Republic of Ghana

Ghana's Third National Communication Report to the UNFCCC

2015 Climate Change Report

Ghana's Third National Communication Report to the UNFCCC

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Foreword

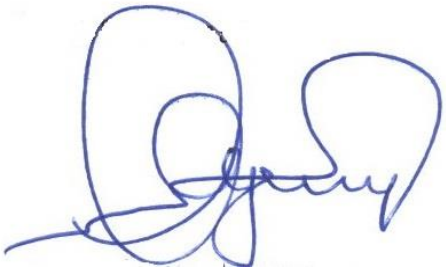
On behalf of Government of the Republic of Ghana, I wish to present Ghana's Third National Communication to the United Nations Framework Convention on Climate Change. As a signatory to the UNFCCC, Ghana considers the publication of this report not only as an effort to meet our obligation under the convention, but to showcase the domestic policies/actions to tackle climate change.

The TNC report has come about after 3 years of hard work of many Ghanaian experts who together had reflected the most comprehensive outlook of climate change is the country and outlined Ghana's efforts to addressing its impacts. The successful preparation of this report is yet another milestone in our effort to make climate change central to the socio-economic transformational agenda we have set for ourselves in the coming years. The national communication highlights that Ghana contributes 33.66 million tons (Mt) CO_2-equivalent (CO_2e) to the global greenhouse emissions. Although the emissions are relatively small compared to the global average and emissions from other developing countries, it has grew significantly over the past two decades. The emissions has the potential to grow more in the coming years if we remain on the same developmental pathway. The report further confirmed that Ghana's major economic sectors continue to be sensitive to the impacts of climate change, particularly with the projected rising temperatures, erratic rainfall, floods and more extreme weather events.

The negative effects of climate change extend to many sectors, such as agriculture to forests, health, and water resources. Different communities in the country by virtue of their geographic location, poverty levels, occupation and gender are confronted with harsh realities of climate change impacts on daily basis. The TNC also emphasized the growing threats of the sea-level rise to communities along coastal regions of Ghana and entire coastal ecosystems. Its impacts on any or all of these pose serious threat to Ghana's ability to achieve the global development Goals and country's aspirational goal of becoming a full-fledged middle-income country. It is in the light of the issues raised above that Ghana has resolved to commit itself to pursue a development model, which will yield multiple folds of benefits; socio-economic prosperity, low carbon and climate resilience economy and preservation of environmental and cultural integrity. It is for these reasons, that Ghana has decisively committed itself to pursue coordinated actions to reduce climate change impacts on most vulnerable people, while continuing to advance national economic development.

The coordinated climate actions have been articulated in the National Climate Change Policy (NCCP) which was officially launched by the President of the Republic of Ghana in 2014. The policy is anchored on the Ghana Shared Growth Development Agenda and will seek to provide medium-term strategy the country and its partners will follow. It is my expectation that the incorporation of the NCCP in the GSGDA will translate into formidable actions and stimulate concerted efforts across all sectors of the Ghanaian society to addressing climate change.

I conclude by underscoring Ghana's determination to building a climate proof society and at the same time pursue economic development agenda that are able to meet the socio-economic needs of Ghanaians and contribute to the global efforts of combating climate change. With this resolve, Ghana is poised to pursue comprehensive climate smart domestic measures and ready to partner with the international community for strategic support. We will reiterate our unflinching resolve to pursue low carbon climate resilient future by putting forward a fair, ambitious and balanced INDC that will truly reflects Ghana long term development aspirations and secure our strategic interest of keeping the globe livable for generations to come.



Hon. Mahama Ayariga (MP)
Minister, Environment, Science, Technology and Innovation

Preface

This report is Ghana's third national communication (TNC) to the UNFCCC. The preparation of the TNC was led by the Environmental Protection Agency (EPA) in partnership with several national collaborating institutions and individuals. Ministry of Environment, Science, Technology and Innovation (MESTI) provided oversight. The report considers the following components: national circumstances, national greenhouse gas (GHG) inventory, GHG mitigation assessment, vulnerability and impacts assessment, climate change education, training and awareness, constraints, gaps, and related Financial, technical and capacity Needs and other Information. It presents a comprehensive up-to-date information on current findings and underlying observation from country level studies and literature, surveys, interviews and assessment conducted as part of the preparation of the TNC. The new evidence, facts and figures and observations obtained are packaged to fulfill the different reporting requirements stipulated in the UNFCCC reporting guideline for the preparation of national communication from Parties not included in the Annex 1. The report is the result of the three-year gathering of information and assessment process designed to paint both big-picture messages and important details on Ghana emission footprint and opportunities for mitigation, how the country is affected by climate change and the efforts being taken or envisaged to address climate change in the context of sustainable development. The focus of this report is in four folds. First, the report will help Ghana meet its reporting obligation under Articles 4 and 12 of the UNFCCC; secondly, provide information to support decision making at all levels and in particular informing national level policy; thirdly, the preparation of the report good way of building and sustaining capacity at the national and last but not least, the information contained in the report will serve as a reliable reference for researchers, NGOs, businesses, industry players and the project developers.

Structure of report

This report contains nine chapters that are logically interlinked. Each chapter I provides information on specific reporting elements of national communication as elaborated by Article 4 (1) and 12 (1) of the Convention and UNFCCC guidelines for national communication by non-Annex I Parties. Chapter 1 sets out the broad context and rationale of the third national communication and summarizes the preparation processes. In Chapter 2, the national circumstances of the country are updated, particularly to include the socio-economic, ecological and development aspects of the country and their interactions with climate change. The National GHG inventory is reported in Chapter 3. It covers a description of the national system, data and methodologies for preparation and compilation of GHG inventories in Ghana. Information on the various measures and policies to facilitate climate change mitigation is presented in chapter 4. The chapter also provides information on the methodologies and analyses of the various sectoral mitigation opportunities. The chapter also shares some of the critical steps taken by Ghana to develop mitigation opportunities and to contribute to future sustainable development prospects of the country. Chapter 5 deals with measures taken to facilitate adequate adaptation to the impacts of climate change. The chapter also presents information from the various sectoral Vulnerability and Adaptation (V&A) Assessments and the subsequent efforts to mainstream climate change into the development planning processes. Chapter 6 is on "Other information" focuses on major cross-cutting issues such as technology transfer, research and systematic observation, information dissemination and networking. Chapter 7 is dedicated to information on climate change education, public participation and awareness. Chapter 8 is the penultimate chapter, and makes an assessment of constraints and gaps, and related financial, technical and capacity needs to enhance implementation of the Convention. Finally any other additional information that were not provided in chapters 1 to 8, are annexed in chapter.

Process for the preparation this report

This report was prepared in accordance with the UNFCCC guidelines for the preparation of national communication for non-Annex I Parties. It took 36 months for the entire report to be completed. The preparation of the report heralded with a stock taking exercise conducted by a third party who had not been involved in the process at all. The stock taking exercise focused on reviewing the strength and weakness encountered during the preparation of the second communication and suggested ways improvement in the third national communication.

The review comments are incorporated with in the finalization of the project document. A national kick-off workshop was organized to mark the official commencement of the preparation of the TNC. During the workshop, a scenario mapping was done to assess the new information that have emerged after the submission of the second national communication. The proposed activities were reviewed and six working teams were formed to plan and carry on activities that assigned to them. Each component of the report was assigned to a specific working group which was led a sector lead institution (detail description of the work of the teams are provided in the relevant sections of the report). All data, reports and interviews used in the assessment were referenced, documented and archived in accordance with the QA procedures adopted for the preparation of the report.

Each working group developed their detail work plan and executed the activities they were assigned to do. The groups held several informal and formal meetings to before, during and after their work. Each group conducted their assessments and use the results to provide the first chapter draft and later submitted to EPA for two round of expert and stakeholder reviews. The expert review was the initial review of the draft report to assess overall consistency of the report with the UNFCCC guidelines and where possible identify factual errors. All the draft chapters review comments were synthesized into a single file for the onward submission to the authors of each chapter. The chapter authors incorporated all comments, suggestions and responses into the first draft to produce the second chapter draft.

Each of the second chapter drafts were submitted to the EPA to compile them into the draft national communication report. The first draft of the national communication report was submitted to UNEP and other international partners review and comments. The comments were included in the first chapter report to produce the second draft. The second draft chapter report was used stakeholder review of the report. The stakeholder review did not only look at the factual, logical and overall coherence of the report, it also looked at policy implication of the underlying findings contained in the reports and particularly, areas for improvement and also where reached work can be initiated. A national stakeholder validation workshop was organized to formally launch the report, and also begin dissemination of the key messages in in the report.

After the national validation workshop, all comments are recorded and synthesized into set of action points that will feed into the next round of reporting. The final report is submitted to MESTI for policy approval and endorsement and submission to the UNFCCCC.

Acknowledgements

The preparation of the TNC has been three years of great learning experience and amazing team work. In many ways, the team we put together from all walks of professions from the knowledge and practice communities exuded high professional and ethical standards at every stage of the work. Even in times where the team could not reach consensus on matters that boarder on data and methodological choices, they strive not compromise on the minimum standards.

The EPA and MESTI, on behalf of the Government of the Republic of Ghana, wish to recognize the immense contributions from all those who offered their distinguished service to the preparation of this report.

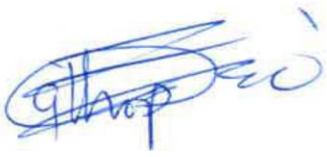
We are appreciative of UNEP/GEF for funding for the preparation of the third national communication report. We are, particularly, very pleased to the enthusiastic partnership we had with Dr. George Manful. We greatly benefitted from his great insight, advice and guidance from the preparation of the project document to compilation and submission of the report. We gratefully acknowledge the patriotic contributions he made in making sure that at every step we took in the process it yielded positive results.

We are thankful to Mr. Daniel S. Amlalo, Executive Director and entire management of the Environmental Protection Agency for providing strategic technical guidance and direction during the preparation of the Third National Communication. We want very much to thank Mr. Amlalo not only for the outstanding direct supervision he provided to support the technical work, but his profound experience displayed in handling matters that had the potential to stall the process. We also want to recognize the experiences EPA management members brought on board to enrich the report during the review process.

Mr. Fredua Agyeman and Peter Dery of MESTI for their insightful advice and support throughout the process of approval of the project to the submission of the report. We are particularly grateful to you for the great lengths you went to secure final sign off of this report before it was submitted.

And to all the international partners that provided technical support during the preparation and review of the report, we say big thank you, we truly value our partnership with you. In this regard, we want to recognize the immense technical contributions we received from UNDP, GIZ, Rainforest Coalition and the UNFCCC secretariat.

Furthermore, we wish to thank various working group members, consultants and other state institutions that were engaged in the entire national communication process, culminating in the preparation of this document. We also recognize and appreciate the level of dedication and commitments exhibited by the various public and civil servants who in diverse ways contributed to producing this report.



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Acronyms and Abbreviations

AAP	-	African Adaptation Programme
ACICP	-	Annually Created Incremental Carbon Pool
ACPC	-	African Climate Policy Centre
ADF	-	Adaptation Fund Board
AfDB	-	African Development Bank
AFOLU	-	Agriculture, Forestry and Other Land Use
AGN	-	Africa Group of Negotiators
AIC	-	Annual Incremental Carbon
ALU	-	Agricultural and Land Use
AMCEN	-	African Ministerial Conference on Environment
ANN	-	Artificial Neural Network
AWS	-	Automatic Weather Stations
BAU	-	Business-as-usual
BiomassWeb	-	Biomass biomass-based Value Webvalue webs
BUR	-	Biennial Update Report
CBEA	-	Community Based Extension Agent
CCAC	-	Climate and clean air coalition
CDM	-	Clean Development Mechanism
CD-REDD	-	Capacity development for REDD Project
CDU	-	Crude distillation Unit
CERSGIS	-	Centre for Remote Sensing and Geographic Information Centre System
CGE	-	Consultative Group of Experts
CH_4	-	Methane
CO_2	-	Carbon dioxide
CO_2e	-	Carbon dioxide-equivalent
COMAP	-	Comprehensive Mitigation Assessment Process
COP	-	Conference of Parties
CPEIR	-	Climate Public Expenditure and Institutional Review
CSIR	-	Council for scientific and Industrial Research
CWGs	-	country-working groups
DERS	-	Domestic electronic registry system
DMC	-	Dynamic prime costs
D-PaMs	-	Dashboard of climate policies and measures
DTRRS	-	Decentralized treatment, re-use and recovery systems
ECREE	-	ECOWAS Centre for Renewable Energy and Energy Efficiency
EF	-	Emission Factors
EFDB	-	IPCC Emission Factor Database
EGTT	-	Expert Group on Technology Transfer
EMT	-	Economic Management Team
EPA	-	Environmental Protection Agency
ERP	-	Emission Reduction Programme
ESP	-	Environmental Sustainability Project
ETPA	-	Information on education, training and public awareness
FAOSTAT	-	FAO Statistics
FASDEP II	-	Food and Agriculture Development Policy

FC	-	Forestry Commission
FIP	-	Forest Investment Plan
FIT	-	Feed-in-tariff
FNC	-	Forth National Communication
FNC	-	Fourth National Communication
FOAT	-	Functional Organizational Assessment Tool
FORIG	-	CSIR-Forest Research Institute of Ghana
GAP	-	Ghana Astronomical Project
GCCES	-	Ghana Climate Change Education change education in Schools
GCIC	-	Ghana Climate Innovation Centre
GDP	-	Gross Domestic Product
GEF	-	Global Environment Facility
GEONETCast	-	Global network of satellite-based data dissemination systems
GhEA	-	Ghana Energy Access Database
GLSS5	-	Ghana Living Standards Survey Five
GMeT	-	Ghana Meteorological Agency
GSGDA	-	Shared Growth and Development Agenda
GSSTI	-	Ghana Space Science and Technology Institute
GTUC	-	Ghana Technology University College
HFZs	-	High forest zones
HSD	-	Hydrological Service Department
INM	-	Integrated Nutrient Management
IPCC	-	Inter-governmental Panel on Climate Change
IPPU	-	Industrial processes and product use
ISSER	-	Institute for Statistical, Social and Economic Research
KNUST	-	Kwame Nkrumah University of Science and Technology
LAP	-	Land Administration Project
GHG	-	Greenhouse Gas
LCA	-	Life Cycle Assessment
LCO	-	Light Crude Oil
LECBP	-	Low Emission Capacity Building Project
LPG	-	Liquefied Petroleum Gas
MDAs	-	Ministries, Departments and Agencies
MDGs	-	Millennium Development Goals
MESTI	-	Ministry of Environment, Science, Technology and Innovation
METASIP	-	Medium Term Agriculture Sector Investment Plan
MIC	-	Middle Income Country
MLNR	-	Ministry of Lands and Natural Resources
MMDAs	-	Metropolitan, Municipal, and District Assemblies
MoFA	-	Ministry of Food and Agriculture
MoI	-	Means of implementation
Mt	-	Million tonnes
N_2O	-	Nitrous oxide
NADMO	-	National Disaster Management Organization
NAMAs	-	Nationally Appropriate Mitigation Action
NCCC	-	National Climate Change Committee
NCRC	-	Nature Conservation Research Centre
NDPC	-	National Development Planning Commission

NFPDP	-	National Forest Plantation Development Programme
NIR	-	National Inventory Report
NTP	-	National Transport Policy
PAC	-	Project Advisory Committee
PaM	-	Policies and Measures
PCS	-	Post-construction support for community managed water system.
PFCs	-	Perfluorocarbons
PSC	-	Project Steering Committee
QA/QC	-	Quality Assurance/Quality Control
RCCs	-	Regional Coordinating Councils
RCMs	-	Regional Circulation Models
RCS	-	Rainwater collection from ground surfaces
REDD+	-	Reducing Emission for Deforestation and Forest Degradation Plus
RFCC	-	Residue Fluid catalytic Cracker
RIPS	-	Regional Institute for Population Studies
RMSC	-	Resource Management and Support Unit
RSO	-	Research and Systematic Observations
RTIMP	-	Root and Tuber Improvement and Marketing
SADA	-	Savannah Accelerated Development Authority
SDGs	-	Sustainable development goals
SE4ALL	-	Sustainable Energy for All Action Plan
SLWM	-	Sustainable Land and Water Management
SWM	-	Solid Waste Management
TAHMO	-	Trans-African Hydro-Meteorological Observation
TNA	-	Technology need and needs assessment
TNC	-	Third National Communication
TTMC	-	Ghana Technology Transfer and Marketing Center
UNCBD	-	United Nations Convention on Biological Diversity
UNDP	-	United Nations Development Programme
UNECA	-	Nations Economic Commission for Africa
UNEP	-	United Nations Environment Programme
UNFCCC	-	United Nations Framework Convention on Climate Change
V&A	-	Vulnerability and Adaptation
VALCO	-	Volta Aluminum Company Limited
VSLA	-	Village savings and lending associations
WAPCo	-	West African Gas Pipeline Company limited
WAPP	-	West Africa Agricultural Product Programme
WASCAL	-	West African Science Service Center on Climate Change and Adapted Land Use
WM	-	scenario with measures
WoM	-	Scenario without measures
WP-MoU	-	Memorandum of Understanding
WRC	-	Water Resources Commission
WSA	-	Water and Sanitation Agency

Executive Summary (ES)

ES was compiled by Daniel Benefor

ES. Executive Summary

ES 1. Background information

Ghana became a party to the United Nations Framework Convention on Climate Change (UNFCCC, hereinafter referred to as the Convention) after ratification in September 1995. Upon ratification, Ghana had committed itself to pursue coordinated actions to reduce greenhouse gas (GHG) emissions and climate change impacts on the most vulnerable people, while continuing to advance national economic development. As a party to the Convention, Ghana has an obligation under Article 4, paragraph 1, and Article 12, paragraph 1 of the Convention to regularly prepare, publish and report its national communication to the Conference of Parties (COP) to the UNFCCC. In 2000 and 2011, the country submitted its first and second national communications respectively to the Conference of Parties (COP) to the UNFCCC. The Third National Communication (TNC) is prepared in compliance consistent with Ghana's obligations under the Convention. The main objective of the TNC was to prepare, update and communicate to the COP, policies and measures Ghana has taken and envisaged to implement the convention in the country and at the regional level.

ES 2. National circumstances

Ghana is a unitary democratic republic governed by the 1992 Constitution where power is shared among the Executive, Legislature and the Judiciary. The President is the head of the Executive arm and is in charge of high-level appointments. The Legislative functions are vested in the National Parliament. There is also the judiciary that is independent of all other branches of government. Within Ghana Government, Ministry of Environment, Science, Technology and Innovation (MESTI) and the Environmental Protection Agency are the key institutions tasked to co-coordinate the implementation of policies and programme on climate change. Ghana has a population of 24,658,823, comprising 12,633,978 females and 12,024,845 males and a growth rate of or growth rate of 2.4% annually. About a quarter of Ghanaians are still poor whilst under a tenth of the population is in extreme poverty. Greater Accra is the least poor region and the Upper West in the dry savannah is the overall poorest. Between the periods 1991-2013, general poverty level reduced from 51.7% to 24.2%.The incidence of extreme poverty reduced by 8.1% from the 2005/06 revised extreme poverty incidence of 16.5%.

Ghana attained Middle Income Country status in November 2010 after rebasing the economy. The main export commodities are precious mineral (gold, bauxite, and manganese), cocoa, timber and recently oil and gas. With the revised GDP estimates, GDP/capita has increased from US$ 1, 067 in 2000 to US$ 1,652 in 2011. The country has largely experienced stable and consistent economic growth since 1960. The size of the Ghanaian economy has expanded by nearly 97% with the GDP increasing from USD1.2 billion in 1960 to USD 35.9 billion in 2012 in real terms. The expanding trend in the economy corresponds to the increasing energy and greenhouse gas (GHG) emission intensities especially in the last couple of years. As the economy expands and population grows, lots of energy resources are utilized to meet the growing demand in industry, transport and households. Ghana government vision for addressing climate change in the medium to long-term is articulated in the Ghana Shared Growth and Development Agenda (GSGDA).

Ghana's climate continued to get warmer whereas rainfall still remains uncertain and difficult to predict. The projected rate of warming is more rapid in the northern inlands than the coastal regions. Projections of mean annual rainfall from different models predict wide range of changes. About half of the models predict increases while the other half project decreases.

ES 3. National greenhouse emissions footprint

ES 3.1 Summary of the national emission and removal related trends

ES 3.1.1 Greenhouse gas inventory

Ghana's total GHG emissions stood at 33.66 million tons (Mt) CO_2-equivalent (CO_2e) in 2012. When the emissions from AFOLU sector were excluded, the total emissions came to 18.49MtCO_2e for the same year. However, in the 2011, which is the official latest reporting year to UNFCCC, Ghana's total GHG emissions, excluding AFOLU sector, was estimated to be 16.51MtCO_2e. The 2011 emissions were 7.9 MtCO_2e higher than 2000 levels and 10.9 MtCO_2e above total emissions recorded in 1990 (see table ES.1).). When the emissions from AFOLU were added, Ghana's total emissions, the net emissions came to 30.60 MtCO_2e for 2011. Similarly, the total emissions grew by 14.28 MtCO_2e over 2000 levels and 16.38MtCO_2e over emissions recorded 1990

Table ES 1: Ghana's net greenhouse gas emissions by sectors under the UNFCCC

Sectors & Sub-sectors	Emissions MtCO_2e					Percent Change		
	1990	2000	2010	2011	2012	1990-2012	2000-2012	2010-2012
1. All Energy (combustion & fugitive)	**3.50**	**5.54**	**11.27**	**11.63**	**13.51**	**286.08**	**143.65**	**19.79**
(1.A1,A2&A5) Stationery energy combustion	2.03	2.73	6.48	6.22	7.05	247.28	158.10	0.09
(1.A5)Transport	1.47	2.81	4.80	5.41	6.46	339.66	129.85	34.67
(1.B) Fugitive emission	0.000	0.003	0.001	0.001	0.002	284.71	-51.74	139.35
2. Industrial Process & Product Use	**0.81**	**0.77**	**0.24**	**0.44**	**0.47**	-42.47	-39.56	**94.24**
3. AFOLU	**8.61**	**7.72**	**14.67**	**14.08**	**15.17**	**76.28**	**96.65**	**3.46**
3A Livestock	1.72	2.20	2.82	2.80	3.05	77.29	38.66	8.01
3B Land	-3.02	-4.00	1.85	1.31	1.84	-160.73	-145.86	-0.96
3C. Aggregated and Non-CO_2 emissions	9.91	9.52	9.99	9.98	10.29	3.83	8.08	3.00
4. Waste	**1.31**	**2.29**	**4.24**	**4.45**	**4.52**	245.97	97.03	6.54
Total emissions (excluding AFOLU)	**5.61**	**8.61**	**15.75**	**16.51**	18.49	229.31	114.81	17.36
Total net emissions (including AFOLU)	**14.22**	**16.32**	**30.42**	**30.60**	**33.66**	136.69	106.22	10.66

The observed general increases in the emission trends corresponded to the on-going structural transformation, which has led to sustained growth and expansion of the national economy. The economic transformation programme has resulted in notable rise in emissions from road transport, electricity generation crude-fired thermal plants, biomass burning in forest, cropland and grassland. Additionally, emissions due to land use changes also recorded significant increases between 1990 and 2010 mainly due to deforestation. However, as a result of the implementation of government's national reforestation programme, emissions from "Land" have seen some decreases between 2010 and 2012 (see figure ES.1).

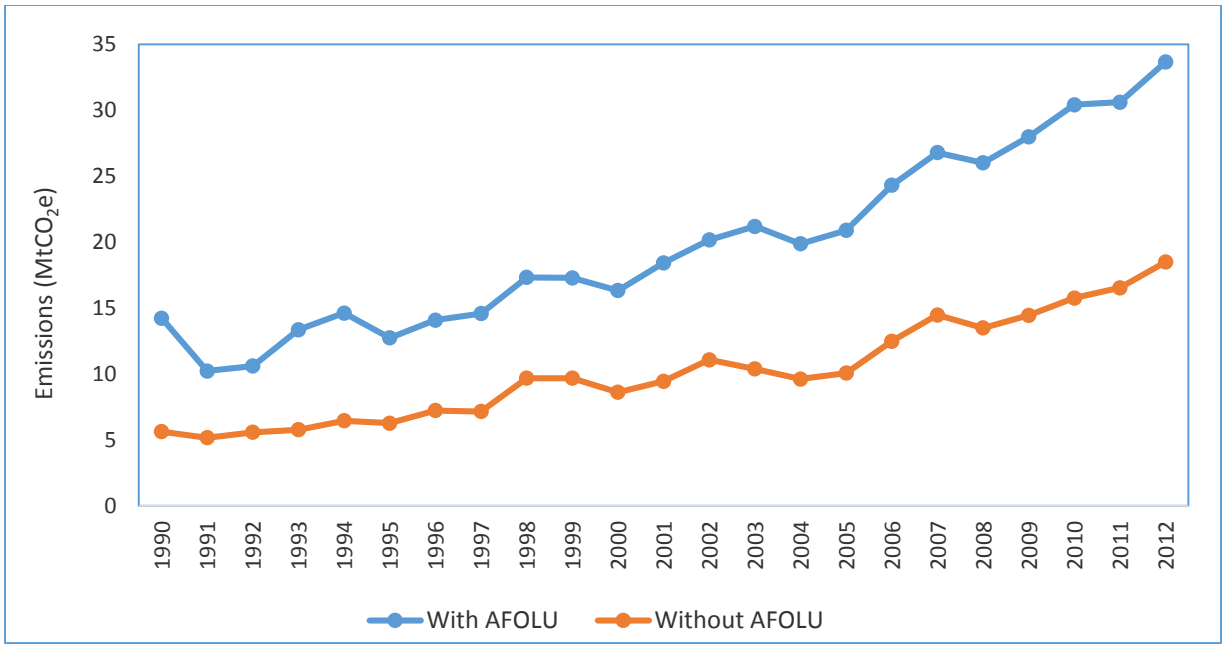

Figure ES 1: Trend of Ghana's total net emissions from 1990-2012 with and without AFOLU

ES 3.1.2GHG Emissions indictors

The impact of population and economic growth on greenhouse emission trend are provided in table ES.2. The figure shown in table ES.2 indicates that Ghana's total net emissions grew along with rising population, GDP and energy consumption. Thus innovative policies and investments are needed to decouple growth from emissions for the benefit of economic development and the global climate.

Table ES 2: Macroeconomic indicators relevant to greenhouses for Ghana

Indicators	1990	2000	2006	2010	2012	Change 1990-2012 (%)	Change 2010-2012 (%)
Population (million)	14.43	18.91	21.88	24.23	25.87	79.3	6.8
GDP (Constant 2006 USD billion)*	5.51	8.39	20.33	16.95#	16.78#	204.5	-1
TPES (Mtoe)**	5.29	7.74	9.06	9.32	11.77	122.49	26.29
Final Consumption (Mtoe)***	4.31	5.41	6.01	6.46	8.16	89.33	26.32
Total Electricity Generated (GWh) ***	5,721	7,223	8,430	10,167	12,024	110	18
*of which is Hydroelectric (GWh)****	*5,721*	*6,609*	*5,619*	*6,996*	*8,071*	41	15
*of which is Oil Products (GWh)****	*0*	*614*	*2,811*	*3,171*	*3,953*	0	25
Total Electricity Consumed*** (GWh)	4,462	6,067	7,362	8,317	9,258	107	11
GDP per capita* (Current USD thousand)	0.4	0.26	0.93	1.33	1.6	300	20.3
TPES per capita (toe)	0.37	0.41	0.41	0.38	0.45	21.62	18.42
Final Consumption per capita (toe)	0.30	0.29	0.27	0.26	0.31	3.33	19.2
GHG emissions per capita (t CO_2 e)	0.39	0.45	0.57	0.64	0.71	82.05	10.9
GHG emissions per GDP unit (kgCO_2e /2005 USD)	1.02	1.03	1.09	1.06	1.00	-1.9	–6.2
Energy Intensity (toe/2005 GDP)	0.96	0.92	0.45	0.55	0.70	-26.9	27.7

* Source: World Bank, National Account (2014), ** Source: International Energy Agency, *** Source: National Energy Statistics. This also takes in account electricity export to neighboring countries and total hours of electricity load shedding
#: Decline in GDP was the result of revision in GDP figures by Ghana Statistical Service

ES.3.2 Overview of source and sink category emission estimates and trends

ES. 3.2.1 Greenhouse gas inventory

The AFOLU sector was the largest source of greenhouse gas emissions followed by the Energy sector. In 2012, the emissions from the AFOLU sector constituted 45.1% (15.2 $MtCO_2e$) of total net emissions. AFOLU emissions increased by 3.5% between 2010 and 2012 (see table ES.1).

For the AFOLU subsector in 2012:

- Emissions from aggregated sources and non-CO_2 emissions sources on land (3C) were the largest source of the total net emissions making up 33.4% (10.3$MtCO_2e$) and grew by 2.9% between 2010 and 2012.
- Livestock emissions amounted to 3.0$MtCO_2e$, which represented 9.9% of the total net emissions and increased by 8% between 2010 and 2012.
- Emissions from land constituted 6.0% (1.8 Mt) of the total net emissions and decreased by 1% between 2010 and 2012.

Similarly within the energy sector

- Stationary energy combustion *(1.A1, 1.A2 and 1.A4)* from point sources were the main contributor to making 38.1% of the total emission excluding AFOLU and increased by 8.8% between 2010 and 2012. When emissions from AFOLU are included, stationery emission made up 22.8% of total emissions.
- Emissions from transport (34.9% of total emissions, excluding AFOLU) increased by 25.7% between 2010 and 2012. With AFOLU emission, transport emissions accounted for 20.9%.
- Fugitive emissions from fossil fuels (0.01% total net emissions, excluding AFOLU) increased by 58.2%between 2010 and 2012.

Industrial Processes and Products Use (IPPU) made up 2.5% of the total emissions (excluding AFOLU) for 2012 and increased 94.2% between 2010 and 2012. When emissions from AFOLU are added, the contribution of IPPU to the total emission decreased to 1.5%.Emissions from the waste sector are 24.4% (4.52 $MtCO_2e$) of the total net emissions (excluding AFOLU) for 2012 and recorded increases of 6.1% between 2010 and 2012. When emissions from AFOLU are added, contributions of the waste sector accounted for 14.6% of the total net emissions.

ES 3.3.2 Overview of source and sink emissions by Gases

In 2012, CO_2 was the dominant gas, which contributed 44% (14.81 Mt) of the total net emissions (including AFOLU). Of the total net CO_2 emission for 14.81 Mt, energy sector contributed 85% (12.59Mt), followed by AFOLU (12.6% - 1.86 Mt) and IPPU (2.4% - 0.35%). When the emissions from AFOLU are excluded from the national totals, carbon dioxide (CO_2) made up 70.1% (12.95 Mt) of the emissions in the same year. Between 2010 and 2012, the CO_2 emissions including AFOLU increased by 14.9%. Nitrous oxide was the second largest emission source, which made up of 30.8% (10.38 $MtCO_2e$) of the total emissions by Methane (24.8% -) and PFCs (0.3%).

ES 4. GHG Mitigation assessment and policy measures

GHG mitigation assessment had been conducted in the following categories. The assessment is followed by identification of policies and measures:

- Energy sector - (which include electricity supply and demand side management covering transportation, residential and commercial, industry categories); and

- Non-energy sectors (forest management and solid waste management). Information on business-as-usual (BAU) scenario, which depicts the future projections of the current situation in the event of continuing with the status quo was generated and used as basis for the mitigation assessment.

In energy sector BAU analysis, Ghana developed two future projection options; scenario without measures (WoM) depicts a future projection where trends in the status quo remain unchanged and none of the government's policy or objectives is achieved and scenario with measures (WM) depicting a future projection that takes into account emission reduction effects of relevant energy policies. For the non-energy sectors, the definition of the future projections in the BAU analysis is similar to WoM under energy sector. TablesES3, ES4 and ES5, presents projections of reference case or "business-as-usual" emission, mitigation scenario and overall effects of mitigations by sectors.

In the energy sector, the identification of eleven technology-based mitigation actions was done through a consultative meeting of the mitigation assessment-working group. The identification process took into account the alignment with the following national policy strategy documents: (a) Ghana shared growth development agenda, (b) National energy policy, (c) SE4ALL Action Plan, (d) National Climate Change Policy and (e) Ghana's 55-list of NAMAs. In doing so, the following list of technologies was identified: (a) Institutional biogas, (b) Efficient industrial motors, (c) Efficient home fridges, (d) Bus Rapid Transit Vehicles, (e) Combined cycles thermal power plants, (f) hydropower plant, (g) solar PV power, (h) afforestation/reforestation, (i) 5% biofuel blend and (j) LPG for cooking (see table ES7).

A multi-Criteria Analysis (MCA) screening tool was used to prioritize the identified technologies into the first top-five. For the non-energy sector, the selection of the mitigation action was done based on the overall emissions contribution and availability of data and tools, which can fit the national scale. Afforestation/Reforestation and solid waste management were the selected technologies for the non-energy energy sectors (see table ES8).

Table ES 3: Mapping of mitigation sectors based on contribution to total national emissions in 2000 and 2010

Inventory Categories	IPCC Code	Mitigation Sectors	Historical Emissions ($MtCO_2e$)		Contribution to National Emissions (%) in 2010
			2000	2010	
Energy	1.A1	Electricity supply	0.48	3.08	10.1%
		Oil Refinery*	0.07	0.15	0.5%
	1.A3	Transportation	2.8	4.80	15.7%
	1.A4	Residential and Commercial	1.48	2.17	7.1%
	1.A2	Industry	0.71	1.11	3.6
Industrial Processes	2		0.78	0.24	0.8
AFOLU (Agriculture)	3A	Agriculture	2.20	2.82	9.2%
AFOLU (Land)	3B	Forest Management	-4.0	1.85	6.1%
AFOLU (Aggregated sources and Non-CO_2emissions)	3C	Other sources	9.52	9.99	32.8%
Waste	4A, 4B 4C and 4D	Waste Management	2.3	4.24	13.9%
Total			**16.31**	**30.49**	**100%**

**Energy supply activities other than electricity generation (power supply) are often reported and analyzed in the sector activities such as oil refining under Energy Industries. The rest of the activities under energy industry are not applicable in Ghana.*

Table ES 4: Projection of Business-as-Usual (BAU) Emissions

Mitigation Sectors	Emissions ($MtCO_2e$)			
	Base Year 2010	Year 2020	Intermediate Year 2030	Projection End Year 2040
A. Energy sector				
A.1 Energy supply				
A.1.1. Electricity supply	3.08	8.24	20.48	45.18
A.2 Energy demand side management				
A.2.1. Residential and Commercial	2.17	2.20	2.28	13.7
A.2.2.Industry	0.71	2.32	6.17	15.9
A.2.3 Transport	4.80	11.35	22.2	43.14
B. Non-energy sector				
B.1 Forest Management**	1.85	3.07	4.29	5.5
B.2 Solid Waste Management*	1.5	1.57	1.64	1.72
Total	14.11	28.75	57.06	125.14

** Solid waste category only ** CO_2 emissions from the Land category only. In 2010, the total emissions of 14.11$MtCO_2e$ cover only the mitigation categories as presented in table ES 3.*

Table ES 5: Projection of Mitigation Scenarios Emissions

Mitigation Sectors	Emissions ($MtCO_2e$)			
	Base Year 2010	Year 2020	Intermediate Year 2030	Projection End Year 2040
1. With measures scenario				
A. Energy sector	0	-0.47	-1.03	-1.11
A.1 Energy supply				
A.1.1. Electricity supply (coal option)	0	-0.02	-0.47	-1.54
A.1.2. Electricity supply (without coal option)	0	0.02	0.47	1.12
A.2 Energy demand side management				
A.2.1. Residential and Commercial	0	0.19	0.29	0.43
2. With additional measures scenario				
B. Energy sector	0	-3.14	-14.55	-39.19
C. Non-energy				
C.1 Afforestation/Reforestation	0	1.88	2.024	2.22
C.2 Solid waste management	0	2.4	4.7	7.1
Total	**0**	**7.52**	**21.27**	**48.51**

In scenario without measures (BAU scenario), Ghana's total emissions projected to grow from 14.11 $MtCO_2e$ in 2010 to 125.14 $MtCO_2e$ by 2040 (see ES table 6). By 2040, the overall effects of the implementation of mitigation actions on the BAU scenario are likely to translate to 76.3 $MtCO_2e$.

Table ES 6: Overall effects of mitigation actions on baseline emissions

Year	Emissions ($MtCO_2e$)		
	BAU Emissions (A)	**Mitigation Scenario emissions (B)**	**Overall effects of mitigation actions on BAU emissions (A-B)**
2010	14.11	0	14.11
2020	28.75	7.52	21.23
2030	57.06	21.27	35.79
2040	125.14	48.51	76.63

The trend of the effects of mitigation actions on the BAU emisisons will increase consistently from 2020 towards 2040.

