is felt over all walks of life when it happens. The destruction of infrastructure, farmlands, loss of lives of humans and animals, famine etc. Table 4.2 shows the cost of economic activities loss as a result of disasters and Table 5.3 shows the destruction of economic activities and lives lost due to extreme disasters.

Table 5.3: Economic Losses Due to Natural Extreme Events and Disasters

Year	Western Region	Central Region	Greater Accra Region	Volta Region	Eastern Region	Ashanti Region	Brong Ahafo Region	Northern Region	Upper East Region	Upper West Region
1987										
1988					200	490				
1989										
1990										
1991		3								
1992										
1993										
1994										
1995			2375							
1996										
1997										
1998										
1999								1961	874	1155
2000										
2001										
2002										
2003										
2004		8.08								
2005			1470			20				
2006				0.25		6.06	80			
2007	20000				100000	150700		1000000	102000	
2008			622680		1900	98000				
2009		1213947	1777214	162	47980	25936				
2010										
2011				80000	170000					
2012	1230880	734438	29780	307754		710520	181000		64695	769057
2013				55000		50500	123608			

Source: National Disaster Management Organisation (NADMO)

5.4.1 People Affected by Natural Extreme and Disasters

Between the years 1985 and 1990, over 8,350 people were affected by extreme disasters. However, between the years 1991 to 1995, this number rose significantly to 2,704,690 and this was mainly due to the July 1995 flood. About 50,550 farmlands were also affected with 190 lives lost in the process. The number of farmlands destroyed didn't change much between 1996 and 2000. Between those years, 50,964 farmlands were affected by natural disaster and 349,633 of the population was affected.

Of very significant to note is the number of lives lost over the years 2006 to 2010. About 224 lives were lost to natural disasters whiles 13,746 houses were destroyed by floods with 1,214,771 of the population affected. Between the years 2011 and 2013, about 477,777 of the population was affected by natural disasters whiles 93,457 houses were destroyed by floods with 15,128 farmlands destroyed in the process as well (Table 5.4).

Table 5.4: People Affected by Natural Extreme and Disasters

Indicator	1985-1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-2013
Number of people injured	4	0	3	6	11	10
Number of people killed	36	190	54	31	224	129
Houses destroyed/Flooded	454	0	900	282	13,746	93,457
Farmland destroyed	1,097	50,550	50,965	345	283	15,128
Population affected	8,350	2,704,690	349,633	28,809	1,214,771	477,777

Source: National Disaster Management Organisation (NADMO)

Chapter 6

Human Settlement and Environmental Health

6.1 Introduction

This chapter contains statistics on the environment with respect to living conditions and environmental health. These statistics are important for the management and improvement of conditions related to human settlements, shelter conditions, safe water, sanitation and health in the context of rapid urbanization, increasing pollution, environmental degradation, disasters, extreme events and climate change.

The capacity of the environment to cope with the environmental impacts caused by human habitation can influence both the health of human settlements and the natural environment. The well-being and health risks associated with the environment and those posed by extreme events and disasters can be mitigated substantially by the prevailing conditions and characteristics of human settlements. Several factors can mitigate or increase the effect of environmental and settlement-related risks on human well-being. These factors include the appropriate infrastructure that can provide water and sanitation, adequate waste disposal, sustainable land use planning, clean and safe transportation, safe building design and other measures of good housing, and ecosystem health. These conditions can improve a given human settlement, human well-being and health. Conversely, vulnerable human settlements are often more impacted by the changing environment and recover more slowly from pollution, environmental degradation, and extreme events and disasters.

6.2 Access to Selected Basic Services

Access to water, sanitation, waste removal services and energy have a positive effect on human health and well-being as they contribute to improved environmental quality.

6.2.1 Improved Drinking water

The distribution of persons with access to drinking water by source as at 2017/2018. The category basic water service contributes 79 percent of the population. The percentages of populations with access to basic drinking water service in urban and rural areas were 93 and 68, respectively. Basic water service refers to access to basic drinking water service as defined by SDG 1.4.1 which looks at water from an improved source. The water collection time, inclusive of queuing, is not more than 30 minutes for a roundtrip. The limited, unimproved and surface water categories compose unimproved water sources.

Direct collection of water from rivers, lakes, streams etc. compose surface water sources; unimproved are unprotected dug wells and springs; and limited improved source requires more than 30 minutes for a roundtrip. Rural areas had a higher proportion of its population using unimproved water sources of 32 percent compared to their counterparts in urban areas with 7 percent (Tables 6.1).

Tables 6.1: Distribution of Persons with Access to Drinking Water by Source

Sources	National	Urban	Rural
Basic Service	79	93	68
Limited	7	3	9
Unimproved	5	3	6
Surface Water	9	1	16

Source - Multiple Indicator Cluster Survey (MICS) Report Ghana Statistical Service, 2017/2018

6.2.2 Improved Sanitation Facility

Basic service refers to the use of improved facilities which are not shared with other households. The proportion of the population using the basic water service was low, 21 percent. The percentages of populations using basic services in urban and rural areas were 25 and 17, respectively (Tables 6.2).

Limited sanitation service includes improved facilities shared with other households, accounted for 45 percent. The urban and rural distributions pattern follows the basic services as the urban had 56 percent of its population while the rural had 35 percent. Unimproved sanitation facilities include flush/pour flush to an open drain, pit latrines without a slab, hanging latrines and bucket latrines, accounted for 13 percent while open defecation, which is nonexistence of a service, contributed 22 percent. The populations with access to unimproved sanitation facilities and practicing open defecation were prevalent in rural localities (Tables 6.2).

Table 6.2: Population Distribution by Sanitation Facility

Sources	National	Urban	Rural
Basic Service	21	25	17
Limited	45	56	35
Unimproved	13	8	18
Open Defecation	22	11	31

Source: MICS Report Ghana Statistical Service, 2017/2018

6.2.3 Population Served by Municipal Solid Waste Collection and Disposal of Liquid Waste Water (percent)

The predominant method of solid waste disposal by most households in Ghana is through public refuse dumps. This constitute 47.8 percent of the population (Table 6.3). Of this, a higher proportion of the population in the rural areas (52.9%) dispose of solid waste at public dumps compared to the urban population (43.7%). Other methods of disposing solid waste among the populace includes collected by refuse collecting companies (21.9%), burning (19.5%), and dumping indiscriminately (10.8%).

Disposal of solid waste at public dumps is the most common method used in the Regions. Three out of four in Western (75.0%), more than two-thirds in Central (68.2%) and Brong Ahafo (67.0%), and more than half in Ashanti (57.5%) and Eastern (55.9%) regions. However, less than two-thirds (65.4%) of the population in Greater Accra method of disposing of solid waste is through collection by refuse collecting companies

Further, the table indicates that a higher proportion of the population in the rural area (93.6%) compared to the urban areas (49.3%) predominantly discharged waste water into open areas. This method, is the most common practice also in all ten regions with the exception of the Greater Accra where more than half of the population (53.6%) discharged waste water into drains (Table 6.3).

Table 6.3: Method of Solid and Liquid Waste Disposal

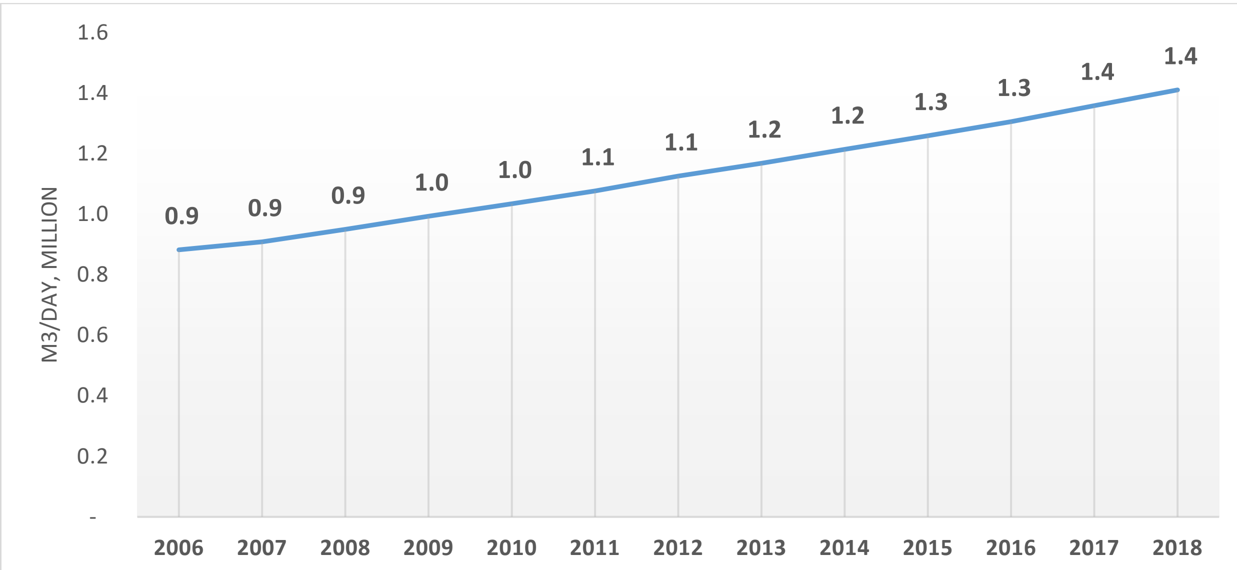
Solid/Waste Water Disposal Method	Ghana	Locality		Region									
		Urban	Rural	Western	Central	Greater Accra	Volta	Eastern	Ashanti	Brong Ahafo	Northern	Upper East	Upper West
Method of solid waste disposal													
Collected	21.9	36.2	3.7	8.0	7.3	65.4	5.7	5.9	27.7	2.6	6.2	8.1	12.5
Burned by household	19.5	16.1	23.8	11.1	18.8	14.6	39.8	28.8	11.5	15.9	23.4	52.8	23.3
Public dump	47.8	43.7	52.9	75.0	68.2	17.4	31.6	55.9	57.5	67.0	33.1	7.2	25.4
Dumped indiscriminately	10.8	3.9	19.6	5.9	5.7	2.7	22.8	9.4	3.3	14.4	37.3	31.9	38.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Method of liquid waste water disposal													
Discharged in open area	68.8	49.3	93.6	78.6	79.5	32.4	86.4	80.0	55.5	91.0	92.3	97.4	95.8
Discharged into drains	25.9	43.1	3.9	15.7	18.6	53.6	6.3	17.6	40.9	7.4	5.3	1.9	2.7
Septic tank	3.7	5.5	1.4	5.1	1.4	12.0	2.0	1.8	1.0	1.4	1.8	0.6	1.2
Discharge into sewer	0.9	1.2	0.6	0.2	0.4	2.0	0.3	0.6	1.8	0.1	0.2	0.2	0.2
Other	0.7	0.8	0.5	0.3	0.1	0.0	4.9	0.0	0.9	0.1	0.4	0.0	0.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Ghana Living Standard Surveys 2018, GSS

6.2.4 Population supplied by water supply industry

Water supplied in cubic meters per day (m^3/Day) to the population has been increasing from year to year. It increased from less than one million (0.9 mm3/Day) to 1.4 million cubic meters per day in 2018 Figure 6.1).

Figure 4.8: Population Supplied by Water - m^3/Day



Source: Ghana Water Company Limited, 2018

6.3 Environmental Concerns Specific to Urban Settlements

The rapid population growth rate in Ghana is presently exerting immense pressure on the natural resources, as well as creating waste management problems in the major towns and cities. The environmental problems associated with urban overpopulation in Ghana are those that have direct bearing on human health, such as basic sanitation and disposal of waste, the shortage of essential facilities and disregard for approved land use allocations. Other problems are overcrowding of commercial and private transports facilities.

6.3.1 Total Number of Vehicles Registered in Ghana by Category

The highest number of vehicles registered of capacities 2000cc and below, for both private and commercial vehicles, were recorded in 1996, 112.991 and 36.475, respectively. The least number of private motor vehicle were of capacity above 2000cc category was 6 recorded in 1995. Private Buses & Coaches also recorded the highest registration in 1996 with a total of 42,501. Private motor vehicles of capacities above 2000cc were most registered in 2013 with 29,074.

During the period the most registered vehicle categories were private motor vehicles of capacity below 2000cc with a record of 731,093, while the least number of vehicle category was private motor vehicle of capacity above 2000cc with 6,372. During the period the highest number of private vehicle registration, 156.559, was recorded in 1996, while commercial vehicle registration had 39,671 as its highest record in 2013. Overall, private registration had the highest number of above 1.2 million (Table 6.5).

For private car registration, the highest was recorded in 1996 year with a total of 156, 559, while commercial car registration recorded the biggest in 2013(39,671 over the twenty-four years). In all, private registration had the highest in total over 1.2 million over the twenty-four years.