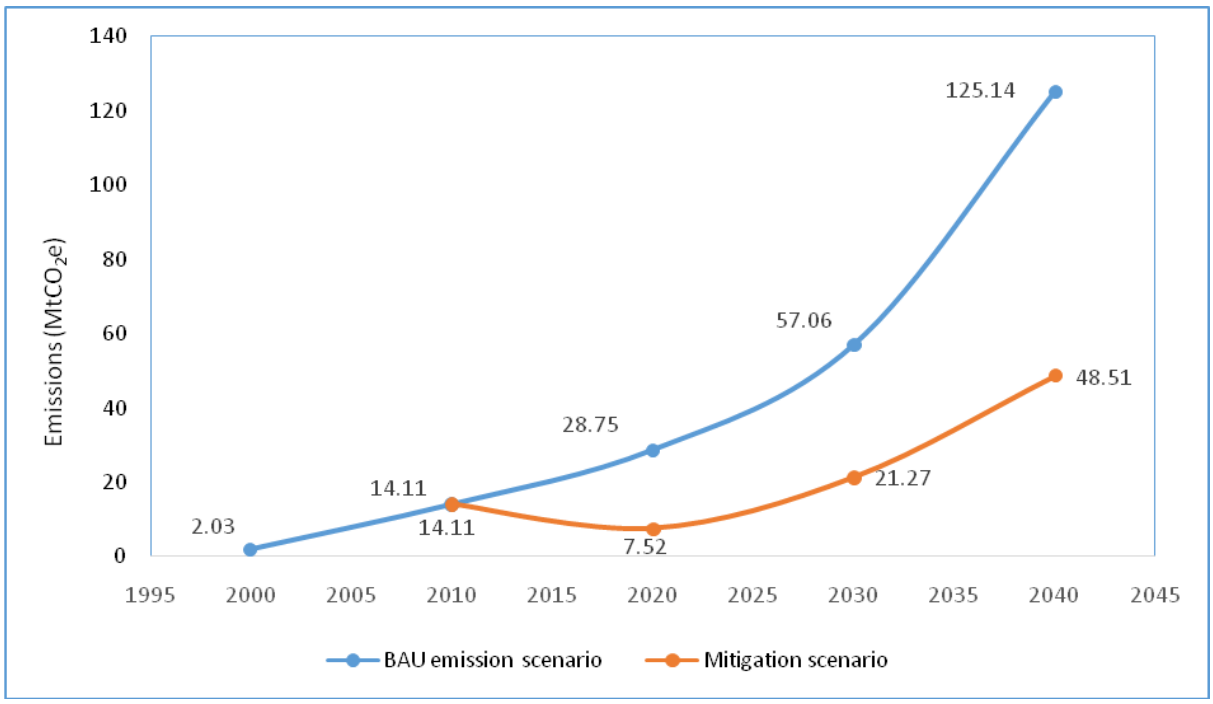

Figure ES 2: Overall effects of mitigation on BAU emission scenario

Table ES 7: List of prioritized mitigation action in the energy sector

Mitigation Action	Economic sector	Lead Agency	Investment costs for implementation to 2040	Estimated split between public private sector and consumer investments*	Abatement potential and sustainable development impacts	Priority Barriers	Alignment with National Policy/Programme removing barriers
Improved Cook stoves and LPG Cook stoves	Energy and forestry	Energy Commission	US$ 0.65billion Improved cook stoves (UD$0.16billion) LPG stoves (US$ 0.49billion)	Improved cook stoves: about 70% consumer costs and 30% Public support costs, LPG stoves: about 80% consumer Cost and 20% public support	- Abatement potential to 2040 of 38.1 $MtCO_2e$ - Health benefits from reduced indoor air pollution. - Lower fuel wood demand and deforestation. - Potential cost savings to households	- Inadequate supply of LPG to meet the increasing demand. - LPG subsidy policy for cooking unsustainable, not equitable, and prone to abuse. - Inadequate storage, filling and distribution infrastructure. - Weak regulation.	Programme – SEA4All Accelerated framework Policy target: 50% LPG penetration by 2020. Reduce wood fuel demand from 72% to 50% by 2020
Bus rapid Transit (BRT)	Transport, Infrastructure , and local government	Ministry of Transport	US$ 0.35 billion	About 70-80% public investment cost for infrastructure and 20-30% private costs for vehicle stock	- Abatement potential to 2040 of 1.63 $MtCO_2e$. - Reduced traffic congestion - Improved local air quality - Improved road safety - Job creation	- Difficult to regulate informal transport service providers. - Inadequate funding - Lack of consistent political commitment - Integration of BRT in road development - Lack of clarity in regulation and enforcement	- National Transport Policy - **Policy target:** 80% of all trips in the urban area should be done through public Mass Transit Systems
Efficient fridges	Energy	Energy Commission	US$ 0.05billion	About 30% public investment through rebate scheme 70% private costs for efficient fridges	- Abatement potential to 2040 of 2.1$MtCO_2$. - Improved E-waste management - Reduce household demand and expenditure on energy - Incomes and job across the value chain	- Lack of funding for rebate scheme - Lack of Investment in local refrigeration assembly plant - Difficulty in disposing or destruction of Ozone depleting substance	Energy Efficiency Standards and Labeling Regulations 2009(LI 1958) Energy Efficiency Regulation, 2008 (LI 1932) Ensure high market standards and prohibit

					- Available energy for 0ther productive economic use - Awareness/consciousness on electricity conservation - Phase out of ODS		importation of inefficient of selected range of electronic appliances.
Institutional biogas	Energy, education and health	Energy Commission	US$ 0.11 billion	About 55% public investment through rebate scheme 45% private costs for cost institutional biogas	- Abatement potential to 2040 of 0.024MtCO_2e. - Reduction in indoor pollution - Improved sanitation - Reduction in out-pocket-expenditure on cooking fuels - Job creation and increase incomes	- Lack of access to improved access to finance, including micro finance. - Limited local professional artisan. - High upfront cost. - Non-existing public capital incentives. - Standardization of biomass plants and registration of firms to ensure efficient monitoring. - There is the need to properly equip the EC and Standards Board to ensure standards.	SEA4ALL accelerated framework Renewable Energy Act

Table ES 8: List of prioritized mitigation action in the non-energy sector

Reforestation of degraded forest	Lands and forestry	Ministry of Land and Natural Resources	US$ 0.8– 1 billion	100% public	- Abatement potential to 2040 of 3.9 $MtCO_2$ - Biodiversity benefits - Sustainable forest products contribute to improved livelihoods - Job creation and improved personal incomes.	- Poor funding arrangement - Uncertainty about benefit sharing arrangements on off –reserve land. - Poor facilitation of off-reserve land acquisition - Weak regulation	- National forest plantation development Programme. - National forest Programme facility - REDD+ - Programme Forest Investment Programme
Landfill with gas collection	Local government, waste, environment	Ministry of Local Government and Rural Development	US$ 0.51 billion	About 30% public investment to equity, 70% private capital cost	- Abatement potential to 2040 of 0.4$MtCO_2e$/yr. - Reduce incidence of fire at landfills. - Additional energy generated - Improve sanitation	- High upfront transaction cost. - No landfill gas collection obligation - Challenges in the operational management of landfills	National Environmental Sanitation Policy Renewable Energy Act

ES 5. Vulnerability, impacts and adaptation assessment

ES. 5.1 Analysis of historical and projected future temperature rainfall patterns

In the analysis of historical temperature records, the observed rate of change in minimum temperature for the period 1960 to 2010 was 2% for the southern (rainforest and coastal agro-ecological zones) and middle part (deciduous and transition zone) of Ghana and 37% for the northern part (Guinea and Sudan savannah zones) of Ghana(see figure ES 3a and ES 3b).

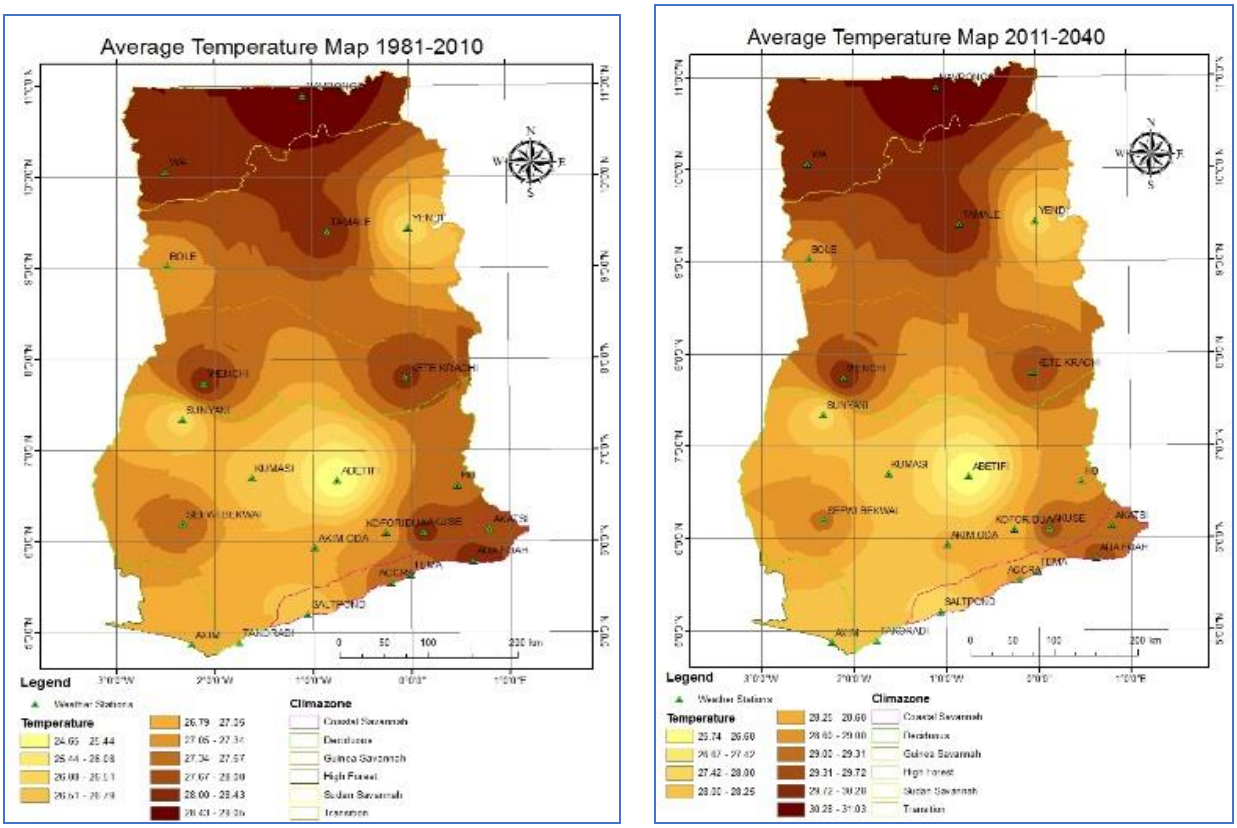

Figure ES 3a: Maps of observed and projected average temperatures 1980-2010 (left) 2011-2040 (right)

The projected mean temperature for Ghana shows that, mean temperatures are likely to increase in the near future (2040) by 3.8% (1.02^{O}C), slight increase in the mid future (2060) by 5.6% (1.5^{O}C) and further increase in the far future by 6.9% (1.8 ^{O}C) (see figure ES 3b). Mean minimum temperatures over the Coastal Savanna Zone are projected to increase by 1.1^{O}C, 2.5^{O}C, 1.9^{O}C, by 2040, 2060 and 2080 respectively. Mean monthly maximum temperature is expected to increase by 1.2^{O}C and 2.1^{O}C by 2040 and 2060.

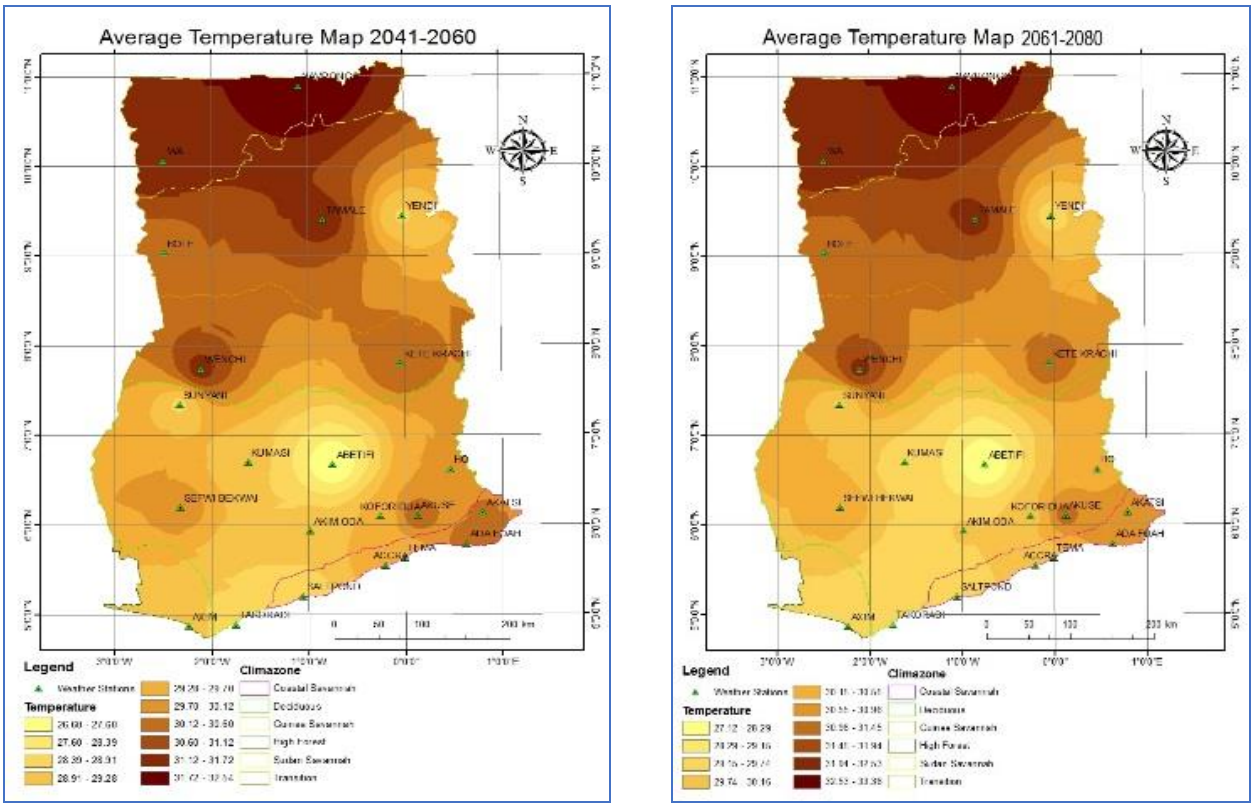

Figure ES 3b: Maps of observed and projected average temperatures 2041-2060 (left) and 2061-2080 (right).

The analysis of the 20 years rainfall records from the 22 synoptic weather stations for the six agro-ecological zones showed variable rate of change in observed rainfall. The rate of change ranges from 333% for the southern (rainforest and coastal agro-ecological zones), 112% for middle (deciduous and transition zone) to 431% for northern parts (Guinea and Sudan savannah zones) of Ghana. Decadal rainfall change was negative for the middle part at -2.8%, but positive for southern (13%) and northern (3.3%). The changes are more intense towards the north than the south for both temperature and rainfall. Based on the historical rainfall patterns (1980-2010), rainfall across the country has been projected to decrease by 2.9% in the near future (2040). This will be followed by a slight increase in the mid future (2060) by 1.1% and later decrease in the far future (2080) by 1.7%. This observation is a reflection of the uncertainty associated with rainfall (see figure ES 4a and ES 4b).

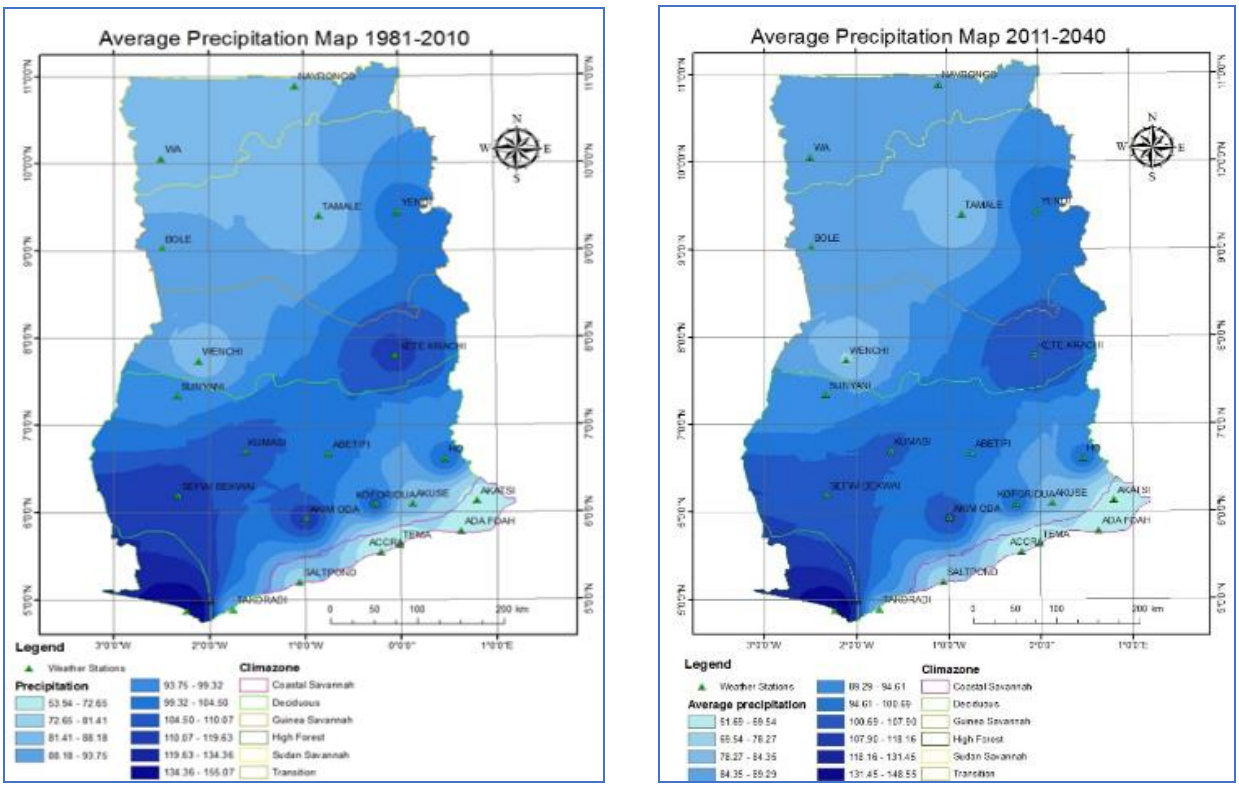

Figure ES 4a: Maps of observed and projected average rainfall 1980-2010 (left) and 2011-2040 (right)

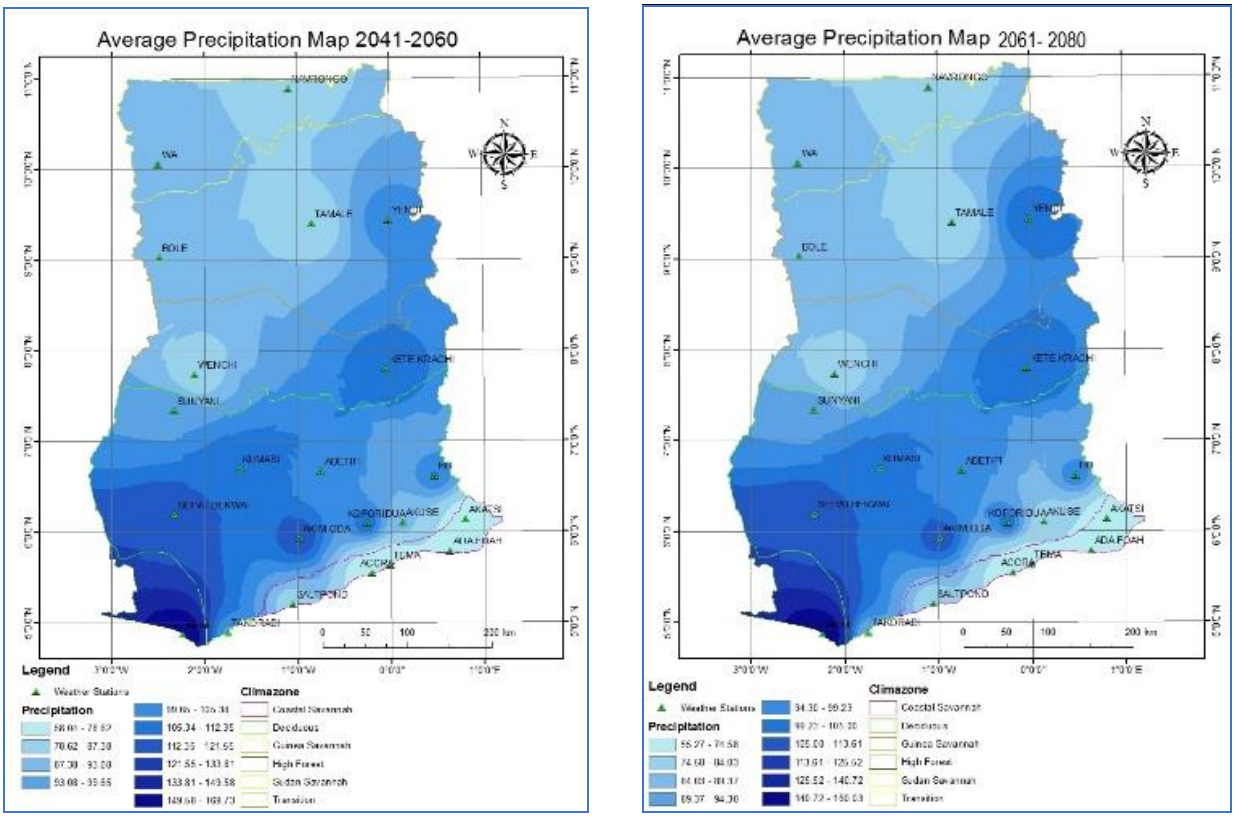

Figure ES 4b: Maps of observed and projected average rainfall 2041-2060 (left) and 2061-2080 (right).

ES. 5.2 Sector vulnerability and impact assessments

The impacts assessment built on the previous study, which focused on agriculture, water and coastal resources. The vulnerability and impact assessment consisted of analysis of the scope and severity of the potential effects of climate change taking into account different future climate projections. The studies further assessed possible adaptation and policy options that can be taken to prepare for climate change. Gaps identified were in the sectoral vulnerability and impact assessment. The assessment identified scope of issues, gaps and emerging sectors that would be considered in the next national communication. Key climate change risks were identified for each zone based 330 community level interviews, analysis of the climate variables and other biophysical factors (see ES 9).

Table ES 9: Climate change risk in the different ecological zones in Ghana (add reference/ source)

Ecological zone	Identified risk	Risk level (ranking)**
Coastal Savannah	Sea level rise	High
	Out-migration	Medium
	Weak livelihood support	Medium
	Sea erosion	Extreme
High forest	Erratic rainfall	Medium
	Late start of rains	High
	Early cessation of rains of rains	High
	Dry spell	Low
Transition	Low rainfall	High
	Rainfall extremes	High
	Crop failures	High
	Reduced minor season rains	Low

	Reduction in major season rains	**High**
	Mid-season break	High
	Shortening of planting seasons	Medium
Guinea and Sudan Savannah	Long dry spell	High
	Frequent flooding	High
	Out-migration	Extreme
	Erratic rainfall	Medium
	Rising temperature	High

In addition, Techie-Obeng (2012), has elicited farmer perceptions and responses to climate change impacts on maize production in the transition and savannah ecological zones of Ghana. The study focused on understanding farmers' perceptions and knowledge on climate variability and change as well as identifying a range of possible adaptation strategies employed by farmers over the years as baseline data for devising effective adaptation options for future climate change through participatory structured interviews. Table ES 10 shows the perception of farmers on factors having adverse impacts on maize production.

Table ES 10: Farmer perception on factors having adverse impacts on maize production

	Relative frequency of responses (%)			
Factors by category	**Wa**		**Wenchi**	
	*Yes	No	Yes	No
(a) Climatic				
Delay in onset of rains	97.3	2.7	96.3	3.7
Irregular and unpredictable rainfall	92.2	7.8	95.7	4.3
Rainfall associated with storm	81.6	18.4	91.4	8.6
Rainfall associated with floods	89.4	10.6	6.7	93.3
Rainfall is generally declining	85.8	14.2	63.2	36.8
Rainfall is generally improving	13.5	86.5	13.5	86.5
Rainfall sometimes ceases during growing season	73.8	26.2	85.3	14.7
Clouds bring more winds than rain	71.6	28.4	75.5	24.5
Early cessation of wet season	12.5	87.5	54.7	85.3
Extreme dry season	77.3	22.7	74.8	25.2
High temperature and extreme heat	77.3	22.7	78.6	21.4
(b) Management				
Decline in soil fertility	37.6	62.4	39.9	60.1
Emergence of stubborn weeds	9.2	90.8	25.8	74.2
Increased damage of maize by 'sentele' parasitic plant	20.5	79.5	0	100
Cost of fertilizers, herbicides, etc	23.5	76.5	22.4	77.6
• Increased birds damage	11.3	88.7	14.7	85.3
Number of respondents (N)	**141**		**163**	

Table ES 11: Priority vulnerability sectors and the adaptation efforts underway

Sector	Scale/coverage	Methods	Tools	Vulnerability & Impacts Identified	Prioritize Adaptation Measures	On-going Adaptation Programmes	Linkages with National Climate Change Policy	Linkages with National Adaptation Strategy
Roots &Tubers	Cassava, Yam and Cocoyam Within the ecological zones (Central, Volta and Ashanti regions for cassava) (Western Region for yam) (Ashanti and Western for cocoyam)	Socio-economic survey for economic and household data Secondary data (production statistics) used for natural yield variability	**Crop model** – DSSATv4 used to evaluate root crops vulnerability, Implications for future climatic change and project expected magnitude of impacts Computer aided modeling, Scenario analysis, Simulation gaming Participatory assessment and qualitative assessment used for interactions between impact of climate change on root and tuber crop yields and national policies	Unreliable, irregular and unpredictable rainfall patterns. Indiscriminate deforestation. Poor or degraded soils as a result of intensive and bad cultivation practices. Prolonged drought increases the population of variegated grasshoppers, which destroy cassava. Generally low income status of root & tuber famers. Heavily dependence of root & tuber on rainfall. Reduction in production due to high temperatures	*Improved Farming technologies or practices* - Varieties with different maturity periods. - Introduce drought resistant varieties - Integrate nutrient management under the various crops - Afforest degraded Forest lands - Alternate cropping *Post-harvest technologies*. - Alternate livelihood especially off farming activities. - Irrigation under root crops production	Root and Tuber Improvement and Marketing (RTIMP) - MoFA West Africa Agricultural Product Programme (WAPP) - MoFA Lessons from Conservation Agricultural Practices – CARE International	**Strategic Themes**: Food and Agriculture **Strategic Focus:** **Focus Area 1:** Development of climate resilient agriculture and food systems **Programme Areas 1.2** Develop and promote climate resilient cropping systems **1.5**. Support to water conservation and irrigation systems **1.6.** Risk Transfer and Alternative livelihood Systems **1.7** Improved Postharvest Management	**Programme Area 7:** minimizing climate change impact and socio-economic development through Agricultural Diversificatio n
Cocoa	National	Informal semi-structured and formal structured surveys (individual interviews.	CASE2 (Cacao Simulation Engine 2)	Generally low income status of cocoa famers due to small size of farms Erratic rainfall patterns in cocoa growing areas	Improved farming practices Drought resistant/tolerant and high yielding varieties Zero tillage non-burning of vegetation and mulching for conservation of soil moisture.	Environmental Sustainability and policy cocoa production Project – Ghana Cocoa Board SNV Cocoa Eco-Project	**Strategic Theme:** Natural Resource Management **Strategic Focus:** Increase carbon sink	**Programme Area 6:** Managing water resources as climate change adaptation to enhanced

		key informant interviews, group interviews focus group interviews) of randomly selected farmers and other stakeholders		Increased degradation of land in cocoa growing areas Increased temperatures leading to drought in cocoa growing areas Generally low and unreliable prices for cocoa Traditional farming practices within the cocoa sector Generally ageing population of cocoa farmers in Ghana Spatial decline of cocoa growing areas	Planting temporary and permanent shade trees to moderate the micro-climatic and edaphic conditions of the cocoa environment. Supplementary water application through irrigation Rehabilitation and restoration of degraded areas *Alternative livelihoods* Development of off-farm income generating activities Alternative land use activities (e.g. planting of other crops such as citrus, livestock farming and fish farming).	Ghana Cocoa Platform (Cocoa Board)	**Programme** 4.4 Conservation of trees through sustainable agro-forestry and on-farm practices	productivity and livelihoods
Fisheries	Marine and inland fisheries	Study fish species: catch, tilapia and sarmollena, physical and socio-economic (survey)	Physical (Canoco 4), Biomass Dynamic Model, Artificial Neural Network (ANN) for meteorological and fishery data	Increasing variability in marine fish stock, reduction in catch rate due to rising seas surface temperature, decreases in freshwater fish landings, generally low income in fishing communities	Aquaculture development, restocking of the fingerlings, reliable extension services including dissemination weather information, monitoring diseases, education	West Africa Fisheries Project (Component Environment and Social Safeguard) – Ghana National Aquaculture Development Plan Ministry of fisheries and aquaculture development	**Strategic Themes**: Food and Agriculture **Strategic Focus:** **Focus Area 1:** Development of climate resilient agriculture and food systems **Programme Areas** Support adaptation and risk reduction in Fisheries sub-sector	**Programme Area 10:** Adapting to climate change; sustainable livelihoods through enhance fisheries resource management

Land Management	Ecological zone specific (upper east in northern dry Ghana, Jachie in humid forest zone, Sekesua-Osonson in the semi-humid forest-savanna zone	Rapid field appraisal, information from satellite imagery, questionnaires survey and group discussions		Land degradation and desertification	Agricultural diversification, Livestock-crop integration, i.e., mixed farming, Rearing more goats than sheep and cattle, as the goats are easier to feed, Adoption of new crop mixtures and rotations, bunding, agro-forestry, water, Adoption of new crop mixtures and rotations, bunding, agro-forestry, water, Drought tolerant crops, Planting and conservation of trees, Land use intensification, Alternative, off-farm jobs, notably small-scale gold mining, 'galamsey'. Harvesting, integrated pest control and other such modern, innovative practices. Moisture conservation, notably mulching, erosion control.	Ghana Environmental Management Programme (MESTI & EPA), Sustainable Land Water Management Project (MESTI, EPA and MoFA), Climate change Adaptation through Integrated Water Resources Management in the three northern regions of Ghana – Water Resources Commission Land Administration Project (Ministry of Lands and Natural Resources	**Strategic Themes**: (a) Natural Resource Management (b) Food and Agriculture **Strategic Focus:** **Focus Area 1:** Development of climate resilient agriculture and food systems **Programme 1.3.** Adaptation of Livestock production systems **Focus Area 4:** Increase carbon sinks **Programme Areas** 4.4. Plantation development (Afforestation, reforestation and forest restoration) **Focus Area 5:** Improve Management and Resilience of Terrestrial and Aquatic Ecosystems **Programme Areas** 5.2. Community-based natural resource management	**Programme Area 3:** Enhancing national capacity to adapt to climate change through improved land us management

							5.3 Promote alternative livelihood through Economic incentive measures	
Climate change and health	Ashanti Region (Southern Ghana), Northern Region - Malaria, Diarrhea, Guinea Worm and Cerebral Spinal Meningitis	Desktop review, questionnaire administration, focus group discussion, key informant interviews and observations, epidemiology survey, household case studies	Multiple regression analysis among climate variable and the three diseases, sustainable livelihood approach for socio-economic health impacts, ANN, MIASMA (Modeling framework for the Health Impact Assessment of Man-Induced Atmospheric changes) MODEL Version 2.0 or LEMRA (Local Eco-epidemiological Malaria Risk Assessment)	1. Measles cases will increase by the year 2080 as a result of increased mean air temperature and reduce rainfall amount. However, measles is on the decrease under the present climate condition. 2. Gradual rise in the incidence of meningitis cases over the range of months where cases of meningitis are high. 3. Risk of increased diarrhea cases due to a reduced rainfall amount and increased mean air temperature.	Breaking the transmission cycle. Destroy breeding grounds of mosquitoes Destroy the larvae in order to break the life cycle. Break the host vector contact and protecting the host. Destroy breeding grounds of Cyclops, Destroy the Cyclops in order to break the life cycle, Break the host vector contact and protecting the host, Management of cases (surgical removal of worms, educating the people, community leaders and village health workers), Reduce Cyclops host contact through; Provision of safe drinking water, Filtration of water to remove Cyclops, Searching for patients with active cases to avoid contact with water,	UNDP climate change and health Project (Ministry of Health), Climate Change and health in Coastal Community in Accra Project (RIPS)	**Strategic Themes**: Equitable social development Strategic focus **Focus area 6:** Addressing Impacts of Climate Change on Human Health **Programme 6.3** Strengthen disease surveillance and response systems **6.4** Improve public health measures (immunization, improved drainage, sanitation and hygiene) especially in vulnerable communities 6.5. Emergency health preparedness e.g. provision of ambulances in vulnerable areas 6.6. Collaboration and partnership for	**Programme Area 8:** Minimizing climate change impacts on human health through improved access to health care **Programme Area 5:** Developing and implementing environmental sanitation strategies to adapt to climate change

					Ensuring that infected persons avoid contact with ponds, Chemical destruction of crustaceans, Vaccination of high risk groups, Increased input to vaccination campaigns, Proper housing and ventilation, effective case management and Education.		improved nutrition, water and sanitation	
Poverty Linkages	Nationwide	Use of secondary data. Supplemented by primary sources of data. Data mainly from national government publications and unpublished reports such as Ghana Poverty Reduction Strategy, Ghana Living Standards Survey, Draft national documents, Core Welfare Indicators Questionnaire	Qualitative and quantitative with the aid of statistical tool, Statistical Package for Social Science (SPSS), Analysis of Variance and Correlation, the use of tables, charts and maps.	Unreliable rainfall patterns. Heavy reliance on rainfall. Inadequate irrigable lands. Harvest failures from improper adaptive strategies. Reduced biological productivity and loss of forest cover. Progressive loss of non-timber forest products. Increased land degradation and loss of cropable land. Reduction in livestock size and nutrition. Disruption in industry productivity due to	Reforestation. Cultivation of species in the environment that they are adapted to. Devise flood/drought early warning systems. Provide alternative skill training for fishing communities. Negotiate regional water-sharing agreements; Providing efficient mechanisms for disaster management; Developing desalination techniques; Planting mangrove belts to provide flood protection;	Africa Adaptation Programme Adaptation Learning Programme and community based adaptation - Care International Climate change and food security in the Afram Plain Building Climate resilience through village savings and lending associations (VSLA) – Care International Innovative insurance products for the adaptation to climate change in Ghana –	Strategic Themes: Disaster Preparedness and Response Strategic Focus: Focus Area 3: Increase Resilience of Vulnerable Communities to Climate Related Risks Programme areas 3.3. Rapid Response and Disaster Management 3.5 Financial Support and Insurance Schemes	Programme Area 2: Alternative livelihood: Minimizing climate change impact for the poor and vulnerable

		(CWIQ) surveys (1998, 2003). Informal interviews and consultations were made with key government officials		possible crises in the energy sector. Disruption in the supply of raw materials e.g. from agriculture, fisheries and forestry. Potential impact on inter-regional trade. Disruption of rainfall patterns will affect Akosombo dam (30% of our energy sources). Higher risk of property insurance. Potential risk from sea level rise such as coastal inundation and erosion. Salt water intrusion into fresh water resources. Disruption of sources of livelihoods e.g. fishing and agriculture Population displacement	Planting salt-tolerant varieties of vegetation; Improving drainage facilities; Establishing setback policies for new developments; Devising flood early warning systems. The use of setback policies for all underdeveloped areas within the coastal zone. This would prevent the construction of immovable structures within hazard areas. Development of woodlots Promote and develop energy efficient technologies Promotion of energy conservation especially in large energy consuming industries. Monitor and control emissions from industries and transport sectors. Promote and develop alternative energy sources such as biomass, wind, mini-hydro etc.	Ghana Insurance Association	3.6 Provision of Social Support Systems	
Gender (focus on	Coastal Savannah	Qualitative survey using	Sustainable livelihood framework The procedure for	Unsafe drinking water	Facilitating equitable access to land;	Land Administration Project (LAP)-Gender –MLNR	**Strategic Theme:** Equitable Social Development	**Programme Area 2:** Alternative

Women livelihoods	Zone of Ghana-Tema, Keta and Kwanyako	questionnaires including focus Groups to a small group of twenty women in a locality selected from the three study areas	qualitative survey described by Roger	They experience discrimination under customary Law and practice in most parts of the country e.g. Land tenure systems and social relations Relatively high fuel wood consumption, which has negative consequences in The rural areas in terms of time spent in collecting or buying firewood; Health and environmental effects from smoke particles; difficulty in sitting Close to the stove to cook due to excessive heat transfer from the stove to the Environment as well as the smoke from the fuel wood; General inconvenience such as increased workload of women and children who collect firewood. Reduction in fishery resources from impacts of climate change Competition from big fishing trawlers Use of chemicals in fishing Inadequate and poor access to financial credit facilities	Security tenure and protection of land rights; Ensuring planned land use; and Developing effective institutional capacity and capability Increase access to health services; Improve the efficiency of health service delivery; Foster partnership with other agencies in improving health by: i Addressing inequalities based on gender, poverty and disability; ii Expand water availability, sanitation and the health environment; iii Improve nutritional status.	National Health Insurance Scheme to improve financing of the health sector and provide access to quality health services to particularly women. Local level mapping of climate change financial allocation from a gender perspective (Abantu for Women Development and IBIS Ghana) Gender action for climate change equality and sustainability project	**Strategic Focus** Focus Area 6: Addressing Impacts of Climate Change on Human Health **Programme area 6.7** Social protection and improved access to healthcare e.g., NHIS	livelihood: minimizing climate change impact for the poor and vulnerable

ES 6. Other information

ES. 6.1 Activities relating to transfer of environmentally sound technologies

Ghana undertook two Technology Needs Assessment (TNA) exercises to identify, select and prioritize technologies that were needed in order to effectively mitigate and adapt to climate change. The two TNA exercises were conducted in 2003 and 2013. The 2003 TNA focused on mitigation technologies in the energy and waste sectors while the 2013 version looked at adaptation technologies in the water and agriculture sectors. The adaptation and mitigation technologies that were selected through the TNA exercise and further revisions are shown in tables ES 11.

Table ES 11: Prioritized technology portfolios and key barriers

Technology Portfolio	2003 TNA	2014 Revisions	Comments
Biofuels	X		
Industrial energy efficiency improvement	X	X	
Energy efficiency lighting	X	X	Aligns with 12 prioritized NAMAs
Solar PVs	X	X	Aligns with Ghana's SE4ALL Action Plan and 12 prioritized NAMAs
Natural gas combined cycle and natural gas distribution system	X	X	
Management technologies and efficiency improvement in transport sub-sector or BRT	X	X	
Wind Energy	X		
Solar Water Heater	X	X	Aligns with Ghana's SE4ALL Action Plan and 12 prioritized NAMAs.
Small and mini hydro	X		Limited potential
Biomass for power generation (co-generation from sawmill residues)	X		
Landfill methane gas capture for power generation	X	X	
Anaerobic and CH_4 generation technologies for waste water handling (Biogas technologies)	X	X	Topmost priority. Aligns with Ghana's SE4ALL Action Plan and 12 prioritized NAMAs.
Incineration	X	X	Target Public Schools and Hospitals
LPG and Improved Stoves		X	Aligns with Ghana's SE4ALL Action Plan
Efficient Fridges		X	

ES. 6.2 Research and systematic observation

E.S 6.2.1 Climate change research

The research needs on climate change are significant and the topic varies widely. The topics identified through a survey related to the following: (a) pathways for indigenous knowledge transfer; (b) socio-economic impacts on local communities; (c) documenting past and on-going ecological and social dynamics, (d) policy-research diagnostics etc. There are a number of on-going researches in Ghana, which focus on different aspects of climate change. The overview of the research are provided under the following five main clusters: (a) land use and agriculture (b) climate change and society, (c) Water and coastal resources, (d) climate modeling and (e) cross-cutting studies.

- West African Science Service Center on Climate Change (WASCAL).
- Improving food security in Africa through increased system productivity of biomass-based value webs (BiomassWeb).
- CECAR-Africa - Enhancing Resilience to Climate and Ecosystem Changes in Semi-Arid Africa: An Integrated Approach (United Nations University Institute for Natural Resources in Africa).
- CLIMAFRICA – CSIR-Crop Research Institute
- Savannah forest boundary transition in West Africa - Coupling the energy balance and hydrology and carbon cycles across the biome - CSIR-Forest Research Institute (FORIG).
- Does shifting Carbon Use Efficiency determine the growth rates of intact and disturbed tropical forests? Gathering new evidence from African forests - CSIR-Forest Research Institute (FORIG).
- Payment for Watershed Services on the role forest in generation of rainfall in Ghana - Nature Conservation Research Centre (NCRC).
- Building climate resilience through risk communication in Ghana's growing coastal cities - Regional Institution for Population Studies (RIPS), University of Ghana, Legon.
- Mapping of Indigenous knowledge in Selected Communities in Ghana (African Adaptation Programme - AAP, Environmental Protection Agency.

E.S 6.2.2 Systematic observation

National Meteorological Observation Network - The synoptic automatic weather stations distributed across the country give coverage of nearly 95% of Ghana's territory for the measurement and monitoring of atmospheric phenomena. The meteorological radar that is located in Accra covers the remaining 5% of the country. The observation network is managed by the Ghana Meteorological Agency which provides climate services to the general public, civil aviation, commercial airlines, military aviation and maritime. The recent addition of the radar monitoring station to the system observation network Infrastructure has boosted the observation capabilities of the GMeT. GMeT is also receiving support from WASCAL to further improve their observation network across the country.

Centre for Remote Sensing and Geographic Services (CERSGIS) - CERSGIS provides support to specialized services on geo-information for observation and monitoring land and coastal resources. The center has spatial infrastructure and technical capacity for providing services on mapping and acquisition of remote sensing imageries across the country. Currently, CERSGIS is part of the partnership in Ghana Agricultural GIS online Platform. The platform gives access to cross-sectional data and GIS data collected by projects including USAID funded ADVANCE and TIPCEE projects, ADRA Ghana Food Security Programme.

Ghana Space Science and Technology Institute (GSSTI) - Ghana Atomic Energy Commission. The GSSTI was established in 2013 to exploit and coordinate space science and technology for socio-economic development of the country. The GSSTI is involved in the establishment, operation and hosting of a space observatory known as the Ghana Astronomical Project (GAP) on the African Very Long Baseline Interferometry (VLBI) to support systematic observation activities in Ghana.

GEONETCast Centre – University of Energy and Natural Resources - The GEONETCast Centre operates GEONETCast platform, which is a near real time, global network of satellite-based data dissemination systems designed to distribute space-based, air-borne and in situ data, metadata and products to various stakeholders. The GEONETCast applications are useful water, disasters, health, energy etc.

ES. 6.3 Participation in international activities

Ghana has contributed to a number of international climate change activities at various levels. The participation in these activities had manifested in support of the efforts to combat climate change both at the national and international levels (see table ES12).

Table ES 12: Ghana's contribution to International initiatives

Participation of international Activities	Description of Activity
Sub- regional (ECOWAS Level)	UNFCCC CDM West Africa Region Collaboration Centre
	ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE)
	West Africa Gas Pipeline Company
	Sustainable Greenhouse Gas Inventory in West Africa
Continent level (Africa Union Level)	Participation in AMCEN
	Africa Group of Negotiators (AGN)
	African Climate Policy Centre (ACPC)
International level (United Nation Level)	UNFFCC and Climate Change Negotiations
	Inter-governmental Panel on Climate Change (IPCC)

ES 7. Education, public participation and awareness

ES. 7.1 Education and public awareness

Many climate change education efforts target formal and informal segments of the society. The education programme do not only focus on increasing public awareness on climate change, but many of the programmes now place emphasizes on behavioral change and community action. Formal climate change education focuses on the review of school curriculum to include climate change in at levels of the educational system. In most of the public tertiary institutions, climate change and related subjects have either been integrated into existing courses or special graduate courses have been designed. For instance, University of Ghana, Legon and Kwame Nkrumah University of Science and Technology introduced special graduate courses on "climate change and sustainable development" and "climate science and meteorology" (see table ES13).

Table ES 13: Overview of climate change and related courses offered by tertiary institutions in Ghana

Course/Programme	Institute/Department	University	Comments
MSc and MPhil in Climate Change and Sustainable Development	School of social sciences & Business School, University of Ghana	University of Ghana, Legon	Multi-disciplinary
Bachelor in Geography	Department of Geography and Resources Development	University of Ghana, Legon	Climatology
MSc. Climate Science and Meteorology	Department of Physics	KNUST	
MSc. Environmental, Science, Policy and Management	Department of Urban and Environmental Management	Institute of Local Government Studies, Accra and Tamale	Climate change to inform decision making processes
Post-graduate studies	Institute of Environmental Studies and Sanitation	University of Ghana, Legon	Climate Change Adaptation
Post-graduate studies	Regional Institute for Population Studies	University of Ghana, Legon	
MSc. Renewable Energy	Mechanical Engineering and Energy Centre	KNUST	Climate mitigation
MA in Environment and Resource Management	Faculty of Integrated development studies	University of development studies	Climate change
MA Geography and Regional Planning	Department of Geography and Regional Planning	University of Cape Coast	Climate Adaptation and mainstreaming issues, Climatology
MSc Sustainable Energy Management	Department of Energy and Environmental Engineering	University of Energy and Natural Resources	Low carbon development issues
Dual Degree Programme in Master of Science in Bio-Economy and Natural Resources	Forest Research Institute (FORIG) and KNUST	University of East Finland	REDD+, Carbon Trading
HND Renewable Energy Systems Engineering	School of Engineering	Koforidua Polytechnic	Climate mitigation
HND Renewable Energy and Energy Efficiency	Department of Engineering	Accra Polytechnic	
HND Renewable Energy and Efficiency Technologies	School of Engineering	Kumasi Polytechnic	

At the secondary school level, there was a certain level of recognition by the Ghana Education Service and Ministry of Education on the need to incorporate climate change into school curriculum, however not much have taken place. It is also important to note that, both at the secondary and primary school levels, there are specific subjects on environmental studies and geography that cover climate change. The informal education and public awareness programme usually target the wider sect of the Ghanaian society. Majority of the informal education and public awareness programme on climate change are done through mass and print media such as radio and TV interviews, jingles, documentaries, community durbars, information vans and dissemination of educational materials. Social media has also become a useful tool to communicate with the general public on climate change issues.

ES. 7.2 Efforts to promote public participation

Ghana's Article 6 action plan identifies public participation as one of the means to generate and sustain public involvement in climate change. In this regard, the EPA has set to roll out the following programmes: (a) Organize bi-annual forum for all organizations working on issues of climate change; (b) Initiate annual climate change youth conference in Ghana; (c) Introduce climate change environmental clubs in each basic and second cycle institutions; (d) Introduce annual Environment day competitions in high schools on climate change; (e) Integrate climate change discussions on radio and TV and (f) Showcase climate change issues on public fairs and exhibitions. The Environmental Protection Agency is implementing the Ghana Climate change education in schools (GCCES) in collaboration with the French Embassy and TU Delft University of Netherlands.

ES. 7.3 Efforts to promote access to information

Below are some of the initiatives underway in Ghana to promote access to climate change information:

- Online climate change data hub – Environmental Protection Agency
- National energy data processing and information center - Energy commission
- National forestry inventory WebGIS portal - Forestry commission
- Ghana climate adaptation network - Center for African Wetlands, University of Ghana
- Access to biomass map online – Nature Conservation Research Centre (NCRC) and Forest Trends
- Ghana climate change agriculture and food security platform - CSIR Animal Research

ES 8. Constraints, gaps, and related financial, technical and capacity needs

ES 8.1 Financial constraints and gaps including needs

The following were the main financial constraints and gaps that were identified by the stakeholders confronting implementation of climate change activities including the preparation of national communications:

- Institutional challenges relating to tracking climate finance
- Duplication of activities and funding
- Lack of transparency on climate finance that have multiple use
- Insufficient transparency on non-financial support for training and technical assistance
- Inadequate financial allocation in national budget.

ES 8.2 Technical, capacity constraints and gaps including needs

Summary of the technical and capacity constraints and gaps are provided in the table E14.

Table ES 14: Summary of the technical and capacity constraints and gaps

Activity	Capacity Needed	Capacity received	Source of Support
Use of 2006 IPCC guidelines and ALU software for AFOLU GHG Accounting	Data processing and management strategies.	Training-on AFOLU data collection and management.	Rainforest Coalition, CD REDD Project
	Training on ALU and IPCC software on ALU	Hands-on training on the use of IPCC software for AFOLU.	
	Training on 2006 IPCC Guidelines and software	Training on GHG Inventory	GIZ Information Matters project
			UNFCCC CGE Training
GHG National System improvement	GHG Data management and institutional arrangement.	GHG MRV Training	UNEP/GEF, Information Matters project
		Training GHG MRV Management	
	Strengthening national system for GHG	Establishment of online climate change data hub	UNEP/GEF, UNDP, Low Emission Capacity Building Project
		Development of GHG Manual	
		Development QA/QC Plan	
Improvement of GHG Inventory Report	Review of national inventory report	Technical review of Energy section of National Inventory Report	GIZ Information Matters project
		Technical review AFOLU section of National Inventory Report	Rainforest Coalition, CD REDD Project, Sustainable GHG Management in, West Africa
		Technical review of entire National Inventory Report	UNFCCC Secretariat
Development of Marginal abatement cost curve	Training on marginal abatement curves	Training on mitigation assessment	UNEP/GEF during preparation of Third National Communication
Improvement in mitigation baseline setting	Training on how to make baseline transparent	Training workshop on baselines	UNEP/GEF during preparation of Third National Communication
			GIZ Information Matters project
Continuous training of GHG Experts	Training new technical expert on GHG at the international level	Training of 6 GHG review experts	UNFCCC GHG Review Training Programme
		Training Programme on the use of Google Earth Collect Facility	Sustainable GHG Management in, West Africa
Development of mitigation scenario for non-energy sector	Training on marginal abatement curves	Training on mitigation assessment	UNEP/GEF during preparation of Third National Communication
Improve forestry-wide mitigation and ensure	Training on setting common baseline with REDD+ forest reference level	-	-

linkages with REDD+ forest reference level			
Revision of climate statistical using RCMs	Access to computational facility to run downscaling	Statistical downscaling of Ghana meteorological data	Dr. Seidou Ousmane, University of Ottawa, Canada
Climate impacts assessment	Use of statistical and dynamic crop and hydrological modeling model	-	-

ES 8.3 The GEF, Annex II Parties, multilateral/bilateral contributions

An amount of US$1,208,746,027 being total climate related financial inflows was received for the period 2011-2014 (equivalent of Gh₵ 2,579,483,625) representing 3.7% of GDP. When the loan from China Development Bank is included, the total financial inflow was US$ 2,208,746,027 (equivalent of GhC 4,713,499,843) which was 6.7% share of GDP. Grants constituted the largest share (69.2%), followed by loans (19.1%), national budget (6.9%) and result-based payment (4.9%). As shown in table 22, the financial flows through bilateral channels was the largest (49.5%), followed by multilaterals (39%), national contributions (5.1), GEF (3.1%). The remaining 3.2% are co-financing (1.7%), private foundations (1.4%) and private sector (0.15) (see ES 15).

Table ES 15: summary of GEF, Annex II Parties, and multilateral/bilateral financial contributions (2011-2014)

	Type of Financial Flow	W/China ($)	W/O China ($)	W/China (Gh₵)	W/O China (Gh₵)	Share of GDP[1](2014)	
						W/China	W/O China
Overall Analysis	Loans	1,231,090,000	231,090,000	2,627,166,026	493,149,808	3.8%	0.7%
	Grants	836,854,027	836,854,027	1,785,860,066	1,785,860,066	2.6%	2.6%
	National Budgets	82,024,000	82,024,000	175,040,546	175,040,546	0.3%	0.3%
	Results based payment	58,750,000	58,750,000	125,373,453	125,373,453	0.2%	0.2%
	Total	2,208,718,027	1,208,718,027	4,713,440,091	2,579,423,872	6.7%	3.7%

	Parameters of financial flows		Mitigation	Adaptation	MoI[2]	SD[3]	Enabling Activities[4]	Totals (s)	Totals (Gh₵)
	Type of financial flow	W/China[5]	1,229,500,000					1,229,500,000	2,623,772,941
Loans		W/O China[6]	229,500,000		1,590,000			231,090,000	493,149,808
Grants			621,089,710	40,226,363	174,635,954	50,000	852,000	836,854,027	1,785,860,066
National budgets			80,024,000		2,000,000			82,024,000	175,040,546
Result-based payment			58,750,000					58,750,000	125,373,453
Bilateral	Channel of financial flow		515,010,000	7,711,048	75,719,505			598,440,553	1,277,081,846
Multilateral			361,906,982	28,026,843	81,815,387	50,000		471,799,212	1,006,827,169
Co-financing			18,000,000		2,000,000			20,000,000	42,680,324
GEF			32,422,727	4,418,182	70,000		852,000	37,762,909	80,586,660
National Funds			62,024,000					62,024,000	132,360,222
Global Fund					Unknown			-	-

[1] Share of total gross domestic products reported in ending 2014. 2014 GDP reported as Gh₵ 70,000,000

[2] Means of implementation. It has been further classified as Mitigation MoI, Adaptation MoI, and Sustainable Development MoI

[3] Sustainable development financial inflows are cash flows that support mitigation, adaptation, MoI and development activities

[4] Enabling Activities dedicated GEF funds to support facilitation of implementation of Rio convention particularly UNFCCC

[5] Financial inflow included China Development Bank loan for the construction of Ghana Gas Processing Plant at Atuabo in Western Region of Ghana

[6] Financial inflow excluding China Development Bank loan for the construction of Ghana Gas Processing Plant at Atuabo in Western Region of Ghana

Private Foundations					16,921,063			16,921,063	36,109,823
Private sector		W/China	1,000,000,000					1,000,000,000	2,134,016,219
		W/O China		70,290	1,700,000			1,770,290	3,777,828
Energy	Recipient sectors	W/China	1,745,939,727					1,745,939,727	3,725,863,694
		W/O China	745,939,727		2,870,000			748,809,727	1,597,972,102
Agriculture			13,250,000	12,689,048				25,939,048	55,354,349
Forestry			140,173,982		21,657,158			161,831,140	345,350,277
Transport			90,000,000					90,000,000	192,061,460
Dev. planning				7,930,214				7,930,214	16,923,205
Environment				11,124,920	19,776,773	50,000	852,000	31,803,693	67,869,597
Health				1,918,182				1,918,182	4,093,431
Interior				5,200,000				5,200,000	11,096,884
Water				1,364,000				1,364,000	2,910,798
Education					16,519,023			16,519,023	35,251,863
Finance					117,403,000			117,403,000	250,539,906
Grand Total		**W/China**	**1,989,363,709**	**40,226,364**	**178,225,954**	**50,000**	**852,000**	**2,208,718,027**	**4,713,440,092**
		W/China	**989,363,709**	**40,226,364**	**178,225,954**	**50,000**	**852,000**	**1,208,718,027**	**2,579,423,873**

1. Introduction

1.1 Background to the national communication process

Ghana became party to the United Nations Framework Convention on Climate Change (UNFCCC, hereinafter referred to as "the Convention") after ratification in September 1995. Upon ratification, Ghana has decisively committed itself to pursue coordinated actions to reduce greenhouse gas (GHG) emissions and climate change impacts on the most vulnerable population while continuing to advance national economic development. As a party to the convention, Ghana has the obligation under Article 4, paragraph 1, and Article 12, paragraph 1 of the Convention to regularly prepare, publish and report its national communications to the Conference of Parties (COP) to the UNFCCC. In 2000 and 2011, the country submitted its first and second national communications to the COP. The preparation of the TNC was carried out pursuant to Ghana's obligations under the convention.

In order to ensure continuity with the previous national communications, the TNC built on the SNC by updating and reporting additional information to reflect the changes that have taken place after the submission of the last national communication in 2011. The preparation of the TNC was informed by the sets of guidelines contained in the annex to decision 17/CP.8. The main objective of the TNC is to present and communicate, to the COP, Ghana's implementation of the Convention and in particular, highlight pertinent issues, gaps, problems, constraints and achievements. The information provided in the TNC covers the period between 2010 and 2014. Updates would be provided in the Fourth National Communication (FNC), which will be launched immediately after submission of the TNC to the COP.

The TNC is also considered by Ghana as a major effort to shape climate change policy development, planning and facilitating its integration into sustainable development. The preparation of the TNC had been very participatory, interactive and delivered in a systematic manner. A stock taking exercise was conducted to review the processes of the two previous national communications. The exercise identified the weaknesses and strengths of the following processes of the national communication and recommended ways to address them in the short-to-medium term: institutional arrangements, system for data acquisition and archiving, training, capacity building retention and information exchange. Based on the key recommendations from the stock taking exercise, the TNC project proposal was developed and approved by GEF through UNEP. The existing institutional arrangements under the SNC was rejuvenated and blended with a new set of experts and institutions to ensure continuity and at the same time benefit from building on existing experiences.

The GEF expedited financing mechanism was the main funding source for preparing the TNC. This was, however, complemented by technical support from the LECBP, CD-REDD, Information matter Project and the Sustainable GHG Management in West Africa Project. Ghana provided additional co-financing in-kind to complement the financial and technical support received to enable the preparation of this report.

Ghana's National Circumstances

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2. National Circumstances

2.1 Major changes to national circumstances since submission of last national communications

Key developments	Description of details
People living in cities and coastal areas doubled in three decades	Ghana's population has more than tripled, from 6.7million in 1960 to 25.37million in 2012 with nearly 52.5% living in urban areas.
	The 2012 population of 25.37million represents an increase of 15.6% over the 2006 population. The population is projected to be more than double its current size by 2040.
	About a quarter - 6million - of the 2012 total population live along the coastline which is about 560km.
Energy-intensive economic growth	In 2011, Ghana attained a lower middle-income status with a per capita income of $1,594.
	The GDP per capita increased to $1,605 in 2012 with total GDP of nearly US$ 40.71billion in the same year.
	The GDP growth is projected to stabilize at 9% from 2015 onwards.
	Structural transformation of the since 2006 has resulted in a shift from agrarian- to a service sector-led (49.9%) economy. This is partly due to the realignment of the basket of activities under the service sector.
	The significant growth in the economy has given rise to a 106.2% increase in the national GHG emissions from 16.32 $MtCO_2e$ in 2000 to 33.66 $MtCO_2e$ in 2012.
Emerging Oil and gas economy	In 2010, Ghana became an oil and gas producing country and recorded a remarkable GDP growth rate of 14.4% (one of the fastest in the world) largely as a result of the impact of the oil revenue.
	A total of 26.4million barrels of oil was produced from the Jubilee fields in 2012, up from 24.2million barrels produced in 2011 all of which were exported offshore.
	For natural gas, out of the 828.3ktoe supplied, 777.2ktoe was imported for electricity generation whereas the remainder was associated gas from the oil fields, some of which were injected and the others flared. The construction of the gas processing plant was expected to be completed by the end of 2014.
Implementation utility price rationalization policy	In 2012, Government of Ghana commenced the implementation of its policy of removing subsidies on petroleum products and electricity to allow for the rolling-out of the automatic prices adjustment system.
Renewable Energy promotion	In 2011, the Renewable Energy, (Act 832) was passed to facilitate government's vision of achieving 10% renewable energy on the public electricity grid by 2020.
	Subsequently a number of measures such as (a) feed-in-tariff rate, (b) renewable energy purchase obligation, (c) connection to distribution and transmission system. A Renewable Energy Fund is being put in place to provide funding to support private sector participation in sustainable electricity generation.
	As part of governments programme to increase renewable energy in the energy mix from <1.5% to 10% by 2020, installation work for 752 off-grid solar systems for remote public institutions started with 50% completed.
	In addition, 255 off- grid solar PV systems have been installed for remote public institutions on lakeside and inland communities.
Improvements in Energy Efficiency	In 2012, Ghana announced the Solar Lantern Replacement Programme, which aimed at distributing of 200,000 solar lamps to rural communities as part of its social mitigation programme following the removal of subsidies on Kerosene and other petroleum products.
	Ghana launched a refrigerator rebate and turn-in scheme in 2012 to facilitate the transformation of the refrigeration appliance market in Ghana. So far 15,000 inefficient refrigeration appliances have been turned in.

	Ghana government distributed 6 million CFL bulbs to replace the old inefficient incandescent bulbs and facilitated the installation of "capacitor banks" in public buildings.
Deforestation projected at 2% per annum	Ghana covers over 23 million hectares of land area out of which nearly 13,628,179 ha is under agricultural use. Ghana's total forest cover is now less than 1.6 million hectares with an annual deforestation rate projected to be 2%.
Warming temperature & variable rainfall patterns	Ghana's mean temperature has increased by about one Degree Celsius since 1960 at an average rate of 0.21°C per decade.
	The rate of increase has generally been more rapid in the northern regions of the country than in the south.
	Mean annual temperature is projected to increase by 1.0 to 4.0°C by 2080. This implies that the frequency of days and nights that are considered 'hot" presently are most likely to increase.
	The projected rate of warming is most rapid in the northern inland regions of Ghana than the coastal regions.
	Mean annual rainfall show a decreasing trend in both Northern and Southern Ghana except the rainforest and the forest transition zones, which recorded increases.
	The projected rainfall for all ecological zones is likely to decrease by about 10% in the rainy seasons. Variations in the projected rainfall patterns in MJJ (May, June, and July) will be more prominent (more than 10%) than SON (September, October, and November) (less 10%) in the next 10 to 60 years.
Vulnerable population and sector defined by geographic spread	Ghana is especially vulnerable to climatic risks due to a combination of frequent natural disasters (flooding, windstorms and heat spells), high population density, draught, poor infrastructure and low resilience to economic shocks.
	The impacts are manifested extensively in the productive economic sectors such as agriculture, water resources, health and fisheries.
	Multiple adaptation challenges are defined by geographic spread and unique vulnerabilities.
Long-term vision for combating climate change	Government of Ghana prepared a National Climate Change Policy, which was based on the national medium term development framework (Ghana's Shared Growth Development Agenda. The policy was launched in July, 2014.

2.2 Government profile

Ghana is a unitary democratic republic governed under the 1992 constitution where power is shared among the executive, legislature and the judiciary. The President is the head of the executive arm and is in charge of high-level appointments. The legislative functions are vested in the national parliament. There is also the judiciary that is independent of all other branches of government. The Supreme Court has broad powers of judicial review. The national house of chiefs, advises on all matters of chieftaincy, customary laws and land administration. Ghana has a local government system with a decentralized national development structure which comprises (a) planning, (b) political, (c) administrative and (d) fiscal. The decentralized local government comprises structures at the national, regional and district levels. The country is divided into 10 administrative regions and 216 Metropolitan/Municipal/District Planning Authorities (MMDAs) each headed by a Chief Executive.

The decentralized planning system comprises the National Development Planning Commission (NDPC) (at the apex), Ministries, Departments and Agencies (MDAs), Regional Coordinating Councils and the District Assemblies. The NDPC by virtue of its statutory functions is required to broadly coordinate, the entire national development planning system. Accordingly, the NDPC works with all MDAs including the Ministry of Environment, Science, Technology and Innovation (MESTI). Among others, the NDPC works closely with MESTI to ensure that climate change is well integrated into the national development planning and

budgeting processes. Within the Ghana Government, MESTI and the EPA are the key institutions that co-coordinate the implementation of policies and programmes (including national and international climate reporting) on climate change.

The National Climate Change Committee (NCCC) is an administrative mechanism hosted by MESTI that facilitates inter-sectoral coordination on climate change issues[7]. There are also dedicated units in the Ministry of Finance, Ministry of Food and Agriculture and Ministry Lands and Natural Resources that are working in areas such as climate finance, climate smart agriculture and REDD+ respectively. In addition, a number of Departments and Agencies such as NADMO, Forestry Commission and Energy Commission, that are also engaged with different aspects of climate change mitigation and adaptation. Universities are involved in (a) generating knowledge through research, (b) human capacity building through training and (c) supporting evidence based decision-making. Table 1 summarizes climate change challenges and opportunities for the key sectors.

Table 1: Institutions and summary of climate change activities relating to their mandates

Institutions/Sector	Strategic Focus
National Development Planning Commission	Ensure integration of climate change issues into national planning and Budgeting processes.
MESTI	Integrate broader climate related environmental issues
EPA	Evaluate and promote relevant climate related technologies.
	National and international climate reporting
Ministry of Finance	Assess implications of climate on economy, growth and budgets.
	Track and capture additional financing from climate funds.
Food & Agriculture	Achieve a “climate-proof” green revolution. (Climate Smart Agriculture).
	Create and promote sustainable low-carbon land use.
Lands and natural resources	Stop deforestation and boost reforestation and afforestation.
	Secure financial opportunities by REDD+ and Forest Investment Programme.
Ministry of Power and Energy Commissions	Promote increased energy efficiency.
	Achieve energy security including doubling renewables on the public grid.
Ministry of Transport	Introduce fuel-efficiency and biofuel requirements.
	Reduce city traffic by promoting public transport.
Others partners	Build awareness and work to inform the public on climate issues.
	Promote disaster risk reduction through early warning systems.
	Support climate initiatives within ministries.
	Effective spatial planning to support climate resilience.

[7] The NCCC is a multi-stakeholder committee of MDAs, Donors, Parliament of Ghana, CSOs, research institutions and the private sector.

2.2.1 Institutional arrangements for preparation of national communication/biennial update

2.2.1.1 Institutional arrangements for the continuous preparation of national communications

Ghana has put in place institutional arrangements for the regular preparation of its national communication. The structures that are in place have evolved from being ad-hoc working groups to decentralized institutional representations. The institutional arrangement is in three tiers (see figure 1). The top tier is the Project Advisory Committee (PAC) which was the highest decision-making body for national communication and provides overall direction and oversight. The PAC met every six months to evaluate progress of work and where necessary make policy decisions. The PAC was made up 13 senior representatives drawn from government, research institutions, academia and civil society. The middle tier entity was the Project Steering Committee (PSC) constituted as the implementation clearinghouse for the national communication.

The work of the PSC was focused on the implementation aspects of national communication whereas that of PAC is strategic. The PSC met regularly, particularly on the basis of its agreed work programme. At the lower tier are 6 country-working groups (CWGs). Each of them focuses on specific aspects of the national communication. The CWGs are largely responsible for the planning, implementation and reporting of activities of the CWG. The membership of the CWG was drawn from relevant private, public institutions, and the knowledge community and is constituted on the basis of competence, experience and relevance. The competent institution that leads the working group is referred to “task institution”. The mandate, roles and reporting of each working group has been explained in the “working package memorandum of understanding”.

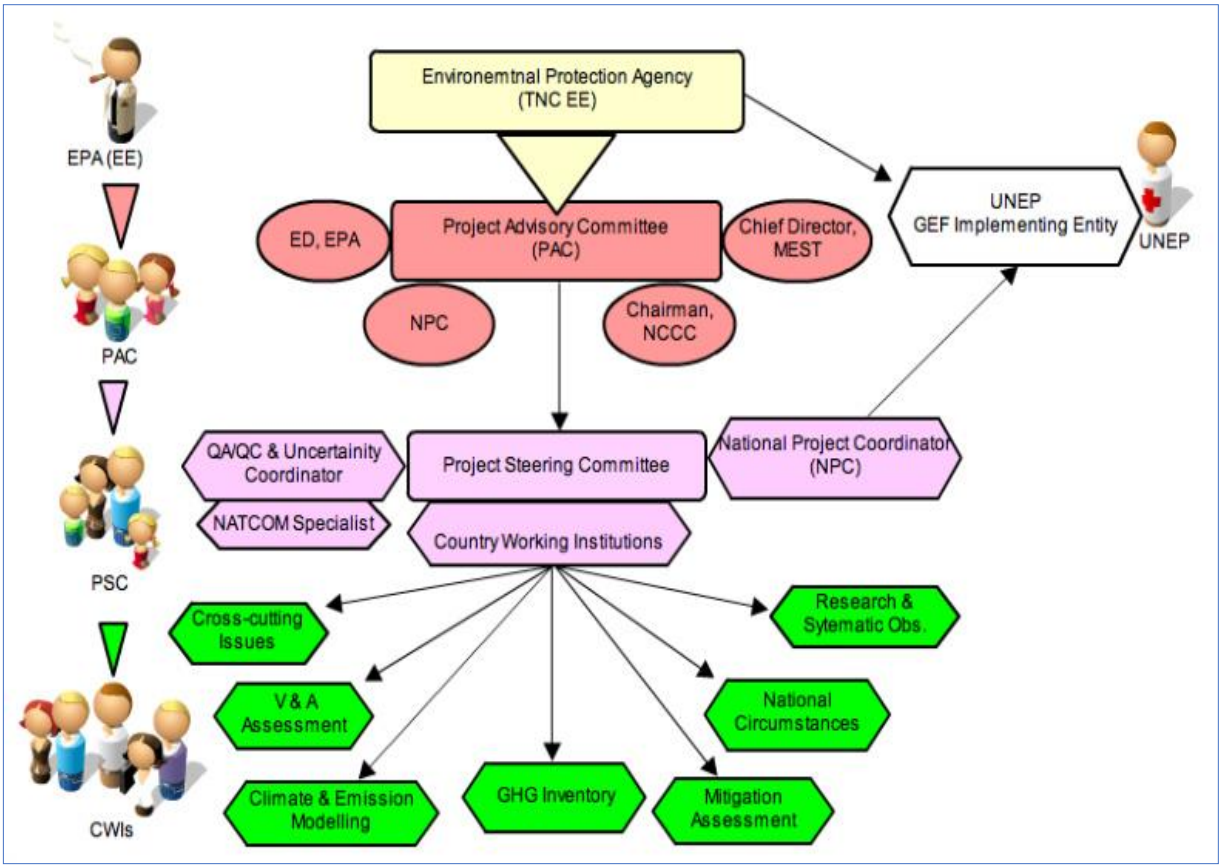


Figure 1: Institutional arrangement of national communication in Ghana

The Working Package Memorandum of Understanding (WP-MoU) drafted for each working group contains specific information on the following: scope of work and responsibilities of the task institution; timelines and reporting outline; data access and management and budget narratives. The purpose of the WP-MoU is to help mainstream and institutionalize the preparation of the national communication effectively, on time and ensure future continuity. The CWGs meet regularly, at least twice in a quarter to discuss progress of activities of the working groups.

2.2.1.2 Linkages with national structures for coordination, planning and implementation of climate change

The structure of government profile for the coordination, planning and implementation of climate change in Ghana is provided in figure 2. The structure reflects the current roles various institutions are playing in the planning and implementation of climate change activities in Ghana. It is important to note that the national system for the preparation of the national communication and the biennial update report is already integrated into the superstructure of national structures for the coordination of planning & implementation of climate change. Clear linkages have been established within the monitoring and evaluation structures and in research and knowledge generation. Apart from the fact that the national system for the preparation of TNC and Biennial Update Report (BUR) were integrated at the national level, the process of preparing the national communication serves as a useful mechanism for creating awareness on climate change in the different sectors as well as building capacities of national experts who are directly involved through learning by doing. In addition, the processes also provide good information for policy planning and reformulation at the various ministries.

Strategic level institutions - One of the critical success factors for climate change mainstreaming in Ghana is to have the highest possible political buy-in vested in the strategic level institutions by law. The strategic level institutions (see figure 2) have the political mandate to define the vision and policy directions national development. They perform this function by setting out development priority areas and allocation of national resources. In Ghana, the decision to commit to "low carbon climate resilient development" emerged from the government's 2020 transformation agenda. This is vision that all government development agencies, development partners and private sector are to work towards achieving it.

Planning, budgeting and overall coordination institutions - The NDPC, Ministry of Finance and MESTI perform the planning, budgeting and coordination functions at different stages and levels of the climate change mainstreaming process. The NDPC coordinates and regulates the decentralized national development planning system in accordance with 480. The central development framework coordinated by the NDPC is useful for the formulation and integration of climate change into national development.

The MOF plays central fiduciary management role in national development planning. Their fiduciary functions relates to budget coordination and fiscal policy setting within the economic development framework. Insofar as, climate change is anchored on the medium term national development priorities, the budget guidelines that will be issued by MOF to the MDAs and MMDAs would justify budget allocations for climate change public investments. MESTI plays the leading role in the overall coordination of the implementation of the national climate change policy, which has three pillars on effective adaptation social development and low carbon development. As the lead institution, MESTI is responsible for coordination and harmonization of climate change activities among the sectors and much as possible ensures alignment to the medium term development plan. This is done through the National Climate Change Committee, which is a multi-stakeholder committee of Ministries, Department and Agencies (MDAs), Donors, Parliament of Ghana, CSOs, research institutions and representatives of the private sector.

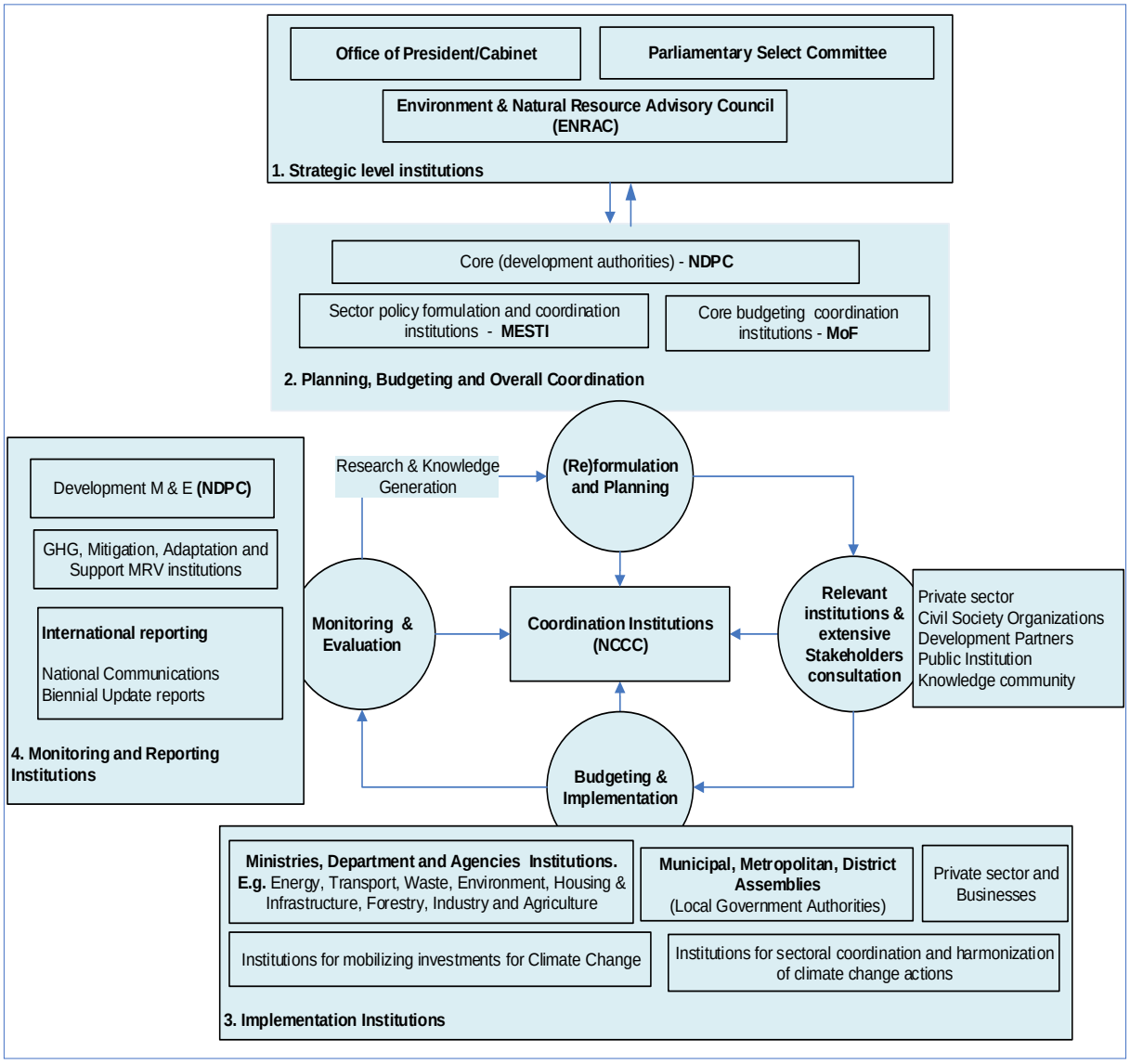


Figure 2: Institutional arrangements for the coordination and implementation of climate change activities

2.2.1.3 Recommendations for future improvements in the institutional arrangements

- *Implementation of institutional arrangements*–roll out the proposed institutional structure to full implementation.
- *Strengthening data handling and management* - Facilitate continuous update of data through regular exchange of data from the primary data providers using the online database.
- *Continuous training* - Organize regular tailor made training programme for national experts, public data providers, private data owners, potential users of the national communication report and new experts who join the process.
- *Further mainstreaming* - Identify the challenges associated with the existing institutional arrangements and where possible, put in place new measures to ensure greater participation involving other relevant bodies.

2.2.2 Key development policies and measures relevant to climate change

Ghana government goal for addressing climate change in the medium to long-term is articulated in the Ghana Shared Growth and Development Agenda (GSGDA). The effective implementation of the GSGDA requires the development of policies and legislative instruments by the various MDAs. Some of the key policies and legislation that are relevant to climate change are provided in table 2.

Table 2: Climate change related national policies, legislation and measures

Sector	Policy	Legislation/ Measures/Instruments	Comments
Ministry of Finance	National Policy on Public Private Partnership		Mobilizing public and private financing to support infrastructure and service delivery.
	National Budget Guidelines	Local Government Act, 1993 (Act 462), Financial Administration (Act 654)	Guide MMDAs in the budgeting for Climate Change activities in their annual budgets.
	Environmental Fiscal Reform Programme	15% Environmental tax on plastics with exemption on pharmaceutical and agricultural sectors	Mobilize funds at the national level to support proper waste disposal.
NDPC	Decentralized planning system	National Development Planning System Act, 1994 (Act 480)	Relevant to mainstreaming of climate change to national, sector and district medium term development plans
Environment	National Climate Change Policy	Is no measure anticipated by way of instruments and legislation	Framework for addressing climate change. Complement efforts of NDPC to facilitate mainstreaming of climate change.
	National Environment Policy		Framework for addressing environment. Complement efforts of NDPC to facilitate mainstreaming of environment.
	Environmental Assessment	Environmental Assessment Regulations, 1999 (L1 1652))	Addressing climate change issues at the project level through permitting and licensing.
		Strategic Environmental Assessment	Strategic level mainstreaming of environment into development policies, plans and programme.
	Akoben Programme	Environmental Protection Agency Act, Act 490	Performance and disclosure rating system for industry, mining and oil marketing companies.
Ministry of Local Government and Rural Development	Local Government Policy	Functional Organizational Assessment Tool (FOAT)	M & E system that evaluates the performance of MMDAs in relation to compliance with Government Policies, rules, regulations and procedures in carrying out their mandated functions. Climate change indicators are part of the assessments.
Ministry of Power	Energy Policy	Renewable Energy Act Feed-in-tariff scheme Renewable Energy Fund	Provide framework for renewable energy promotion.
		National Energy Fund	Funding for energy research and seed capital for development of renewable systems.