Table 6.4: Vehicles Registered in Ghana by Category

YEAR	PTE MV UPTO 2000CC	COMM MV UP TO 2000CC	PMV ABOVE 2000 CC	CMV ABOVE 2000 CC	PRIVATE BUSES & COACHES	COMM BUSES & COACHES	TOTAL PRIVATE	TOTAL COMMERCIAL	TOTAL
1995	17,248	2,941	6		10,387		**27,641**	**2,941**	**30,582**
1996	112,991	36,475	1,067		42,501		**156,559**	**36,475**	**193,034**
1997	24,134	5,490	26		9,114		**33,274**	**5,490**	**38,764**
1998	22,693	4,869	71		11,443		**34,207**	**4,869**	**39,076**
1999	24,434	12,004	6,249		9,843		**40,526**	**12,004**	**52,530**
2000	27,552	5,104	5,196		5,469		**38,217**	**5,104**	**43,321**
2001	17,953	5,568	5,343		2,676		**25,972**	**5,568**	**31,540**
2002	18,512	6,015	7,143		2,601		**28,256**	**6,015**	**34,271**
2003	20,564	5,110	7,778		2,916		**31,258**	**5,110**	**36,368**
2004	20,333	7,642	7,189		4,882		**32,404**	**7,642**	**40,046**
2005	22,949	6,686	8,715		5,585		**37,249**	**6,686**	**43,935**
2006	23,806	7,249	11,127	-	7,399	-	**42,332**	**7,249**	**49,581**
2007	29,633	7,757	15,296	-	9,791	-	**54,720**	**7,757**	**62,477**
2008	31,628	7,040	17,374	-	11,737	-	**60,739**	**7,040**	**67,779**
2009	25,128	7,868	17,414	-	8,810	-	**51,352**	**7,868**	**59,220**
2010	22,444	8,321	17,442	-	9,506	-	**49,392**	**8,321**	**57,713**
2011	44,220	14,208	14,530	484	2,958	4,793	**61,708**	**19,485**	**81,193**
2012	30,294	23,181	22,886	763	4,290	6,950	**57,470**	**30,894**	**88,364**
2013	35,099	29,971	29,074	969	5,390	8,731	**69,563**	**39,671**	**109,234**
2014	36,253	16,933	22,465	749	3,631	5,882	**62,349**	**23,564**	**85,913**
2015	27,073	12,215	20,822	694	2,918	4,726	**50,813**	**17,635**	**68,448**
2016	26,391	12,800	22,760	758	2,316	3,752	**51,467**	**17,310**	**68,777**
2017	32,619	12,873	21,607	746	2,628	4,964	**56,854**	**18,583**	**75,437**
2018	37,142	14,582	22,742	1,209	2,341	6,820	**62,225**	**22,611**	**84,836**
TOTAL	**731,093**	**272,902**	**304,322**	**6,372**	**181,132**	**46,618**	**1,216,547**	**325,892**	**1,542,439**

Source: Driver & Vehicle Licensing Agency (DVLA), 2019

6.4 Water-Related Diseases and Conditions

Water is essential to the existence of man and all living things. Water, SDG 6 is a crosscutting element and linked to more than eight Goals. Improving water services and uses are essential for increasing hygiene and sanitation services that affect productive life of peoples, health, and nutrition and food production. According to GLSS 7 report, the main source of water supply for drinking is through the pipe-borne (27.3%), well (28.5%), and other, 36.1 percent. Further, lack of potable water, occurrence of drought or floods expose the population to water- related diseases.

6.4.1 Water-Related Diseases and Conditions

The highest reported cases of outpatient morbidity environmental-related water diseases in Ghana is Malaria. The reported cases increased from 3.1 million in 2002 to 10.8 million in 2013. It then, declined to 7.0 million in 2014 and further to 6.9 million in 2016 (Table 6.6). This is followed by upper respiratory tract infections recording a total case of 27.6 million cases from 2002 to 2016. The highest number of cases was recorded in 2015 (3.9 million) and the least, 0.52 million in 2003.

With regards to Diarrhea, the highest number of reported cases were recorded in 2016 (1.6 million) with the least in 2002 (0.3 million). Nationally, whilst Diarrhea recorded a total of 12.2 million cases, skin diseases, rheumatism and other joint pains, intestinal worms, chickenpox, Typhoid fever, and pneumonia recorded cases ranging between 1.9 million to 11.5 million.

Table 6.5: Environmental-Related Diseases (Outpatient Morbidity), 2002-2016

Year	Malaria	Upper Respiratory Tract Infections	Diarrhea	Skin Diseases	Rheumatism and Other Joint Pains	Intestinal Worms	Chicken Pox	Typhoid Fever	Pneumonia
2002	3,140,980	532,531	287,816	308,848	146,907	133,302	35,667	31,791	77,064
2003	3,359,191	519,652	322,404	325,262	146,552	151,330	19,614	53,825	77,477
2004	3,379,527	549,398	331,998	314,436	142,834	119,885	45,512	65,333	76,742
2005	3,799,158	581,323	352,384	352,295	162,162	134,440	-	76,293	83,154
2006	3,861,348	632,755	345,454	341,044	183,144	130,071	-	67,780	91,491
2007	5,384,685	920,806	452,250	539,197	270,296	208,429	-	89,444	124,403
2008	5,041,025	794,301	385,737	422,948	254,518	165,534	77,790	93,026	85,386
2009	7,096,440	1,306,354	590,286	622,391	429,708	256,699	157,383	141,607	106,858
2010	8,208,670	1,695,666	737,804	814,224	603,834	374,637	209,728	179,497	121,477
2011	10,171,448	2,718,135	1,083,005	1,168,196	948,428	540,733	363,418	247,303	177,404
2012	10,171,448	2,718,135	1,083,005	1,168,196	948,428	540,733	363,418	247,303	177,404
2013	10,839,392	3,549,464	1,530,739	1,511,787	1,369,466	804,472	506,402	339,877	236,585
2014	6,961,077	3,379,534	1,573,569	1,335,465	1,474,615	830,557	606,471	334,103	204,984
2015	7,316,615	3,896,550	1,515,189	1,187,674	1,546,744	855,677	603,607	337,120	-
2016	6,959,525	3,840,246	1,570,557	1,143,556	1,612,609	816,106	671,144	384,704	235,052
Total	**95,690,529**	**27,634,850**	**12,162,197**	**11,555,519**	**10,240,245**	**6,062,605**	**3,660,154**	**2,689,006**	**1,875,481**

Source: Ghana Health Service, facts and figures 2017

Chapter 7

Environmental Protection, Management and Engagement

7.1 Introduction

This chapter provides information on environmental protection and resource management expenditure to improve the environment and maintain ecosystem health. Statistics on environmental governance, institutional strength, enforcement of regulations and extreme event preparedness are also considered. The chapter also provides brief information on the regulatory instruments, Multilateral Environment Agreements (MEAs) and Conventions the country has signed onto as part of global efforts to addressing a wide array of emerging environmental issues.

7.2 Environmental Regulation and Instruments

In Ghana, the Environmental Protection Agency (EPA) is mandated as the lead institution in environment to provide technical advice on environmental protection and sustainable development to the Ministry of Environment, Science, Technology and Innovation.

The functions of the EPA among others include the promotion of environmental education, research, monitoring and regulation, and preparation of standards and guidelines for environmental management. The EPA is also responsible for the protection and improvement of Ghana' environment. This includes enforcing environmental policy and legislation, prescribing standards and guidelines, inspecting and regulating businesses and responding to emergency incidents, issuance of environmental permits and pollution abatement notices for controlling waste discharges, emissions, deposits or others sources of pollutants and issuing directives, procedures or warnings for the purpose of controlling noise.

A number of institutions including the Forestry Commission, Minerals Commission, Energy Commission, Water Resources Commission, Fisheries Commission, Lands Commission, among others are also mandated by law to regulate various aspects of the environment. Table 7.2 and 7.3 presents a list of legislation in grouped under different environment themes and a schedule of some regulated pollutants in Ghana.

Table 7.2: List of Legislation in Grouped Under Different Environment Themes

No.	Environment Theme	Legislation
1	Air Pollution	• Environmental Protection Agency Act, 1994 (Act 490) • Management of Ozone Depleting Substances and Products Regulations,2005
2	Coastal and Marine Environment	• Fisheries Act, 2002 • Maritime Zone (Delimitation) Act,1986 • Wetlands Management (RAMSAR Sites) Regulations,1999
3	Energy and Mineral Resources	• Atomic Energy Commission Act,2000 • Diamonds Act,1972 • Energy Commission Act, 1997 • Ghana National Petroleum Act,1983 • Minerals Commission Act,1993 • Minerals Export Duty (Abolition) Act,1987 • Minerals Health Areas Act,1925 • Small Scale Gold Mining Act,1989 • Volta River Development Act,1961 • West African Gas Pipeline Act,2004
4	Flora and Fauna	• Animals (Artificial Insemination) Act,1955 • Animals (Control and Importation) Act,1952 • Control and Prevention of Bush Fires Act,1990 • Economic Plants Protection Act,197 • Forest Plantation Development Act,2000 • Timber Resource Management Regulation Act,1998 • Timber Operations Act • Tree and Timber Act,1974 • Timber Resource Management Regulations,1998 • Timber Industry and Ghana Timber Marketing Board Act,1977 • Wild Animals Preservation Act 1961(Act 43)
5	Human Development and Settlement	• Concessions Act,1939 • Concessions Act,1962 • Copyright Act,2005 • Centre For Scientific and Industrial Research Act,1996 • Centre For Scientific Research into Plant Medicine Act,1975 • Confiscated Assets (Recovery and Disposal) Committee Act,1979 • Food and Drugs Board• Administration of Lands, Act 1962 • Ghana Ports and Harbors Authority Act,1986 • Ghana Maritime Security Act, 2004 • Ghana Maritime Authority Act,2002 • Ghana Shipping Act,2003 • Ghana National Fire Service Act, 1997 • Ghana Meteorological Agency Act,2004 • Ghana Tourist Control Authority Act,1973

No.	Environment Theme	Legislation
		• Ghana Standards Board (Food, Drugs and Other Goods) General Labelling Rules,1992 • Infectious Diseases Act,1908 • Local Government Act, • Local Government Service Act • Seeds (Certification and Standard) Act,1972 • Standards Authority Act,1973 • Telecommunications (Frequency Registration and Control) Act,1977 • Town and Country Planning Act,1945 • Towns Act,1992 • Traditional Medicine Practice Act,2003, • Vaccination Act,1919 • Weights and Measures Act
6	Hazardous Substances/Chemical	• Mercury Act,1989 • Hazardous and Electronic Waste Control and Management Act, 2016
7	Land Management	• Lands Commission Act,1994 • Lands Miscellaneous Provision Act,1963 • Land Planning and Soil Conservation Act,1953 • Landed Properties of Ghana, Rubber Estates Limited and Fire Stone Act,1977 • Land Registry Act,1962rrigation Development Authority Act,1977 • Lands (Statutory Wayleaves) Act,1963 • Land Title Registration Act,1986
8	Noise Control	• Local Governance Act 2016 (Act 936)
9	Solid Waste Management	• Abandoned Property (Disposal)Act ,1974 • Environmental Assessment Regulations 1999, (LI 1652) • Local Government Act (1994), Act 462
10	Water Management and Pollution	• Beaches Obstructions Act,1897 • Environmental Protection Agency Act, 1994(Act 490) Part I & II • Ghana Water and Sewerage Corporation Act 1965 (Act 310) • Rivers Act,1903 • Water Resources Commission Act, 1996 (Act 522)

Source: Environmental Protection Agency, 2019

Table 7.3: List of Some Regulated Pollutants

No.	Name	Chemical Abstracts Service (CAS) Numbers	Categories	Maximum Allowable Levels	Year Adopted	Brief Description
1.	2,4,5-T and its salts and esters	93-76-5 (*)	Pesticide			2,4,5-Trichlorophenoxyacetic acid, a synthetic auxin, is a chlorophenoxy acetic acid herbicide used to defoliate broad-leafed plants
2.	Alachlor	15972-60-8	Pesticide			Alachlor is an herbicide from the chloroacetanilide family. It is an odorless, white solid. The greatest use of alachlor is for control of annual grasses and broadleaf weeds in crops.
3.	Aldicarb	116-06-3	Pesticide			Aldicarb is a carbamate insecticide which is the active substance in the pesticide Temik. It is effective against thrips, aphids, spider mites, lygus, fleahoppers, and leafminers, but is primarily used as a nematicide.
4.	Aldrin	309-00-2	Pesticide			Aldrin is an organochlorine insecticide that was widely used until the 1990s, when it was banned in most countries. Aldrin is a member of the so-called "classic organochlorines" (COC) group of pesticides.
5.	Azinphos-methyl	86-50-0	Pesticide			Azinphos-methyl (Guthion) is a broad-spectrum organophosphate insecticide. Like other pesticides in this class, it owes its insecticidal properties (and human toxicity) to the fact that it is an acetylcholinesterase inhibitor (the same mechanism is responsible for the toxic effects of the V-series nerve agent chemical weapons).