		Energy Efficiency Standards and Labeling Regulations, 2005 (LI1815), Energy Efficiency Standards And Labeling (Household Refrigerating Appliances) Regulations, 2009 (LI 1958)Energy Efficiency Standards And Labeling (Household Refrigerating Appliances) Regulations, 2009(LI 1958)	Obligation to display a label, which indicates the energy efficiency rating of the product before the first retail sale. It is an offence under LI. 1815 to import, display for sale or sell Air Conditioners and Compact Fluorescent Lamps in Ghana unless they meet the minimum performance standards and are properly labeled.
		Energy Efficiency Regulations, 2008Regulations, 2008 (LI 1932)	Prohibition of Manufacture, Sale or Importation of Incandescent Filament Lamp, Used Refrigerator, Used Refrigerator-Freezer, Used Freezer and Used Air-Conditioner
		Automatic utility and petroleum price formulae	Phasing-out of subsidies on utility and petroleum products
Transport	National Transport Policy	10-year over-aged vehicle importation tax	Disincentive for importing over-aged vehicles.
		Annual road worthy certification for all vehicles	Yearly physical inspection of vehicles before road worthy certificates are issued.
		Motor Emission Standards	Proposed standards for mobile and stationery engine emissions and fuel economy.
Forestry	National and Wildlife Policy	Stumpage Fees	Surcharge on timber
		Annual allowable cuts	Cut off threshold of volumes of timber harvested every year
		Ban on chain saw operations	
		Timber certification	Implementation of timber certification through the Voluntary Partnership Agreement with the EU
Waste Management	National Environmental Sanitation Strategy and Action Plan	MMDAs Bye-laws.	
Manufacturing industry		Environmental Assessment Regulations 1999 (L1 1652)	Promotion of cleaner production
		Environmental Protection Agency Act, 1994 (Act 490)	
Ministry of Communication		Ghana Meteorological Agency Act 2004(Act 682)	Weather forecasting, early warning, provision of metrological services

2.3 Geographic profile

Ghana, with a total land area of 239,460km^2 is located in West Africa on the Guinea Coast and lies close to the equator between latitude 11.50N and 4.50S and longitude 3.50W and 1.30E. The country has seven distinct ecological zones (see figure 3).

About 70% of the total land area of Ghana is used for agriculture. Figure 5 shows the composition of land uses in Ghana. Between 1961 and 2011, agricultural lands increased from 51% of the total land area of Ghana to 69.9% (World Bank, 2014). Forest lands, between 1990 and 2011, fell from 36.7% of the total land area of Ghana to 21.2% (World Bank, 2014). Agricultural irrigated land constitutes only 0.2% of total agricultural land. Agricultural machinery use is 4.5 tractors per 100sq. km of arable land. The country is made of two broad ecological zones. The forest zone covers much of the southern 30% of Ghana, whereas the savanna zone covers the drier northern 70% (MLNR, 2012).

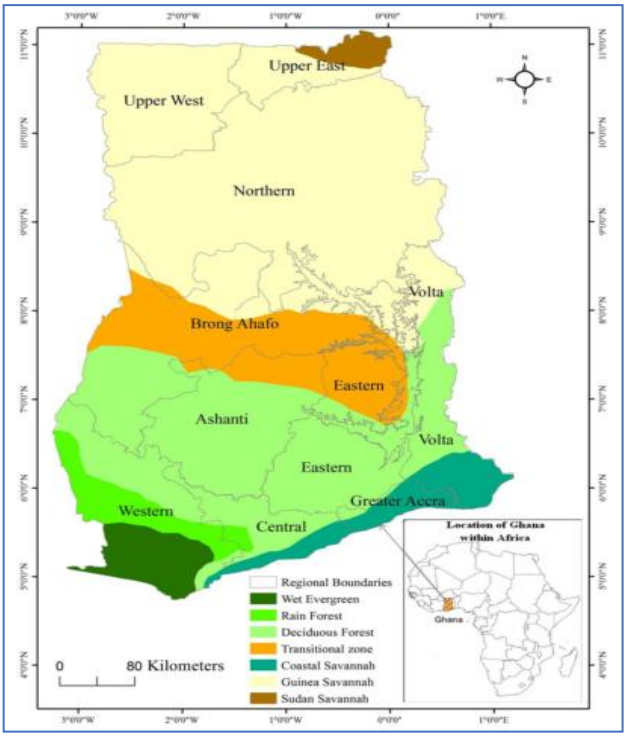


Figure 3: Map of Ghana showing Eco-zones

2.4 Climate profile

Ghana's climate is tropical and strongly influenced by the West Africa monsoon winds. The climate is generally warm with variable temperatures masked by seasons and elevation. The northern part of the country generally records one rainy season, which begins in May and lasts until September. Southern Ghana on the other hand records two rainy seasons from April to July and from September to November. Several recent ensemble models have confirmed that the temperature has increased by 1.0^{O}C since 1960, at an average rate of 0.21^{O}C per decade (see figure 4).

The rate of increase has generally been more rapid in the northern regions of Ghana than in the south. Between 1960 and 2003 - (a) the average number of 'hot' days per year has increased by 48 (an additional 13.2% of days) (b) the number of hot nights per year increased by 73 (an additional 20% of nights), (c) the frequency of cold days per year has decreased by 12 (3.3% of days) and the number of cold nights per year has decreased by 18.5 (5.1% of days). Annual rainfall is highly variable on inter-annual and inter-decadal timescales. This means that long-term trends are

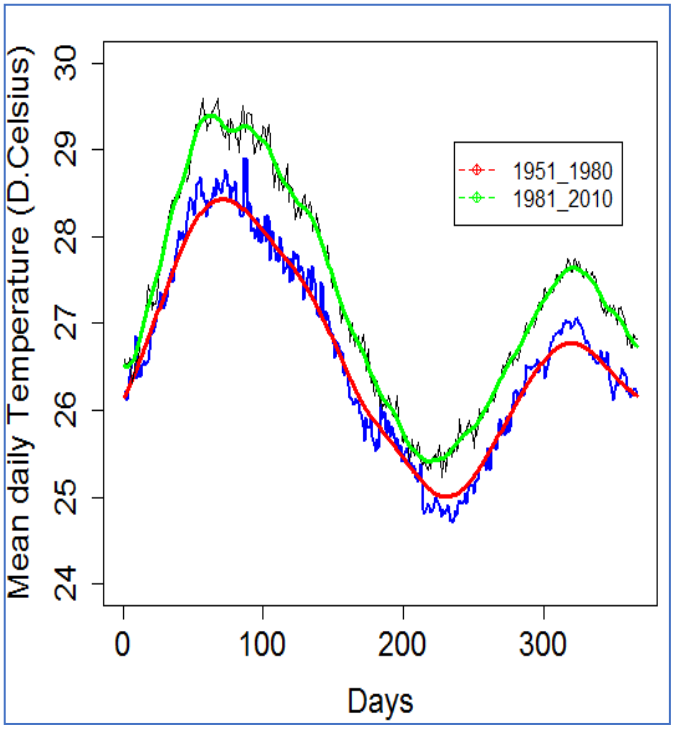


Figure 4: Mean annual temperature cycle

difficult to identify. Rainfall was particularly high in the 1960s and decreased to relatively low levels in the late 1970s and early 1980s, which represented an average of 2.3mm decrease per month per decade between 1960 and 2006. There is no evidence of a trend in the proportion of rainfall that falls in "heavy" events since 1960.

2.4.1 Climate projections in Ghana

Ghana will continue to get warmer

a. Mean temperature is projected to increase by 1.0-3.0^{O}C by 2060, and 1.5^{0}C to 5.2^{O}C by the 2090s. The projected rate of warming is more rapid in the northern inlands than the coastal regions.
b. All projections indicate substantial increases in the frequency of days and nights that are considered 'hot'. There are likelihoods that 'hot' days will occur on 18-59% of days by 2060.
c. Most projections indicate decreases in the frequency of days and nights that are considered cold.

Rainfall will continue to be uncertain and difficult to predict.

a. Projections of mean annual rainfall from different models predict wide range of changes. About half of the models predict increases while the other half project decreases.
b. The proportion of total annual rainfall that falls in heavy events tends towards an increase in the ensemble projections.
c. Projected changes in 1-and 5-day rainfall maxima trend towards increases, but projection ranges between both increase and decrease in all seasons.

Sea level rise will continue intensely in already vulnerable coastal areas

a. Scenarios of sea level changes with respect to 1999 mean, predicts an average rise of 5.8cm, 16.5cm and 34.5 cm. by 2020, 2050 and 2080 respectively.

2.5 Demographic profile

As at 2010, the total population of Ghana stood at 24,658,823, comprising 12,633,978 females and 12,024,845 males (GSS, 2012) as shown in table 3. The population pyramid for the two census years (see figure 5) depict a typical scenario in developing countries, with a broad base denoting a youthful population, and a narrow apex, indicating fewer aged persons.

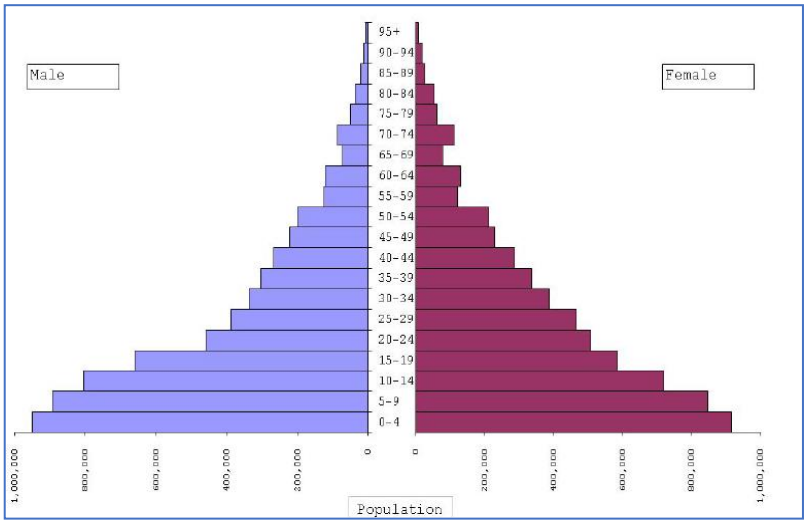


Figure 5: Age structure by sex and age groups (Source: GSS, 2012)

The average annual population growth rate has decreased from 2.8%, 2.6% to 2.4% in the 80s, 90s and 0 0s respectively although it is still amongst the highest in the West Africa sub-region. With an average

annual growth rate of 2.4% per annum, Ghana's population is projected to reach 49 million by 2040. There are nearly 5.59 million households with an average size of 4.4 persons per household. Currently, Ghana's population is largely urban with 56.2% of all persons residing in urban areas, while 43.8% reside in the rural areas. The high urban population with annual growth of 4.2% means many people are migrating to urban areas (see figure 6). Greater Accra has the highest proportion of migrants (60.3%) (GSS, 2014). The steady rise in rural-urban migration further compounds the challenge of overstretched infrastructure and services in the urban areas. The overall implications are that as more people leave the rural areas to seek better lives in the cities, agricultural productivity declines.

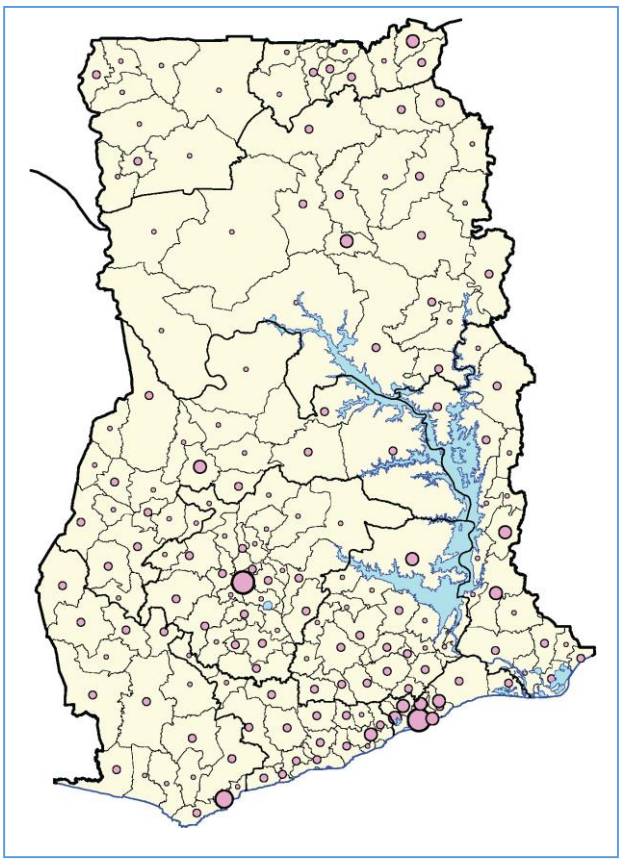


Figure 6: Population distribution by districts and region. (Source: GSS, 2012)

About a quarter of Ghanaians are poor whilst under a tenth of the population live in extreme poverty. Greater Accra is the least poor region and the Upper West in the dry savannah is the overall poorest (GSS, 2014). Between the periods 1991-2013, general poverty level reduced from 51.7% to 24.2%. The incidence of extreme poverty reduced by 8.1% from 2005/06 revised extreme poverty incidence of 16.5%. Extreme poverty is also a rural phenomenon, with as many as over 1.8 million persons living in extreme poverty in rural areas (GSS, 2010). Extreme poverty is particularly high in the rural Savannah at 27.3% and this locality accounts for nearly three-fifths of those living in extreme poverty in Ghana. An estimated 12 million Ghanaians live in the savannah dry lands and coastal belt (560km stretch), which are considered the most vulnerable to the impacts of climate change.

Table 3: Demographic indicators and population growth trends rates in the 2010 population and housing census

Indicators	Population (million)				Project Population in 2040 (000s)	Mean Income/ Household (Gh₵)
	1990	2000	2010	2012		
Ghana	14.73	19.17	24.23	25.87	54.19#	1,217
Urban	5.39	8.27	12.02	13.05#	41.30#	1,415
Rural	9.34	10.90	12.21	12.82#	12.89#	1,067
Population largest city	1.20	1.67	2.42	2.47	3.36	
Access to electricity (% of population)	48.5	60.5	70.3	70.7	90	
Population living within the 560km coastal belt			12,000			

#: Projected population based on growth

2.6 Macro economy

Ghana is endowed with natural resources such as deposits of gold, diamond, manganese and bauxite. In addition, Ghana also has significant arable lands and forests, and recently commenced commercial production of oil. These are the major natural resource base that support economic growth of the country. Ghana's major export commodities are crude oil, cocoa, minerals, timber and electricity. In 2011, the total oil production was estimated at 24,195,895 barrels (an average of 66,290 barrels per day) all of which was lifted offshore. A total of 2,220,546.09 MMBtu of associated gas was produced from the oil fields some of which were either re-injected or flared. Latest estimates put the cost of environmental degradation at 9.7% of GDP. The country has largely experienced stable and consistent economic growth since 1960. The size of the Ghanaian economy has expanded by nearly 97% with the GDP increasing from USD1.2 billion in 1960 to USD 35.9 billion in 2012 in real terms (Ministry of Finance, 2012). The expanding trend in the economy corresponds to the rising energy and greenhouse gas emission intensities especially in the last couple of years (see table 4). As the economy expands and population grows, lots of energy resources are utilized to meet the growing demand in industry, transport and households.

Table 4: Macroeconomic indicators relevant to greenhouse gas emissions and removals in Ghana

Indicators	1990	2000	2006	2010	2012	Change 1990-2012 (%)	Change 2010-2012 (%)
Population (million)	14.43	18.91	21.93	24.66	25.91	79.6	5.1
GDP (Constant 2005 USD billion)*	5.51	8.39	11.42	14.80	18.52	236.1	67.5
Total Primary Energy Supply (Mtoe)**	5.29	7.74	9.06	9.32	11.77	122.5	26.3
Final Energy Consumption (Mtoe)***	4.31	5.41	6.01	6.46	8.16	89.3	26.32
GDP per capita* (Current USD thousand)	0.4	0.26	0.93	1.33	1.6	300	20.3
TPES per capita (toe)	0.37	0.41	0.41	0.38	0.45	21.6	5.7
Final Consumption per capita (toe)	0.30	0.29	0.27	0.26	0.31	3.3	19.2
GHG emissions per capita (t CO_2 e)	0.39	0.45	0.57	0.64	0.71	82.1	10.9
GHG emissions per GDP unit (kg CO_2e /2005 USD)	1.02	1.03	1.09	1.06	1.00	-2.0	–5.7
Energy Intensity (toe/2005 GDP)	0.96	0.92	0.79	0.63	0.64	-33.3	1.6

* Source: World Bank, National Account (2014), ** Source: International Energy Agency, *** Source: National Energy Statistics.

Ghana attained Middle Income Country (MIC) status in November 2010 after rebasing the economy. With the revised GDP estimates, GDP/capita has increased from USD1, 067 in 2000 to USD 1,652 in 2011. In the past 20 years, growth has accelerated, averaging 6.4% per year over the past ten years, except in 2011, when the GDP growth spiked at 14.4% after the addition of the oil and gas revenues (Ministry of Finance, 2012). The GDP (oil and non-oil) is projected to stabilize between 5%- 8% beyond 2015 because of the overall improvements in economic outputs of the productive sectors, which are (a) services (48%); (b) Industry (22%); (c) Agriculture (23.1%); Manufacturing (6%) (GSS, 2012).

2.6.1 Economic/fiscals instruments relevant to climate change

2.6.1.1 Environmental fiscal reforms (Draft Legislation for Ghana Green Fund Act)

Ghana is currently formulating national legislation leading to the setup of the "Ghana Green Fund". The objectives of the Fund are to:

- Facilitate, co-finance and channel investments required to implement adopted environment and climate change policy and law, including investments in climate change adaptation & mitigation, waste management, industrial pollution & resource use, sustainable forestry, biodiversity & nature protection, sustainable transport, as well as other sectors covered by environmental and climate change policy;
- Leverage commercial and foreign finance for environmental and climate change investments;
- Develop capacity of stakeholders in the areas of project preparation, project appraisal and project finance, enabling Ghana to absorb larger amounts of environmental and climate change investment finance and;
- Support, through Fund investments, the sustainable development of Ghana, including respective investments in infrastructure, industry, tourism, agriculture, fishery and safeguarding the economic and social interests of those who live and work in the country (MoF, 2014).

The fund shall be governed by the Ghana Green Fund Board of Directors and the Ghana Green Managing Director in accordance with the provisions of the proposed Act, the Fund Regulations and other applicable laws and regulations. The initial capital of the Fund shall be GHS 5,000,000 (equivalent of USD 1.4million at an exchange rate of 3.7). The proposed fund shall receive the following types of revenues:

- Allocations to the Fund from national and sub national government budgets to form or increase the capital of the Fund and/or to occasionally co-finance specific investment programme of the Fund;
- Donations to the Fund from foreign, bilateral and multilateral organizations;
- Voluntary contributions and donations to the Fund;
- Revenues from taxes, royalties, duties, sale of natural resources, charges, fees and fines earmarked to the Fund in compliance with the law;
- Credits from banks or investors, provided that these are used exclusively to co-finance Fund projects and programme according to Section 11, paragraph 3 of the Act. Such credits may not exceed the capital of the Fund and;
- Revenues and receipts from managing free resources of the Fund and (g) other sources of funds in compliance with the law.

2.6.1.2 Ghana climate innovation centre (GCIC)

The objective of the GCIC is to establish local institutional capacity to support Ghanaian entrepreneurs and new ventures involved in developing profitable and locally appropriate solutions to climate change mitigation and adaptation. Through its programmes, activities and financing, the GCIC and its network of partners and stakeholders will provide a country-driven approach to solving climate, energy and resource challenges and support economic development through job creation. The USD 17.2 million programmes will provide targeted support, mentoring, training and funding facilitation to up to 100 companies in Ghana over 5 years (World Bank, 2014). Initial funding for GCIC is from the Danish Government through

the World Bank. The total investment required is USD 17,206,500 of which USD 10m expected contribution from DANIDA.

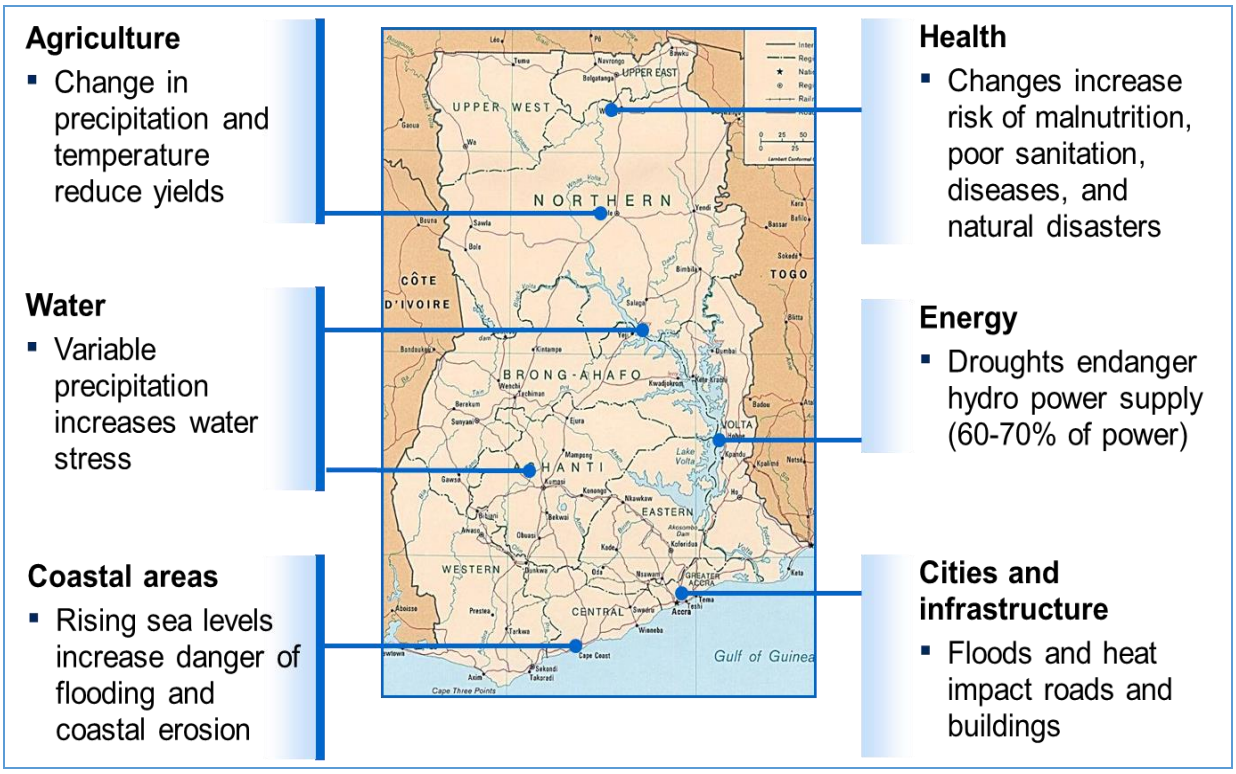
The sectors of focus are:

- Energy efficiency (industrial and household),
- Domestic waste management,
- Solar energy,
- Water supply management and purification and;
- Climate smart agriculture.

Through modeling the GCIC's deal flow using benchmarks from company data in the region, it is projected that after 5 years, revenues of up to 100 GCIC-assisted companies will generate the equivalent of approximately USD 28.6 million in economic impact. This will assist up to 304,000 people to increase their resiliency to climate change through providing increased access to cleaner sources of energy and better and more efficient sources of water and agricultural resources. In the long term (over 10 years), assuming continued financial support, it is projected that GCIC-supported ventures will generate close to 10,720 cumulative jobs and mitigate over 661,598 tons of CO_2e.

2.7 Major climate change vulnerabilities

Ghana faces significant challenges of the negative impacts of climate change which directly or indirectly affects ecology, economy and society. The pervasiveness of the impact of climate change is generally influenced by the type of economic sectors, geographic spread (ecological zones) and poverty levels. Figure 8 shows the spread of key climate vulnerabilities in specific localities in the country. Some of the key adaptation efforts are in following areas (a) health sector, (b) sustainable land and water management, (c) root and tuber improvements, (d) community early warning systems, (e) improved water storage etc.



2.8 Natural resources availability and dependency

Ghana's natural resource base accounts for vast portion of the country's economy. About half of the economic outputs from the following sectors are dependent on natural resources - agriculture and livestock (29%), forestry and wood processing (7%), fisheries (4%), electricity and water (3%) and tourism (5%) (World Bank, 2006).

2.8.1 Freshwater resources

Freshwater covers nearly 5% (11,800km^2) of the total land area of Ghana (EPA, 2004) made of the Volta, South Western and Coastal river systems. Table 5 shows the surface freshwater systems in Ghana. The total annual run-offs are 54 billion m^3 of which 37.8 billion m^3 originates within Ghana and 16.2 billion m^3 outside Ghana. The amount of ground water is determined by geology of the basin. The yield varies from 45m^3/h to 18m^3/h in the Voltaian formation and the limestone aquifers located in the southeastern and western part of Ghana. The total annual recharge is estimated between 157.7mm and 195mm. There is

an estimated 30.3 billion m^3 of renewable internal freshwater resources (World Bank, 2012) with a declining per capita of 1,935.4cm^3 in 1992 to 1213.7cm^3 in 2011. An average of 0.982 billion m^3 is withdrawn annually to support economic activities: The major economic uses of freshwater are for the following: (a) hydroelectric generation (require 37,843million m^3/year), (b) agriculture (livestock watering and irrigation – 66.4%, (c) industry (9.67%) and (d) domestic (23.93%) uses. Freshwater resources are at risk because of (a) inappropriate management, (b) high rates of logging, (c) fuel wood extraction, (d) poor agricultural practices, (e) surface mining, (f) desertification and (g) above all negative impacts of climate variability and change. This is leading to increasing rural poverty as well as high sensitivity to human and natural disasters.

Table 5: Surface freshwater systems in Ghana

Drainage systems	River Bodies	Catchments	Comments
Volta river	Black Volta, White Volta, Oti, Daka, Pru, Sene, Afram and Oti	70% of freshwater coverage	Least run of 146,000m^3/km^2/year
South Western	Bia, Tano, Offin Ankobra and Pra rivers	22% of freshwater coverage	Highest run off of 245,000m^3/km^2/year
Coastal	Ayensu, Densu, Ochi-Amissah, Ochi-Nakwa, and Tordzie/Aka rivers	8% of freshwater coverage	202,000m^3/km^2/year

Source: Adapted from Bawakyillenuo and Asante, 2012

2.8.2 Land-based resources

2.8.2.1 Agricultural and non-agricultural land uses

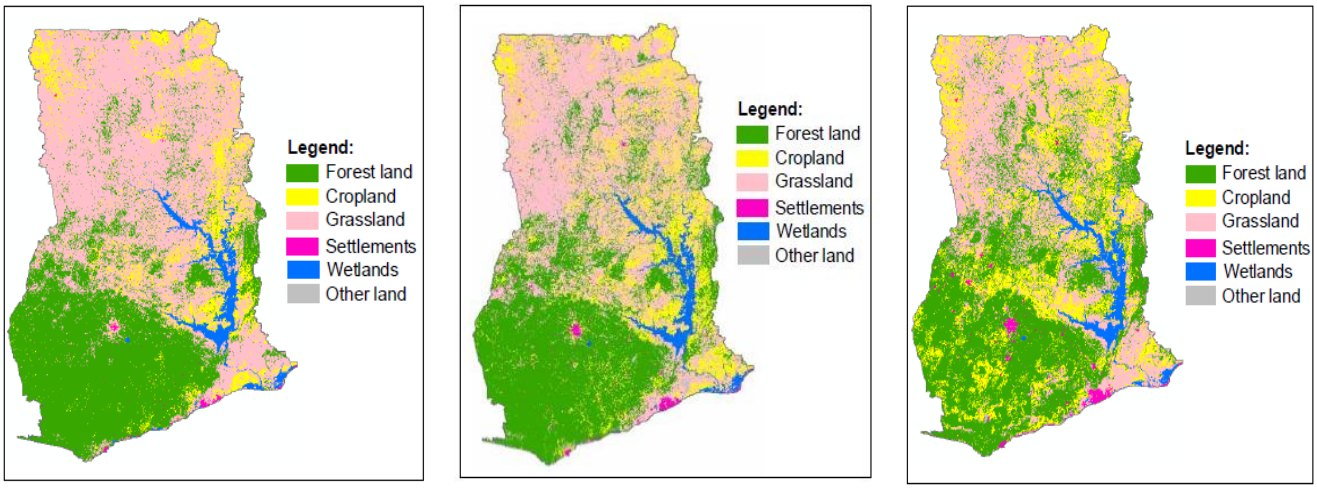
Land use other than cultivation for the production of food is classified as non-agricultural land use. These include: forestry, wildlife, mining, settlements, industrial estate development, military and defense, transport networks etc. It has been estimated that the total agricultural land use of Ghana was about 70 % of the total land area of the country in 2011, representing about 0.44 increase over 2010 (FAOSTAT, 2013). The rest of the land space is shared among other non-agricultural use (forest and others). Forestlands have dwindled by 0.51% from 2010 to 2011, while other land use has increased by 0.07%. This confirms that land use is not static and over the past century, there has been visible shift of forestlands to agricultural and other settler-oriented projects. Cocoa farming and food crop production have been the dominant land use in the high forest zones (HFZs) of Ghana. In the savannah woodlands, food crop production, grazing lands and charcoal burning have been the dominant land uses.

2.8.2.2. Non-Agricultural lands

Forest resources

There are two main types of natural forest in Ghana: the closed forest located in the southwestern and middle belt and Savannah forest found in the north. Apart from environmental and ecological functions, the forest sector contributes about 6% to Gross Domestic Product (GDP), employs about 2.5million people and exports wood products worth about $200million annually (source). Nearly 60% of total primary supply comes from biomass (wood fuel and charcoal). Ghana's total forest cover has dwindled from 8.2million hectares at the turn of the last century to less than 1.6million hectares in 2011. The decline in the forest

cover is mainly due to human-induced deforestation estimated at, 2% per annum (MLNR, 2012) (see figure 9). The condition of Ghana's forest has been in decline for many years, particularly in the 1970s (FC, 2010). Many forest reserves are heavily encroached and degraded, and the off-reserve stocks are being depleted. The problem largely is one of gradual degradation of the forest reserves rather than deforestation; and is incremental and not dramatic with no single driver. FC, 2010 identified the key agents of deforestation and forest degradation as: agricultural expansion [c.50%], harvesting of wood [c.35%], population and development pressures [c.10%] and mineral exploitation and mining [c. 5%]. There are, however, differences in the high forest zone and savannah areas. Being drier and more open in the savannah, fires and overgrazing play more important role than in the high forest zone; charcoal production is also important is focused on specific areas of the country.



Wood removal for fuel wood and charcoal production is estimated at 30 million m3 per year, whilst forest timber logging and harvesting from the regulated sector amounts to 3.72 million m3 per year for export and 1.8million m3/year by predominantly illegal logging for the domestic market (Euronet Consulting, 2012). Fuel wood extraction is projected to increase from 18 million tons in 2000 to 25 million tons in 2020 (ISSER, 2013). Ghana's total terrestrial carbon stocks are estimated as 2.04Gt comprising 1.6Gt in above and below ground and about 0.34Gt in soils to 1m depth. Between the savannah and forest zones, carbon stocks ranges from 30.88-93.47MgC/ha to 28.64MgC/ha -34.05MgC/ha. In cultivated areas within the high forest zones, soil carbon stocks ranges from 28.27MgC/ha -72.7MgC/ha where as those in the savannah areas have carbon stocks that range from 18.46MgC/ha-32.04MgC/ton. Mangrove distributions along the Ghanaian coast are quite substantial. Mangrove above ground biomass ranges from 378-2077MgC/ha for undisturbed, with degraded mangrove areas, carbon stocks ranges from 146.88-529.59MgC/ha. The estimated percentage of total land area of Ghana prone to desertification is 64.97% representing about 165,000km^2 with the Upper East and eastern part of the Northern Region facing the greatest desertification threat on an area of about 78,718 km^2 (Dorm-Adzobu, 2010).

2.8.3 PaMs in the AFOLU (Land) sector relevant to GHG emissions

2.8.3.1 Summary of GHG emission trends in the AFOLU (Land) sector

The total emissions from land increased from 3.02 $MtCO_2$ in 1990 to 18.4 $MtCO_2$ in 2012. The key drivers are structural changes in Ghana's economy which has led to deforestation from the following: (a) increases food production through expansion croplands (b) forest to grassland conversions due to fires through animal grazing or unintended wildfires (c) increases in demand for wood and wood products.

A. National forest plantation development programme (NFPDP)

In order to address the high rate of deforestation and forest degradation in Ghana, government reintroduced the national plantation development programme in 2010. This PaM seeks to (a) restore the forest cover of degraded forest lands, (b) generate employment as means to reduce rural poverty and (c) reduce the wood deficit situation in the country at a rate of 20,000ha/yr. The NFPDP has been revised to allow private sector participation under the Expanded Plantation Programme. The targets for 2012 were: 10,700 ha of degraded lands planted both on and off reserve, maintenance of 20,990.91 ha of 2010. For 2011 the targets were: 10,000ha of degraded lands planted and maintenance of 57,000 ha of established plantations.

B. Emission reduction programme (ERP) – Ghana cocoa REDD+ programme

The aim of the Ghana Cocoa REDD+ Programme is to reduce degradation and deforestation in a manner that hopes to foster a more sustainable, climate smart cocoa sector and landscape. This programme is part of the Ghana FCPF under the World Bank. Maintaining a singular focus on cocoa as a driver, however, is not sufficient. The proposed ERP will therefore address other key drivers in the programme's landscape, which can be tackled and can benefit from the cross-sectoral, public-private engagement that the programme will align. Ghana's Cocoa Forest REDD+ programme is globally unique and highly ambitious in its scope and scale.

The programme seeks to significantly reduce emissions across the HFZ that are driven by cocoa farming and other key drivers to secure the future of Ghana's forests, significantly improve livelihoods opportunities for farmers and forest users, and establish a results-based planning and implementation framework through which the government, the private sector, civil society, and local communities can collaborate. The proposed programme will have the following planned activities (a) activities to reduce emissions from cocoa and other agricultural drivers, (b) activities to reduce emissions from illegal logging (c) activities to reduce emissions from illegal mining. These interventions are expected to avoid a total of 598,2$MtCO_2e$ emissions from deforestation. Overall, the programme could generate significant carbon revenue, in excess of USD 227 million for the period 2021-2025.

C. Forest investment plan (FIP)

This is one of Ghana's PaM to reduce emission from the forestry sector. The FIP seeks to support Ghana's efforts to reduce emissions from deforestation and forest degradation (REDD+) by financing activities to address the drivers of deforestation and degradation ($50 million). The Ghana Forest Investment Plan (FIP) deal directly or indirectly with key drivers of deforestation. The objective of FIP is to achieve transformational impact, i.e. reduce carbon emissions, enhance forest carbon stocks, and deliver co-benefits. The FIP, approved in December 2012, has three main projects distinctively supported by WB, AfDB and IFC. These are:

- Reducing pressure on natural forests through an integrated landscape approach and increasing wood production and carbon stocks through, rehabilitation of natural forests (WB),
- Engaging local communities in REDD+ / Enhancing Carbon Stocks and focusing on promoting climate SMART agriculture including more sustainable cocoa production based on conservation and sustainable management of natural forests (AfDB)
- Engaging the private sector in REDD+ by developing industrial and fuel wood plantations (IFC).

2.8.4 Mineral resources

There are also unexploited economic deposits of iron ore, limestone, kaolin, feldspar, silica sand, and others[8]. Mineral exploitation has been very vital for the socio-economic development of Ghana (see figure 7). In 2010 for instance, 49.2% of Ghana's export earnings came from mineral resources with 3.3% a contribution to GDP (ISSER, 2011). The commencement of commercial exploitation and export of Ghana's crude oil saw significant increase in the sector's contribution to GDP from 2011.

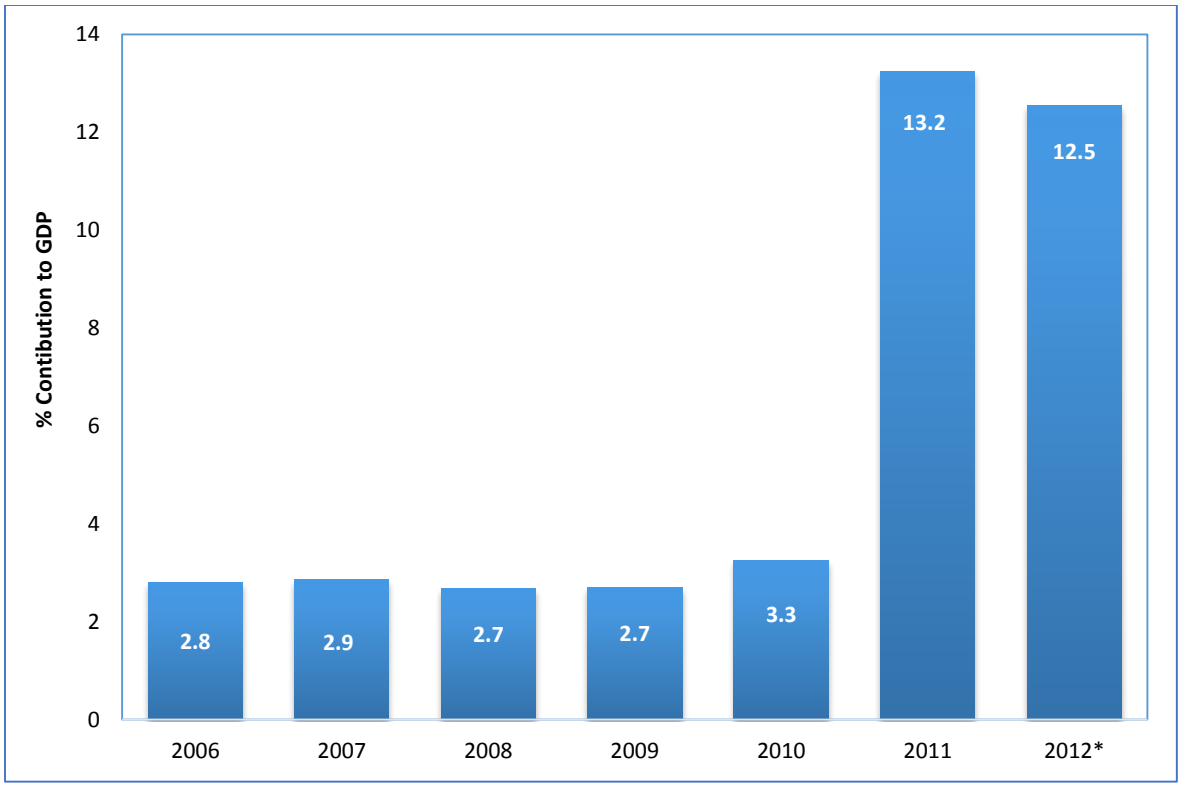


Figure 7: Contribution of mining and quarrying to GDP including oil and gas
Source: Ghana Statistical Service, 2012

Noting the possible negative impacts of mining on the country as a whole, the Ministry of Lands and Natural Resources has facilitated the passage of the Mineral Development Fund Bill to help address developmental issues in mining communities. Also, there has been the establishment of Regional Task Forces to complement efforts by the National Security to deal with the illegal mining situation in the country (GoG, 2013).

[8] See www.ghana-mining.orgwww.ghana-mining.org (Accessed: 23/02/13)

2.8.5 Biodiversity and ecosystem resources

Biological resources in Ghana are estimated as follows: 2,974 indigenous plant species, 504 fishes, 728 birds, 225 mammals, and 221 species of amphibians and reptiles (Allotey, 2007). There are 16 legally constituted wildlife reserves, covering about 5.3% of the country's total land surface area (GoG, 2010). The ecosystem goods and services that are derived from the biological resources offer unique economic opportunities to ecotourism, medicinal plants, non-timber forest product etc. Human induced fragmentations and degradation of the biologically diverse landscapes are some of the major threats to the conservation of the biological resources and ecosystem services. Ghana's high forest zones fall within the West African Biodiversity Hotspot identified by Conservation International.

2.8.6 Agricultural lands

2.8.5.1 Agriculture

The Agricultural sector is made up of (a) crops including cocoa, (b) livestock, (d) forestry and logging and (e) fishing. The growth of the Agricultural sector declined significantly from 5.3% in 2010 to 0.8% in 2011. Agriculture is predominantly practiced on small scale using simple technology and depends heavily on rainfall. The use of irrigation to counter the effects of poor rainfall is particularly low across the country. By 2002, the total area under formal irrigation was around 11,000 hectares whereas the potential area, including inland valleys that could be developed for irrigation, is estimated at 500,000 hectares.[9] Although the output of cassava is increasing, a projection using climate scenarios and crop model (CROPSIM-cassava and CROPGRO (ARGRO980-tanier) showed that, with increasing temperature and solar radiation, cassava and cocoyam productivity or yields would be reduced by 3% and 11%, 13.5% and 29.6%, and 53% and 68% in 2020, 2050 and 2080 respectively (Sagoe, 2006). Based on a 20-year baseline climate observation, it is projected that yields of maize and other cereal crop will reduce by 7% by 2050. As shown by table 6, the total estimates of agricultural land use of Ghana in 2010 was 13,628,179ha. About 57.6 percent of the total agricultural land area was cultivated through rain-fed and irrigation practices.

Available data from MOFA shows an increasing trend in the growth of the number of major livestock from 2006 to 2011.With the exception of pigs, which had no change in production; all the other livestock types had an increase in the number of herds in 2011. Cattle, sheep and goats increased by 0.69 percent, 1.13 percent and 1.12 percent respectively in 2011 (ISSER, 2012). The little available rangelands are therefore subjected to overgrazing and "planned" bush burning for grass regeneration. Socially, the insufficiency of rangelands has also led to the creation of friction between the Fulani herdsmen and food crop farmers in the country. Unfortunately overgrazing leads to desertification while especially large ruminants are sources of methane emission.

Table 6: Agricultural Land use of Ghana in 2010

Types of Land use	Hectares	Percent
Total Land Area	23,853,900	100
Agricultural Land Area	13,628,179	57.1
Area under cultivation (2010)	7,846,551	57.6
Total area under irrigation (2010)	30,269	0.2
Area not under cultivation (2010)	5,781,628	42.4

Sources: Adapted from MOFA, 2011

[9] Between 1 and 2 percent of the irrigation potential of the country has been developed (Bawakyillenuo and Kpieta, 2013 citing National Investment Brief, 2008).

2.8.5.2 Summary of GHG emission trends in the AFOLU (Livestock and Aggregated emissions source) sector

The total emissions from land increased from 3.02MtCO_2 in 1990 to 18.4MtCO_2 in 2012. The key drivers are structural changes in Ghana's economy which have led to deforestation from the following: (a) increases food production through expansion of croplands (b) forest to grassland conversions due to fires through animal grazing or unintended wildfires (c) increases in demand for wood and wood products, (d) some increases in fertilizer importation.

A. Sustainable land and water management programme (Savannah Zone)

The objective of the Sustainable Land and Water Management (SLWM) Additional Financing Project for Ghana is to expand the area under sustainable land and water management practices in selected watersheds. The additional financing will ensure the adoption of the sustainable land and water management practices aimed at reducing land degradation and enhancing maintenance of biodiversity in the Kulpawn-Sissili and Red Volta watersheds. The project will focus less on spatial planning at a large scale, with no additional financing towards it since the spatial planning activities are expected to be completed within the original timeframe. Component 2 originally included five sub-components which are now grouped into four sub-components for (i) systems, capacity and monitoring for SLWM; (ii) implementation of SLWM (sub-projects); (iii) national sustainable land management and Payment for Environmental Services monitoring and; (iv) management of biodiversity corridors. The project has potential to reduce total direct and indirect emission off 51,847tCO_2e per year over 20 years. The overall cost of the additional funding is USD 8.75 million.

2.8.6 Energy Sector

2.8.6.1 Energy resources

Ghana is relatively well endowed with a variety of energy resources including biomass, hydrocarbons, hydropower, solar and wind. It also has the capacity to produce modern bio-fuels. Biomass resources consist mainly of wood fuels from forest and woodlands, agro-waste and municipal waste. Electricity is mainly produced from hydro and thermal sources. The remaining hydro resources are only suitable for development into medium, small and mini-hydro plants. The country imports crude oil for refining and for thermal power generation. In 2012, a total of 1,209.5kt of crude oil was imported for refining and for power generation. Ghana's offshore and voltaic basins hold huge potential for oil and gas production. Commercial quantities of oil and gas have been discovered in the deep waters of the country and production started in 2010. Appraisals conducted on two discovered oil fields, the Deep-water Cape Three Points and Deep water Tano indicate that the fields contain expected recoverable reserves of about 800 million barrels of light crude oil, with an upside potential of about 3 billion barrels. As the economy expands and population increases, the trend of total primary energy and final consumption of energy recorded corresponding increases for the period 1990 to 2012 (see figure 8).

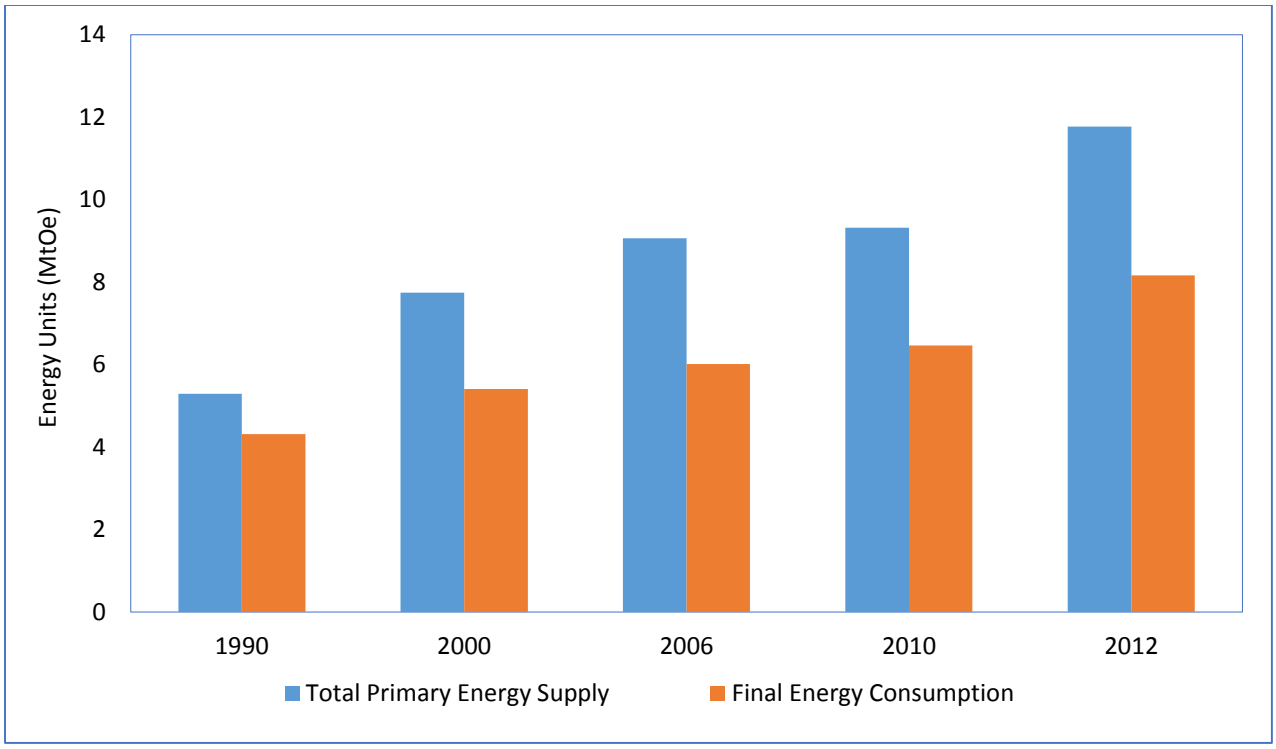


Figure 8: Total primary energy supply and total energy consumed

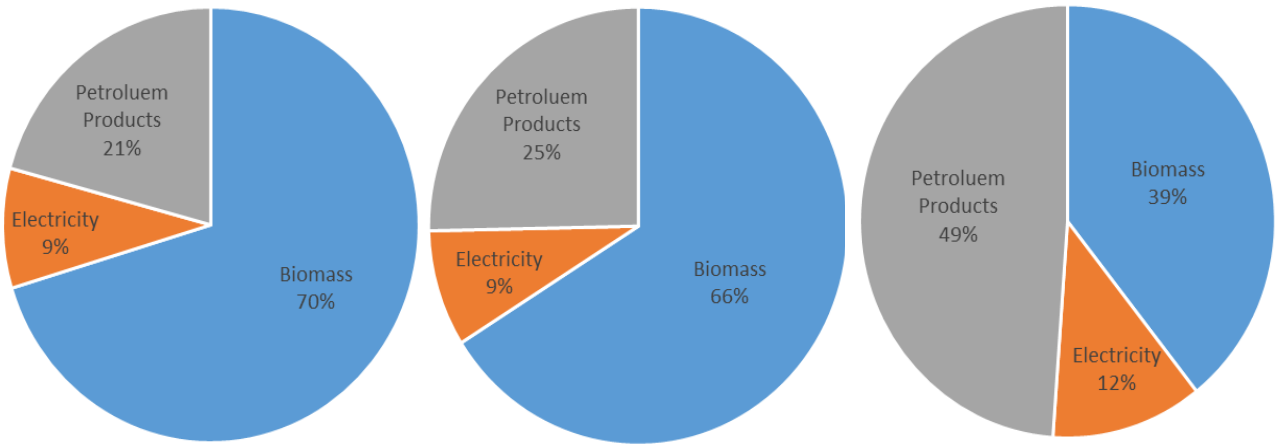


Figure 9: share of final energy consumption from 1990 (left), 2000(middle) and 2012(right)

The share of final energy consumption has shifted from biomass-dominant to petroleum product (see figure 9).

2.8.6.2 Renewable energy

The geographical location of Ghana makes it possible for the country to receive abundant sunshine, which could be harnessed for solar power generation. The average levels of solar radiation are estimated to be in the range of 4.4 - 5.6 kWh/m^2/day. The sunshine durations have been estimated to be between 1,800 – 3,000 hours per annum. Studies conducted indicate that the southeastern coastal portion of the country has good wind regimes that could also be harnessed for wind power generation. The average wind speed along the coastline is estimated to be between 6 and 7 meters per second at a height of 50 meters. The gross wind electric potential is about 5,600 MW representing 1,128km^2 (MOP, 2012)

2.8.6.3 Biomass energy

Biomass consists mainly of agricultural crops/residue, wood/wood waste, animal waste and organic component of municipal waste. Wood fuels (firewood and charcoal) continue to form a big proportion of the final energy consumption in Ghana (see figure 10). The main sources of wood fuel in Ghana are dead trees, forest clearings, logging residues and sawmill residues. Majority of the charcoal is produced using rudimentary methods such as the earth mounds which have a very low wood to charcoal conversion efficiency. Approximately six tonnes of wood yields 1t of charcoal when the inefficient earth mound method is used. It is estimated that in 2012, a total of about 11,387 kilotons of wood fuel was produced out of which a total of 6429 kilotons was consumed in the forms of firewood and charcoal. Firewood constituted about 78% of the total wood fuel consumed in 2012. Though the residential and the commercial sectors are the main consumers of wood fuel, large quantities of wood fuel is also consumed by the industrial sector as boiler fuels. It is estimated that with annual rainfall of 1,300 – 2,200mm, about 243PJ/yr. or 65,000GWh/yr. of wood fuel could be obtained from the existing tropical forests (MOP, 2012).

2.8.6.4 Electricity generation

In Ghana, electricity generation is from mainly hydroelectricity (Akosombo and Kpong) and thermal sources. This is projected to increase to 5,000MW by 2020. The electricity generation has moved from exclusively totally hydropower generation, to a mix of hydro and thermal generation (see figure 10). Ghana's total installed electricity generation has increased from 1072MW (only hydro only) in 1990, to about 2,280MW in 2012. The installed generation capacity of 2,280MW in 2012 consisted of 1180 MW of hydro and 1100MW of thermal. The total power generation in 2012 was 12,024GWh consisting of 8,071GWh hydro and 3,953GWh thermal. A third hydropower plant (Bui Hydro Plant) is expected to add 400MW to the existing hydropower generation capacity when it comes on stream in 2014. The country has developed all of the large hydropower potentials and is now left with only medium, small and mini potentials for future development. Ghana is considering several options for the diversification of its thermal electricity generation, which also include importation of coal to fire thermal plants.

The key hydro sites for future development are Pwalugu (48MW), Juale (87MW) and Hemang (75MW). The reliance on the hydroelectric dams also makes the country vulnerable to climate change and variability especially, in times of low rainfall. As shown in figure 10, there has been a significant increase in thermal power generation since 1997 when it was introduced into the country's electricity generation mix. Thermal power generation has increased from 35GWh in 1997 when it was fully introduced into the generation mix to about 3,954 GWh in 2012. The thermal power plants use Light Crude Oil (LCO), imported natural gas from Nigeria and occasionally diesel for power generation. It is expected that additional 100 Million Metric Standard Cubic Feet per day of natural gas will be available to augment thermal electricity generation from the gas processing plant at Atuabo in the Western Region of Ghana. Ghana's probable

reserves are estimated at approximately 5 Trillion cubic feet. Ghana Gas Company expects to receive between 70-120 Million Standard Cubic feet per day of gas from the Jubilee Partners.

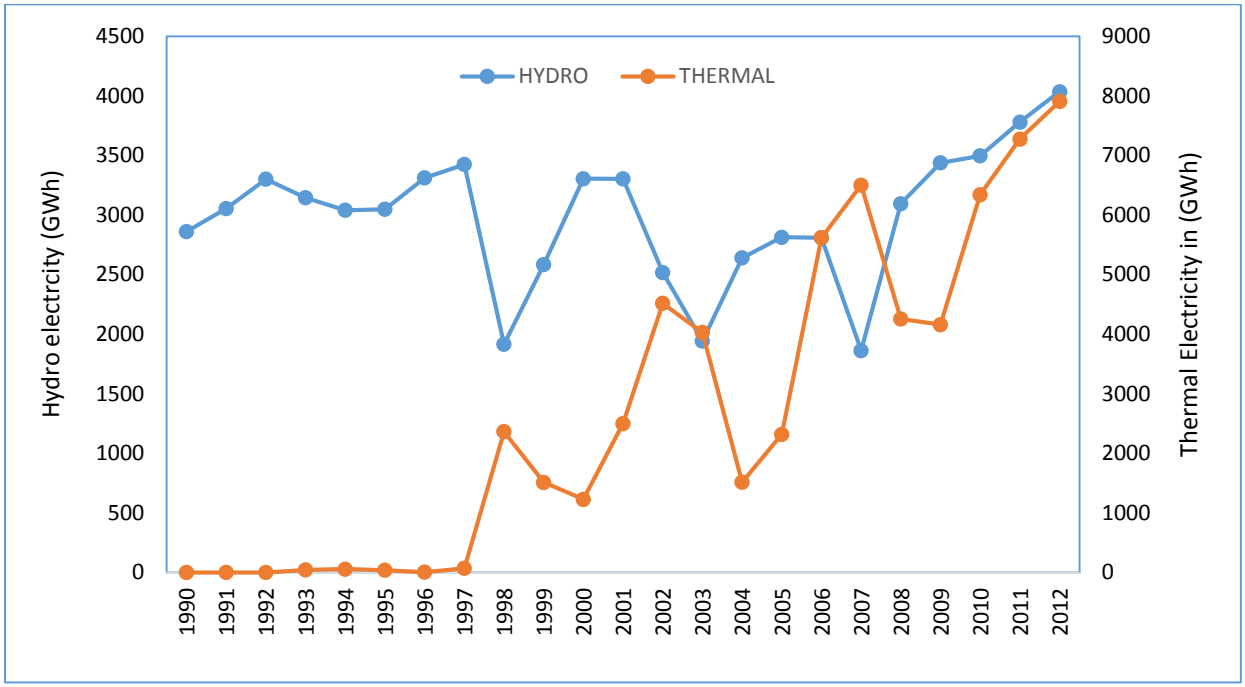


Figure 10: Share of hydro and thermal power generation (1990-2012)

With demand for public electricity currently standing at 1400MW and at 10% growth rate per annum, the World Bank, (2013) forecast is that, by 2022, the electricity generation capacity balance will still be dominated by hydroelectric, renewables and gas powered combined cycle thermal plants. Large investments in the region of US$4 billion are needed in the next 10 years to meet the expanding electricity demand.

2.8.6.5 Petroleum products

Ghana is a net importer of oil even though commercial production of oil started in 2010. The country imports four main types of petroleum products: crude oil, premium, gas oil and LPG. The importation of crude oil has been decreasing since 2008, with the sharpest decrease coming in 2009 (see figure 11). In 2010, the country imported about 11.75 million barrels of oil valued at US$ 942.23 million. This decreased to 11.4 million barrels of oil in 2011. The volume and values of other petroleum products such as premium, gas oil and LPG increased in 2011 over the 2010 levels. This is because the only oil refinery that produces petroleum products to augment the imports has not been functional to full capacity. The refinery has been fraught with cash flow challenges to the extent that it is no longer viable to continue operating the refinery until an efficient turn-around plan is put in place. The capacity of the refinery is 45,000 barrels per stream day. The refinery produces LPG, gasoline, diesel, kerosene and fuel oils for local consumption and for export. The same products are also imported to supplement local production. The refinery has installed a Residue Fluid Catalytic Cracker (RFCC) which further converts the residue from the Crude Distillation Unit (CDU) of the refinery into high value products such as LPG and high-octane gasoline. The refinery in addition to electricity uses petroleum coke, fuel oil and fuel gas for its operations.

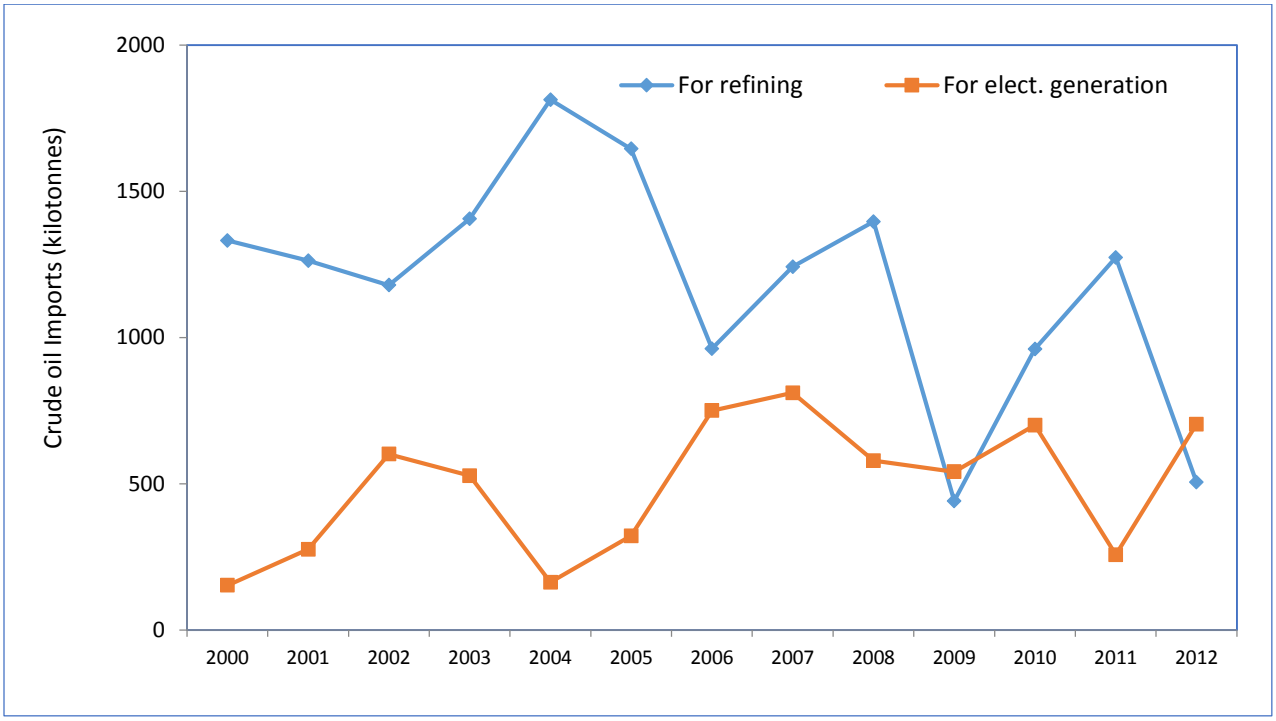


Figure 11: Trend crude oil imports for the period 2000 to 2012.

In 2010, Ghana started producing oil and gas in commercial quantities for the offshore market. Currently crude oil production stands at 100,000 barrels per day. A total of 26.4million barrels of crude oil were produced from the jubilee field in 2012 up from 24.2 million barrels produced in 2011. Currently, all the crude oil produced locally is exported. According to Ministry of Finance, (2013) from 2007 to date, 22 new hydrocarbon discoveries have been made in the offshore. This means that in the near future, the overall oil and gas production capacity in Ghana is likely to go up. In 2012, Ghana also started developing an integrated 59km offshore-pipelined gas infrastructure project. The gas processing plant is expected to kick-in by 2014.

2.8.6.6 PaMs in the energy sector relevant to GHG emissions

Summary of GHG emission trends in the energy sector

Between 2000 and 2012, GHG emissions from the stationery energy combustion increased by 61.3 per cent (4.3MtCO_2e). The key drivers are structural changes in Ghana's economy, increasing energy demand due to rising number of electrified households, expanding commercial/industrial activities and household incomes.

[1]. Electricity supply (diversification fuel supply)

In 2012, emissions from electricity supply from thermal plants became the second most important source of GHG emission in the energy sector, amounting to 3.2MtCO_2e. The main input fuels for thermal electricity generation were light crude oil, diesel and natural gas. The breakdown of the fuel shares has shifted from crude Oil (14.53PJ), diesel (0.02PJ) in 2000 to crude oil (10.99PJ), diesel (0.32PJ) and natural gas (16.5PJ). Apart from the fact that the share of thermal electricity to the total electricity generation mix has increased from 8.5% in 2000 to 32.9% in 2012, the fuel mix has shifted from crude oil to natural gas. This resulted in corresponding increases in GHG emissions from 0.48MtCO_2e to 3.18MtCO_2e in the

same period. However, Ghana expects that with the continued implementation of a set of comprehensive policies and measures especially those focusing on fuel substitution of crude oil with natural gas and technology modernization of the existing thermal power plant will contribute to the reduction of emissions by 2040. The positive change is already notable in the 2012 emissions, with the significant reduction in production of electricity from light crude oil between 2000 and 2012 and an increase in electric energy from natural gas (LCO-NG replacement). The growing investments in technology conversion of single cycle oil/gas thermal power plant to combined cycle will promote high efficiency and have positive spin-off benefits for GHG emission reduction. With additional 100 Million Metric Standard Cubic Feet per day of natural gas from Atuabo gas processing plant, thermal electricity generation from natural gas is expected to increase.

[2]. Renewable energy

The production of electric energy from renewable sources in Ghana is expected to increase over the next few years (target at 10% by 2020), especially from solar, wind and landfill gas. There are two major PaMs that seek to help achieve the set target. These are: (a) renewable energy business development programme which aim at creating enabling business environment for grid-connected electricity generation through the Renewable Energy, 2011 (Act 832) feed-in-tariff (FIT) scheme and grant for renewable energy business development service, and (b) promotion of off-grid RE applications through Solar PV Electrification and Mini-grid Electrification Programme. This initiative has resulted in over 6,000 solar systems with an installed capacity of 3.2MW being put in place. (MOP, 2012). Government recently launched a 200,000-rooftop solar system project in homes. The project is expected to save nearly 120MW of electricity daily.

Modern energy for cooking - switch to LPG for all those who can afford it (with a focus on those living in urban areas), which is linked to the 50% LPG penetration target by 2020. This programme is one of the high impacts priority actions in the SEA4ALL[10]accelerated framework. In addition, a massive programme to promote the use of improved energy-efficient and smoke-free cook stoves for those who will continue to use biomass for cooking, is covered under this initiative. This is one of the strategies for achieving the national target of reducing demand for wood fuels from 72% to 50% by 2020.

[3]. Energy efficiency

PaMs promoting efficient energy use in industry in Ghana are primarily focused on the efficient use of electrical energy in households, commercial/service and industry. The country's Energy Efficiency Standards and Labeling Regulations 2009(LI 1958) and Energy Efficiency Regulations, 2008 (LI 1932) are the two main laws that seek to ensure high market standards and prohibit importation of selected range of inefficient electronic appliances. The labeling programme makes it obligatory to display a label which indicates the energy efficiency rating of products such as domestic refrigeration appliances, lighting bulbs and non-ducted air conditioners before the first retail sale. Similarly, L1 1932 prohibits the importation of inefficient incandescent bulbs, used refrigerators and air conditioners.

Households and commercial/service sectors – Promotion of energy efficiency programme in households include (a) awareness creation on electricity conservation in homes such as switch-off-the freezer campaign which resulted in nearly 70MW of electricity during the World Cup tournament and the save-a-watt campaign by switching off unused appliances (b) refrigerating appliances market transformation programme initiated to reduce the energy consumption of refrigerating appliances from the current average of 1,200kWh to 600kWh per appliance per annum. Under this programme, consumers who turn

[10] Sustainable energy for all action plan for Ghana, 2013

in their old refrigerating appliances are supported financially to pay part of the cost of a new efficient refrigerator. So far over 4,000 inefficient refrigerators have been replaced nationwide and (c) inefficient incandescence bulbs have been replaced with 6 million compact fluorescent filament lamps. For commercial/sector operators, energy conservation has focused on promoting awareness on electricity audit and installation of power correction factor devices in public buildings.

Installation of power factor correction devices in public buildings – Ghana introduced a PaM to facilitate installation of Automatic Capacitor Banks (ACB) in selected public buildings. In the first phase, 26 ACBs were installed in 26 selected public institutions.

Electricity transmission – On the supply-side, power generation, transmission and distribution infrastructures are being revamped to improve efficiency and reduce power system losses.

[4]. Sustainable Energy for All (SE4ALL) Action Plan

[A] China-Ghana south-south cooperation on renewable energy technology transfer

This initiative seeks to facilitate exchange of expertise and technology between China and Ghana, building on China's unique development experience. The aim is to address Ghana's need to increase the universal energy access by effectuating off-grid community-based electrification, increasing the share of renewable energy, and promoting the productive uses of energy - hereby also supporting broader socio-economic and environmental objectives, most notably poverty reduction through employment generation and supporting action on climate change mitigation. The initiative will do so by creating an enabling environment - in Ghana for absorbing new technology and in China for providing it appropriately. The initiative also promotes the production of renewable energy technologies in Ghana with a strong focus on private sector development and inclusion. In China, the project will support the review and updating of South-South Cooperation policies and guidelines and build solid capacity for China to engage more systematically in South-South Cooperation in order to support Ghana's national development goals and priorities for poverty reduction and provision of energy. The estimated project budget is $ 2,720,000.

[B] Installation of 200 institutional biogas plants

As part of the Sustainable Energy for All action plan, Ghana aims to establish 200 institutional biogas systems for boarding schools, hospitals and prisons. The 200 systems will be the first phase of a more extensive programme facilitating the installation of many more institutional biogas systems. Accordingly, a feasibility study is being conducted which should lead to a ready-to-implement programme for the Ghana Energy Commission, to establish the 200 institutional biogas systems, including the funding. The installation of the 200 biogas systems, has potential to reduce emissions, save cost input of fuel for the target users, improve sanitation and above all create jobs.

E. Oil and gas sector

It is policy of government not to flare associated natural gas during oil production to avoid resource wastage and protect the environment. The associated natural gas from the oil production is therefore being re-injected into the oil well for the future. A gas processing plant is being constructed to make it possible to process and use the associated natural gas, mainly for power generation. The gas processing plant is expected to become operational in 2014.

2.8.7 Transportation sector

Development of the transport sector has been identified as one of the keys to accelerate development towards achieving and sustaining macroeconomic stability (GoG, 2010).The transportation and storage service sub-sector's contribution to the GDP increased to about 11.4% in 2012 from 3.8% in 2008. The major economic activities that support the sub-sector are: road, rail, civil aviation and water navigation. The national transport policy provides the broad vision of attaining an effective, sustainable and efficient transportation hub in the sub-region. Description of the state of the sub-sectors is as follows:

2.8.7.1 Road transport

Road transport is by far the most dominant carrier of freight and passenger in Ghana's land transport system. It carries over 95% of all passengers and freight traffic and reaches most communities. Ghana's road network increased from 38,000km in 2000 to nearly 120,818km in 2011 (Ministry of Transport, 2010). The percentage of paved roads decreased from 19.6% of total roads in 1990 to 12.6% in 2009. There has been rapid growth of vehicle population in recent years. The effects of this are the traffic congestion in urban areas resulting in longer travel distances, increasing travel times and cost etc. Between 2000 and 2011, vehicle population increased by nearly 62.7% from 52,881 to 141,819 at an annual growth rate of 9.4%. Diesel, petrol and LPG are the main fuels used in road transport activities. Since 2000, total fuel consumption has increased from 910ktoe to 1518.75ktoe. Currently, there are no Ghana is developing standards to regulate for controlling vehicular emissions. The existing inspection regime largely focuses on the physical condition of the vehicle although capacity exists in the private sector to undertake emissions testing.

2.8.7.2 Civil Aviation – Domestic airline industry

The domestic aviation industry in Ghana has seen tremendous growth over the last 2 years not just in terms of the number of airlines in active operations in the country but more importantly, in terms of passenger uplift. Currently there are 4 active airlines operating scheduled, public services in the domestic aviation industry, with about 3 more expected to launch their operations in the near future. The total passenger uplift for the last 4 months of 2011 was 53% more than the previous 4 months (from 51,330 passengers for the period May to August 2011, to 78,323 for the period September to December 2011). The unprecedented growth continued in 2012, with passenger uplift growing by 199% over 2011 (544,583 passengers in 2012 as against 181,863 in 2011). The growth continued in 2013 and was expected to continue in the coming years. As Ghana's economy grows and the size of the middle/working class grows, the number of people who can afford air travel increases. The projections are that in a few of years domestic aviation is likely to expand. This will have implications driven by a demand for expanded infrastructure for airports and aviation fuel consumption. The total aviation fuel consumption has increased from 18.64ktoe in 2002 to 110.11ktoe in 2011. Bunkering services for aviation fuel (AKT) to support international commercial airlines are also on the increase.

2.8.7.3 Inland water navigation

The Volta Lake transport system is the main inland water transport in Ghana connecting the south to the north. It spans about 450km from the south to the north with ports at Akosombo in the south and Buipe and Yapei in the North (Ministry of Transport, 2010). Some of the major items transported by the Volta Lake transport are petroleum products, cement and agricultural commodities. It also provides passenger services, mostly for the rural population along the lake. The lake transport operates cargo vessels, ferries and motor boats for its passenger and also freight transport. In 2010, the passenger service, consumed 894.9kl of diesel to cover nearly 39million annual passenger-km and 45million annual tonnes-km respectively (Communication with Volta Lake Transport, 2013).

2.8.7.4 Railways

Rail transport in Ghana has seen a general decline in recent years. Although its freight services are generally regular in the western corridor for transporting bauxite, timber and other goods, the passenger services (both intercity and intra city) has reduced considerably except the Accra-Tema route where some limited services are provided. In 2010, Ghana's total railway network was 956km which carried nearly 181million tonnes-km of goods and 85 million passenger-km (source).

2.8.7.5 PaMs in the transportation sector relevant to GHG emissions

Summary of GHG emission trends in transportation

Between 2000 and 2012, GHG emissions from transportation increased by 56.5 per cent (3.6 $MtCO_2e$). The key drivers are structural changes in Ghana's economy which translated in the continuing increase in the number of passenger vehicles and expanding domestic aviation industry. Some of the policies and measures in transportation that are relevant to GHG emissions are as follows:

[1] Policy on over aged vehicles

The Custom, Excise and Preventive Service Act 634 introduced a penalty system which was imposed on imported over aged vehicles in 2002. The policy was part of the measures introduced to discourage the importation of old vehicles into the country by imposing an additional penalty on import duties. This PaM has had far-reaching benefits for the economy in reducing government expenditure on importation of petroleum products, minimizing fuel demand and thus leading to some unintended emission savings. The penalties range from (a) 5% of cost, insurance and freight (CIF) value - age exceeds 10 years but does not exceed 12 years, 20% of CIF Value - 12 years but does not exceed 15 years, 50% of CIF value - age exceeds 15 years.

[2] Perverse LPG subsidy policy

Household LPG subsidy PaM triggered unintended demand in commercial transport due to favorable price disparities compared with gasoline. Although this PaM had some positive benefits to emission savings because of the LPG fuel substitution, it also contributed to increasing demand for LPG over what was supplied. The combined effects were market shortage of LPG and the target of the subsidy was misdirected.

[3] Product pricing and deregulation

Ghana has instituted a deregulation policy to reform the fuel market and adopt automatic price adjustment formulae of oil products. The market reform led to greater private sector participation in the oil products supply chain and as a result several ranges of high grade fuel are available at the ex-pump market. The adoption of the automatic price adjustment formulae for oil products pricing, aims at rolling back government subsidies on the products and allowing market forces to determine fuel prices. The aggregate effects of these PaMs will lead to some emission savings because it provides an incentive to economize in the use of petroleum products, reduce multiple vehicle use by families, ease of traffic congestion, and long stays in traffic and the associated loss of productive time.

1.8.8 Building stock and urban structure

The Ghana Living Standards Survey Five (GLSS5) (GSS, 2008) revealed the following circumstances on architecture in Ghana: nationally 49 percent and 45 percent of households used mud and cement/sandcrete blocks respectively in constructing house walls; 76 percent of households in the urban areas live in dwellings constructed with cement/sandcrete blocks while 73 percent of rural households

live in dwellings constructed mainly with mud. Nationwide, about 23.6 percent of rural households use thatch to roof (with about 45 percent of households in the rural savannah using thatched roofs); and 12 percent use asbestos. Houses built with mud and roofed with thatch are vulnerable to climate variability elements such as, storms and torrential rains. .

2.8.9 Industrial sector

The industrial sector which is the second largest sector, recorded a growth rate of 7% in 2012 with an actual outturn of 41.1% in 2011. The sector is engaged in the following activities: mining and quarrying, petroleum, manufacturing, construction, water and sewerage and electricity. The main manufacturing industries in the country are cement, iron and steel, aluminum smelter, pulp and paper, food and beverages etc. The largest aluminum smelter in Ghana is the Volta Aluminum Company Limited (VALCO) which is currently operating a single pot. Apart from VALCO, that is a primary manufacturing industry from which process emissions are expected, the activities of the remaining industries are generally secondary or tertiary in nature. The industrial sector is one of the highest consumers of energy in the Ghanaian economy, consuming about 48.9% of electricity in 2011 (Energy Commission, 2012). Consequently, energy-based GHG emissions are expected from the industrials such as iron and steel, construction, textiles, wood and wood products etc.

2.8.10 Waste sector

Over the last decade, the annual rate of solid waste generated has increased from about 5,770 metric tons/day in 1990 to about 13,989 metric tons/day in 2012 (NIR, 2012). The waste problem is more serious in urban areas than the rural areas, owing to higher population, prevailing economic activities and consumption patterns. Sprawling new suburbs with no access to roads, social infrastructure and waste collection services, compound the situation. The breakdown of the waste stream are as follows: (a) food waste including garden and wood waste (73%), (b) paper waste (8%), (c) textile (4%), plastic (8%) and others including inert/metals (7%). Out of the 13,989 metric tons/day, of waste generated, 80% ends up in the final disposal sites (source). Of the reaming 20%, 14.7% is dumped illegally, include quantities composted and others are missed from the material in transition, 1.9% is buried, 3.3% is openly burnt and incinerated and 0.1% recycled. The fraction of waste that gets to the landfill has increased from 60% in 2000 to 80% in 2012 due to the greater participation of the private sector in waste management in the country.

The greater participation of the private sector in waste management also led to the halving of the fraction of waste dumped elsewhere from 28.2% in 2000 and also increased the capacity to incinerate and compost. Disposal of solid waste to land with relatively deeper depth and to sanitary landfill sites is increasingly common in urban waste management. There are also potentials for waste to energy and compost. Other forms of disposal such as incineration and recycling still remain untapped. Decentralized treatment, re-use and recovery systems (DTRRS) for sewage management in bio-digesters; and aerobic composting of sewage developed in Ghana are currently being piloted in peri-urban communities. The DTRRS technologies are already being promoted in Ghana. Several of the DTRRS technologies have been installed in institutions, hospitals, schools and in hotels to address the sanitation and water problems associated with uncontrolled discharge of septic and fecal sludge, contributing to land-based sources of polluting the beaches, rivers and water courses – a main cause of public-health related diseases such as cholera and typhoid outbreak.

2.8.10.1 PaMs in the Waste sector relevant to GHG emissions

Summary of GHG emission trends in the waste sector

The total emissions from the sector have increased from 1.3 MtCO2e in 1990 to 4.52 MtCO2e in 2012. The key drivers are structural changes in Ghana's economy, rising population, expanding commercial/industrial activities and changing lifestyles.

[1] Waste management

Increased participation of the private sector in waste management has improved the amount of waste getting to the landfill, although there are no obligations for landfill operators to collect gas. This has accounted for the increases in the emissions.

2.8.11 Tourism sector

The tourism sub-sector's growth and development has a multiplier effect on other sectors in the economy. In 2010, it was the 4th highest foreign exchange earner (estimated at USD 1.3 billion from about 700,000 international travelers. It is therefore a priority area in Ghana's Medium Term Development Policy Framework (GoG, 2010). Climate change puts Ghana's touristic sites and potential sites at great risk, because majority of these sites are ecologically sensitive.

2.9 Development policies and sector priorities

2.9.1 Development policies

Ghana's socio-economic transformation agenda has been set out in the President's Coordinated Programme of Economic and Social Development Policy (CPESDP) for 2014-2020. The country's medium-term development framework which is the operational vehicle for the transformation agenda and focuses on the following priorities; (a) social development; (b) economic development; (c) infrastructure development;(d) natural resources management and; (e) Transparent, Accountable and Responsive Governance. The strategic priority interventions in the transformation agenda that relate to climate change are anchored on the natural resource management pillar. Therefore the broad medium-term goal is articulated Ghana Shared Growth and Development Agenda.

In Ghana, the implementation of the MDGs has been closely linked to the National Policy Framework. The GSGDA, which is Ghana's National Medium Term Policy Framework, has mainstreamed climate change into all its seven thematic areas. It was formulated to ensure continued pursuit of macroeconomic stability and the sustainable exploitation of Ghana's natural resource endowments. These will be achieved through strategic investments in human capital, infrastructure, human settlements, science, technology and innovation, to drive industrialization, particularly in manufacturing. Strategies identified in GSGDA having a bearing on climate change include the following:

- *Adaptation strategies*: enhanced early warning systems; alternative livelihoods; enhanced national capacity to adapt to climate change through improved land use management; enhanced research and awareness creation; development and implementation of environmental sanitation strategies; management of water resources; agricultural diversification; improved access to healthcare; demand and supply side measures on adapting the national energy system to impacts of climate change; sustain livelihoods through enhanced fisheries resource management.