No.	Name	Chemical Abstracts Service (CAS) Numbers	Categories	Maximum Allowable Levels	Year Adopted	Brief Description
6.	Binapacryl	485-31-4	Pesticide			Binapacryl was used as a miticide and fungicide. Chemically, it is an ester derivative of dinoseb. Although binapacryl has low toxicity itself, it is readily metabolized to form dinoseb, which is highly toxic.
7.	Captafol	2425-06-01	Pesticide			Captafol is a fungicide. It is used to control almost all fungal diseases of plants except powdery mildews
8.	Carbofuran	1563-66-2	Pesticide			Carbofuran is one of the most toxic carbamate pesticides.
9.	Chlordane	57-74-9	Pesticide			Chlordane, or chlordan, is an organochlorine compound used as a pesticide.
10.	Chlordimeform	6164-98-3	Pesticide			Chlordimeform is an acaricide (pesticide) active mainly against motile forms of mites and ticks and against eggs and early instarsof some *Lepidoptera* insects.
11.	Chlorobenzilate	510-15-6	Pesticide			Chlorobenzilate is a pesticide that is not currently used in the United States or Europe. It was used as an acaricide against mites on citrus trees, including deciduous fruit trees.
12.	Dichlorodiphenyltrichloroethane (DDT)	50-29-3	Pesticide			Dichlorodiphenyltrichloroethane, commonly known as DDT, is a colorless, tasteless, and almost odorless crystalline chemical compound, an organochlorine. It was originally developed as an insecticide, then it became infamous for its environmental impacts.
13.	Dieldrin	60-57-1	Pesticide			Dieldrin is an organochloride originally produced as an insecticide. Dieldrin is closely related to aldrin, which reacts further to form dieldrin.

No.	Name	Chemical Abstracts Service (CAS) Numbers	Categories	Maximum Allowable Levels	Year Adopted	Brief Description
14.	Dinitro-ortho-cresol (DNOC) and its salts (such as ammonium salt, potassium salt and sodium salt)	534-52-1	Pesticide			Dinitro-*ortho*-cresol (DNOC) is an organic compound with the structural formula $CH_3C_6H_2(NO_2)_2OH$. It is a yellow solid that is only slightly soluble in water. DNOC and some related derivatives have been used as herbicides.
15.	Dinoseb and its salts and esters	88-85-7 (*)	Pesticide			Dinoseb is a common industry name for 6-sec-butyl-2,4-dinitrophenol, a herbicide in the dinitrophenol family. It is a crystalline orange solid which does not readily dissolve in water. Dinoseb is banned as an herbicide in the EU and USA because of its toxicity
16.	EDB (1,2-dibromoethane)	106-93-4	Pesticide			1,2-Dibromoethane, also known as ethylene dibromide (EDB), is an organobromine compound with the chemical formula (CH_2Br_2). Although trace amounts occur naturally in the ocean, where it is formed probably by algae and kelp, it is mainly synthetic. It is a dense colorless liquid with a faint sweet odor, detectable at 10 ppm, is a widely used and sometimes-controversial fumigant. The combustion of 1,2-dibromoethane produces hydrogen bromide gas that is significantly corrosive.t has been used as a pesticide in soil and on various crops.
17.	Endosulfan	115-29-7	Pesticide			Endosulfan is an off-patent organochlorine insecticide and acaricide that is being phased out globally.
18.	Ethylene dichloride	107-06-2	Pesticide			The chemical compound 1,2-dichloroethane, commonly known as ethylene dichloride (EDC),

No.	Name	Chemical Abstracts Service (CAS) Numbers	Categories	Maximum Allowable Levels	Year Adopted	Brief Description
						is a chlorinated hydrocarbon. It is a colourless liquid with a chloroform-like odour.
19.	Ethylene oxide	75-21-8	Pesticide			Ethylene oxide is an organic compound. It is a cyclic ether and the simplest epoxide: a three-membered ring consisting of one oxygen atom and two carbon atoms. Ethylene oxide is a colorless and flammable gas with a faintly sweet odour.
20.	Fluoroacetamide	640-19-7	Pesticide			Fluoroacetamide is an organic compound based on acetamide with one fluorine atom replacing hydrogen on the methyl group. it is a metabolic poison which disrupts the citric acid cycle and was used as a rodenticide.
21.	HCH (mixed isomers)	608-73-1	Pesticide			Hexachlorocyclohexane (HCH), formally known as benzene hexachloride (BHC), is a synthetic chemical that exists in eight chemical forms called isomers. The different isomers are named according to the position of the hydrogen atoms in the structure of the chemical. However, imported γ-HCH is available in the United States for insecticide use as a dust, powder, liquid, or concentrate. It is also available as a prescription medicine (lotion, cream, or shampoo) to treat and/or control scabies (mites) and head lice in humans.
22.	Heptachlor	76-44-8	Pesticide			Heptachlor is an organochlorine compound that was used as an insecticide. Usually sold as a white or tan powder, heptachlor is one of the cyclodiene insecticides.

No.	Name	Chemical Abstracts Service (CAS) Numbers	Categories	Maximum Allowable Levels	Year Adopted	Brief Description
23.	Hexachlorobenzene	118-74-1	Pesticide			Hexachlorobenzene, or perchlorobenzene, is an organochloride with the molecular formula C_6Cl_6. It is a fungicide formerly used as a seed treatment, especially on wheat to control the fungal disease bunt. It has been banned globally under the Stockholm Convention on Persistent Organic Pollutants.
24.	Lindane (gamma-HCH)	58-89-9	Pesticide			Lindane, also known as *gamma-*hexachlorocyclohexane (γ-HCH), gammaxene, Gammallin and sometimes *incorrectly* called benzene hexachloride (BHC) is an organochlorine chemical and an isomer of hexachlorocyclohexane that has been used both as an agricultural insecticide and as a pharmaceutical treatment for lice and scabies.
25.	Mercury compounds, including inorganic mercury compounds, alkyl mercury compounds and alkyloxyalkyl and aryl mercury compounds	CAS numbers	Pesticide			Mercury is a chemical element with the symbol Hg and atomic number 80. It is commonly known as quicksilver and was formerly named hydrargyrum. A heavy, silvery d-block element, mercury is the only metallic element that is liquid at standard conditions for temperature and pressure
26.	Methamidophos	10265-92-6	Pesticide			Methamidophos, trade name "Monitor," is an organophosphate insecticide. Crops grown with the use of methamidophos include potatoes and some Latin American rice. Many nations have used methamidophos on crops, including developed nations such as Spain, United States, Japan, and Australia. Due to its toxicity, the use

No.	Name	Chemical Abstracts Service (CAS) Numbers	Categories	Maximum Allowable Levels	Year Adopted	Brief Description
						of pesticides that contain methamidophos is currently being phased out in Brazil.
27.	Monocrotophos	6923-22-4	Pesticide			Monocrotophos is an organophosphate insecticide. It is acutely toxic to birds and humans, so it has been banned in the U.S., the E.U. and many other countries. Monocrotophos is principally used in agriculture, as a relatively cheap pesticide.
28.	Parathion	56-38-2	Pesticide			Parathion, also called parathion-ethyl or diethyl parathion and locally known as "Folidol", is an organophosphate insecticide and acaricide. It is highly toxic to non-target organisms, including humans, so its use has been banned or restricted in most countries.
29.	Pentachlorophenol and its salts and esters	87-86-5 (*)	Pesticide			Pentachlorophenol (PCP) is an organochlorine compound used as a pesticide and a disinfectant.
30.	Phorate	298-02-2	Pesticide			Phorate is an organophosphate used as an insecticide and acaricide. At normal conditions, it is a pale-yellow mobile liquid poorly soluble in water but readily soluble in organic solvents. It is relatively stable and hydrolyses only at very acidic or basic conditions. It is very toxic both for target organisms and for mammals including human.
31.	Toxaphene (Camphechlor)	8001-35-2	Pesticide			Toxaphene was an insecticide used primarily for cotton in the southern United States during the late 1960s and 1970s.Toxaphene is a mixture of over 670 different chemicals and is produced by

No.	Name	Chemical Abstracts Service (CAS) Numbers	Categories	Maximum Allowable Levels	Year Adopted	Brief Description
						reacting chlorine gas with camphene. Toxaphene was banned in the United States in 1990 and was banned globally by the 2001 Stockholm Convention on Persistent Organic Pollutants. It is a very persistent chemical that can remain in the environment for 1–14 years without degrading, particularly in the soil.
32.	Tributyltin compounds	1461-22-9, 1983-10-4, 2155-70-6, 24124-25-2, 4342-36-3, 56-35-9, 85409-17-2	Pesticide			Tributyltin (TBT) is an umbrella term for a class of organotin compounds which contain the (C4H9)3Sn group, with a prominent example being tributyltin oxide. For 40 years TBT was used as a biocide in anti-fouling paint, commonly known as bottom paint, applied to the hulls of ocean-going vessels. The TBT slowly leaches out into the marine environment where it is highly toxic toward nontarget organisms.
33.	Trichlorfon	52-68-6	Pesticide			Metrifonate (INN) or trichlorfon (USAN) is an irreversible organophosphate acetylcholinesterase inhibitor.[3] It is a prodrug which is activated non-enzymatically into the active agent dichlorvos. It is used as an insecticide.
34.	Dustable powder formulations containing a combination of benomyl at or above 7%, carbofuran at or above 10% and thiram at or above 15%	137-26-8, 1563-66-2, 17804-35-2	Severely hazardous pesticide formulation			Carbofuran is a carbamate pesticide of very high toxicity. It is an acute poison, absorbed by inhalation of dust and spray mist; from the gastrointestinal tract; and, to a lessor extent through the intact skin. Early symptoms of poisoning may include headache, weakness, giddiness and nausea. Thiram is a dithiocarbamate of slight acute toxicity and potential long-term toxic effects. It may be

No.	Name	Chemical Abstracts Service (CAS) Numbers	Categories	Maximum Allowable Levels	Year Adopted	Brief Description
						absorbed from the gastrointestinal tract; by inhalation of spray mist or dust; and through intact skin. Benomyl is a benzimidazole fungicide. Acute toxicity of benomyl is low, but it has the potential of causing dermal sensitization.
35.	Methyl-parathion (Emulsifiable concentrates (EC) at or above 19.5% active ingredient and dusts at or above 1.5% active ingredient)	298-00-0	Severely hazardous pesticide formulation			Parathion methyl, or methyl parathion, is an organophosphate pesticide and insecticide, possessing a organothiophosphate group. It is structurally very similar to parathion-ethyl. It is not allowed for sale and import in nearly all countries around the world, while a few allow it under subject to specified conditions only.
36.	Phosphamidon (Soluble liquid formulations of the substance that exceed 1000 g active ingredient/l)	13171-21-6	Severely hazardous pesticide formulation			Phosphamidon is an organophosphate insecticide first reported in 1960. It acts as a cholinesterase inhibitor.
37.	Actinolite asbestos	77536-66-4	Industrial			Actinolite is a member of the amphibole class of asbestos minerals. Amphiboles break apart into small, straight, needle-like fibers that are easily airborne and pose a greater risk of inhalation and disease than the serpentine asbestos chrysotile.
38.	Anthophyllite asbestos	77536-67-5	Industrial			Anthophyllite asbestos is a member of the amphibole class of asbestos minerals. This classification is friable and crumbles into straight, fibrous strands of the mineral that resemble needles. The needle-like form of amphibole asbestos makes them more likely to become inhaled and embedded within lung

No.	Name	Chemical Abstracts Service (CAS) Numbers	Categories	Maximum Allowable Levels	Year Adopted	Brief Description
						tissue compared to the curly serpentine fibers of chrysotile.
39.	Amosite asbestos	12172-73-5	Industrial			With a high absorption ability, amosite was commonly used in materials to reduce condensation or provide acoustic insulation against sound travel. Around the 1970s, many countries banned its use as its highly friable fibers were discovered to be quite dangerous, second only to crocidolite in its ability to cause asbestos-related cancers.
40.	Crocidolite asbestos	12001-28-4	Industrial			Crocidolite is a type of asbestos with a deceptively captivating appearance that hides the material’s deadly nature. This mineral in its asbestos form is recognized as the most harmful and carcinogenic of all asbestos minerals.
41.	Tremolite asbestos	77536-68-6	Industrial			The fibrous form of tremolite is one of the six recognized types of asbestos. This material is toxic, and inhaling the fibers can lead to asbestosis, lung cancer and both pleural and peritoneal mesothelioma. Fibrous tremolite is sometimes found as a contaminant in vermiculite, chrysotile (itself a type of asbestos) and talc.
42.	Commercial octabromodiphenyl ether (including Hexabromodiphenyl ether and Heptabromodiphenyl ether)	36483-60-0, 68928-80-3	Industrial			Octabromodiphenyl ether (octaBDE, octa-BDE, OBDE, octa, octabromodiphenyl oxide, OBDPO) is a brominated flame retardant which belongs to the group of polybrominated diphenyl ethers (PBDEs)

No.	Name	Chemical Abstracts Service (CAS) Numbers	Categories	Maximum Allowable Levels	Year Adopted	Brief Description
43.	Commercial pentabromodiphenyl ether (including tetrabromodiphenyl ether and pentabromodiphenyl ether)	32534-81-9, 40088-47-9	Industrial			Pentabromodiphenyl ether (also known as pentabromodiphenyl oxide) is a brominated flame retardant which belongs to the group of polybrominated diphenyl ethers (PBDEs). Because of their toxicity and persistence, their industrial production is to be eliminated under the Stockholm Convention, a treaty to control and phase out major persistent organic pollutants (POP)
44.	Hexabromocyclododecane	134237-50-6, 134237-51-7, 134237-52-8, 25637-99-4, 3194-55-6	Industrial			Hexabromocyclododecane (HBCD or HBCDD) is a brominated flame retardant. Its primary application is in extruded (XPS) and expanded (EPS) polystyrene foam that is used as thermal insulation in the building industry. Other uses are upholstered furniture, automobile interior textiles, car cushions and insulation blocks in trucks, packaging material, video cassette recorder housing and electric and electronic equipment.
45.	Perfluorooctane sulfonic acid, perfluorooctane sulfonates, perfluorooctane sulfonamides and perfluorooctane sulfonyls	1691-99-2, 1763-23-1, 24448-09-7, 251099-16-8, 2795-39-3, 29081-56-9, 29457-72-5, 307-35-7, 31506-32-8, 4151-50-2, 56773-42-3, 70225-14-8	Industrial			Perfluorooctanesulfonic acid (conjugate base perfluorooctanesulfonate) (PFOS) is an anthropogenic fluorosurfactant and global pollutant. PFOS was the key ingredient in Scotchgard, a fabric protector made by 3M, and numerous stain repellents.

No.	Name	Chemical Abstracts Service (CAS) Numbers	Categories	Maximum Allowable Levels	Year Adopted	Brief Description
46.	Polybrominated Biphenyls (PBBs)	13654-09-6, 27858-07-7, 36355-01-8	Industrial			Polybrominated biphenyls (PBBs), also called brominated biphenyls or polybromobiphenyls, are a group of manufactured chemicals that consist of polyhalogenated derivatives of a biphenyl core. PBBs usually exist as colorless to off-white solids. PBBs soften at 72 degrees Celsius and decompose above 300 degrees Celsius. They have low vapor pressure, are very soluble in benzene and toluene, and insoluble in water. They are degraded by UV light. PBBs are used as flame retardants of the brominated flame-retardant group.
47.	Polychlorinated Biphenyls (PCBs)	1336-36-3	Industrial			A polychlorinated biphenyl (PCB) is an organic chlorine compound with the formula C12H10−xClx. Polychlorinated biphenyls were once widely deployed as dielectric and coolant fluids in electrical apparatus, carbonless copy paper and in heat transfer fluids. With the discovery of PCBs' environmental toxicity, and classification as persistent organic pollutants, their production was banned by United States federal law in 1978, and by the Stockholm Convention on Persistent Organic Pollutants in 2001.
48.	Polychlorinated Terphenyls (PCTs)	61788-33-8	Industrial			Polychlorinated terphenyls (PCTs) are a group of chlorine derivative of terphenyls. They are chemically related to polychlorinated biphenyls and have similar chemical properties. They have very low electrical conductivity, high heat stability, and high resistance to alkalies

No.	Name	Chemical Abstracts Service (CAS) Numbers	Categories	Maximum Allowable Levels	Year Adopted	Brief Description
						and strong acids. They are non-flammable and insoluble in water.
49.	Short-chain chlorinated paraffins (SCCP)	85535-84-8	Industrial			SCCPs are primarily used in metalworking applications and in polyvinyl chloride (PVC) processing. SCCPs are also used as plasticizers and flame retardants in a variety of applications, including in paints, adhesives and sealants, leather fat liquors, plastics, rubber, textiles and polymeric materials.
50.	Tetraethyl lead	78-00-2	Industrial			TEL is a petro-fuel additive, first being mixed with gasoline (petrol) beginning in the 1920s as a patented octane rating booster that allowed engine compression to be raised substantially. This in turn caused increased vehicle performance and fuel economy.
51.	Tetramethyl lead	75-74-1	Industrial			Tetramethyllead, also called tetra methyllead and lead tetramethyl, is a chemical compound used as an antiknock additive for gasoline.[1] Its use is being phased out for environmental considerations
52.	Tributyltin compounds	1461-22-9, 1983-10-4, 2155-70-6, 24124-25-2, 4342-36-3, 56-35-9, 85409-17-2	Industrial			Tributyltin (TBT) is an umbrella term for a class of organotin compounds with a prominent example being tributyltin oxide. For 40 years TBT was used as a biocide in anti-fouling paint, commonly known as bottom paint, applied to the hulls of ocean-going vessels. Bottom paint improves ship performance and durability as it reduces the rate of biofouling (the growth of organisms on the ship's hull).

No.	Name	Chemical Abstracts Service (CAS) Numbers	Categories	Maximum Allowable Levels	Year Adopted	Brief Description
53.	Tris (2,3 dibromopropyl) phosphate	126-72-7	Industrial			Tris(2,3-dibromopropyl) phosphate ("tris") is a chemical once widely used as a flame retardant in plastics and textiles
54.	Perfluorohexane sulfonic acid (PFHxS), its salts and PFHxS-related compounds	355-46-4	Industrial			PFHxS is a chemical used as a surfactant in a variety of industrial and commercial products such as food packaging, stain and water-resistant materials, fire-fighting foams and paint additives. The likely environmental sources are from introduction via commercial production or during use (such as with fire-fighting foams).
55.	Dechlorane Plus	13560-89-9	Industrial			Dechlorane plus is a polychlorinated flame retardant produced by Oxychem.
56.	Methoxychlor	72-43-5	Pesticide			Methoxychlor is a synthetic organochloride insecticide, now obsolete. Methoxychlor was used to protect crops, ornamentals, livestock, and pets against fleas, mosquitoes, cockroaches, and other insects. It was intended to be a replacement for DDT, but has since been banned based on its acute toxicity, bioaccumulation, and endocrine disruption activity.

Source: Environmental Protection Agency, 2019

7.3 Participation in MEAs and Environmental Conventions

Ghana is a party to a number of various Multilateral Environment Agreements (MEAs) and has ratified, and signed onto these Agreements and Conventions to protect and conserve the environment. The underlisted MEAs and Conventions have been adopted by Ghana.

7.3.1 Agreement on the Conservation of African-Eurasian Migratory Water birds (AEWA)

The Agreement on the Conservation of African-Eurasian Migratory Water birds (AEWA) is an intergovernmental treaty dedicated to the conservation of migratory water birds and their habitats across Africa, Europe, the Middle East, Central Asia, Greenland and the Canadian Archipelago. Developed under the framework of the Convention on Migratory Species (CMS) and administered by the United Nations Environment Programme (UNEP), AEWA brings together countries and the wider international conservation community in an effort to establish coordinated conservation and management of migratory water birds throughout their entire migratory range**.** This was signed on Friday, April 1, 1988 and ratified on Saturday, October 1, 2005. The implementing agency is the Wildlife Division of the Forestry Commission is Name of organization: Wildlife Division of the Forestry Commission.

7.3.2 Cartagena Protocol

The Cartagena Protocol on Bio safety to the Convention on Biological Diversity is an international agreement which aims to ensure the safe handling, transport and use of living modified organisms (LMOs) resulting from modern biotechnology that may have adverse effects on biological diversity, taking also into account risks to human health. It was adopted on 29 January 2000 and entered into force on 11 September 2003. This agreement was signed on Friday, June 12, 1992. It has an accession status with the implementing organization being Environmental Protection Agency (EPA).

7.3.3 Convention on Biological Diversity (CBD)

The Convention on Biological Diversity (CBD) entered into force on 29 December 1993. It has 3 main objectives; the conservation of biological diversity, the sustainable use of the components of biological diversity and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. The agreement was signed on Friday, June 12, 1992 and ratified on Monday, August 29, 1994. It has a ratification status with Ministry of Environment, Science, and Technology & Innovation (MESTI) being the implementing agency.

7.3.4 Gaborone Declaration for the Sustainability of Africa (GDSA)

The Gaborone Declaration for Sustainability in Africa stemmed from a 2012 Summit on Sustainability with visionary, corporate leaders and heads of states of nine African countries including the host country, Botswana. The succession to signature was done on October, 2012 and this was ratified on Monday, August 29, 1994. The implementing agency is Ministry of Environment, Science, and Technology & Innovation (MESTI)**.**

7.3.5 Minamata Convention on Mercury

The Minamata Convention on Mercury is a global treaty to protect human health and the environment from the adverse effects of mercury. It was agreed at the fifth session of the Intergovernmental Negotiating Committee on mercury in Geneva, Switzerland at 7 a.m. on the morning of Saturday, 19 January 2013 and adopted later that year on 10 October 2013 at a Diplomatic Conference (Conference of Plenipotentiaries), held in Kumamoto, Japan. The Succession to Signature was held on Wednesday, September 24, 2014 and Ratified on Thursday, March 23, 2017. Environmental Protection Agency (EPA) is the implementing agency {Enviromental Protection Agency, 2017 #658}.

7.3.6 Montreal Protocol

The Montreal Protocol, finalized in 1987, is a global agreement to protect the stratospheric ozone layer by phasing out the production and consumption of ozone-depleting substances (ODS). The stratospheric ozone layer filters out harmful ultraviolet radiation, which is associated with an increased prevalence of skin cancer and cataracts, reduced agricultural productivity, and disruption of marine ecosystems. The United States ratified the Montreal Protocol in 1988 and has joined four subsequent amendments. The United States has been a leader within the Protocol throughout its existence, and has taken strong domestic action to phase out the production and consumption of ODS such as chlorofluorocarbons (CFCs) and halons. The Succession to Signature was done on Wednesday, September 16, 1987 and Ratification held on Tuesday, July 14, 1992. Environmental Protection Agency (EPA) is the implementing agency.

7.3.7 Stockholm Convention

The Stockholm Convention on Persistent Organic Pollutants was adopted by the Conference of Plenipotentiaries on 22 May 2001 in Stockholm, Sweden. The Convention entered into force on 17 May 2004. It is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or on the environment. The Succession to Signature was done on Wednesday, May 23, 2001 with the ratification status signed on Friday, May 30, 2003. The implementing organization is Environmental Protection Agency (EPA).

7.3.8 Sustainable Development Goals (SDGs)

In September 2015, the General Assembly adopted the 2030 Agenda for Sustainable Development that includes 17 Sustainable Development Goals (SDGs). Building on the principle of "leaving no one behind", the new Agenda emphasizes a holistic approach to achieving sustainable development for all. The Succession to Signature was done In September 2015 and Ratified in September 2015, bearing a status of member. Environmental Protection Agency (EPA) is the agency in charge of implementation.

7.3.9 United Nations Convention to Combat Desertification (UNCCD)

The United Nations Convention to Combat Desertification (UNCCD) is the sole legally binding international agreement linking environment and development to sustainable land management. The Convention addresses specifically the arid, semi-arid and dry sub-humid areas, known as the dry lands, where some of the most vulnerable ecosystems and peoples can be found. Succession to Signature was done in Saturday, October 15, 1994 and the Ratification held on Friday, December 27, 1996. The Environmental Protection Agency (EPA) is the focal organization in charge of implementation.

7.3.10 United Nations Framework Convention on Climate Change (UNFCCC)

The United Nations Convention on the Law of the Sea also called the Law of the Sea Convention or the Law of the Sea treaty is the international agreement that resulted from the third United Nations Conference on the Law of the Sea, which took place between 1973 and 1982. The Succession to Signature was held on Friday, December 10, 1982 and Ratified on Tuesday, June 7, 1983. Environmental Protection Agency (EPA) is the implementing agency.

7.3.11 United Nations Convention on the Law of the Sea (UNCLOS)

The United Nations Convention on the Law of the Sea also called the Law of the Sea Convention or the Law of the Sea treaty is the international agreement that resulted from the third United Nations Conference on the Law of the Sea, which took place between 1973 and 1982. The agreement was signed on Friday, December 10, 1982 and ratified on Tuesday, June 7, 1983. Environmental Protection Agency (EPA) is the implementing agency.