- *Mitigation measures:* promotion of energy efficiency in all aspects of life; improvement of transport services and facilities; promotion of sustainable forest management and implementation of forest governance initiatives; education and efficient management practices; and improvement of waste management mechanisms and the development of a long-term national low carbon development strategy (LCDs) towards sustainable development. Figure 12 presents the linkages between development policies and low carbon development opportunities in Ghana. The linkages are established with the high level medium-term transformation agenda set out by the President in the CPESDP and the GSGDA and how the sector policies drives emission reduction actions at sub-national levels.

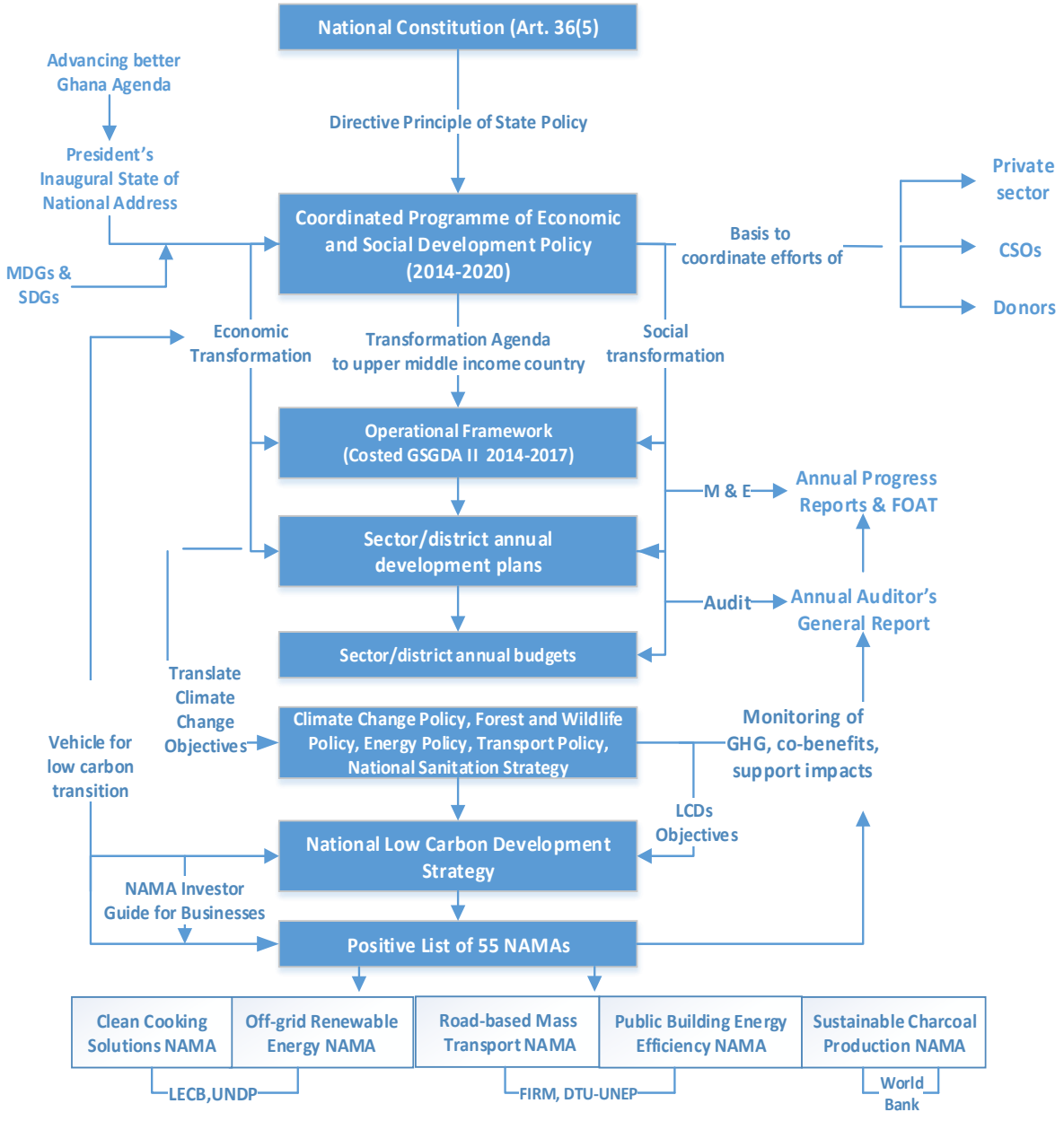


Figure 12: Relationship between development policies and low carbon opportunities

2.9.2 Sector priorities

Key sectors such as agriculture, transportation and energy have mainstreamed climate change and other environmental issues into their priorities based on GSGDA.

Medium Term Agriculture Sector Investment Plan (2011-2015) - Medium Term Agriculture Sector Investment Plan (METASIP) has been developed based on FASDEP II objectives with a target for agriculture sector GDP growth of at least 6% annually and government expenditure allocation of at least 10% of the national budget within the plan period. These targets are in conformity with the agricultural performance targets, which meet the standards of both national and international Institutions. Programmes outlined under METASIP are: Food security and emergency preparedness; increased growth in incomes; increased competitiveness and enhanced integration into domestic and international markets; Sustainable management of land and environment; Science and technology applied in food and agriculture development and improved institutional co-ordination.

Transport Sector Medium-Term Development Plan (2012-2014) - The Transport Sector Medium-Term Development Plan has an implementation time-frame of three years, based on the seven goals of the National Transport Policy (NTP). The aim of these seven goals are to establish Ghana as a transportation hub for the West African Sub-Region; create and sustain an efficient transport system that meets user needs; integrate land use, transport planning, development planning and service provision; create a vibrant investment and performance-based management environment that maximize benefits for public and private sector investors; ensure sustainable development in the transport sector; develop adequate human resources and apply new technology**.**

Energy Policy and Energy Development Strategy - The energy sector vision is to develop an "Energy Economy" that would ensure secure and reliable supply of high quality energy services for all sectors of the Ghanaian economy, to become a net exporter of oil and power by 2012 and 2015, respectively. Within the context of energy sector vision, the goal of the energy sector is to make energy services universally accessible and readily available in an environmentally sustainable manner. Specific objectives of the sector are as follows:

- Secure long term fuel supplies for the thermal power plants;
- Reduce technical and commercial losses in power supply;
- Support the modernization and expansion of energy infrastructure to meet growing demands and ensure reliability;
- Increase access to modern forms of energy;
- Improve the overall management, regulatory environment and operations of the energy sector;
- Minimize the environmental impacts of energy supply and consumption through increased production and use of renewable energy and make energy delivery efficient;
- Ensure cost recovery for energy supply and delivery;
- Ensure the productive and efficient use of energy;
- Promote and encourage private sector participation in the energy sector; and
- Diversify the national energy mix by promoting renewable energy sources.

2.9.3 Mainstreaming climate change

Ghana's medium-term development strategy is captured in the Ghana Shared Growth and Development Agenda (2010 to 2013). Not only has climate change been integrated into Ghana's decentralized planning system, it has also reflected in a number of sector plans. In all, climate mainstreaming is taking time to gradually trickle down into the various facets of national development. Although having climate change issues included in the national development and sector policies and plans is a significantly important step, it is yet to cascade into budgeting, implementation, monitoring and evaluation. Below are summaries of the various aspects of climate change mainstreaming efforts:

- *Climate change in 2011-2012 National and Budgeting guidelines:* Having climate change in the GSGDA, the NDPC and Ministry of Finance included climate change in the national planning and budgeting guidelines for 2011-2012 respectively. The MMDAs and MDAs were required to be guided by these two guidelines in the preparation of their annual sector plans.

- *National Budget does not directly allocate funds to climate change programme but funding is implied*- funding for climate change in the national budget is not explicitly delineated. The Ministry of Finance is planning to undertake climate public expenditure and institutional review.

- *FOAT model exemplifies linkages with M&E* - The FOAT model links M&E to performance of MMDAs in order to transfer additional multi-donor funds. Among the range of indicators is the percentage weight on climate change.

- *Guidebook for Mainstreaming of Climate Change and Disaster Risk Reduction for MMDAs* – The NDPC and EPA developed a guidebook for mainstreaming climate change and disaster risk reduction into district medium term development plans. This has been used as the basis for training the then 170 District Assemblies.

- *Create High level awareness* - High level awareness raising programme for Members of Parliament, Council of State, Economic Management Team (EMT), Ministers of State, Chief Directors of key Ministries, District Chief Executives and Regional Co-ordinating Directors on mainstreaming climate change and disaster risk management into planning and budgeting at the sector and district level.

- Training on the use of mainstreaming guide book- Training of Ministries, Departments and Agencies (MDAs); Metropolitan, Municipal, and District Assemblies (MMDAs) on mainstreaming of climate change into planning and budgeting.

- *Policy briefs on climate change and development* – 19 policy advisory series produced on the themes of development planning, agriculture, education, forestry, health, tourism, transport, human settlement disaster risk management, coastal zone and resources, water resources, energy, private sector finance, public finance, opportunities, gender, indigenous knowledge, capacity and technology.

2.10 Linkages with implementation of multilateral agreement and other initiatives

Ghana is a party to about seventeen multilateral agreements on sustainable developments. A number of national implementation structures have been put in place to support Ghana meet its commitments under these various agreements.

2.10.1 Rio conventions and Kyoto protocol

Ghana has ratified the three Rio Conventions and taken active steps to meet its obligations under them. The Rio Conventions are (a) United Nations Framework Convention on Climate Change (UNFCCC), (b) United Nations Convention on Biological Diversity (UNCBD) and (c) United Nations Convention to Combat Desertification (UNCCD). The Ministry of Environment Science, Technology and Innovation is responsible for coordinating the implementation of the Rio conventions through its Environmental Agreement Coordination Unit. The focal points of the UNFCCC, UNCBD and UNCCD are located in EPA and MESTI respectively. In order to facilitate the implementation of the Rio conventions in Ghana, the following national documents have been prepared: National Climate Change Policy (UNFCCC), National Action Plan to Combat Desertification (UNCCD) and National Biodiversity Strategy and Action Plan (UNCBD). As a party to the Kyoto protocol, Ghana has put in place a number of structures to support its implementation at the national level. These are: CDM Designated National Authority for CDM, national carbon trading committee and the technical committee to screen CDM projects.

2.10.2 Other multilateral agreements

Below is an in exhaustive list of multilateral agreements (see table 7) to which Ghana is either a signatory or a party. These include:

Table 7: List of international conventions on the Environment in which Ghana participated

No	Convention	Date of Accession/Ratification
1	International Plant Protection Convention, Rome, 1951	22 February, 1991
2	International Convention for Prevention of Pollution of the sea by Oil London, 154 (as amended in 1962 and 1969). London, 155 (as amended in 1962 and 1969)	17 August, 1962
3	Convention on Fishing and Conservation of the Living Resources of the Seas, Geneva, 1958	29 April, 1958 (signed)
4	Convention on the Continental Shelf, Geneva, 1958	29 April, 1958
5	Convention concerning the Protection of Workers Against lionizing Radiations, Geneva, 1960	7 November, 1961
6	Convention on African Migratory Locust, Kano, 1962	28 November, 1963
7	Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and under Water, 1963	27 November, 1963
8	International Convention for the Conservation of Atlantic Tunas, Rio de Janeiro, 1966	17 April, 1968
9	Treaty on Principles Governing Activities of States in the Exploration and use of Outer Space including the Moon and the Other Celestial Bodies, London, Moscow, Washington, 1967	3 March 1967
10	African Convention on the Conservation of Nature and Natural Resources, 1969 (Ghana is yet to ratify the revised version of this Convention which is yet to come into force).	17 May, 1969

11	Copenhagen Amendment to the Montreal Amendment on Substances that Deplete the Ozone Layer, Copenhagen, 1992	30 September 2000
12	International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Causalities, Brussels, 1969	20 April, 1978
13	Convention on Wetlands of International Importance Especially as Waterfowl Habitat, Ramsar, 1971	22 February, 1988 (Ac)
14	Treaty on the Prohibition of the Emplacement of Nuclear Weapons and other Weapons of Mass Destruction on the Sea Bed and the Ocean Floor and in the Subsoil thereof, London, Moscow, Washington, 1971	6 June 1975
15	International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, Brussels 1971 and the 1976 Protocol.	20 April,1978
16	Convention on the Prohibition of the Development Production and Stockpiling of Bacteriological (Biological) and Toxin Weapon and on Their Destruction, London, Moscow Washington, 1972.	6 June, 1972
17	Convention Concerning the Protection of the World Cultural and Natural Heritage, Paris, 1972	4 July, 1975
18	International Convention for the Prevention of Pollution from Ships and Protocol (MARPOL 73/78)	3 September, 1991
19	Convention on International Trade in Endangered Species of Wild Fauna and Flora, Washington, 1973	14 November, 1975
20	Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques, Geneva, 1976.	22 June, 1978
21	Convention Concerning the Protection of Workers against Occupational Hazards in the Working Environment Due to Air pollution, Noise and Vibration, Geneva, 1977	27 May, 1986
22	Protocol Concerning Cooperation in Combating Pollution in Cases of Emergency, Abidjan, 1981	20 July, 1989
23	International Tropical Timber Agreement, Geneva 1983	9 March, 1985
24	United Nations Convention on the Law of the Sea, Montego Bay, 1982.	7 June, 1983
25	Vienna Convention for the Protection of the Ozone Layer, Vienna, 1985.	24 July 1989 (Ac)
26	Montreal Protocol on Substances that Deplete the Ozone Layer, Montreal, 1987	24 July, 1989
27	Convention on the Conservation of Migratory Species of Wild Animals, Bonn, 1979	19 January, 1988
28	Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal, Basel, 1989	12 March, 2003
29	London Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer, London, 1990	24 July, 1992
30	Convention for Cooperation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region, Abidjan,1981	20 July, 1989
31	United Nations Framework Convention on Climate Change, New York, 1992	6 September, 1994
32	Convention on Biological Diversity, Rio de Janeiro,1992	29 August, 1994
33	United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and / or Desertification, Particularly in Africa, Paris, 1994	27 December, 1996
34	Treaty Establishing the African Community, 1991	25 October, 1991
35	Convention on Nuclear Safety	6 July 1995 (signed)
36	Beijing Amendment to the Montreal Protocol	8 August 2005
37	Montreal Amendment to the Montreal Protocol	8 August 2005

38	Amendment to the Basel Convention on the Control of Trans boundary Movements of Hazardous Wastes and Their Disposal, Geneva, 1995	9 June, 2005
39	Rotterdam Convention on Prior Informed Consent Procedure For Hazardous Chemicals and Pesticides in International Trade, Rotterdam, 1998	12 March, 2003
40	Cartagena Protocol on Biosafety	12 March,2003
41	Protocol on Liability and Compensation	30 May, 2003
42	Stockholm Convention on Persistent Organic Pollutants	30 May, 2003

In the implementation of these multilateral agreements, Ghana is faced with challenges such as inadequate co-ordination and integration among the conventions, inadequate participation and ownership of programmes and plans, as well as under resourced institutions to implement them.

2.10.3 Other national initiatives

Issues on climate change have synergies with the following national initiatives. The strategic linkages between climate change and other on-going national initiatives are shown in figure 13.

- Green Economy Assessment (GE)
- Climate and Clean Air Coalition (CCAC)
- Millennium Development Goals (MDGs) and 2015 sustainable development goals (SDGs)
- Millennium Challenge Development Authority (MiDA) Compact 2
- SE4ALL Action Agenda 2020
- Savannah Accelerated Development Authority (SADA)
- Hyogo Framework for Action (2005-2015) – Ghana Plan of Action on Disaster Risk Reduction & Climate Change Adaptation (CCA).

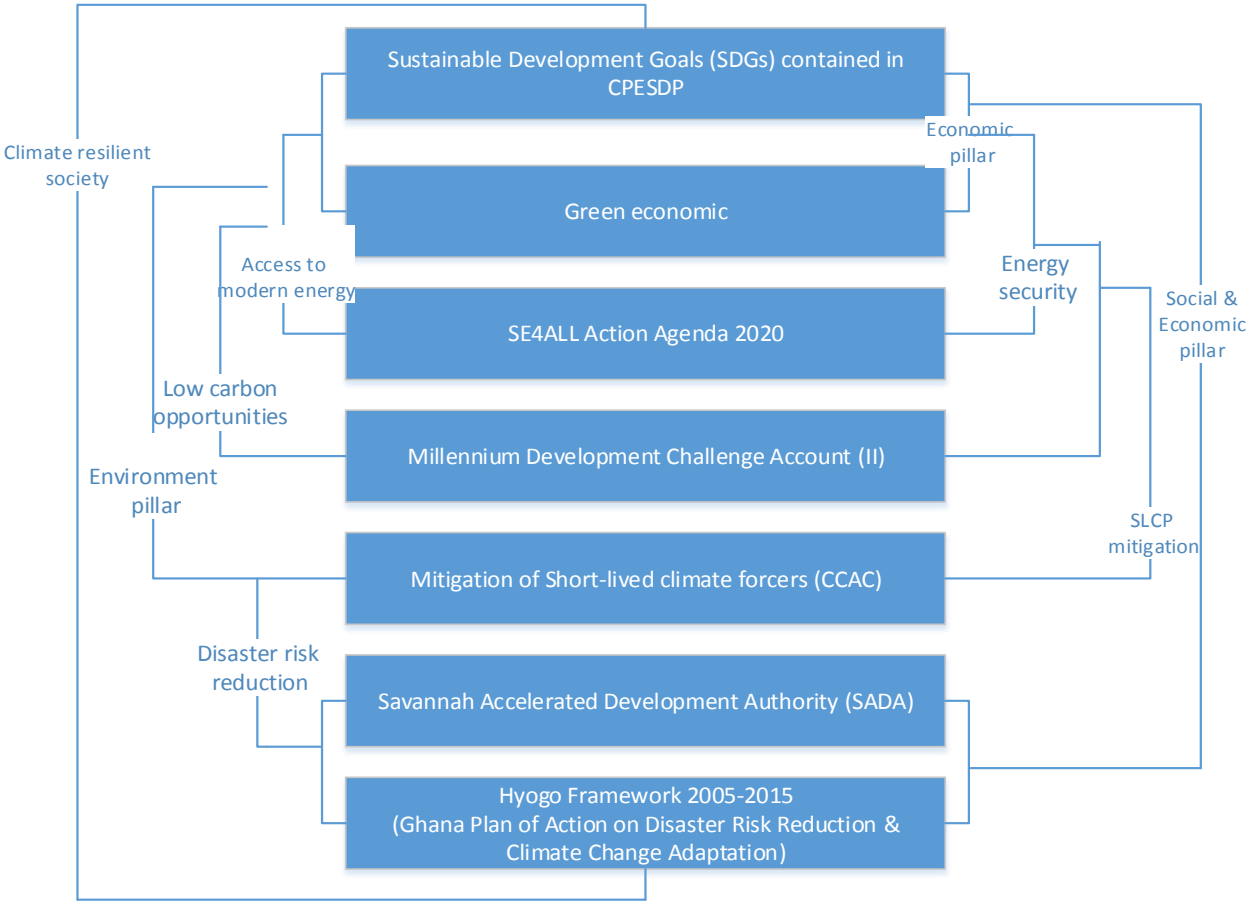


Figure 13: Inter-linkages among climate change and other sustainable development initiatives in Ghana

National GHG Emissions Inventory

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3. Information on National Greenhouse Gas Inventory

3.1 Overview of the inventory

This section presents a summary of the GHG results for the period 1990-2012. Detailed description of the results, methodology and processes used for the preparation of the national inventory is contained in the 2014 NIR. The NIR and associated tables are submitted to the UNFCCC in fulfilment of Ghana's obligations, in part, under the enhanced national communication reporting (Article 12, paragraph 1(a), of the Convention, decisions 1/CP.16 para 60(a-b) and to comply with reporting requirements in the preparation of its first biennial update report (BUR) and consistent with Decision 1/CP.16 para 60(c). Although this is the second time Ghana has prepared a NIR, it is the first NIR submitted to the UNFCCC under the "BUR" reporting mechanism. The GHG emission estimates have been compiled based on the methodologies contained in the Intergovernmental Panel on Climate Change, (IPCC Guidelines for National Greenhouse Gas Inventories IPCC 2006). The use of the 2006 IPCC guidelines was to ensure that the GHG emission estimates were as practicable, transparent, complete, consistent comparable and accurate (TCCCA) through time and comparable with inventories produced in other countries with similar national circumstances. The inventory estimate covers direct anthropogenic GHG emissions by sources and removals by sinks and include CO_2, CH_4, N_2O and PFCs. The emissions/removals from the following four economic sectors have been estimated; (1) Energy, (2) Industrial processes and product use (IPPU), (3) Agriculture, Forestry and Other Land Use (AFOLU) and (4) Waste.

3.2 Brief description of national system for sustainable inventory preparation

Ghana has a national inventory system that is capable of supporting the continuous preparation of robust national GHG inventories on a sustainable basis. For the national system to function efficiently, a number of reforms have been introduced, since 2006, as part of the long-term improvement strategies. The reforms have brought about greater improvements in the operation of the national system. Figure 14 below shows the main elements introduced in the national system.

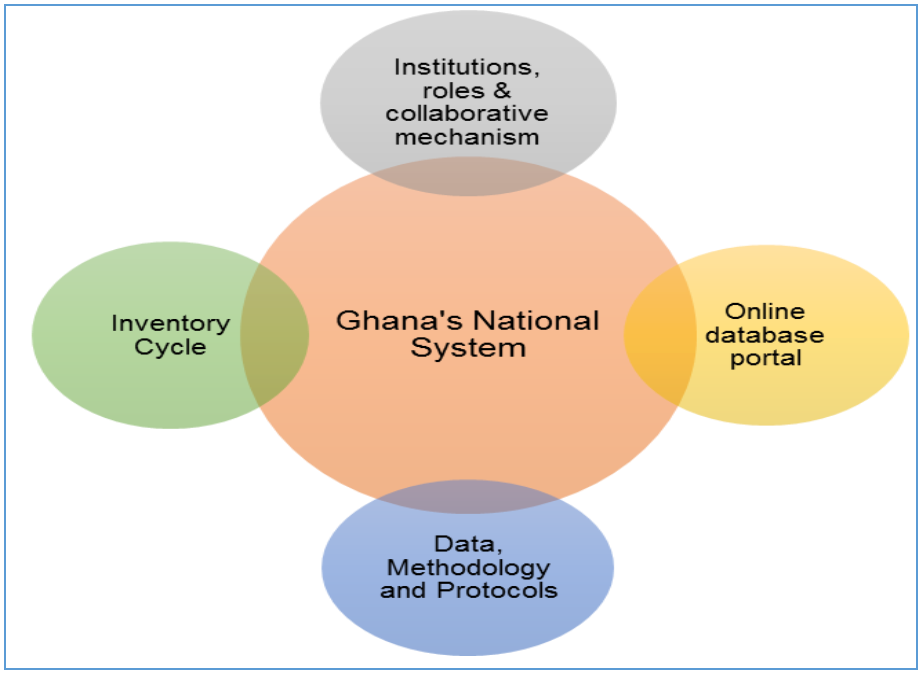

Figure 14: Elements of the GHG Inventory National System

3.2.1 Description of institutional arrangements

The revised institutional arrangements involve nearly thirty experts from sixteen different public and private institutions. The roles and, responsibilities of each institution and their reporting lines are arranged to reflect the levels of interlinkages contained in the respective memorandum of understanding. The Environmental Protection Agency (EPA) is established by Act 490, 1994 and is designated as the national entity for the preparation of Ghana's national GHG inventory. The EPA functions as the "single national entity". As the "single national entity" the EPA collaborates with the inventory stakeholders to undertake management of activity data and emissions factors, compilation of emission estimates from the sectors, quality control/quality assurance, improvement planning, and preparation of the reports. The MESTI is responsible for the official approval and endorsement of NIR and onward submission to UNFCCC. Within the EPA, the UNFCCC Focal Point and Climate Change unit is the national inventory entity and is directly responsible for the management of the entire inventory process. The unit ensures that delivery of the inventory is timely, of good quality and above all meets international standards (see figure 15).

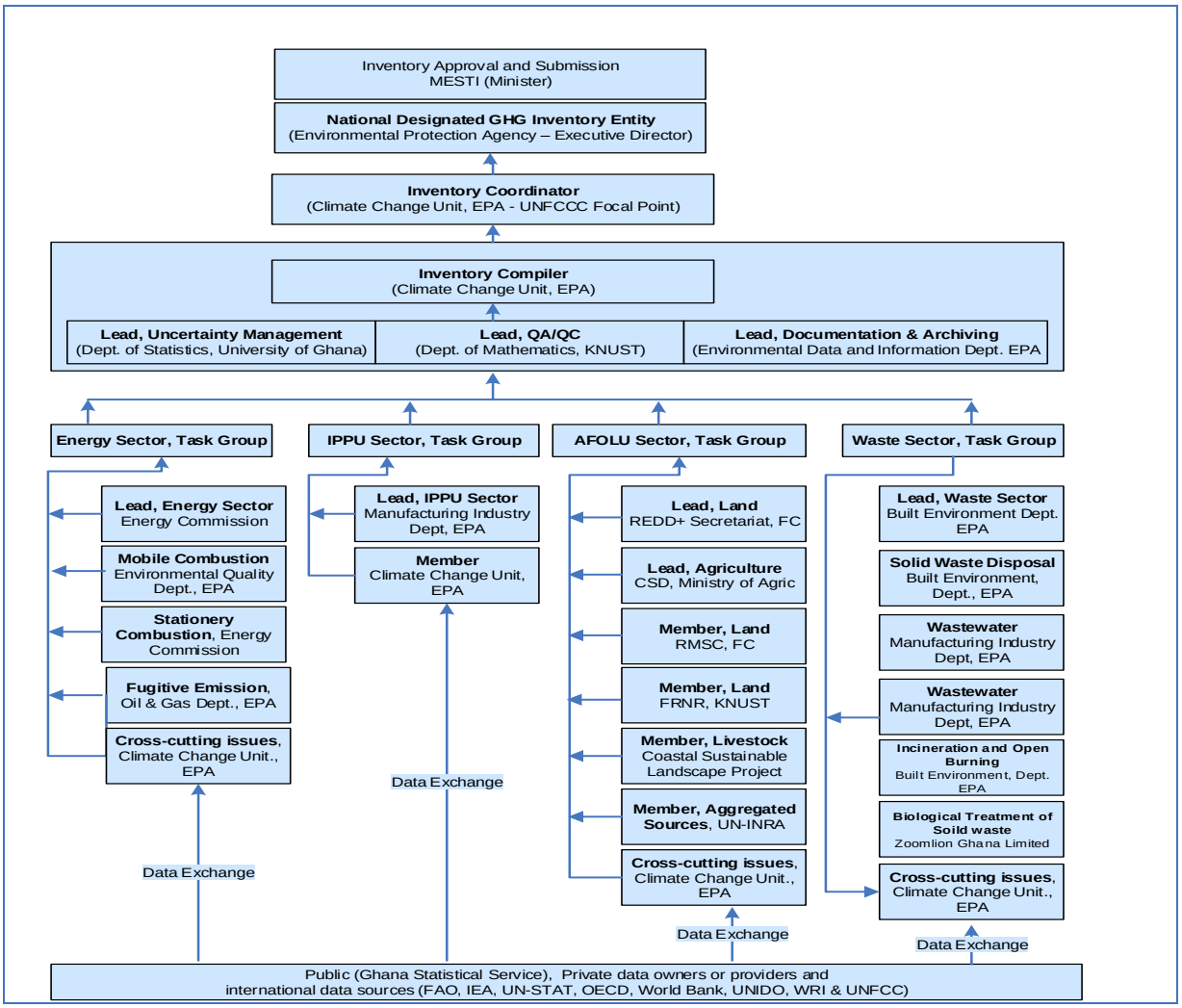

Figure 15: Functional institutional arrangements for the preparation of the national GHG inventory

The inventory complier also serving in the capacity as the generalist, the uncertainty management lead, QA/QC lead and the documentation and archiving lead are responsible for cross-cutting issues both at the national and sector levels. The 4 working groups that are responsible for completing inventory for the four sectors are: Energy, IPPU, AFOLU and Waste. Each working group has a lead and membership was drawn from public and private organizations. In addition, there were a number of institutions that supplied data to the inventory compliers.

3.2.2 Means of data acquisition and I.T set-up behind data management system

The lead inventory sector institution is responsible for the identification and sourcing of all datasets at the national and international levels in collaboration with the inventory compiler. As much as possible, the sector's lead institution, identifies all the data needs and the institutions where the data will be sourced. After initial contacts with the data owners/providers, the sector lead institution directly requests the data from the source with administrative help from the EPA. In case where EPA receives request from the sector lead institution, data requests are made to of relevant institutions indicating what form of data is required, covering years, data format and the main use of the data in the inventory through an official letter. The EPA data request letters, especially those to industrial plants, usually make reference to the relevant provisions to the EPA, Act 490, which allows EPA access to certain level of information. The collected data goes through several steps of documentation procedures to ensure proper referencing. Initial technical and quality evaluation of the data is done before transmission to the working teams. All data are documented and stored in the online database for archiving and retrieval.

The online database system hosts all GHG inventory data and related information (see figure 16). The database is meant to help streamline documentation and archiving of all GHG data, reports and publications. The database contains (a) all inputs data from each sector, (b) datasheet for each sector, (c) emission estimates from the IPCC software for all sectors from 1990-2012, (d) IPCC 2006 software database, (f) completed QA/QC templates for sectors, and (g) all reports, documentations. The IT infrastructure of the database (server, backend database resources) is managed by the IT team of EPA. The general public and the GHG inventory team have access to the online database through this IP address 197.253.69.38 or www.epa.gov.gh/tnc.www.epa.gov.gh/tnc. The inventory data, individual results sheets and the database file are transmitted to the administrator of the online database for archiving and publication on the internet.

3.2.3 Strategies for long term improvement in the National Inventory System

The reforms in the national system that have started will continue in the coming years to ensure that it operates efficiently on sustainable basis. The following specific actions will be undertaken:

Strengthening data handling and management - Facilitate continuous update of country-specific activity data through regular exchanges of data from the primary data providers using the online database. In this regard, selected officials from Energy Commission (responsible for publication of annual energy statistics), Ministry of Food and Agriculture (responsible for publication of Agriculture Facts and Figures), Driver Vehicle Licensing Authority (responsible for Vehicle annual inspection) Forestry Commission etc, will be given limited right of access to the online database to upload new datasets where necessary. Discussions will start on ways to effectively incorporate GHG data collection into "facility level" environmental reporting managed by the EPA. The facility environmental reporting can be done through (a) Annual Reports; (b) Environmental Management Plans; and (c) "Akoben" industry performance rating system.

Continuous training: Organize regular tailor made training for national experts, public data providers, private data owners, potential users of the GHG results and new experts who join the inventory process. Additional experts would be nominated for inclusion in the UNFCCC roster of experts to allow them benefit from the training. The training will help build capacity and awareness and also give opportunity to experts from Ghana to learn-on-the-job based on the experiences from the review of GHG inventories from Annex I Parties.

Further mainstreaming: Identify the challenges associated with the existing institutional arrangements and where necessary put in place new measures to ensure greater participation of other relevant bodies. Continue with the discussions on harmonizing national statistics on reporting to international agencies (especially FAO, IEA, World Bank).

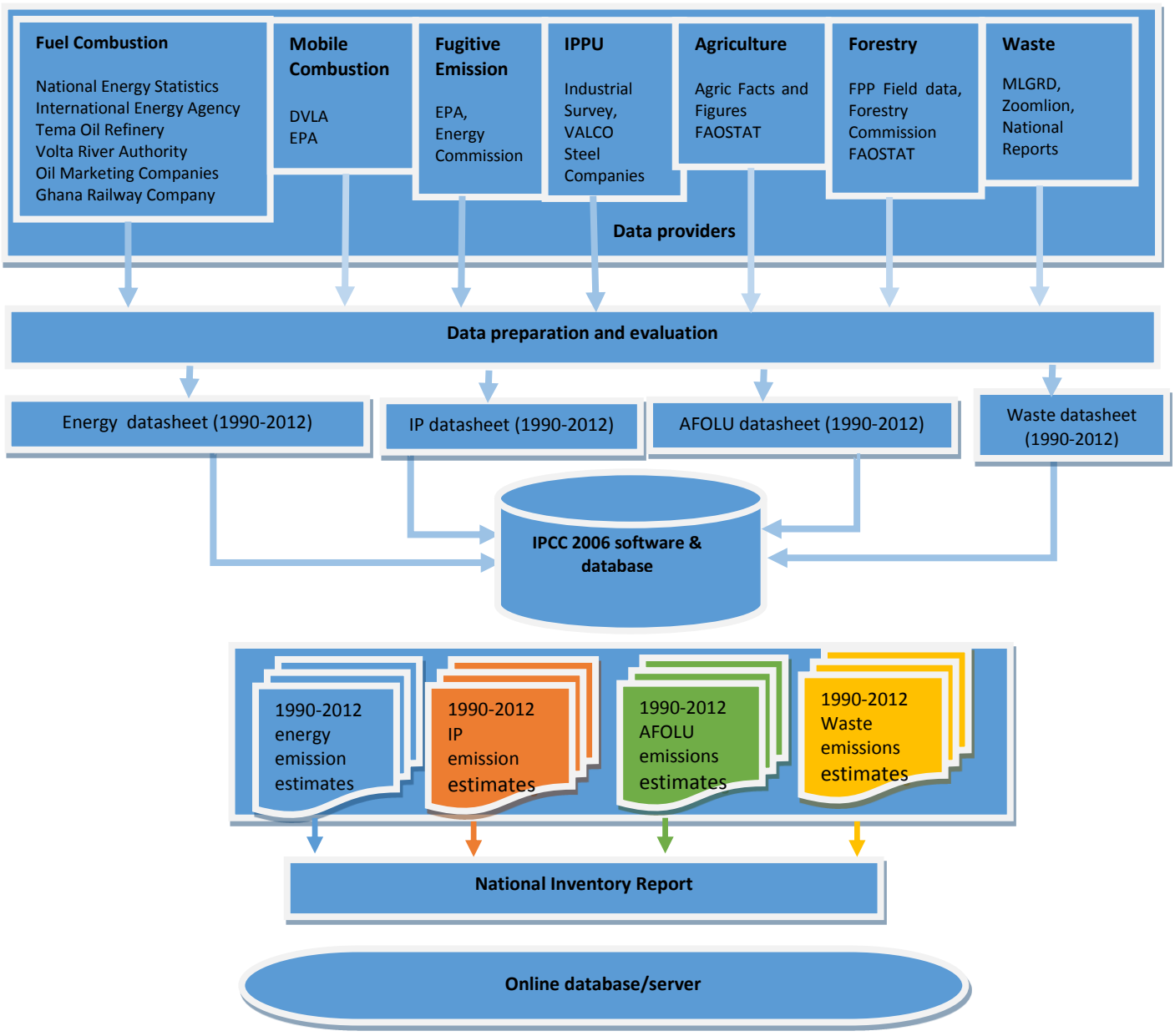

Figure 16: Inventory data structure and relationships among them

3.3 Brief description of methodology and data sources

The emissions inventory has been conducted from a series of steps and using a range of data from diverse sources. The emissions were not directly measured but were estimated through the application methodologies that link emissions to data on observable economic activities in the country. The estimation of the emissions and removals used a combination of: (a) country-specific methods and data; (b) IPCC methodologies and (c) emission factors (EFs). The methods were consistent with the 2006 IPCC guidelines for national greenhouse gas inventories (IPCC 2006) and are to the extent possible, in line with international practice. Generally, tier 1 IPCC methodology were applied, however there were selected categories such as transport (1.A3), land (3B), IPPU (2C) and solid waste disposal (4a) for which higher tier methodology were used. The methodology has seen some improvements over the previous years. This is

as a result of: (a) the continuous use of new and additional country-specific activity data and (b) the shift from the Revised 1996 IPCC guidelines to the 2006 guidelines. Emission Factors were mainly obtained from: (a) facility-level plants; (b) country-specific or regional and international studies and IPCC Emission Factor Database (EFDB). Default emission factors from the IPCC EFDB were used in many of the categories, however, in cases where the country or region specific emission factors existed, priority was given to it. An overview of the methods and emission factors applied for the calculation of the emissions is presented in table 8.

Table 8: Mapping of methods and emission factors

GHG Source and Sink Categories		CO_2		CH_4		N_2O		PFC-CF_4		PFC-C_2F_6		HFCs	
		Meth	EF	Meth	EF	Meth	EF	Meth	EF	Meth	EF	Meth	EF
1.	Energy	T1, T2	D, CS	D, T1	D, CS	D, T1	D, CS						
1.A	Fuel Combustion	T1,T2	D, CS	T1,T2	D, CS	T1,T2	D, CS						
1.A 1	Energy Industries	T1	D	T1	D	T1	D						
1.A 2	Manufacturing Industries and Construction	T1	D	T1	D	T1	D						
1.A 3	Transport	T1,T2	D, CS	T1,T2	D, CS	T1,T2	D, CS						
1.A 4	Other Sectors	T1	D	T1	D	T1	D						
1.B	Fugitive Emissions			T1	D								
1.B1	Solid Fuels			NO	NO								
1.B2	Oil and Natural Gas			T1	D								
1.B3	Other Emission from Energy Production			NO	NO								
2	Industrial Process	D, PS	D, PS	NE	NE	NE	NE	T2	PS	T2	PS	NE	NE
2.A	Mineral Products	D	D	NE	NE	NE	NE						
2.B	Chemical Industry	NO	NO	NO	NO	NO	NO						
2.C	Metal Production	T2	PS	NE	NE	NE	NE	T2	PS	T2	PS		
2.D	Non-Energy Products from Fuels and Solvent Use	T1	D										
2E	Electronics Industry	NO	NO	NO	NO	NO	NO						
2.F	Product Uses as Substitutes for											NE	NE

	Ozone Depleting Substances												
3	Agriculture, Forestry, and Other Land Use	T1,T2	D, CS	T1	D	T1	D						
3.A	Livestock			T1	D								
3.B	Land	T2	CS										
3C	Aggregate sources and non-CO2 emissions sources on land	T1	D	T1	D	TI	D						
4	Waste	T1	D	T1	D	T1	D						
4.A	Solid waste disposal			D	D	D	D						
4.B	Biological Treatment of Solid Waste			TI	D	T1	D						
4.C	Incineration and Open Burning of Waste	T1	D	TI	D	T1	D						
4.D	Wastewater Treatment and Discharge			T1	D	T1	D						

Key: CS= Country-Specific, PS= Plant-Specific, NE = Not Estimated, NO=Not Occurring, D = Default IPCC methodology and emission factor, EF = Emission Factor, Meth=Methods, T1, T2 - Levels of Tiers

The inventory was prepared using a mix of data sources from national and international institutions. During data collection, priority was given to data that have been generated in the country. In cases where the required data was not available in the country, the data from international organizations such as FAO, IEA, World Bank was used. Table 9 provides an overview of the data used in the inventory.