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Annexes

Annex 1: Threatened plant species and Threat categories of Ghanaian plants species listed on the IUCN Red Data

IUCN Red List Category	Scientific name	Common Name
CR	Asclepias kamerunensis	
CR	Aubregrinia taiensis	
CR	Talbotiella gentii	
EN	Aldrovanda vesiculosa	Waterwheel
EN	Chrysophyllum azaguieanum	
EN	Cola boxiana	
EN	Dactyladenia hirsuta	
EN	Dalbergia setifera	
EN	Hemandradenia chevalieri	
EN	Hunteria ghanensis	
EN	Hymenostegia gracilipes	
EN	Lecaniodiscus punctatus	
EN	Monocyclanthus vignei	
EN	Neolemonniera clitandrifolia	
EN	Okoubaka aubrevillei	Death Tree
EN	Pericopsis elata	African Teak
EN	Placodiscus attenuatus	
EN	Placodiscus pseudostipularis	
EN	Pteleopsis habeensis	
EN	Pyrenacantha cordicula	
EN	Sericanthe toupetou	
EN	Tieghemella heckelii	Cherry Mahogany
EN	Vepris heterophylla	
VU	Afrostyrax lepidophyllus	
VU	Afzelia africana	Afzelia
VU	Alafia whytei	
VU	Albizia ferruginea	Albizia
VU	Allexis cauliflora	
VU	Amanoa bracteosa	
VU	Amanoa strobilacea	
VU	Anopyxis klaineana	
VU	Ansellia africana	Leopard Orchid
VU	Anthocleista microphylla	
VU	Anthonotha vignei	
VU	Antrocaryon micraster	Antrocaryon
VU	Berlinia occidentalis	
VU	Calycosiphonia macrochlamys	
VU	Cassipourea hiotou	
VU	Ceropegia rhynchantha	

IUCN Red List Category	Scientific name	Common Name
VU	Citropsis gabunensis	
VU	Coffea togoensis	
VU	Cola reticulata	
VU	Cola umbratilis	
VU	Copaifera salikounda	
VU	Cordia platythyrsa	West African Cordia
VU	Craibia atlantica	
VU	Croton aubrevillei	
VU	Cryptosepalum tetraphyllum	
VU	Cussonia bancoensis	
VU	Dactyladenia dinklagei	
VU	Deinbollia molliuscula	
VU	Deinbollia saligna	
VU	Desmostachys vogelii	
VU	Diospyros barteri	
VU	Drypetes afzelii	
VU	Drypetes pellegrinii	
VU	Drypetes singroboensis	
VU	Encephalartos barteri	
VU	Entandrophragma angolense	
VU	Entandrophragma candollei	Cedar Kokoti
VU	Entandrophragma cylindricum	Sapele
VU	Entandrophragma utile	
VU	Garcinia afzelii	
VU	Garcinia epunctata	
VU	Garcinia kola	
VU	Gilbertiodendron bilineatum	
VU	Gilbertiodendron splendidum	
VU	Gluema ivorensis	
VU	Guarea cedrata	Scented Guarea
VU	Guarea thompsonii	Black Guarea
VU	Heritiera utilis	
VU	Isolona deightonii	
VU	Khaya anthotheca	African Mahogany
VU	Khaya grandifoliola	Large-leaved Mahogany
VU	Khaya ivorensis	African Mahogany
VU	Khaya senegalensis	Dry Zone Mahogany
VU	Lophira alata	Azobe
VU	Lovoa trichilioides	African Walnut
VU	Milicia regia	
VU	Millettia warneckei	
VU	Mitragyna ledermannii	

IUCN Red List Category	Scientific name	Common Name
VU	Mitragyna stipulosa	
VU	Nauclea diderrichii	
VU	Neostenanthera hamata	
VU	Nesogordonia papaverifera	
VU	Nothospondias staudtii	
VU	Ouratea amplectens	
VU	Pavetta lasioclada	
VU	Pavetta mollissima	
VU	Phyllanthus profusus	
VU	Pierreodendron kerstingii	
VU	Piptostigma fugax	
VU	Placodiscus bancoensis	
VU	Placodiscus boya	
VU	Placodiscus bracteosus	
VU	Placodiscus oblongifolius	
VU	Pseudagrostistachys africana	
VU	Pterygota bequaertii	
VU	Pterygota macrocarpa	
VU	Rhodognaphalon brevicuspe	
VU	Rhytachne furtiva	
VU	Robynsia glabrata	
VU	Sapium aubrevillei	
VU	Schumanniophyton problematicum	
VU	Spathandra barteri	
VU	Sterculia oblonga	Yellow Sterculia
VU	Synsepalum aubrevillei	
VU	Tapura ivorensis	
VU	Terminalia ivorensis	Black Afara
VU	Trichilia ornithothera	
VU	Trichoscypha cavalliensis	
VU	Trichoscypha mannii	
VU	Turraeanthus africana	
VU	Uvariodendron occidentale	
VU	Uvariopsis tripetala	
VU	Vitellaria paradoxa	Shea Butter Tree
VU	Warneckea memecyloides	
VU	Xylopia elliotii	
VU	Zanthoxylum chevalieri	

Annex 2: Types of Soils in Ghana

2018	Types of Soils in Ghana							
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
1	**Central**	Acrisols				Acrisols are defined by the presence of a subsurface layer of accumulated kaolinitic clays and also by the lack of an extensively leached layer below the surface horizon		
			Abonku-eja/awuaya-nkansaku	29623.553	>100			
			Achimfu-kuntu/asokwa-suprudu	587.209	>100			
		Acrisols				Acrisols are defined by the presence of a subsurface layer of accumulated kaolinitic clays and also by the lack of an extensively leached layer below the surface horizon		
			Asikuma-atewa/ansum-oda	522.797	>100			
			Atukrom	14284.172	>100			
			Edina-bronyibima/benya-udu	10375.288	>100			
			Kumasi-asuansi/nta-ofin	339639.837	>100			
			Nzima-bekwai/oda	104296.948	>100			
		Arenosols				Arenosols have very low water-holding capacities. They are highly siliceous and also extremely low in all essential nutrients		
			Keta-goi	1563.953	55			
		Cambisols				Cambisols are characterized by the absence of a layer of accumulated clay, humus, soluble salts, or iron and aluminum oxides. They differ from unweathered parent material in their aggregate structure, colour, clay content, carbonate content, or other properties that give some evidence of soil-forming processes.		
			Apeosika-pershi	490.516	>100			

2018			Types of Soils in Ghana					
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
		Fluvisols				Fluvisols are found on alluvial plains, river fans, valleys and tidal marshes and have a clear evidence of stratification. They have severe constraints for agricultural use as low pH-values, toxic aluminum levels and high concentrations of salts.		
			Ayensu-chichiwere	7090.195	>100			
			Chichiwere-kakum	25141.098	>100			
		Leptosols				Leptosols is a very shallow soil over highly calcareous material that is extremely gravelly.		
			Adzintam-yenku	14745.136	23			
			Fete-bediesi	5629.088	90			
			Nyanao-tinkong/opimo	7159.245	30			
		Lixisols				They are soils with subsurface accumulation of low activity clays and high base saturation. They develop under intensive tropical weathering conditions and sub humid to semi-arid climate.		
			Adawso-bawjiasi/nta-ofin	20997.323	>100			
		Solonchaks				Solonchaks are defined by high soluble salt accumulation within 30 cm (1 foot) of the land surface and by the absence of distinct subsurface horizonation (layering), except possibly for accumulations of gypsum, sodium, or calcium carbonate or layers showing the effects of waterlogging. Solonchaks are formed from saline parent material under conditions of high evaporation—conditions encountered in closed basins under warm to hot climates with a well-defined dry season, as in arid, Mediterranean, or subtropical zones.		
			Oyibi-muni	3912.703	>100			

2018				Types of Soils in Ghana				
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
			Oyibi-muni/keta	1940.765	>100			
		Vertisols				Vertisols are characterized by a clay-size-particle content of 30 percent or more by mass in all horizons (layers) of the upper half-metre of the soil profile, by cracks at least 1 cm (0.4 inch) wide extending downward from the land surface, and by evidence of strong vertical mixing of the soil particles over many periods of wetting and drying. They are found typically on level or mildly sloping topographyin climatic zones that have distinct wet and dry seasons. Vertisols contain high levels of plant nutrients, but, owing to their high clay content, they are not well suited to cultivation without painstaking management.		
			Osibi-bumbi	8779.828	>100			
			Lagoon	1665.481	>100			
			Nsaba-swedru/nta-ofin	46082.739	>100			
2	**Greater Accra**	Acrisols			>100	Acrisols are defined by the presence of a subsurface layer of accumulated kaolinitic clays and also by the lack of an extensively leached layer below the surface horizon		
			Manfe	168.052	>100			
			Nyigbenya	2052.604	>100			
			Nyigbenya-agawtaw	4776.679	>100			
			Nyigbenya-haacho	32865.644	>100			
			Oyarifa-manfe	17514.506	>100			

2018				Types of Soils in Ghana				
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
		Arenosols				Arenosols have very low water-holding capacities. They are highly siliceous and also extremely low in all essential nutrients		
			Goi	845.543	>100			
			Keta	1235.898	55			
			Keta-oyibi	1451.158	>100			
		Cambisols				Cambisols are characterized by the absence of a layer of accumulated clay, humus, soluble salts, or iron and aluminum oxides. They differ from unweathered parent material in their aggregate structure, colour, clay content, carbonate content, or other properties that give some evidence of soil-forming processes.		
			Amo-tefle	39721.945	>100			
			Ashaiman	77.752	>100			
			Beraku-krabo	1747.046	>100			
			Toje	6422.788	>100			
			Toje-agawtaw	22693.112	>100			
		Fluvisols				Fluvisols are found on alluvial plains, river fans, valleys and tidal marshes and have a clear evidence of stratification. They have severe constraints for agricultural use as low pH-values, toxic aluminum levels and high concentrations of salts.		
			Ayensu-chichiwere	11452.413	>100			
		Gleysols				Gleysols occur on wide range of unconsolidated materials, mainly fluvial, marine and lacustrine sedim ents of Pleistocene or Holocene age, with basic to acidic mineralogy. They exhibit a greenish-blue-grey soil color due to anoxic wetland conditions.		
			Ada	502.99	>100			

2018				Types of Soils in Ghana				
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
			Ada-oyibi	62484.152	>100			
		Leptosols			>100	Leptosols is a very shallow soil over highly calcareous material that is extremely gravelly .		
			Fete	32978.413	>100			
			Fete-bediesi	29344.171	90			
			Kloyo	2096.318	50			
			Korle	4323.174	>100			
			Nyanao-tinkong/opimo	4484.484	30			
		Luvisols				Luvisols have mixed mineralogy, high nutrient content, and good drainage which make them suitable for a wide range of agriculture such as grains , orchards and vineyards		
			Adawso-bawjiasi/nta-ofin	185820.242	>100			
		Luvisols				Luvisols have mixed mineralogy, high nutrient content, and good drainage which make them suitable for a wide range of agriculture such as grains , orchards and vineyards		
			Aveime-ada	11266.844	>100			
			Aveime-zipa	2568.739	>100			
			Danfa-dome	1776.907	>100			
			Doyum-agawtaw	15448.123	>100			
			Simpa-agawtaw	51899.959	>100			
		Plinthosols			>100	Plinthosols form under a variety of climatic and topographic conditions. They are defined by a subsurface layer containing an iron-rich mixture of clay minerals (chiefly kaolinite) and silica that hardens on exposure into ironstone concretions known as plinthite. The impenetrability of		

2018	Types of Soils in Ghana							
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
						the hardened plinthite layer, as well as the fluctuating water table that produces it, restrict the use of these soils to grazing or forestry, although the hardened plinthite has value as subgrade material for roads or even as iron ore (the iron oxide content can be as high as 80 percent by mass).		
			Chuim-gbegbe	911.659	>100			
		Solonchaks			>100	Solonchaks are defined by high soluble salt accumulation within 30 cm (1 foot) of the land surface and by the absence of distinct subsurface horizonation (layering), except possibly for accumulations of gypsum, sodium, or calcium carbonate or layers showing the effects of waterlogging. Solonchaks are formed from saline parent material under conditions of high evaporation—conditions encountered in closed basins under warm to hot climates with a well-defined dry season, as in arid, Mediterranean, or subtropical zones.		
			Oyibi-muni	9997.175	>100			
		Solonetz			>100	Solonetz soils are defined by an accumulation of sodium salts and readily displaceable sodium ions bound to soil particles in a layer below the surface horizon (uppermost layer). This subsurface layer also contains a significant amount of accumulated clay. Because of the high sodium content and dense, clay-rich subsoil, irrigated agriculture of these soils requires extensive reclamation—through leaching with fresh water and the construction of engineered drainage systems.		

2018	Types of Soils in Ghana							
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
			Agawtaw	33242.273	>100			
			Songaw	2176.711	>100			
		Vertisols			>100	Vertisols are characterized by a clay-size-particle content of 30 percent or more by mass in all horizons (layers) of the upper half-metre of the soil profile, by cracks at least 1 cm (0.4 inch) wide extending downward from the land surface, and by evidence of strong vertical mixing of the soil particles over many periods of wetting and drying. They are found typically on level or mildly sloping topographyin climatic zones that have distinct wet and dry seasons. Vertisols contain high levels of plant nutrients, but, owing to their high clay content, they are not well suited to cultivation without painstaking management.		
			Akuse	70610.905	>100			
			Alajo	467.445	>100			
			Lupu	5100.098	>100			
			Tachem	4285.018	>100			
		N/A						
			Lagoon	15264.558				
			Volta Lake	884796.701				
				1866138.693				
3	**Oti**	Acrisols				Acrisols are defined by the presence of a subsurface layer of accumulated kaolinitic clays and also by the lack of an extensively leached layer below the surface horizon.		
			Nyankpala	11060.691	>100			

2018			Types of Soils in Ghana					
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
			Osumbi-didinla	8028.662	>100			
			Oyarifa-krabo	7777.021	>100			
			Techiman	5126.234	>100			
		Arenosols				Arenosols have very low water-holding capacities. They are highly siliceous and also extremely low in all essential nutrients		
			Ketre-sangebi/banda-chaiso	16252.081	>100			
		Cambisols		12649.525	>100	Cambisols are characterized by the absence of a layer of accumulated clay, humus, soluble salts, or iron and aluminum oxides. They differ from unweathered parent material in their aggregate structure, colour, clay content, carbonate content, or other properties that give some evidence of soil-forming processes.		
			Amo-chichiwere/dayi-angela	12649.525	>100			
		Fluvisols				Fluvisols are found on alluvial plains, river fans, valleys and tidal marshes and have a clear evidence of stratification. They have severe constraints for agricultural use as low pH-values, toxic aluminum levels and high concentrations of salts.		
			Adankpa	2463.676	>100			
			Nterso-zaw	3408.019	>100			
		Leptosols				Leptosols is a very shallow soil over highly calcareous material that is extremely gravelly.		
			Adomi-kpeyi	50741.672	>100			
			Agramma-nyanfo/torkor	7160.904	>100			
			Domanbin-denteso	54777.792	>100			
			Fete-salom	37714.719	>100			
			Fete-salom/abotakyi-kitasi	4161.239	>100			

2018	Types of Soils in Ghana							
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
			Kadjebi-wawa/ketre-konsu	3739.206	>100			
			Kintampo	5056.911	20			
			Salom-mate/banda-chaiso	18650.967	>100			
		Luvisols				Luvisols have mixed mineralogy, high nutrient content, and good drainage which make them suitable for a wide range of agriculture such as grains, orchards and vineyards		
			Kpelesawgu	266116.731	>100			
		Luvisols				Luvisols have mixed mineralogy, high nutrient content, and good drainage which make them suitable for a wide range of agriculture such as grains , orchards and vineyards		
			Dadiekro-lima	8583.555	>100			
			Ejura-amantin/denteso	59248.769	>100			
		Planosols			>100	Planosols are characterized by a subsurface layer of clay accumulation. They occur typically in wet low-lying areas that can support either grass or open forest vegetation. They are poor in plant nutrients, however, and their clay content leads to both seasonal waterlogging and drought stress. Under careful management they can be cultivated for rice, wheat, or sugar beets, but their principal use is for grazing.		
			Blengo-botoku/kudzra-edo	101477.504	>100			
			Lima-volta	4600.091	>100			
		N/A		9127.972	>100			
			No data					
			Pegi-agu	1850.797	>100			

2018			Types of Soils in Ghana					
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
4	**Eastern**	Acrisols				Acrisols are defined by the presence of a subsurface layer of accumulated kaolinitic clays and also by the lack of an extensively leached layer below the surface horizon		
			Adujansu-bechem/nta-ofin	9386.673	>100			
			Atewa-ansum	44333.289	>100			
			Kumasi-asuansi/nta-ofin	12082.521	>100			
			Manfe-fete	11769.062	>100			
			Nzima-bekwai/oda	821.317	>100			
			Oyarifa-krabo	11644.404	>100			
			Oyarifa-manfe	1118.571	>100			
			Wiawso-shi	716.362	>100			
		Arenosols				Arenosols have very low water-holding capacities. They are highly siliceous and also extremely low in all essential nutrients.		
			Atewiredu	275.808	>100			
			Atewiredu-katie	2215.569	>100			
			Bediesi-sikaben	53452.944	>100			
		Cambisols				Cambisols are characterized by the absence of a layer of accumulated clay, humus, soluble salts, or iron and aluminum oxides. They differ from unweathered parent material in their aggregate structure, colour, clay content, carbonate content, or other properties that give some evidence of soil-forming processes.		
			Amo-chichiwere/dayi-angela	386.036	>100			
			Amo-tefle	268.387	>100			

2018				Types of Soils in Ghana				
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
		Fluvisols				Fluvisols are found on alluvial plains, river fans, valleys and tidal marshes and have a clear evidence of stratification. They have severe constraints for agricultural use as low pH-values, toxic aluminum levels and high concentrations of salts.		
			Birim-awaham/kakum-chichiwere	142.824	>100			
			Denteso-sene	13432.538	>100			
			Dewasi-wayo	16839.484	>100			
		Leptosols				Leptosols is a very shallow soil over highly calcareous material that is extremely gravelly.		
			Adomi-kpeyi	15715.52	>100			
			Fete-salom	9260.283	90			
			Kintampo	2902.679	20			
			Korle-okwe	1567.207	>100			
			Kowani-techiman-santaboma/bediesi	29953.399	58			
			Nyanao-tinkong/opimo	17545.716	>100			
			Wenchi-kumayili	17730.602	>100			
			Yaya	3274.861	>100			
			Yaya-bediesi-/bejua	94629.341	>100			
			Yaya-otrokpe	19140.448	>100			
			Yaya-pimpimso/bejua	11129.098	80			
		Lixisols				They are soils with subsurface accumulation of low activity clays and high base saturation. They develop under intensive tropical weathering conditions and sub humid to semi-arid climate.		
			Adawso-bawjiasi/nta-ofin	4000.849	>100			
			Bediesi-sutawa/bejua	62311.453	>100			

2018	Types of Soils in Ghana							
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
			Bediesi-yaya/asuansi-atewa	11860.916	>100			
			Damongo-murugu-techiman	20137.798	>100			
			Damongo-techiman/ejura-sene	4217.27	>100			
			Kpelesawgu-changnalili/amantin	1963.049	30			
			Nankese-akroso/nta-ofin	2064.964	>100			
			Pimpimso-sutawa/bejua	14592.035	>100			
			Somusie-denteso	52604.273	>100			
		Luvisols				Luvisols have mixed mineralogy, high nutrient content, and good drainage which make them suitable for a wide range of agriculture such as grains , orchards and vineyards		
			Ejura-amantin/denteso	1076.384	>100			
			Ejura-kpelesawgu/denteso	1764.381	>100			
			Nankese-koforidua/ nta-ofin	30093.528	>100			
			Simpa-agawtaw	1232.54	>100			
		Planosols				Planosols are characterized by a subsurface layer of clay accumulation. They occur typically in wet low-lying areas that can support either grass or open forest vegetation. They are poor in plant nutrients, however, and their clay content leads to both seasonal waterlogging and drought stress. Under careful management they can be cultivated for rice, wheat, or sugar beets, but their principal use is for grazing.		
			Ablade-kpelesawgu	5449.2	>100			

2018	Types of Soils in Ghana							
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
			Blengo-botoku/kudzra-edo	486.216	>100			
		Regosols				Regosols are characterized by shallow, medium- to fine-textured, unconsolidated parent material that may be of alluvial origin and by the lack of a significant soil horizon (layer) formation because of dry or cold climatic conditions. Regosols occur mainly in polar and desert regions, occupying about 2 percent of the continental land area on Earth.		
			Kungwani	403.279	>100			
		Vertisols				Vertisols are characterized by a clay-size-particle content of 30 percent or more by mass in all horizons (layers) of the upper half-metre of the soil profile, by cracks at least 1 cm (0.4 inch) wide extending downward from the land surface, and by evidence of strong vertical mixing of the soil particles over many periods of wetting and drying. They are found typically on level or mildly sloping topographyin climatic zones that have distinct wet and dry seasons. Vertisols contain high levels of plant nutrients, but, owing to their high clay content, they are not well suited to cultivation without painstaking management.		
			Akuse	1244.672	>100			
		N/A						
			No data	52125.846				
			Nsaba-swedru/nta-ofin	3500.517	>100			
			Pegi-agu	1284.403	>100			
5	**Ashanti**							

2018	Types of Soils in Ghana							
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
		Acrisols				Acrisols are defined by the presence of a subsurface layer of accumulated kaolinitic clays and also by the lack of an extensively leached layer below the surface horizon		
			Adujansu-bechem/nta-ofin	12006.393	>100			
			Akumadan-afrancho	4058.118	>100			
			Akumadan-bekwai/oda	39736.042	>100			
			Asikuma-atewa/ansum-oda	23925.388	>100			
			Asuansi-kumasi	19406.39	>100			
			Asuansi-wacri/suko	13795.788	>100			
			Atukrom	68895.685	>100			
			Atukrom-asikuma/ansum	72608.953	>100			
			Bekwai-zongo/Oda	26764.588	>100			
			Boamang-suko	44344.056	>100			
			Bomso-asuansi/nta-ofin	44662.17	>100			
			Juaso-bompata/asuboa-pamasua	352830.444	>100			
			Kotei	1224.948	>100			
			Kumasi-asuansi/nta-ofin	217899.956	>100			
			Mim/Oda	108553.417	>100			
			Nzima-bekwai	3745.46	>100			
			Nzima-bekwai/Oda	824040.706	>100			
			Nzima-boi	184332.93	>100			
			Wiawso-shi	1376.883	20			
		Arenosols				Arenosols have very low water-holding capacities. They are highly siliceous and also extremely low in all essential nutrients		

2018	Types of Soils in Ghana							
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
			Aya-yenahin/bepo	16277.589	>100			
			Kobeda	16867.418	10			
		Fluvisols				Fluvisols are found on alluvial plains, river fans, valleys and tidal marshes and have a clear evidence of stratification. They have severe constraints for agricultural use as low pH-values, toxic aluminum levels and high concentrations of salts.		
			Birim-awaham/kakum-chichiwere	75108.083	>100			
			Denteso-sene	46573.932	>100			
		Gleysols			>100	Gleysols occur on wide range of unconsolidated materials, mainly fluvial, marine and lacustrine sedim ents of Pleistocene or Holocene age, with basic to acidic mineralogy. They exhibit a greenish-blue-grey soil color due to anoxic wetland conditions.		
			Bejua-pakpe	137.356	>100			
			Oda	483.071	>100			
			Tanoso	16399.431	>100			
		Leptosols				Leptosols is a very shallow soil over highly calcareous material that is extremely gravelly.		
			Jamasi	4165.823	5			
			Kasele-kowani	5920.154	>100			
			Kintampo	2222.038	20			
			Kobeda-amuni/bekwai	22831.439	>100			
			Nyanao-tinkong/opimo	1844.638	30			
			Yaya	4595.143	10			
			Yaya-pimpimso/bejua	55747.866	80			
		Lixisols				They are soils with subsurface accumulation of low activity clays and		

2018	Types of Soils in Ghana							
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
						high base saturation. They develop under intensive tropical weathering conditions and sub humid to semi-arid climate.		
			Bediesi-sutawa/bejua	14963.527	>100			
			Birem-cheriase	4639.647	>100			
			Damongo-ejura	38953.907	>100			
			Damongo-murugu-techiman	19483.237	>100			
			Damongo-techiman/ejura-sene	69990.672	>100			
		Luvisols				Luvisols have mixed mineralogy, high nutrient content, and good drainage which make them suitable for a wide range of agriculture such as grains , orchards and vineyards		
			Ejura-amantin/denteso	2793.522	>100			
			Ejura-kpelesawgu/denteso	109550.658	>100			
		Planosols				Planosols are a type of intrazonal soil of humid or sub humid uplands having a strongly leached upper layer overlying a clay hardpan. They have an E soil horizon that results from prolonged exposure to stagnant water within 100cm of the surface.		
			Ablade-kpelesawgu	98193.987	>100			
		N/A						
			Lagoon	4777.954	>100			
			No data	1294.471				
			Nsaba-swedru/nta-ofin	549493.567	>100			
			Nta-ofin	3429.911	>100			
6	**Brong Ahafo**	Acrisols				Acrisols are defined by the presence of a subsurface layer of		

2018	Types of Soils in Ghana							
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
						accumulated kaolinitic clays and also by the lack of an extensively leached layer below the surface horizon.		
			Batia	16121.347	>100			
			Besua	13105.268	>100			
			Kumasi-asuansi/nta-ofin	108794.498	>100			
			Nkrankwanta	71694.757	>100			
			Nzima-bekwai/oda	905229.494	>100			
			Yakasi	8336.518	>100			
		Fluvisols				Fluvisols are found on alluvial plains, river fans, valleys and tidal marshes and have a clear evidence of stratification. They have severe constraints for agricultural use as low pH-values, toxic aluminum levels and high concentrations of salts.		
			Birim-awaham/kakum-chichiwere	38038.55	>100			
		Gleysols				Gleysols occur on wide range of unconsolidated materials, mainly fluvial, marine and lacustrine sediments of Pleistocene or Holocene age, with basic to acidic mineralogy. They exhibit a greenish-blue-grey soil color due to anoxic wetland conditions.		
			Tanoso	16072.684	>100			
		Leptosols				Leptosols is a very shallow soil over highly calcareous material that is extremely gravelly.		
			Banda (hill)	4215.184	>100			
			Murugu-kintampo	5685.225	>100			
		Lixisols				They are soils with subsurface accumulation of low activity clays and high base saturation. They develop under intensive tropical weathering conditions and sub humid to semi-arid climate.		