Table 9: Description of activity data sources

Sector		Data Type	Data Source	Principal Data Providers
1. Energy Sector				
1.A1	Energy Industry	Fuel types, Fuel consumption, supply Crude oil and petroleum products production, Imports and exports	National Energy Statistics Refinery Product Balance National Energy Plan IEA Database	Energy Commission, National Petroleum Authority, Tema Oil Refinery, Ministry of Energy and Petroleum, Thermal Electricity Generation Utility Companies (VRA, Sunon Asogli, Takoradi International Company TICO and other independent power producers etc, and the IEA
1.A2	Manufacturing Industry and Construction	Fuel types, fuel consumption, supply, Feedstock, Fuels for Non-energy Use	National Energy Statistics Industry survey data, 2013 National Industry Census, 2003	Energy Commission, Manufacturing Industry Department of the Environmental Protection Agency, Manufacturing and Construction Industries, Ghana Statistical Service.
1.A3	Transport	Fuel Types, fuel Consumption by Vehicles, Aviation, Rail and Navigation, Number of Registered vehicles, Vehicle Types	Vehicle registration Database, Petroleum Product Sales Data, Railway Fuel Consumption data, Water Transport Fuel Consumption Data	Energy Commission, Environmental Quality Department of Environmental Protection Agency, Driver Vehicle Licensing Authority, Oil Marketing Companies (particularly, Shell Ghana Limited, Total Ghana Limited), Ministry of Transport, Ghana Railway Company, Volta Lake Transport Company, Ghana Bunkering Services
1.A4	Other Sectors	Fuel consumption per fuel type	National Energy Statistics National Energy Plan, National Census Report, Ghana Living Standard Survey Report	Energy Commission Ghana Statistical Service
1.B	Fugitive emissions from fuels	Gas flared, Gas produced, Gas injected and Gas consumed on site, Refinery input (crude oil)	Oil Exploration and Production Data Oil refinery data in the Energy Statistics	Ghana National Petroleum corporation Oil Exploration and Production, Companies Environmental Protection Agency Tema Oil Refiner
1. Industrial Process and Product Use				
2.A	Mineral Industry	Industrial production and Plant specific emission factors	Environmental Reports EPRPD Database Industry Survey Industrial data from facilities.	Volta Aluminum Company Limited Tema steel works, Aluworks Environmental Protection Agency
2.C	Metal Industry			
2.D	Non-Energy Products from Fuels and Solvent Use	Amount of non-energy use of diesel and kerosene		
2. Agriculture, Forestry and Other Land use				
3.A1 and 3.A2	Enteric Fermentation & Manure Management	Animal population, Fractions of manure, management practices	Agriculture Facts and Figures FAOSTAT Expert Judgment	Ministry of Food and Agriculture – Statistics Research and Information Directorate, UN Food and Agriculture Organization, AFOLU Team
3.B1	Forest land	Land use maps, land use change map, land use change matrix	Forest Preservation Programme, 2012	Forestry Commission, Ghana
		biomass estimates for 5 IPCC pools (AGB, BGB, deadwood, herb, litter and soil)		

		Climate zones, soil stratifications and ecological zone maps	IPCC database	IPCC
		Industrial round wood	RMSC, FAOSTAT	Forestry Commission, Ghana FAO
		Wood fuel production	Energy Statistics	Energy Commission
		Areas affected by fire	Expert Judgment	AFOLU Team
3.B2	Cropland	Land use maps, Land use change map, Land use change matrix	Forest Preservation Programme, 2012	Forestry Commission, Ghana
		biomass estimate for 5 IPCC pools (AGB, BGB, deadwood, herb, litter and soil)		
		Climate zones, soil classification and ecological zone maps	IPCC database	IPCC
3.B3	Grassland	Land use maps, Land use change map, Land use change matrix	Forest Preservation Programme, 2012	Forestry Commission, Ghana
		biomass estimate for 5 IPCC pools (AGB, BGB, deadwood, herb, litter and soil)		
		Climate zones, soil classification and ecological zone maps	IPCC database	IPCC
3.C1	Biomass burning	Areas affected by fire in cropland, forestland and grassland	Expert Judgment	AFOLU Team
		Mass fuel available for burning	Forest Preservation Programme, 2012	Forestry Commission, Ghana
3.C3	Urea application	Annual Urea consumption figures	Agriculture Facts and Figures	Ministry of Food and Agriculture – Statistics Research and Information Directorate,
3.C4	Direct N_2O emissions from managed soils	Annual generic NPK consumption	Agriculture Facts and Figures	Ministry of Food and Agriculture – Statistics Research and Information Directorate,
3.C5	Indirect N_2O emissions from managed soils	Annual crop production in tonnes per annum		
3.C6	Indirect N_2O emissions from manure management	Animal population (cattle, goats, sheep, swine, donkey, poultry, horse)	Agriculture Facts and Figures	Ministry of Food and Agriculture – Statistics Research and Information Directorate,
		Fractions of manure management practices	Expert Judgment	AFOLU Team
3.C7	Rice cultivation	Annual rice production areas	Agriculture Facts and Figures	Ministry of Food and Agriculture – Statistics Research and Information Directorate
		Proportions of annual rice production area under rain fed, irrigated and upland systems	National Rice Development strategy	Ministry of Food and Agriculture
4. Waste				
4A	Solid Waste Disposal	Waste Generation, Population Figures, Composition, amounts of waste deposited, means of	Published national reports, Ghana Statistical Services, Sanitation Directorate of MLGRD, World Bank	National Environmental Sanitation Strategy & Action Plan (NESSAP), Population Census Reports and Ghana Living Standards Survey 2008, Private Waste Management

		disposals and their various percentages	Country Database, Private Waste Management Companies and Civil Engineering Department, KNUST, EPA	Companies(Zoomlion Ghana Limited, Waste care, etc.), and NGOs Academia (Civil Engineering Department, KNUST), Second National Communication Report from EPA.
4B	Biological Treatment of Solid Waste	Fraction of waste composted, number of compost plants	Private Waste Management	Private Waste Management Companies (Zoomlion Ghana Limited) and NGOs. Expert judgment by the Waste Team
4C	4C.1 Waste Incineration	Amount and types solid waste incinerated, type of incinerator including capacities and combustion efficiencies	Ghana Health Services, Ministry of Local Government and Rural Development,	National Environmental Sanitation Strategy Action Plan document and Ghana Health Service Facts and Figures, and Expert Judgment by the Waste Team
	4C.2 Open Burning of Solid Waste	Population, proportion of population burning waste, duration of burning in number of days per year, fraction of waste burnt relative to the total amount treated.	Published national reports, Ghana Statistical Services, Sanitation Directorate of MLGRD,	National Environmental Sanitation Strategy & Action Plan (NESSAP), Population Census Reports and Ghana Living Standards Survey 2008, Expert Judgment by Waste Team
4D	4D.1 Domestic wastewater treatment and discharge	Population, Wastewater Generated per year, Wastewater treated per year, Wastewater Treatment Systems and their various percentages, Protein Consumption, GDP/capita	Ghana Statistical Services, Sanitation Directorate of MLGRD, World Bank, Ghana Health Service, Ministry of Food and Agriculture	National Environmental Sanitation Strategy & Action Plan (NESSAP), Population Census Reports and Ghana Living Standards Survey 2008, Multiple Cluster Indicator Survey data World Bank Country Database, FAO Expert Judgment by Waste Team
	4D.2 Industrial wastewater treatment and discharge	Industrial coverage, Total Industry Product Quantity of wastewater generated Type of Wastewater Treatment / discharge System	Industry survey	Industrial Outputs data collected during national survey, EMPs Expert Judgment by Waste Team

3.4 Summary of emissions/removals trends

3.4.1 Aggregated national emission trends

Ghana's total GHG emissions were 33.66 million tons (Mt) carbon dioxide-equivalent (CO_2e) in 2012. This represented an increase of 10.7% on total emissions recorded in 2010, and an increase of 106.2% and 136.7% above 2000 and 1990 levels respectively. The net national GHG emissions in 2012 was 18.49 $MtCO_2e$ when emissions and removals from the AFOLU sector were excluded (see figure 17).

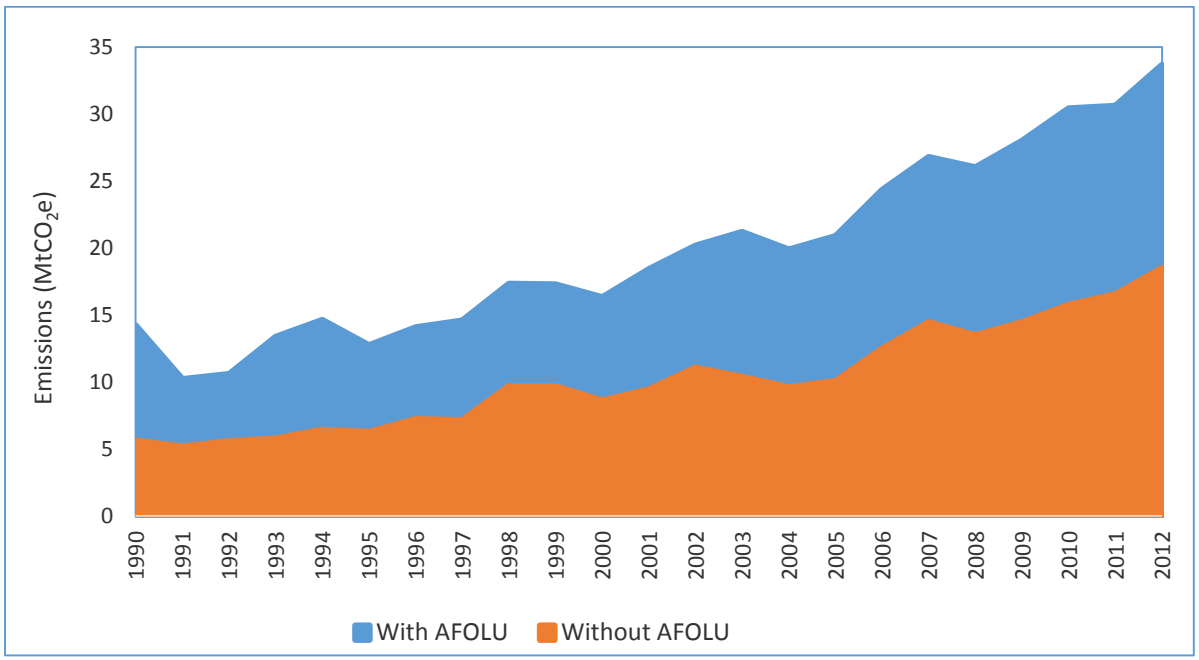

Figure 17: National emission trends with and without AFOLU

The observed increases in the emission trends corresponded to the on-going structural economic transformation agenda which has led to sustained growth and expansion of the national economy. The expansion in the economy has resulted in notable rise in emissions from road transport, electricity generation from crude-fired thermal plants, increasing demand for biomass use. In addition, emissions from land use change also recorded increases between 1990 and 2012 mainly due to deforestation. However, with the continuous implementation of government's national reforestation programme, emissions from "land" have seen some decreases between 2010 and 2012 (see table 10).

Table 10: Total greenhouse gas emissions by sectors

Sectors & Sub-sectors	Emissions $MtCO_2e$					Percent Change		
	1990	2000	2010	2011	2012	1990-2012	2000-2012	2010-2012
1. All Energy (combustion & fugitive)	**3.50**	**5.54**	**11.27**	**11.63**	**13.51**	**286.08**	**143.65**	**19.79**
(1.A1,A2&A5) Stationery energy combustion	2.03	2.73	6.48	6.22	7.05	247.28	158.10	0.09
(1.A5)Transport	1.47	2.81	4.80	5.41	6.46	339.66	129.85	34.67
(1.B) Fugitive emission	0.000	0.003	0.001	0.001	0.002	284.71	-51.74	139.35
2. Industrial Process & Product Use	**0.81**	**0.77**	**0.24**	**0.44**	**0.47**	-42.47	-39.56	**94.24**
3. AFOLU	**8.61**	**7.72**	**14.67**	**14.08**	**15.17**	**76.28**	**96.65**	**3.46**
3A Livestock	1.72	2.20	2.82	2.80	3.05	77.29	38.66	8.01
3B Land	-3.02	-4.00	1.85	1.31	1.84	-160.73	-145.86	-0.96

3C. Aggregated and Non-CO_2 emissions	9.91	9.52	9.99	9.98	10.29	3.83	8.08	3.00
4. Waste	**1.31**	**2.29**	**4.24**	**4.45**	**4.52**	245.97	**97.03**	**6.54**
Total emissions (excluding AFOLU)	**5.61**	**8.61**	**15.75**	**16.51**	18.49	**229.31**	**114.81**	**17.36**
Total net emissions (including AFOLU)	**14.22**	**16.32**	**30.42**	**30.60**	**33.66**	**139.69**	**106.22**	**10.66**

In 2012, the AFOLU sector was the largest source of GHG emissions followed by the energy sector. The rest of the emissions came from the waste sector and industrial process and product use. CO_2 was the dominant GHG which contributed 44% (14.81 Mt) of the total net emissions (including AFOLU). Nitrous oxide was the second largest emission source constituting 30.8% (10.38 $MtCO_2e$) of the total emissions by CH_4 (24.8% -) and PFCs (0.3%) (see figure 18).

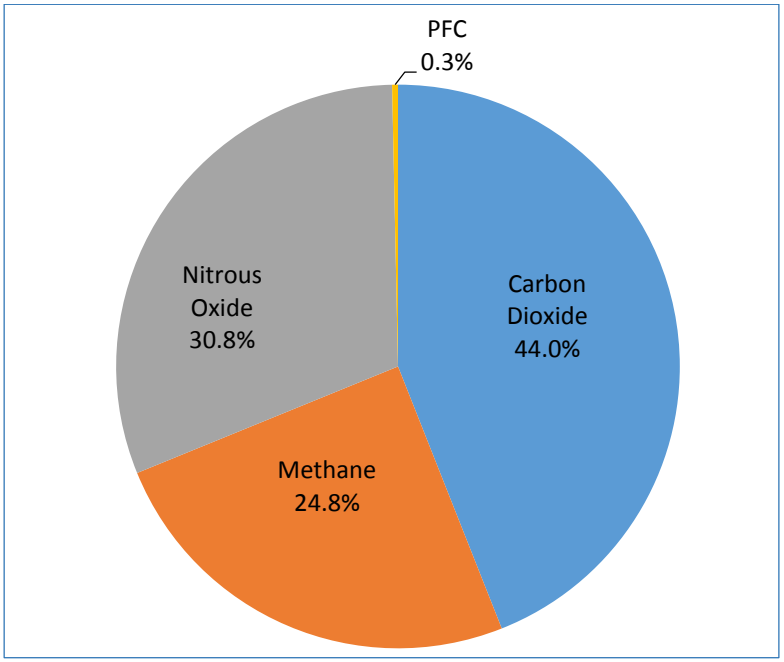

Figure 18: Contribution of gases to national emissions in 2012

Of the total net CO_2 emissions of 14.81 Mt, energy sector contributed 85% (12.59Mt), followed by AFOLU (12.6% - 1.86 Mt) and IPPU (2.4% - 0.35%). When the emissions from AFOLU are excluded from the national totals, CO_2 make up 70.1% (12.59 Mt) of the emissions in the same year. Between 2010 and 2012, the CO_2 emissions including AFOLU increased by 14.9% (see table 11).

Table 11: Distribution of emissions contribution by sectors in 2012

Sector and sub-sectors	CO_2 [%]		CH_4 [%]		N_2O [%]	
	W/O AFOLU	With AFOLU	W/O AFOLU	With AFOLU	W/O AFOLU	With AFOLU
1. All Energy (combustion & fugitive)	**97.2**	**85.03**	**13.72**	**7.7**	**35.7**	**2.62**
Stationery energy combustion	50.0		94.4			
Transport	50.0		5.5			
Fugitive emission	0					
2. Industrial Process & Product Use	**2.7**	**2.39**	**0.0**	**0.0**	**0.0**	**0.00**
3. AFOLU		**12.6**		**44.2**		**92.7**
Livestock				57.5		9.58
Land		*98.7*		0		0
Aggregated and non-CO_2 emissions		*1.26*		42.5		90.4
4. Waste	0.03	**0.03**	**86.3**	**48.1**	**64.3**	**4.72**
Total net emissions (w/ AFOLU)		**100**		**100**		**100**
Total emissions (w/o AFOLU)	**100**		**100**		**100**	

For the year 2012, the AFOLU sector was the largest of national sources of GHG representing 45.1% of total emissions (see table 12), followed by the energy sector (40.1%), waste (13.4%) and industrial processes (1.4%). When emissions from AFOLU were excluded from the national totals, the emissions from the energy sector make up 73% of the total emissions. The remaining 24% and 3% were emissions from waste and IPPU sectors respectively.

Table 12: Net national emissions by Sectors in 2012

Sectors and sub-sectors	Emissions				Share of Total Emissions		
	Mt	$MtCO_2e$					
	CO_2	CH_4	N_2O	PFC	Total	%	%
1. All Energy (combustion & fugitive)	12.59	0.64	0.27	0.00	13.51	73	40.1
Stationery energy combustion	6.29	0.60	0.15	0.0	7.0	38	
Transport	6.30	0.04	0.12	0.0	6.5	35	
Fugitive emission	0.00	0.00	6.4E-06	0.0	0.002	0	
2. Industrial Process & Product Use	0.35	0.00	0	0.11	0.47	3	1.4
4. Waste	0.00	4.02	0.49	0.0	4.5	24	13.4
3. AFOLU	1.86	3.70	9.62	0.00	15.17	100	45.1
Livestock	0.00	2.13	0.9	0.0	3.0	20	
Land	1.84	0.00	0.0	0.0	1.8	12	
Aggregated and Non-CO_2 emissions	0.02	1.57	8.7	0.0	10.3	68	
Total net emissions (including AFOLU)	**14.81**	**8.36**	**10.38**	**0.11**	**33.66**		**100**
Total emissions (excluding AFOLU)	**12.95**	**4.66**	**0.76**	**0.11**	**18.49**	**100**	

Within the energy sector, emissions from stationery energy combustion (mainly from power plants and industrial point-sources) made up 52.2% of total emissions, followed by emissions from mobile combustion (transport) accounting for 47.8%. The remaining 0.01% came from fugitive emission sources in the oil and gas industry.

3.4.2 Description of emissions and removals by gases

3.4.2.1 Carbon dioxide emissions

In 2012, carbon dioxide emissions amounted to 14.8 Mt accounting for 48% of total GHG emissions. When emissions from AFOLU were excluded, CO_2 made up 42% share of the total GHG emissions. They increased by 100.7% from -0.11Mt in 1990 to 14.8Mt in 2012 (see figure 22). The increases were observed in all the sectors except waste where CO_2 emissions declined. The AFOLU sector recorded the highest increase in CO_2 emissions (261.8%). Emissions reduced from a net sink of -3.1 Mt in 1990 to 1.86 Mt in 2012 (see figure 21). The substantial rise in CO_2 in the AFOLU sector corresponded to the increasing intensity of land use change among forestland, croplands and grasslands. Conversions that took place on grassland and cropland contributed most to the CO_2 emissions on land for the period 1990-2012. Similarly CO_2 emissions from forestland saw a rise of 68% for the same period.

For the energy sector, CO_2 emissions made up the largest share of gases accounting for 93% of t total GHG emissions with transport and electricity generation as the main sources. Between 1990 and 2012, CO_2 emissions rose by 79.3% from 2.6 Mt in 1990 to 12.59 Mt in 2012 (see figure 19). The increases in CO_2 emissions were mainly due to the increasing emission contributions from the transport and energy industries. The rise in CO_2 emissions was as a result of the following specific factors (a) increasing traffic congestion in urban areas, (b) increasing thermal electricity in the generation mix (c) increased use of stand-by generators in commercial activities during load shedding periods, by the utility companies and (d) kerosene use in both domestic (non-electrified rural areas) and commercial activities (in parts of the urban areas) for lighting.

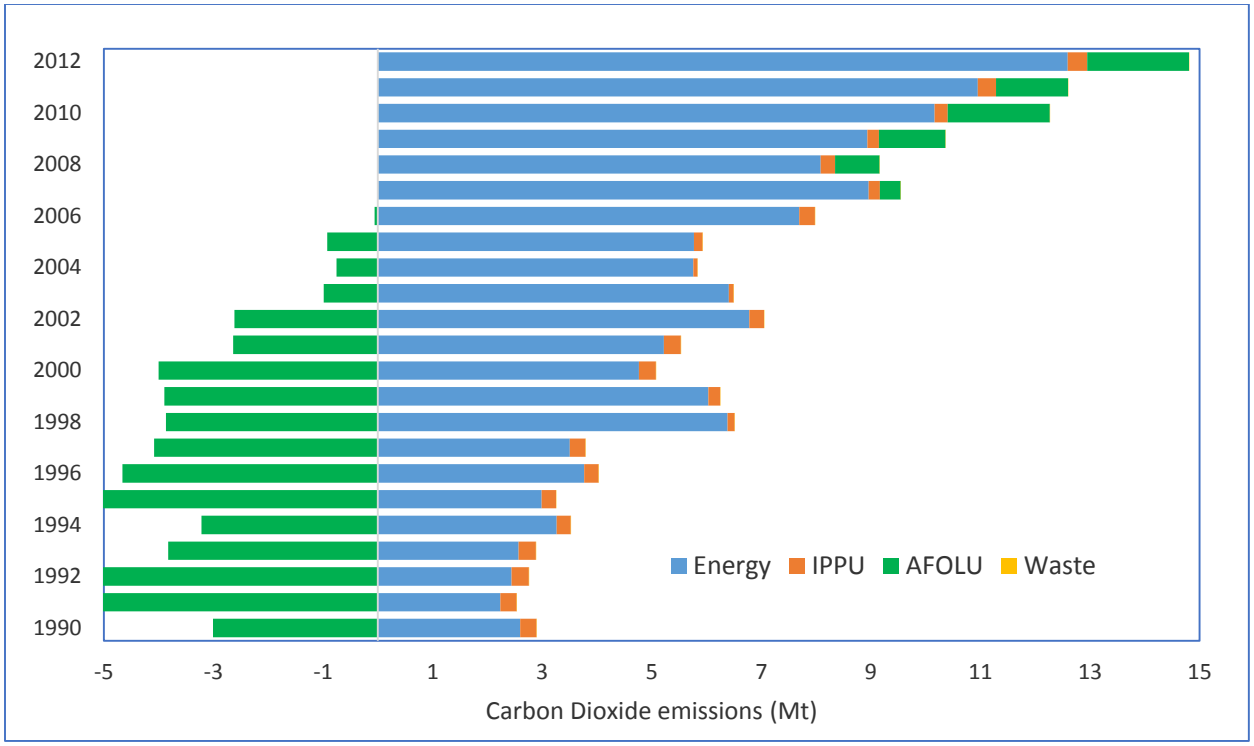

Figure 19: Chart showing trend of rising net CO_2 emissions from 1990 to 2012

3.4.2.2 Methane emissions

The total methane emissions were estimated at 8.4 $MtCO_2e$ representing 24.8% of the total GHG emissions in 2012. Methane emissions from the waste sector were the largest source contributing 48.1% followed by AFOLU (44.2%) and energy (7.7%). Although there was overall increase in the methane emissions trend, for the period 1990-2012, not all the individual sectors recorded increases (see figure 20). While the methane emissions in the waste sector saw 75.9% rise for the same period, that of AFOLU (-29.9%) and energy (-12.7%) sectors recorded decreases. In the AFOLU sector, enteric fermentation in livestock and biomass burning were the main sources of methane emissions. The rise in the number livestock and frequent burning of biomass through land clearing contributed to the emissions in the sector. Methane was the most important gas in the waste sector. It constituted 89.1% of the total emissions from the waste sector in 2012. Wastewater treatment and discharges were the dominant sources of methane (63.3%) followed by solid waste disposal (35.8%).The rising methane emissions from wastewater treatment was due to the growing proportion of domestic liquid waste which are not adequately treated before discharge into the environment. This had a strong correlation with the rising urban population in Ghana.

The growing urbanization in the country put significant pressure on the sewerage infrastructure which is incapable of meeting the load capacity. Furthermore, the CH_4 emissions increases also corresponded with the amounts of solid waste collected and disposed of throughout the period 1990-2012.The increasing amount of waste collected and disposed of, emphasizes the policy shift, over the years, in solid waste service provision from sole provision by central government to local governments and currently to involvement of the private sector. Historically, in the early 1990s, a policy shift towards private sector-led development, led to contracting out and franchising of solid waste collection services to the private sector in Accra and Tema. The shift helped to increase the amount of waste collected and deposited for treatment at landfill sites. This policy shift yielded some level of efficiency in waste collection and disposal. However, not much has been done to improve management of waste disposal sites. In addition, the existing policy does not offer clarity on landfill gas management.

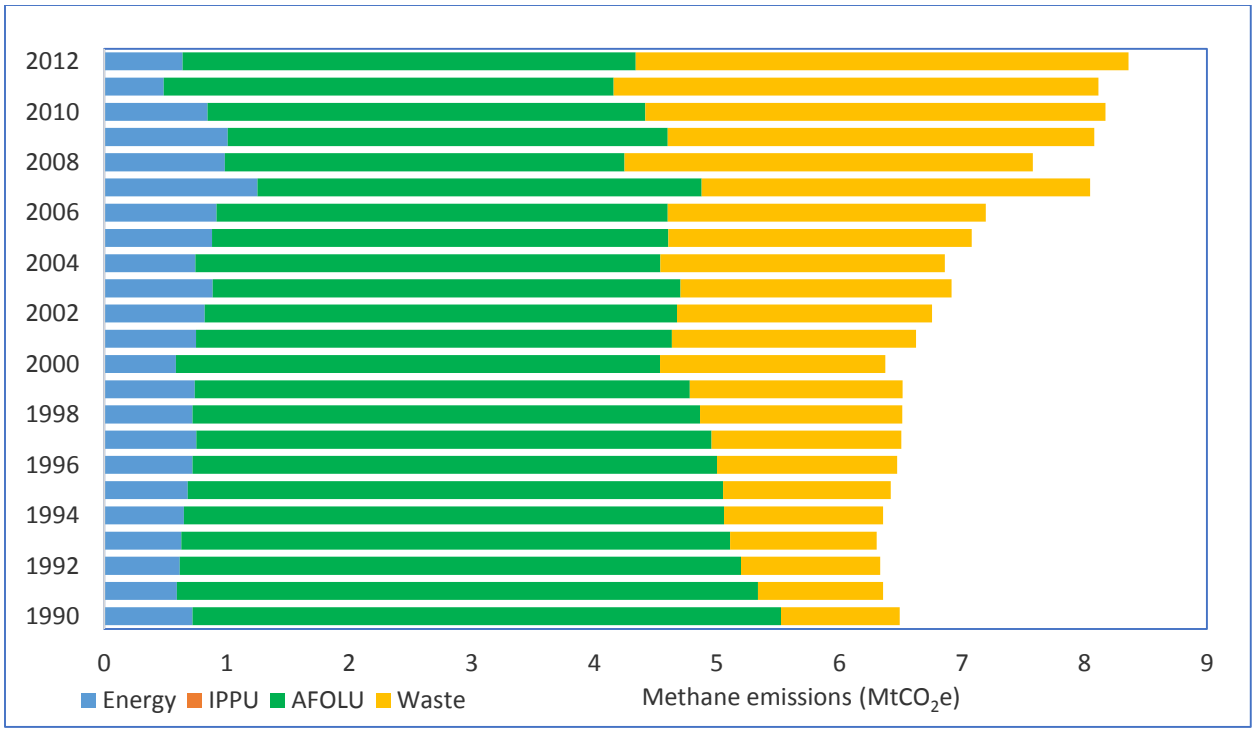

Figure 20: Chart showing rising trend of CH_4emissions from 1990 to 2012

3.4.2.3 Nitrous oxide emissions

Nitrous oxide emissions were the second important GHG emission in the country. It was estimated at 10.38 $MtCO_2e$ representing 30.8% of the total GHG emissions in 2012. For the period 1990-2012, N_2O emissions grew by 29.5% resulting from biomass burning and application of artificial nitrogen-based fertilizer in the AFOLU sector (see figure 21). The AFOLU sector was the largest source of nitrous oxide emissions followed by the waste sector incineration and open burning.

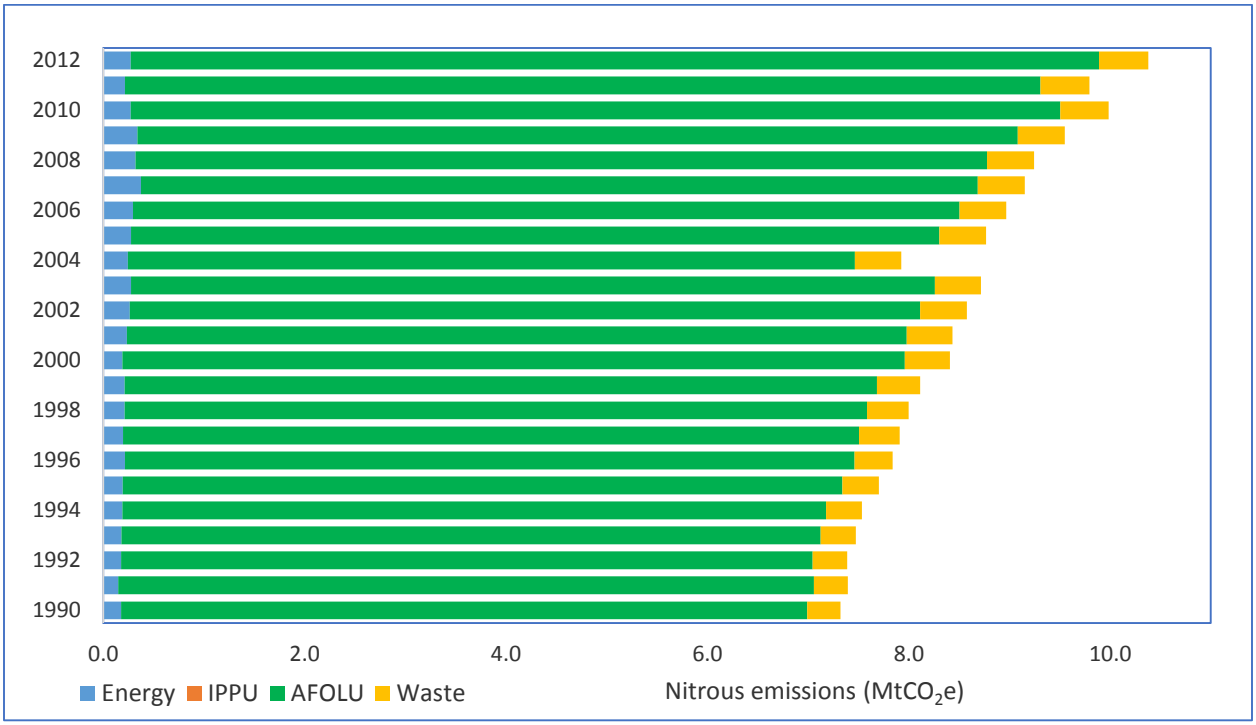

Figure 21: Chart showing rising trend of N_2O emissions from 1990 to 2012

3.4.2.4 Perfluorocarbon (PFC) emissions

Perfluorocarbons emissions were the least important GHG emission in the country. It was estimated at 0.11$MtCO_2e$ which represented 0.4% of the total GHG emission in 2012. Aluminum production in the IPPU sector was the only source of PFC emissions. The emissions showed a consistent decrease from 0.52$MtCO_2e$ in 1990 to 0.11$MtCO_2e$ in 2012 (see figure 22). The general decline in PFC emissions coincided with the periods where the Volta Aluminum Company Limited recorded lower productivity.

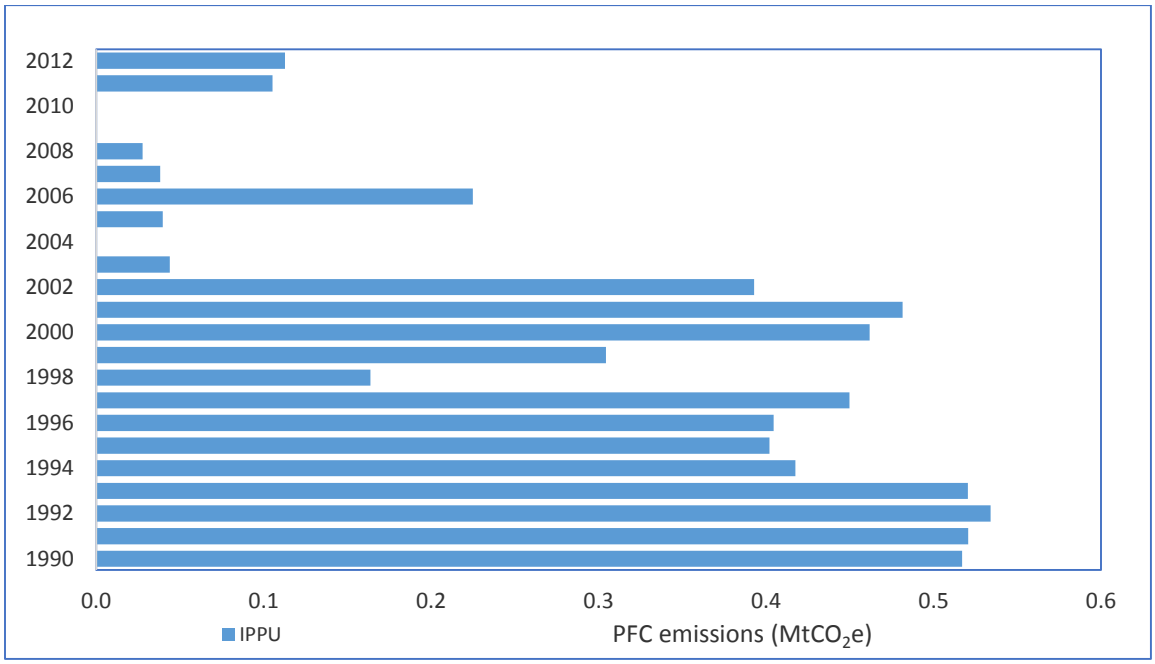

Figure 22: Chart showing of decreasing PFC emissions from 1990 to 2012

3.4.3 Description of emissions and removals by sectors

In 2012, the total emissions of 15.2 $MtCO_2e$ from the AFOLU sector constituted the largest source of GHG emissions in Ghana, which accounted for 45% of total national emissions. The 15.2 $MtCO_2e$ emissions in 2012 represented 96.5% above the share of the total emissions in 2000. Within the AFOLU sector, emissions from aggregated sources and non-CO_2emissions from land, contributed the largest share of 2.3%. The energy sector was the second largest source of emissions accounting for 40.1% of national total emissions. This share was 6.3% lower than that of 2000. Majority of the emissions in the sector were mainly from stationery fuel combustion (52%) and transport (48%) sources. The remaining 16.2% were from the waste (14.6%) and IPPU (1.5%) sectors.

Over the period 1990-2012, total emissions from most of the sectors showed increasing trends except emissions from the IPPU sector, which showed a slight decline (see figure 23). In terms of changes in trends, emissions from IPPU sector recorded the highest increase of 135% from 2010 to 2012. For the energy sector, similar increases were observed, but it was not as sharp as that of the IPPU sector. The emissions increased from 3.5 $MtCO_2e$ in 1990 to 13.5 $MtCO_2e$ in 2010, and further increased by 19.5% in 2012. Similarly, waste sector emissions rose by 71% and 7.1% from 1990 and 2010 to 2012 respectively. The AFOLU sector also recorded a 32.7% increase in emissions between 1990 and 2012 and 5.3% from 2010 to 2012.

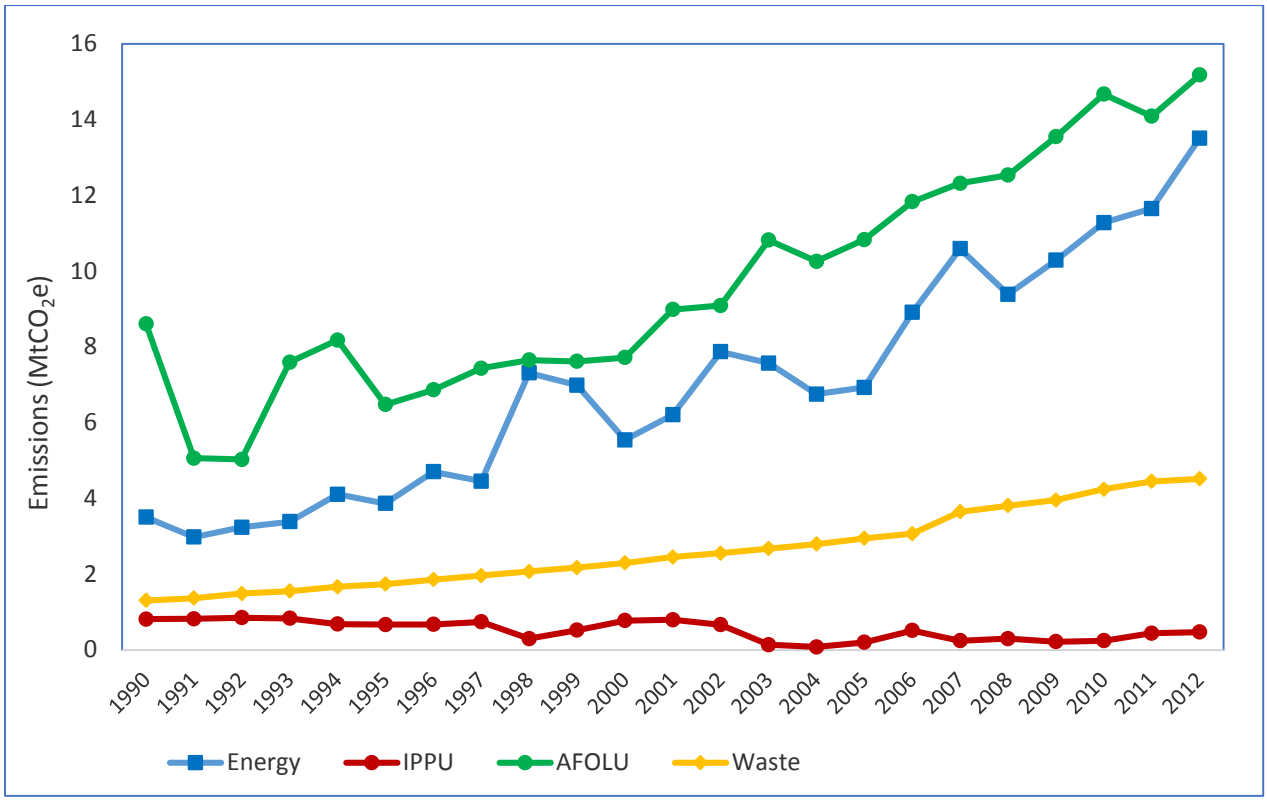

Figure 23: Trends of total emissions according to sectors

The key drivers of the emission trends in the various sectors are as follows:

- **AFOLU** – The increases in emissions from AFOLU since 1990 was mainly driven by the emissions from forest land converted to cropland and grassland, biomass burning through wildfires, increases in animal populations, crop production, fertilizer use, and associated emissions.
- **Energy Sector**: The largest sectoral increase in emissions over the 1990 to 2012 period, of 52% (7 $MtCO_2e$), was from the stationary energy sector driven partly by increasing energy demand due to rising number of electrified households, expanding commercial/industrial activities and household incomes. The main driver for the increase in transport emissions was the continued growth in the number of passenger vehicles and expanding domestic aviation industry.
- **IPPU**: The decrease in emissions since 1990 is primarily driven by the declining operational capacity of the only Aluminum Plant in Ghana (VALCO).
- **Waste**: The increase in the net emissions from waste are due to growing populations, changing lifestyles and operational and management challenges at most landfill sites.