2018	Types of Soils in Ghana							
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
			Banda	110068.622	30			
			Damongo-murugu	20200.918	>100			
			Damongo-murugu-techiman	52826.213	>100			
			Debibi	125802.844	>100			
			Drobo	65461.695	>100			
			Dumboli	4788.526	>100			
			Farmang	2829.251	>100			
		Luvisols			>100	Luvisols have mixed mineralogy, high nutrient content, and good drainage which make them suitable for a wide range of agriculture such as grains , orchards and vineyards		
			Botokrom	2959.648	>100			
		N/A			>100			
			Gyapekrom	7312.422	20			
7	**Ahafo**	Acrisols				Acrisols are defined by the presence of a subsurface layer of accumulated kaolinitic clays and also by the lack of an extensively leached layer below the surface horizon		
			Adujansu-bechem/nta-ofin	132102.09	>100			
			Asuansi-kumasi	13704.583	>100			
			Atukrom	109843.778	>100			
			Atukrom-subin-adujansu	67264.386	>100			
			Hwidiem	29508.692	>100			
			Kumasi-asuansi/nta-ofin	8462.936	>100			
			Nzima-bekwai	3449.47	>100			

2018	Types of Soils in Ghana							
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
			Nzima-bekwai/oda	16876.58	>100			
		Fluvisols				Fluvisols are found on alluvial plains, river fans, valleys and tidal marshes and have a clear evidence of stratification. They have severe constraints for agricultural use as low pH-values, toxic aluminum levels and high concentrations of salts.		
			Alluvial	9447.494	>100			
		Gleysols				Gleysols occur on wide range of unconsolidated materials, mainly fluvial, marine and lacustrine sedim ents of Pleistocene or Holocene age, with basic to acidic mineralogy. They exhibit a greenish-blue-grey soil color due to anoxic wetland conditions.		
			Oda	178.795	>100			
		Nitisols				Nitisols is a deep, red, well-drained soil with a clay content of more than 30% and a blocky structure.		
			Susan	134429.75	>100			
		N/A						
			Nta-ofin	892.77	>100			
8	**Bono East**	Fluvisols				Fluvisols are found on alluvial plains, river fans, valleys and tidal marshes and have a clear evidence of stratification. They have severe constraints for agricultural use as low pH-values, toxic aluminum levels and high concentrations of salts.		
			Denteso-sene	155136.576	>100			
			Sene	7765.776	>100			
		Gleysols				Gleysols occur on wide range of unconsolidated materials, mainly fluvial, marine and lacustrine sedim ents of Pleistocene or Holocene age, with basic to acidic mineralogy. They		

2018	Types of Soils in Ghana							
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
						exhibit a greenish-blue-grey soil color due to anoxic wetland conditions.		
			Bejua-pakpe	8692.805	>100			
			Tanoso	59263.524	>100			
		Leptosols				Leptosols is a very shallow soil over highly calcareous material that is extremely gravelly.		
			Kowani-kasele/kpelesawgu	13117.275	58			
			Kowani-santaboma/kete-krachi	2298.07	58			
			Kowani-techiman-santaboma/bediesi	27754.381	58			
			Murugu-kintampo	2171.927	>100			
			Wenchi (boval)	9158.049	5			
			Wenchi-kumayili	5411.785	10			
		Lixisols				They are soils with subsurface accumulation of low activity clays and high base saturation. They develop under intensive tropical weathering conditions and sub humid to semi-arid climate.		
			Bediesi-sutawa	78870.338	>100			
			Bediesi-sutawa/bejua	270614.255	>100			
			Damongo-murugu	233513.257	>100			
			Damongo-murugu-techiman	95495.24	>100			
			Damongo-techiman/ejura-sene	60447.424	>100			
			Kowani-santaboma/denteso-sene	1438.557	>100			
			Kowani-santaboma/kete-krachi	5600.128	>100			
			Kpelesawgu-changnalili	302113.222	30			

2018	Types of Soils in Ghana							
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
			Kpelesawgu-changnalili-kungawni	23626.194	30			
			Kpelesawgu-kumayili-wenchi	65034.573	50			
			Somusie-denteso	88132.868	>100			
		Luvisols				Luvisols have mixed mineralogy, high nutrient content, and good drainage which make them suitable for a wide range of agriculture such as grains, orchards and vineyards		
			Ejura-amantin/denteso	430747.724	>100			
		Planosols				Planosols are a type of intrazonal soil of humid or sub humid uplands having a strongly leached upper layer overlying a clay hardpan. They have an E soil horizon that results from prolonged exposure to stagnant water within 100cm of the surface.		
			Lima	52710.214	>100			
			Lima-volta	119334.724	>100			
		N/A						
			No data	133523.988	>100			
9	**Northern**	Planosols	Lima-volta Association		>100 cm	Soils developed in humid and sub humid climates with rainfall of 500 to 1300 mm; have a clayey B horizon (Argillic, natric or kandic horizon) and base saturation greater than 50% calculated from NH_4OAc-CEC at pH 7; slightly to moderately acidic	All exposed areas (moderate to severe)	
		Lixisols	Mimi-techiman		>100 cm			
		Planosols	Lima		>100 cm			

2018				Types of Soils in Ghana				
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
		Lixisols	Kpelesawgu-kumayili-wenchi		>30 cm			
		-	Changnalili-lima-kpelesawgu					
		Lixisols	Tanina					
		Plinthosol	Sambu-pasga		>87cm			
		Leptosols	Kintampo		>20 cm			
		Lixisols	Kpelesawgu		>100 cm			
		Acrisols				Acrisols are defined by the presence of a subsurface layer of accumulated kaolinitic clays and also by the lack of an extensively leached layer below the surface horizon		
			Nyankpala	206681.202	>100			
		Fluvisols				Fluvisols are found on alluvial plains, river fans, valleys and tidal marshes and have a clear evidence of stratification. They have severe constraints for agricultural use as low pH-values, toxic aluminum levels and high concentrations of salts.		
			Denteso-sene	276.193	>100			
			Nterso-zaw	803.914	>100			
		Leptosols			>100	Leptosols is a very shallow soil over highly calcareous material that is extremely gravelly.		
			Adomi	4062.342	>100			
			Adomi-kpeyi	10662.326	>100			
			Gushiagu-kasele	22076.208	20			
			Jagogo	813.202	8			
			Kintampo	530.921	20			
			Nyankpala	869.673	>100			

2018			Types of Soils in Ghana					
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
			Pigu	1412.814	8			
			Pigu-kpelesawgu	1010.936	>100			
			Walewale	868.068	5			
			Wenchi	9969.584	10			
			Wenchi-kintampo	2605.998	10			
			Wenchi-lumo	475.032	10			
			Wenchi-sambu	8297.109	20			
		Luvisols				Luvisols have mixed mineralogy, high nutrient content, and good drainage which make them suitable for a wide range of agriculture such as grains , orchards and vineyards		
			Damongo-murugu/tanoso	14534.477	>100			
			Kpelesawgu	101119.737	>100			
			Kpelesawgu-changnalili	73768.568	30			
			Lapliki	8691.155	>100			
		Luvisols				Luvisols have mixed mineralogy, high nutrient content, and good drainage which make them suitable for a wide range of agriculture such as grains , orchards and vineyards		
			Bimbila	62348.204	>100			
		Planosols		266263.255	>100	Planosols are characterized by a subsurface layer of clay accumulation. They occur typically in wet low-lying areas that can support either grass or open forest vegetation. They are poor in plant nutrients, however, and their clay content leads to both seasonal waterlogging and drought stress. Under careful management they can be cultivated for rice, wheat, or		

2018			Types of Soils in Ghana					
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
						sugar beets, but their principal use is for grazing.		
			Blengo-botoku/kudzra-edo	28146.402	>100			
			Lima-Volta	238116.853	>100			
		Plinthosol				Plinthosols form under a variety of climatic and topographic conditions. They are defined by a subsurface layer containing an iron-rich mixture of clay minerals (chiefly kaolinite) and silica that hardens on exposure into ironstone concretions known as plinthite. The impenetrability of the hardened plinthite layer, as well as the fluctuating water table that produces it, restrict the use of these soils to grazing or forestry, although the hardened plinthite has value as subgrade material for roads or even as iron ore (the iron oxide content can be as high as 80 percent by mass).		
			Sambu-pasga	68304.721	>100			
			Sirru	10502.04	>100			
		Plinthosols				Plinthosols form under a variety of climatic and topographic conditions. They are defined by a subsurface layer containing an iron-rich mixture of clay minerals (chiefly kaolinite) and silica that hardens on exposure into ironstone concretions known as plinthite. The impenetrability of the hardened plinthite layer, as well as the fluctuating water table that produces it, restrict the use of these soils to grazing or forestry, although the hardened plinthite has value as subgrade material for roads or even as iron ore (the iron oxide content can be as high as 80 percent by mass).		
			Lumo	667.487	>100			

2018			Types of Soils in Ghana					
No.	Regions	Soil Order	Soil Group Family	Coverage/ Extent (Ha)	Depth[1] (cm)	General Description	Area affected by Soil Erosion (Ha)	Area affected by desertification (Ha)
			Pumpu	46765.791	55			
		N/A						
			Changnalili	9180.525	30			
			Changnalili-lima-kpelesawgu	16751.59	30			
10	**North East**	Cambisols				Cambisols are characterized by the absence of a layer of accumulated clay, humus, soluble salts, or iron and aluminum oxides. They differ from unweathered parent material in their aggregate structure, colour, clay content, carbonate content, or other properties that give some evidence of soil-forming processes.		
			Bombi-yaroyiri	6346.772	>100			
		Fluvisols				Fluvisols are found on alluvial plains, river fans, valleys and tidal marshes and have a clear evidence of stratification. They have severe constraints for agricultural use as low pH-values, toxic aluminum levels and high concentrations of salts.		
			Dagare	13939.334	>100			
			Nterso-zaw	1140.766	>100			
			Siare-dagare	109388.88	>100			
			Siare-pani	5588.798	>100			
		Gleysols			>100	Gleysols occur on wide range of unconsolidated materials, mainly fluvial, marine and lacustrine sedim ents of Pleistocene or Holocene age, with basic to acidic mineralogy. They exhibit a greenish-blue-grey soil color due to anoxic wetland conditions.		
			Berenyasi-kupela	657.465	>100			

2018				Types of Soils in Ghana				
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
		Leptosols				Leptosols is a very shallow soil over highly calcareous material that is extremely gravelly.		
			Chereponi	360.67	>100			
			Chuchuliga	38.959	20			
			Jagogo	6256.067	>100			
			Kagu	170801.09	42			
			Kintampo	23380.248	20			
			Kintampo-mimi	110190.668	>100			
			Klopu	4462.695	>100			
			Kpea	6702.342	>100			
			Mogo	219.385	>100			
			Pigu	476.489	8			
			Pigu-kpelesawgu	7070.852	8			
			Walewale	6805.607	>100			
			Wenchi	969.006	>100			
			Wenchi (boval)	2463.131	5			
			Wenchi-lumo	1372.168	>100			
			Wenchi-sambu	1090.222	20			
			Wenchi-techiman	7386.024	20			
			Yagha	10807.922	>100			
		Luvisols				Luvisols have mixed mineralogy, high nutrient content, and good drainage which make them suitable for a wide range of agriculture such as grains, orchards and vineyards		
			Bianya	2798.006	>100			
			Kpelesawgu	504028.102	>100			

2018				Types of Soils in Ghana				
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
			Lapliki	72583.029	>100			
			Mimi	179194.536	>100			
			Mimi-techiman	38479.564	>100			
			Nambari	10092.262	>100			
			Sanda	4696.126	80			
			Tanchera	17856.592	>100			
		Luvisols			>100	Luvisols have mixed mineralogy, high nutrient content, and good drainage which make them suitable for a wide range of agriculture such as grains, orchards and vineyards		
			Nangodi	662.598	30			
		Planosols			>100	Planosols are characterized by a subsurface layer of clay accumulation. They occur typically in wet low-lying areas that can support either grass or open forest vegetation. They are poor in plant nutrients, however, and their clay content leads to both seasonal waterlogging and drought stress. Under careful management they can be cultivated for rice, wheat, or sugar beets, but their principal use is for grazing.		
			Lima-volta	257990.814	>100			
		Plinthosol			>100	Plinthosols form under a variety of climatic and topographic conditions. They are defined by a subsurface layer containing an iron-rich mixture of clay minerals (chiefly kaolinite) and silica that hardens on exposure into ironstone concretions known as plinthite. The impenetrability of the hardened plinthite layer, as well as the fluctuating water table that produces it, restrict the use of these soils to grazing or		

2018						Types of Soils in Ghana		
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
						forestry, although the hardened plinthite has value as subgrade material for roads or even as iron ore (the iron oxide content can be as high as 80 percent by mass).		
			Nalerigu-kintampo	59515.644	75			
			Sirru	12840.296	>100			
		Plinthosols			>100	Plinthosols form under a variety of climatic and topographic conditions. They are defined by a subsurface layer containing an iron-rich mixture of clay minerals (chiefly kaolinite) and silica that hardens on exposure into ironstone concretions known as plinthite. The impenetrability of the hardened plinthite layer, as well as the fluctuating water table that produces it, restrict the use of these soils to grazing or forestry, although the hardened plinthite has value as subgrade material for roads or even as iron ore (the iron oxide content can be as high as 80 percent by mass).		
			Lumo	64399.179	>100			
			Pumpu	35677.871	55			
			Pusiga	45917.158	>100			
		Vertisols				Vertisols are characterized by a clay-size-particle content of 30 percent or more by mass in all horizons (layers) of the upper half-metre of the soil profile, by cracks at least 1 cm (0.4 inch) wide extending downward from the land surface, and by evidence of strong vertical mixing of the soil particles over many periods of wetting and drying. They are found typically on level or mildly sloping topographyin climatic zones that have distinct wet and dry seasons. Vertisols contain high levels		

2018						Types of Soils in Ghana		
No.	Regions	Soil Order	Soil Group Family	Coverage/ Extent (Ha)	Depth[1] (cm)	General Description	Area affected by Soil Erosion (Ha)	Area affected by desertification (Ha)
						of plant nutrients, but, owing to their high clay content, they are not well suited to cultivation without painstaking management.		
			Pani-kupela	12188.416	>100			
		N/A						
			Changnalili	12079.396	30			
			Changnalili-lima-kpelesawgu	2570.055	30			
			Kolingu	34653.489	60			
11	**Savannah**	Acrisols				Acrisols are defined by the presence of a subsurface layer of accumulated kaolinitic clays and also by the lack of an extensively leached layer below the surface horizon		
			Techiman-tampu	391995.58	>100			
		Arenosols				Arenosols have very low water-holding capacities. They are highly siliceous and also extremely low in all essential nutrients		
			Kunkwa	5855.778	>100			
		Fluvisols				Fluvisols are found on alluvial plains, river fans, valleys and tidal marshes and have a clear evidence of stratification. They have severe constraints for agricultural use as low pH-values, toxic aluminum levels and high concentrations of salts.		
			Dagare-kunkwa	2655.668	>100			
			Nterso-zaw	7089.733	>100			
			Siare-dagare	74015.022	>100			
			Siare-lapliki	4496.577	>100			
		Leptosols						

2018				Types of Soils in Ghana				
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
			Kagu	67706.537	42	Leptosols is a very shallow soil over highly calcareous material that is extremely gravelly.		
			Kintampo	63482.633	20			
12	**Upper East**	Planosols	Lima-Volta Association		>100 cm	Soils developed in humid and sub humid climates with rainfall of 500 to 1300 mm; have a clayey B horizon (Argillic, natric or kandic horizon) and base saturation greater than 50% calculated from NH_4OAc-CEC at pH 7; slightly to moderately acidic	All exposed areas (moderate to severe)	
		Lixisols	Lapliki		>100 cm	Soils developed in humid and sub humid climates with rainfall of 500 to 1300 mm; have a clayey B horizon (Argillic, natric or kandic horizon) and base saturation greater than 50% calculated from NH_4OAc-CEC at pH 7; slightly to moderately acidic	All exposed areas (moderate to very severe)	
		Lixisols	Tanchera		>100 cm	Soils developed in humid and sub humid climates with rainfall of 500 to 1300 mm; have a clayey B horizon (Argillic, natric or kandic horizon) and base saturation greater than 50% calculated from NH_4OAc-CEC at pH 7; slightly to moderately acidic	All exposed areas (moderate to very severe)	
		Plinthosols	Pusiga		>30 cm	Extreme weathering, mixtures of quartz, kaolin, free oxides, and organic matter	All exposed areas (moderate to very severe)	
		Leptosols	Wenchi-kintampo		>10 cm			
			Kolingu					
		Gleysols	Berenyasi-kupela		>100 cm	They are mostly formed from colluvial and alluvial materials.		
		Leptosols	Kintampo-mimi		>100 cm			
		Luvisols	Nangodi		>30 cm			

2018				Types of Soils in Ghana				
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
		Leptosols	Yagha		>100 cm			
		Leptosols	Tongo		>10 cm			
		Leptosols	Chuchuliga		>20 cm			
		Leptosols	Bongo		>40 cm			
		Lixisols	Bianya		>100 cm			
		Lixisols	Varempere-tafali		>100 cm			
		Fluvisols	Dagare		>100 cm	Young soils with have weak to moderate horizon development. They are mostly formed from colluvial and alluvial materials.	All exposed areas (moderate to very severe)	
		Lixisols	Mimi		>100 cm			
13	Upper West	Arenosols	Kunkwa Consociation		>100 cm	Soils of arid regions, such as desert soils; some are saline or sodic, have calcic, gypsic horizons; may have ochric epipedon, sometimes argillic or natric horizons	All exposed areas (slight to moderate)	
		Fluvisols	Siare-dagare Association		>100 cm	Young soils with little or no profile development	All exposed areas (slight to moderate)	
		Vertisols	Pani-kupela Association		>100 cm	Dark clay soils containing large amounts of swelling clay minerals (smectite), soils crack widely during the dry season and become very sticky in the wet season	All exposed areas (slight to moderate)	
		Leptosols	Kagu Consociation		>100 cm		All exposed areas (moderate to very severe)	

2018						Types of Soils in Ghana		
No.	**Regions**	**Soil Order**	**Soil Group Family**	**Coverage/ Extent (Ha)**	**Depth[1] (cm)**	**General Description**	**Area affected by Soil Erosion (Ha)**	**Area affected by desertification (Ha)**
		Lixisols	Tanina Consociation		>100 cm	Soils developed in humid and sub humid climates with rainfall of 500 to 1300 mm; have a clayey B horizon (Argillic, natric or kandic horizon) and base saturation greater than 50% calculated from NH_4OAc-CEC at pH 7; slightly to moderately acidic	All exposed areas (moderate to very severe)	
			Kolingu Consociation		>60 cm		All exposed areas (moderate to severe)	

Source: Source: Council for Scientific and Industrial Research (CSIR) – Soil Research Institute

Notes

1 Indicate the range where necessary

Remarks:

i. Soil Group Family names are in Soil Association (Groups of Soil) whiles single names are in Consociation;

ii. Data on Soil erosion has not been geo-referenced and it's quite old; and

iii. No data on desertification.

Annex 3: Fresh Surface Water Abstraction Data for Irrigation per Region

Irrigation Scheme by District	Major Crop(s)	Water Source	Fresh Surface Water Abstraction for Irrigation in Agriculture (mio m3)									
			2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Western Region	-											
Nzema East	-											
Kikam	Rice	Franza River	0	0	0	0	0	0	0	0	0	0
Sefwi-Wiawso	-											
Aponapon		River Tano	0	0	0	0	0	0	0	0	0	0
Wassa Amenfi	-											
Mosease	Vegetables	River Tano	0	0	0	0	0	0	0	0	0	0
		Surface Water Abstration for Irrigation (mio m3/y)	***0***	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Central Region	-											
Mfantseman Municipal	-											
Mankessim	Vegetables	Apropong River	0.000	0.032	0.045	0.039	0.030	0.040	0.020	0.037	0.076	0.070
Bafikrom	Rice, Vegetables		0	0	0	0	0	0	0	0	0	0.018
Gomoa East	-											
Okyereko	Rice	Ayensu River	0.000	0.288	0.751	0.309	0.500	0.750	0.030	0.568	0.887	0.031
		Surface Water Abstration for Irrigation (mio m3/y)	***0***	***0.32***	***0.80***	***0.35***	***0.53***	***0.79***	***0.05***	***0.61***	***0.96***	***0.10***
Greater Accra												

Irrigation Scheme by District	Major Crop(s)	Water Source	Fresh Surface Water Abstraction for Irrigation in Agriculture (mio m3)									
			2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Ashaiman Municipal												
Ashaiman	Rice, Vegetables	Dzorwulu River	0.330	0.200	0.420	0.440	0.350	0.620	0.410	0.520	1.000	0.480
Dagbe West												
Dawhenya	Rice	Dechidaw River	0.528	0.572	0.720	0.620	0.900	0.000	0.880	2.680	4.000	1.900
Shai Osudoku												
KIS	Rice	Volta River	14.930	19.520	23.980	24.210	25.510	30.320	20.160	28.540	28.069	19.460
Ga South Municipal												
Weija	Vegetables	Densu River	0.430	0.070	0.270	0.280	0.450	0.460	0.710	0.310	0.500	0.310
Ningo Prampram	-											
Ada		Volta	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.140	0.020
		Surface Water Abstraction for Irrigation (mio m3/y)	***16.22***	***20.36***	***25.39***	***25.55***	***27.21***	***31.40***	***22.16***	***32.05***	***33.71***	***22.17***
Eastern Region												
Kwahu South												
Amate	Volta River	Vegetables	0.000	0.182	0.048	0.110	0.000	0.000	0.000	0.000	0.000	0.000

Irrigation Scheme by District	Major Crop(s)	Water Source	Fresh Surface Water Abstraction for Irrigation in Agriculture (mio m3)									
			2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Fanteakwa												
Dedeso	Volta River	Vegetables	0.000	0.009	0.030	0.013	0.000	0.000	0.000	0.000	0.000	0.000
		Surface Water Abstraction for Irrigation (mio m3/y)	***0.00***	***0.19***	***0.08***	***0.12***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***
Volta Region												
Akatsi District												
Afife/Weta	Rice, Vegetables	Agali / Kplipka Rivers	8.670	12.636	9.922	11.947	13.081	12.938	13.267	12.251	9.721	17.424
Kpandu Municipal												
Kpandu Torkor	Vegetables	Volta River	0.000	0.140	0.058	0.059	0.057	0.076	0.037	0.000	0.000	0.000
North Tongu												
Aveyime	Rice	Volta River	0.000	0.000	0.041	0.710	0.793	0.749	0.797	0.473	0.770	1.146
Dordorkope 1	Vegetables	Volta River	0.000	0.000	0.000	0.000	0.000	0.000	0.373	0.125	0.294	0.302
Dordorkope 2	Vegetables	Volta River	0.000	0.000	0.000	0.000	0.000	0.000	0.308	0.070	0.000	0.000
		Surface Water Abstration for Irrigation (mio m3/y)	***8.67***	***12.78***	***10.02***	***12.72***	***13.93***	***13.76***	***14.78***	***12.92***	***10.78***	***18.87***
Ashanti Region												

Irrigation Scheme by District	Major Crop(s)	Water Source	Fresh Surface Water Abstraction for Irrigation in Agriculture (mio m3)									
			2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Asante Akim North												
Annum valley	rice, vegetables	Anum & Oweri Rivers	0.297	0.000	0.869	0.538	0.779	0.644	0.260	0.425	0.741	0.789
Offinso North												
Akumadan	Vegetables	Akumadan River	0.000	0.166	0.109	0.301	0.384	0.219	0.551	0.272	0.086	0.157
		Surface Water Abstraction for Irrigation (mio m3/y)	***0.30***	***0.17***	***0.98***	***0.84***	***1.16***	***0.86***	***0.81***	***0.70***	***0.83***	***0.95***
Brong Ahafo												
Wenchi East												
Akurobi	Vegetables	Yoyo River	0.000	0.000	0.000	0.000	0.000	0.028	0.083	0.029	0.000	0.000
Subinja	Vegetables	Subin River	0.172	0.173	0.219	0.153	0.105	0.032	0.011	0.058	0.033	0.018
NewLongoro	Vegetables	Sambel/Chiridi	0.000	0.000	0.000	0.000	0.042	0.037	0.092	0.007	0.000	0.000
Techiman Municipal												
Tanoso	Vegetables	Tano River	0.274	0.162	0.193	0.256	0.206	0.085	0.053	0.092	0.042	0.042

Irrigation Scheme by District	Major Crop(s)	Water Source	Fresh Surface Water Abstraction for Irrigation in Agriculture (mio m3)									
			2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Nkoranza South												
Sata	Vegetables	Sataso	0.000	0.082	0.036	0.076	0.059	0.140	0.091	0.123	0.060	0.022
		Surface Water Abstraction for Irrigation (mio m3/y)	***0.45***	***0.42***	***0.45***	***0.48***	***0.41***	***0.32***	***0.33***	***0.31***	***0.14***	***0.08***
Northern Region												
Tolon Kumbungu District												
Bontanga (Wuba)	Rice, Vegetables	Bontanga	1.771	2.977	3.068	3.689	3.567	4.002	4.438	3.142	5.119	3.169
Golinga	Rice, Vegetables	Kornin, Jolo, sayima stream	0.495	0.502	0.393	0.205	0.267	0.311	0.221	0.174	0.337	0.560
Savelugu Nanton District												
Libga	Rice, Vegetables	River Perusun	0.140	0.102	0.062	0.178	0.099	0.139	0.139	0.156	0.157	0.181
		Surface Water Abstraction for Irrigation (mio m3/y)	***2.40***	***3.58***	***3.52***	***4.07***	***3.93***	***4.45***	***4.80***	***3.47***	***5.61***	***3.91***
Upper East												
Kassena Nankana												

Irrigation Scheme by District	Major Crop(s)	Water Source	Fresh Surface Water Abstraction for Irrigation in Agriculture (mio m3)									
			2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Tono	Rice, Vegetables	River Tono	6.144	9.543	12.028	16.014	12.713	13.025	14.247	4.500	26.700	20.400
Bolgatanga Municipal												
Baare	Cereals, Vegetables	Baareboka river	0.000	0.000	0.000	0.000	0.000	0.000	0.058	0.067	0.057	0.018
Bongo District												
Vea	Rice, Vegetables	Yarigatanga River	2.692	2.572	1.390	1.123	1.070	0.821	0.652	0.748	1.783	1.271
Bawku West District												
Goog	Vegetables	Sambolekuliga river	0.000	0.000	0.000	0.267	0.000	0.000	0.501	0.618	0.724	0.945
		Surface Water Abstraction for Irrigation (mio m3/y)	***8.84***	***12.11***	***13.42***	***17.40***	***13.78***	***13.85***	***15.46***	***5.93***	***29.26***	***22.63***

Source: Ghana Irrigation Development Authority (GIDA)