3.5 Identification of key categories

The level assessment approach was used in identifying key categories from 1990 to 2012 while trend assessment was used to identify key categories for 2012 using 1990 as the base year. The total emissions from the key categories amounted to 17.57 $MtCO_2e$ in the year 2012, representing 57% of Ghana's total GHG emissions (without AFOLU). When AFOLU emissions were included, total emissions from the key categories came to 26.13 $MtCO_2e$ in 2012 which was 84.7% of the total national emissions. With the inclusion of the AFOLU sector emissions in the analysis, "land converted to cropland" and "forest land

remaining forest land" were identified as the most significant of the key categories (i.e. contributing more than 45% of the emissions) in 2012 (see tables 13 and 14). When the AFOLU sector emissions was excluded from the analysis, the most, significant key categories in 2012 were, road transport (liquid fuels), wastewater treatment and discharge and public electricity generation (liquid fuels).

Table 13: Identified key categories using level assessment in 2012

IPCC Code	IPCC Categories	Gas	Cumulative Total
3.B.2.b	Land Converted to Cropland	CO_2	0.2
3.B.1.a	Forest land Remaining Forest land	CO_2	0.5
3.B.1.b	Land Converted to Forest land	CO_2	0.6
3.B.3.b	Land Converted to Grassland	CO_2	0.7
1.A.3.b	Road Transport	CO_2	0.8
3.C.4	Direct N_2O Emissions from managed soils	N_2O	0.8
4.D	Wastewater Treatment and Discharge	CH_4	0.8
1.A.1	Energy Industries - Liquid Fuels	CO_2	0.8
3.A.1	Enteric Fermentation	CH_4	0.9
3.C.1	Emissions from biomass burning	N_2O	0.9
1.A.4	Other Sectors - Liquid Fuels	CO_2	0.9
4.A	Solid Waste Disposal	CH_4	0.9
3.C.1	Emissions from biomass burning	CH_4	0.9
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	0.9
3.C.5	Indirect N_2O Emissions from managed soils	N_2O	1.0

Table 14: Identified key categories using trend assessment for the period 1990-2012

IPCC Code	IPCC Categories	Gas	Cumulative Total
3.B.1.a	Forest land Remaining Forest land	CO_2	0.4
3.B.1.b	Land Converted to Forest land	CO_2	0.7
3.C.1	Emissions from biomass burning	N_2O	0.7
3.C.1	Emissions from biomass burning	CH_4	0.8
3.B.3.b	Land Converted to Grassland	CO_2	0.8
1.A.3.b	Road Transport	CO_2	0.9
1.A.1	Energy Industries - Liquid Fuels	CO_2	0.9
3.B.2.b	Land Converted to Cropland	CO_2	0.9
4.A	Solid Waste Disposal	CH_4	0.9
2.C.3	Aluminum production	PFCs	0.9
1.A.4	Other Sectors – Biomass	CH_4	0.9
1.A.1	Energy Industries - Gaseous Fuels	CO_2	0.9
3.C.4	Direct N_2O Emissions from managed soils	N_2O	1.0

In terms of trend assessment, CO_2 emissions from "forestland remaining forestland" and "land conversions to forestland" were the key categories. This was followed by N_2O and CH_4 emissions from biomass burning (see table 13).

3.6 Information on Quality Assurance/Quality Control (QA/QC) procedures

3.6.1 Description of roles and responsibilities

The sector leads were given responsibilities of ensuring that adequate QA/QC procedures were performed in the inventory, its supporting documents and spreadsheets. The EPA also doubled as the back stopper of QA/QC and focused on the following: (a) creating a checklist of QA/QC procedures, based on "EPA's Procedures template for Quality Assurance/Quality Control and Uncertainty Analysis" for the team members to follow, (b) collecting and reviewing checklists for completeness, and following up when necessary to ensure that the required QA/QC procedures were observed, (c) delivering all documentations to the online database manager, and (d) facilitating all technical reviews at the national and international levels.

3.6.2 Implementation of QC Procedures

The Tier 1 QC procedures Ghana implemented in the inventory is listed in table 15:

Table 15: Summary of the QC procedures implemented in the Inventory

QA procedures	Description of tasks	Responsibility(ies)
Internal consistency	Ensured that the total GHG emissions equaled the sum of the individual emission from the sectors and categories.	Inventory compiler
	Ensured that the total GHG emissions equaled the sum of the emissions by gas.	
	Compared data in tables to calculation spreadsheets and to the text in order to ensure that all reported the same estimates.	
	Ensured that parameters used in multiple categories (e.g., population) were consistent across categories.	
	Ensured that the emissions data is reported in a manner consistent with the calculation tables in the Non-Annex 1 National Communications Reporting Guidelines	
	Ensured that the selection and application of the estimation methods were consistent with IPCC guidelines.	
Documentations	Created back-ups of all documentations in hard and soft copies and uploaded files in a central storage facility online	Inventory compilers
	Moved all files and documentations to an "online GHG database"	Online database manager
	Reviewed, approved and harmonized sector files to ensure consistency in filing.	Inventory compilers

3.6.3 External review QA procedures

International third party review

External reviews by experts offer the opportunity to uncover technical issues related to the application of methodologies, selection of activity data, development and selection of emission factors. Based on their knowledge and experience in areas related to the inventory. The listed experts and/or organizations indicated in table 16, below were sent a draft copies of the inventory for review three months before publication. The review package that were sent to the third party reviewers included (a) data inputs, (b) inventory datasheets and results and (c) inventory report.

Table 16: List of experts for external review of national GHG inventory

Reviewer (Name)	Affiliation/Organization	Sector or Category	Comments
Zoltan Somogyi	EU – Hungary	AFOLU	Review was done as part of the CD-REDD Project through Rainforest Coalition with support from the German Government.
John Watterson & Ross Hunter	Ricardo-AEA	Energy Sector	Review was done as part of the Information Matters Project through GIZ with support from the German Government
Dominique Revet	UNFCCC	Draft inventory report	Request from Ghana for informal review of draft NIR
Sabin Guendehou	Benin	AFOLU	Review was done as part of the Sustainable GHG Management Project in West Africa through UNFCCC with support from the Australian Government

National third party review

In addition, all the sector inventory results were also subjected to "internal disclosure and assessment" by the relevant Ministries, Department and Agencies (MDAs). The "internal disclosure assessment" was done through four "reality check" meetings that were held at the various MDAs to collect inputs on (a) policy implications of the sector estimates (b) practical steps that are needed to be taken to facilitate further mainstreaming of inventory in the sector and (c) how to strengthen the linkages with research. Furthermore internal technical and policy review was done by selected management members at MESTI and EPA under the overall coordination of the Executive Director, EPA. Out of the 15 people who did review, 5 of them focused on the reviewing the TNC. They are (a) Mrs. Angela Tutu Mensah (Deputy Director, Public Relations –EPA); Mr. Emmanuel Osae Quansah (Head, Ozone/Climate Change -EPA), Dr. Emmanuel Techie-Obeng (Climate Change Unit, EPA) and Mr. Fredua Agyeman (Director of Environment, MESTI).

3.7 General uncertainty assessment

The processes for estimating GHG emissions has inherent uncertainties. Generating activity data and emission factors, either through physical measurements or modeling carries certain levels of uncertainty. Datasets that are produced through such processes introduce inherent uncertainties into the inventory. In addition, use of expert judgement to inform infilling of time series data gaps for activity data, default emission factors are possible sources of uncertainties in the inventory. Managing these uncertainties, and reducing them over time, is recognized by the IPCC Good Practice reports (IPCC 2000, 2003) as an important element of the inventory preparation and development. Ghana has conducted a tier 1 uncertainty analysis across the sectors in line with the IPCC Good Practice reports (2000, 2003). However, because most of the activity data were mainly from secondary sources that hardly reported uncertainty ranges in their metadata, qualitative approach backed by experts' judgment were used to assign the uncertainty ranges based on the sources of data in a consistent and transparent manner. In addition, the uncertainty ranges associated with the IPCC emission factors were also used. Using the IPCC recommended minimum uncertainty range of ±5% for facility level activity data, the uncertainty ranges were assigned to each activity based on the source. The spread of uncertainty ranges was assumed to increase according to the level of verifiability and reliability of the source of data. Table 11 shows the uncertainty range based on input activity data. Table 17 shows the uncertainty range based on input activity data.

Table 17: Range of uncertainty range input for activity data

Activity data source	Uncertainty Range		Comments
	Plus	Minus	
Facility level measurement	5%	5%	Applied to Volta Aluminum Plant (VALCO)
Peer reviewed literature	5%	5%	
Research results	5%	5%	
Enumeration	4%	2%	Driver Vehicle and Licensing Authority data type
Industry archive	6.5%	6%	(Ghana railway company type)
International sources	6%	5.50%	(FAO, IEA, WB, etc)
National reports			Including strategies, action plans etc.
Annual reports	5%	5.5%	
Project reports	5%	5.5%	
Energy Statistics	6%	5.5%	
National Census	5%	5%	
Ghana Living Standard Survey	5%	5.5%	
Expert judgment	15%	12%	
Personal Communication	10%	10%	

At an aggregate level, using IPCC good practice tier 1 methods, the overall uncertainty surrounding the inventory estimate for 2012 was estimated at ±2.1%.

3.8 General assessment of the completeness

Assessments of completeness for each sector have been provided under the sector-specific description section. The general overview of completeness is as follows:

Geographic coverage

The geographic coverage is complete. The inventory covered the entire territorial boundary of the Republic of Ghana. Thus none of the 10 administrative regions in Ghana was left uncovered by the inventory.

Sectors (sources and sinks)

All sources or removals of direct GHG gases, outlined in the 2006 IPCC Guidelines, were covered in the inventory except the following activities which were considered insignificant in the country or where there data was not available:

- 1A.2a – Iron and steel
- 1A.2b – Non-ferrous metals
- 1A.2i – Mining (excluding fuel) and quarry
- 1B.2a.iii.5 – Distribution of oil products
- 2F – Product use as substitute to ozone depleting substances
- 3B.4 – Wetlands
- 3B.5 – Settlements
- 3B.6 – Other lands
- 3D.i – Harvested wood products

Gases

Majority of the direct gases have been covered under this inventory. These direct gases which include CO_2, CH_4, N_2O and PFCs (CF_4 and C_2F_6). HFCs have not been considered in this inventory due to data unavailability.

Notation keys

NE (not estimated):
There were categories reported as NE because of lack of requisite data. These sources are:

- 1A.2a – Iron and steel
- 1A.2b – Non-ferrous metals
- 1A.2i – Mining (excluding fuel) and quarry
- 1B.2a.iii.5 – Distribution of oil products
- 2F – Product use as substitute to ozone depleting substances
- 3B.4 – Wetlands
- 3B.5 – Settlements
- 3B.6 – Other lands
- 3D.i – Harvested wood products

NO (not occurring)
The highest number of source categories marked with NO is found in the industrial processes sector, as most of these do not occur in the country.

3.9 Planned improvements

During the inventory, certain areas were identified for future improvements to ensure building greater confidence into the inventory estimation by reducing uncertainties to the extent possible. Table 18, 19 and 21 contain the list of identified planned improvement activities and the next steps that must be taken.

Table 18: Description of planned improvement areas for energy sector

Category	identification of planned improvement areas	prioritization of improvement activities	responsibility and next steps	Expected time to resolve
1.A4b other sector commercial/institutional	Survey on source-specific commercial/institutional generators: fuel consumption, installed capacity, population.	KC	Energy commission and EPA	Next inventory
1.A1b – Electricity generation	Develop or request IPPs to report on their plant-specific emissions and emission factors	KC	EPA & Energy Commission	Next inventory
1.A2a	Allocate fuel share to iron and steel industries (support activities)	Non-KC	Energy team	Next inventory
All Categories	Conduct survey to update and review existing sectoral fuel consumption share		Energy Statistic Team. Energy Commission	Medium-long term improvement in the reporting in Energy Statistics
1.A3b – Road Transport	Survey to update the existing 2005 data on fuel allocation to the various vehicle classes.	KC	DVLA, EPA and Energy Commission	Medium to long term bearing in mind on-going project on roadmap emission and
	Survey to improve the technology-based classification of the vehicle based EU			

	standards (in addition focus on separating functional catalytic device).			fuel economy standards by 2020.
	Survey to establish fuel economy baseline for different classes of fairly new vehicles (120,000 to 50,000km)		DVLA, EPA and Energy Commission, private garages	
	Separate portions of the total fleet used for freight transport from passenger transport		Energy Team	Next inventory
1.A3a – Civil aviation	Collect additional ATK consumption, LTO of domestic airlines data from OMCs , Civil Aviation Authority, and the Airlines	Non-KC	Energy Team	Next two inventories
	Additional data collection with the aim of producing tier 2 estimates – data on domestic air traffic movement (LTO),	Non-KC	Energy Team	next inventory
1.A3c Railways	Reconcile the Ghana Railway Company's and IEA diesel consumption for rail transport to ensure consistency and transparency.	Non-KC	Energy Team	next inventory
	Collect additional data from Ghana Railway Company on the following: (a) number of trains in service, (b) annual distances or destinations covered and (c) technologies of the trains	Non-KC	Energy Team	next inventory
Bunkering fuels	Collect additional specific data on ATK and diesel for bunkering services	-	Energy Team	Next inventory

Table 19: Description of planned improvement areas for AFOLU sector

Improvement tasks	Responsibility & Collaborators	Priority	Next Step	Target	Assumptions
Develop all-embracing new land representation schemes with definitions(include possibility of delineating tree crops from annual crop areas)	FC, EPA, UNU-INRA, Rudan, CERGIS, Geomatics-KNUST, FAO, NATU-KNUST, Cocoa Board	High	Explore possibility of making a link with the FPP process as follow-up. EPA can only facilitate.	Next Inventory	Funding is secured on time
Reprocess land use maps and LUC matrices	FC, AFOLU Team	High	AFOLU technical team from the collaborating institutions will proceed with these activities following the initial action		
Overlay land cover maps with map of eco-zones, climate and soil and recalculate land use change maps		High			
Integrate maps on perennial crops (mainly cocoa and rubber) in land use maps and recalculate		High			
Reconsider the dealing with wetlands and eliminate some ways of change between categories.		High			

Reconsider factors that express speed of land use change in the 1970s and 1980s		High			
Cross-check area estimates from LUC matrices with data available at the plantation unit		High			
Include the annual fire hotspots and overlay on the land use maps to assign disturbances to land use subcategories	FC	High	Link with AGRYMET	Next Inventory	FC to initial contact with AGRYMET supported by EPA
Work on biomass inventory	FC and FORIG	High			
Include the biomass density estimates for plantations	FC and FORIG	High	EPA to follow-up with FC and FORIG	Next Inventory	Contact FORIG
Remove outliers from biomass plot estimation (dead wood estimates)	FC and FORIG	High			Contact FC for updates
Quality check deadwood calculations in inventory data	FC and FORIG	High			Contact FC
Explore possibility of surveying of non-forest trees, in settlements and communities(Measure AGB and fuel wood collections in settlements and integrate these values in the inventory)	FC and FORIG and EPA	Medium	Float call for proposal for the selection of the vendors	Next Inventory	Fund secured by EPA
Explore possibility of including trees in annual croplands	FC & MoFA	Medium	include in the discussions of the AFOLU collaborating team	Next Inventory	part of the activity 1
Explore possibility of reducing uncertainty associated with time series data (infilling of data gaps)	AFOLU Team	Medium	EPA to coordinate revision of existing estimates.	Next Inventory	Funding is secured on time
Account for the burning of crop residues beyond the burning of fields	MoFA	Low	MoFA to lead AFOLU team in the identification, collection and inclusion of data in to the inventory	Next Inventory	Funding for NC4 and BUR2 will cover this activity
Account for multiple cropping rice	MoFA and AFOLU Team	Low			
Include harvested wood products	FC	Low			
Include crop residues from plantain	MoFA and EPA	Low			
Clarify the fertilizer use in rice	MoFA and EPA	Low			

Table 20: Description of planned improvement areas for waste sector

Improvement tasks	Responsibility & Collaborators	Priority	Next Step	Target	Assumption
Collect additional data on solid waste generation rate and waste classification	Built Environment Department, EPA, Civil Engineering Department, KNUST, MLGRD, AMA, KMA, STMA, TMA	medium	Contact relevant institutions to include data need into yearly surveys and research	next inventory	Funding is secured on time
Revise solid waste generation rates and waste stream fractions with new datasets	Waste inventory team	high	EPA to coordinate revision of existing estimates	next inventory	
Separate solid disposal further to managed, unmanaged and uncategorized	Waste inventory team	medium	EPA to coordinate	next inventory	Availability of new solid waste dataset
Revise fraction of solid waste biologically treated through composting	Built Environment Department, EPA and Zoomlion Ghana Limited	medium	EPA and Zoomlion to take lead	next inventory	
Revision of the fraction of solid waste incinerated and openly burnt	Built Environment Department, EPA	medium	EPA to contact Ghana Health Service and Ghana Education Service to include in their survey	next inventory	
Update existing survey data on industrial and domestic waste	Manufacturing Industry Department, EPA	high	EPA to initiative review of industrial survey	next inventory	Funding is secured on time

Table 21: Description of planned improvement areas for IPPU sector

Item	Description
Data improvements	Conduct industrial survey in country to identify all possible sources according to the IPCC guidelines for both formal and informal sources and ensure data is collected and sources maintained for future inventories.
	Identify, track and monitor any potential new source of emission for inclusion in inventories according to the IPCC guidelines.
	Identify additional data collection sources for lime production. Particular attention will be given to collecting enough data to fill in time series gaps.
	Collect comprehensive data on ODS substitute gas (HFCs) especially in the refrigeration and air-conditioning sectors.
	Collect data for 1990 to 2004 and include the data from a second plant established in country relying on the latest guidance from the IPCC on the use of facility-level data in national inventories.
Methodological improvements	Improvement in estimates on non-energy use and feedstock to ensure internal consistency
	Analyze data reported for dolomite use by the cement industry and limestone use as fluxes in the steel recycling plants which would be useful to improve the emission estimates for the Limestone and Dolomite Use source category. In implementing improvements and integration of data from the plant, the latest guidance from the IPCC on the use of facility-level data in national inventories will be relied upon. Additionally, future improvements include revisiting the methodology to ensure the use of tier 2 method for all years to improve emissions calculations.
	Analyze data reported particularly for all three steel plants that would be useful to improve the emission estimates for the Iron and Steel Production source category. It will be important to ensure time series consistency, as the facility-level reporting data from the facilities may not be available for all Inventory years as required for this inventory. The latest guidance from the IPCC on the use of facility-level data in national inventories will be taken into account.

Mitigation assessment and policy measures

Contributors

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4. GHG Mitigation Assessment and Policy Measures

4.1. Structure of mitigation assessment

This section contains the results and description of the processes of GHG mitigation assessment. It is reported in two parts. Part one contains documentation of the systematic process for conducting the mitigation analysis. Information on the processes have been provided under the following captions (a) key sectoral emission analysis, (b) institutional arrangements for mitigation activities, (c) methods and data sources, (d) mitigation analysis archiving system and (e) plans for further mitigation. The second part presents technical details of results that emerged from the mitigation assessment. The results are presented for individual and aggregated measures, which is under energy and non-energy sectors. Extra information is provided on the details of prioritized "abatement measures" and the description of the screening of the list of mitigation actions.

4.2 Documentation of mitigation assessment

4.2.1 Key Sectoral emission analysis

4.2.1.1 Mapping inventory categories to mitigation sectors

The preparation of the mitigation assessment component of Ghana's TNC involved mapping of emissions inventory estimates of key sectors of the mitigation analysis. The mapping helped to create a link between the GHG estimates and the mitigation assessment. This step also included documenting business-as-usual (BAU) emissions projection that was used in the mitigation assessment. A first important step is mapping emissions from traditional categories used in inventories (e.g., energy, industrial process, agriculture and forestry) into sectors and categories more commonly used in mitigation analyses (i.e., energy supply, residential and commercial, transportation), both for historical and future years. This process provided insight in prioritizing mitigation analysis in the sectors with the highest current emissions, as well as the greatest emissions growth. Table 21 presents the key emissions sources in Ghana for the most recent base year. In order to better facilitate assessment of mitigation options, this table also provides highlights of the mapping of inventory categories to sectors suitable for mitigation analysis. For example, the inventory category of energy CO_2 emissions can be broken down into electricity generation (power supply), transportation, residential/commercial, and industrial sectors, based on where fossil fuels are combusted.

Due to lack of technical/economic data and non-availability of appropriate mitigation tools, the mitigation assessment was limited to the following categories: (a) energy sector - (which include electricity supply and demand side management covering transportation, residential and commercial, industry categories) and (b) non-energy sectors (forest management and solid waste management). Information on business-as-usual (BAU) scenario, which depicts future emission projections of the current situation in the event of status quo continue. In energy sector BAU analysis, Ghana developed two future projection options. Scenario without measures (WoM), depicts a future projections where trends in the status quo remain unchanged and none of government's policy or objectives are achieved. The scenario with measures (WM) depicting a future projection that takes into account emission reduction effects of relevant energy policies. For the non-energy sectors, the definition of the future projections in the BAU analysis is similar to WoM under the energy sector. Tables 22, 23 and 24, present a projection of reference case or "business-as-usual" emissions, mitigation scenario and overall effects of mitigation by sectors.

Table 22: Mapping of mitigation sectors based on contribution to total national emissions in 2000 and 2010

Inventory Categories	IPCC Code	Mitigation Sectors	Historical Emissions ($MtCO_2e$)		Contribution to National Emissions (%) in 2010
			2000	2010	
Energy	1.A1	Electricity supply	0.48	3.08	10.1%
		Oil Refinery*	0.07	0.15	0.5%
	1.A3	Transportation	2.8	4.80	15.7%
	1.A4	Residential and Commercial	1.48	2.17	7.1%
	1.A2	Industry	0.71	1.11	3.6
Industrial Processes	2		0.78	0.24	0.8
AFOLU (Agriculture)	3A	Agriculture	2.20	2.82	9.2%
AFOLU (Land)	3B	Forest Management	-4.0	1.85	6.1%
AFOLU (Aggregated sources and Non-CO_2 emissions)	3C	Other sources	9.52	9.99	32.8%
Waste	4A, 4B 4C and 4D	Waste Management	2.3	4.24	13.9%
		Total	**16.31**	**30.49**	**100%**

**Energy supply activities other than electricity generation (power supply) are often reported and analyzed in the sector activities such as oil refining under Energy Industries. The rest of the activities under energy industry are not applicable in Ghana.*

Table 23: Projection of business-as-usual (BAU) emissions

Mitigation Sectors	Emissions ($MtCO_2e$)			
	Base Year 2010	Year 2020	Intermediate Year 2030	Projection End Year 2040
A. Energy sector				
A.1 Energy supply				
A.1.1. Electricity supply	3.08	8.24	20.48	45.18
A.2 Energy demand side management				
A.2.1. Residential and Commercial	2.17	2.20	2.28	13.7
A.2.2.Industry	0.71	2.32	6.17	15.9
A.2.3 Transport	4.80	11.35	22.2	43.14
B. Non-energy sector				
B.1 Forest Management**	1.85	3.07	4.29	5.5
B.2 Solid Waste Management*	1.5	1.57	1.64	1.72
Total	14.11	28.75	57.06	125.14

** Solid waste category only ** Focused on CO_2 emissions from land only. Total emissions of 14.11 $MtCO_2e$ cover only the mitigation categories as presented in Table 22*

Table 24. Projection of mitigation scenarios emissions

Mitigation Sectors	Emissions ($MtCO_2e$)			
	Base Year 2010	Year 2020	Intermediate Year 2030	Projection End Year 2040
1. With measures scenario				
A. Energy sector	0	-0.47	-1.03	-1.11
A.1 Energy supply				
A.1.1. Electricity supply (coal option)	0	-0.02	-0.47	-1.54
A.1.2. Electricity supply (without coal option)	0	0.02	0.47	1.12
A.2 Energy demand side management				
A.2.1. Residential and Commercial	0	0.19	0.29	0.43
2. With additional measures scenario				
B. Energy sector	0	-3.14	-14.55	-39.19
C. Non-energy				
C.1 Afforestation/Reforestation	0	1.88	2.024	2.22
C.2 Solid waste management	0	2.4	4.7	7.1
Total	**0**	**7.52**	**21.27**	**48..51**

4.2.1.2 Overall effects of mitigation actions on baseline emissions

In scenario without measures (BAU scenario), Ghana's total emissions is projected to grow from 14.11 $MtCO_2e$ in 2010 to 125.14 $MtCO_2e$ by 2040 (see table 25). By 2040, the overall effect of the implementation of mitigation actions on the BAU scenario is likely to translate to 76.3 $MtCO_2e$.

Table 25. Overall effects of mitigation actions on baseline emissions

Year	Emissions ($MtCO_2e$)		
	BAU Emissions (A)	**Mitigation Scenario emissions (B)**	**Overall effects of mitigation actions on BAU emissions (A-B)**
2000	2.03	0	2.03
2010	14.11	0	14.11
2020	28.75	7.52	21.23
2030	57.06	21.27	35.79
2040	125.14	48.51	76.63

The trend of the effects of mitigation actions on the BAU emisisons will increase consistently from 2020 towards 2040. Figure 24 shows the overall impacts of the mitigation actions on BAU scenario.

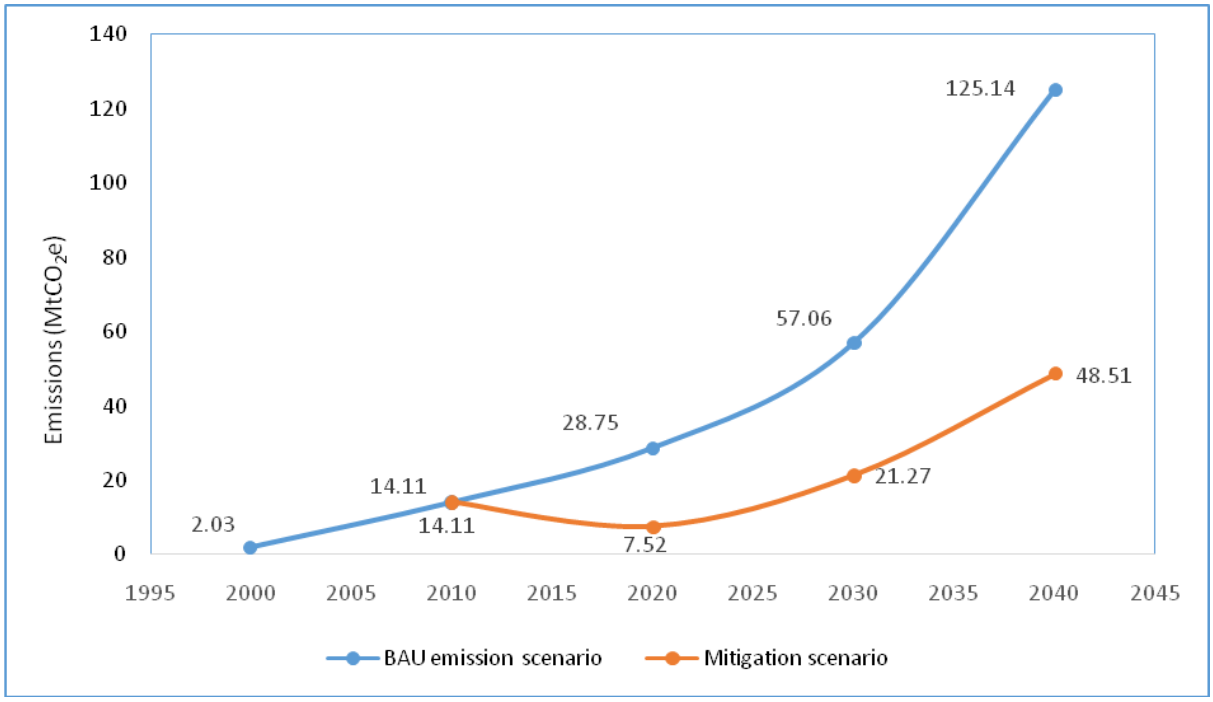

Figure 24: Overall effects of mitigation actions on BAU emission scenario

4.2.2 Institutional arrangements for mitigation assessment

This section summarizes existing institutional arrangements for GHG mitigation assessment in Ghana, and helped the mitigation teams to evaluate and document the strengths and weaknesses of these existing arrangements. The description of the institutional arrangements includes providing information on existing arrangements and their status, and identification of areas for future improvements. Table 27 provides an overview of the institutional arrangements of the current GHG mitigation assessment working group. Tables 25 gives an overview of the relationship between the designated mitigation organization and UNFCCC Focal Point Agency. Table 26 contains information on the mitigation-assessment working group. The information covers roles and responsibilities, contact addresses and additional comments on what needs to be done to strengthen the relationship among the working group institutions.

Tables 26 and 27 provide additional information on sectoral institutional arrangement for the energy and non-energy sectors as well as suggested measures for potential improvements. In table 26, the information that has been provided on sectoral institutional arrangements covers roles, institutions, contact addresses and comments on how the functional relationships among the working group institutions is managed. The EPA is the designated mitigation assessment agency and host of the UNFCCC focal point. The Agency is responsible for coordinating the planning, preparation and reporting of the mitigation assessment. Within the Agency, the climate change unit undertakes day-to-day management of the mitigation assessment. The unit prepares work plan for the sectoral mitigation teams, assists in data request and ensures that the deliverables that meet high quality standards are submitted on time. The unit doubles as the documentation and single storage location of all data. The unit also helped to identify various institutions that made up the mitigation assessment-working group and prepared the memorandum of understanding (MOU). The mitigation-working group was further divided into four

sector sub-teams, which focused on energy, solid waste management, AFOLU and crosscutting issues. Each sub-team was made up of three or four institutions that have relevant experience in the category.

Table 26: Designated mitigation assessment agency

Designated National GHG Mitigation Assessment Preparation Agency/Organization	Describe the arrangements or relationships between Mitigation Assessment Agency/Organization and UNFCCC Focal Point Agency	UNFCCC Focal Point and UNFCCC Focal Point Agency
Energy Commission	Member of mitigation assessment working group responsible for energy categories. UNFCCC Focal Point Agency manages the entire assessment process from planning, preparation and reporting.	Mr. K. Y. Oppong Boadi, Environmental Protection Agency
Energy Centre, KNUST		
Forestry Commission	Member of mitigation assessment working group responsible for Forest Management. UNFCCC Focal Point Agency manages the entire assessment process from planning, preparation and reporting.	
Ministry of Food & Agriculture		
Economics Department, University of Ghana, Legon	Member of mitigation assessment working group responsible for financial and economic modeling.	
CDM/DNA – MESTI	Member of mitigation assessment working group responsible for policy and strategy alignment.	
Environmental Protection Agency (Built Environment Department.)	Member of mitigation assessment working group responsible for solid waste management. UNFCCC Focal Point Agency manages the entire assessment process from planning, preparation and reporting.	
Environmental Protection Agency (Manufacturing Industry Department and Built Environment Dept.)	Member of mitigation assessment working group responsible for industrial processes. UNFCCC Focal Point Agency manages the entire assessment process from planning, preparation and reporting.	

Table 27: National Mitigation Assessment Team

Role	Name	Organization	Contact Information	Comments
Mitigation Team Leader	Dr. Joseph Essandoh	Energy Commission	Email: jeyeddu@hotmail.com Tel: 020-818-7199	Daniel Benefoh of Environmental Protection Agency backstopped the team leader.
Electricity Supply Sector Lead	Mr. Mawunyo Dzobo	Energy Commission	Email: mdzobo@yahoo.co.uk Tel: 0242-613-476	The sector lead ensured strong linkages with the strategic national energy planning process.
Transport Sector	Mr. Kennedy Amankwa	Energy Commission	Email: kenamankwah@yahoo.co.uk Email: kenamankwah@yahoo.co.uk Tel: 0242-261-212	Member of the national GHG inventory working group on energy.
Residential and Commercial Sector	Paula Edze	Energy Commission	Email: pedze@energycom.gov.gh Tel: 026-567-6250	Coordinator, SE4ALL Secretariat
Industry Sector	Edward Awafoe	The Energy Centre	Email: awafoe@hotmail.com Tel: 024-497-7104	
Forest Management Sector Lead	Kingsley Amoako/ Robert Bamfo	Ministry of Food and Agriculture Forestry Commission	Email:kingkwaw@yahoo.com Tel: 020-741-1864 Email: bamforobert@yahoo.com Tel: 020-823-7777	Other members of the Land sector include Mohammed Yakubu, Winston Asante, Nicholas Jingre, Kwame Agyei, Kwabena Asubonteng

Solid Waste Management Lead	Mr. William Acquah Hayfron	Environmental Protection Agency	Email:willieacquah@yahoo.com Tel: 024-463-3684	
Economic/Integrated Analysis	Dr. Daniel Twerefou,	University of Ghana Economics, Dept.	Email:twerefou@yahoo.co.uk Tel: 0244-603-676	
Linkages with policy and Market mechanisms	Peter Dery	CDM/DNA, MESTI	Email:peterjdery@yahoo.co.uk Tel: 0243-646749	
Archive (Data and Document)	Daniel Benefoh Tutu	Environmental Protection Agency	Email : dbenefor2000@yahoo.com Email : dbenefor2000@yahoo.com Tel: 0246-114-652	Member of the national GHG inventory-working group on energy.

Table 27 gives further information on sectoral roles and responsibilities performed by the various sub-team members. The roles were mainly on (a) coordination of the mitigation assessment process, (b) technical analysis in the categories, (c) review of results and methodological choices, (d) data collection and provision and (f) data archive. The table also provides additional information on how the specific details on the assigned tasks to the sub-teams were executed and the challenges that need to be addressed in order to make it work better in the next mitigation assessment.

Table 28: Institutional arrangement and roles

Role	Organization	Contact(s)	Contact Information	Participated in meetings?	Comments
Mitigation assessment lead-overall coordination of GHG mitigation assessment	Ghana Energy Commission/ Environmental Protection Agency	Dr. Joseph Essandoh and Daniel Benefoh	Email: jeyeddu@hotmail.com Tel: 020-818-7199 Email: dbenefor2000@yahoo.com Tel: 0246-114-652	Yes.	A formal MOU was signed between EPA and lead institutions that constituted the mitigation assessment-working group. Coordinated series of technical and stakeholder meetings were held (15 meetings in all) on the following: (a) GHG mitigation assessment training (b) scoping of mitigation assessment and work plan, (c) data collection strategies and (d) informal working sessions. Responsible for the collation of sector reports in mitigation assessment report.
Mitigation assessment working group conducting sector technical analysis	Energy Commission, EPA, Energy Centre, Ministry of Food and Agriculture, KNUST, Forestry Commission, United Nations University	Refer to table 27	Refer to table 27	Yes	The working group institutions were put into sectors teams (Energy, transport, AFOLU, Industrial Processes and Waste Management. Each team was tasked to (a) identify all data sources, (b) strategize to collect and process data and (c) choose appropriate tool for conducting the sector mitigation assessment and prepare sector reports.
Working Group members conduct expert reviewer	University of Ghana, Economics Dept. CDM/DNA-MESTI, EPA	Refer to table 27	Refer to table 27	Yes	Responsible for ensuring linkages with national and sector policies and the administration of CDM and any other market mechanisms. In addition, group members conducted technical review of the methodology and the results.
Data providers	SPPD - Energy Commission	Mr. Mawunyo Dzobo	Email:mdzobo@yahoo.co.uk Tel: 0242-613-476	Yes	Provided input data for LEAP analysis under energy sector. LEAP data was used in the Strategic National Energy Plan (SNEP). Data was requested through combination of forma (official letter) and informal (verbal communication with staff) means.
	Ghana Statistical Services	Mr. Francis Dzah	Email:f.dzah2002@gmail.com Tel: 0242-546810	Yes	Facilitated access to publicly available data on Ghana living standards surveys, housing and multiple indicators cluster surveys.
	Ministry of Finance	Mr. Kwesi Asante	Email: kwaseantus@yahoo.com Tel: 0244-654193	Yes	Data on climate finance tracking
	NDPC	Mr. Isaac Kwasi Eweh	Email: isaac_ew@yahoo.com Tel: 0244-4205720	Yes	Provided annual progress reports. Tracking of implementation development policies
	Forestry Commission	Mr. Mohammed Yakubu	Email: myakubu@yahoo.com	Yes	Provided data on forest plantation
	Environmental Protection Agency	Built Environment Department		Yes	Provided data on solid waste management
Data Archiving	Environmental Protection Agency	Climate change unit	Email: dbenefor2000@yahoo.com Tel: 0246-114-652	Yes	Documentation and archiving

4.2.2.1 Potential Improvements in institutional arrangement

Table 29 covers selected areas in the management structure of the mitigation assessment for improvements. The improvements covers: (a) collecting complete datasets, (b) strengthening working relationships among stakeholder institutions, (c) developing capacity through continuous training (d) accessing appropriate mitigation assessment tools and above all (e) widening participation to include new relevant stakeholders.

Table 29: Potential improvement in the management structure of national mitigation assessments

Sector	Strengths in Management Structure of National Mitigation Assessments	Potential Improvements in Management Structure of National Mitigation Assessments
Electricity supply	Reliable plant level electricity supply data. Data on projected electricity supply was adequate since the independent power producers provided it. The regular annual publication of electricity supply data in the national energy statistics is a good source of data.	• Collect data on country-specific emissions factors for representative electricity thermal plants. • Liaise with Volta River Authority to begin facility level accounting. • Collect additional data on indigenous natural gas supply once it comes on line in full stream in 2015. • Improve economic forecast data in the electricity sub-sector
Transportation	Availability of vehicle population data from DVLA in different technology and weight classifications from 1990 to 2012.	• Work with private vehicle inspection companies to collect improved data on annual mileage. • Conduct survey to collect data on passenger or freight km in collaboration with Ministry of transport and DVLA including circulation data • Improve data on the correlation between passenger/freight transport and sector GDP and motorization rate. • Technical training on transport modelling including domestic aviation.
Residential and commercial buildings	Ghana Living standard survey was a major source of household data on energy consumption and expenditure on household energy demand	• Improve data on relationship between economic and population forecast and household electricity demand.
Industry sector	Data from Industrial and commercial surveys as part of the preparation of strategic national energy plan.	• Update data on industrial and commercial energy consumption and supply through survey. • Start a programme to involve industrial and commercial facilities in energy and emissions accounting.
Forest management	National plantation development programme annual report provides good data on plantation areas, target and investment expenditures	• Training and capacity enhancement on mitigation assessment modeling tools in the AFOLU • Expand assessment to include other AFOLU activities • Collect additional data on AFOLU and ensure that AFOLU baseline reflect the REDD+ forest reference levels.
Solid waste management	Data from only commercially operated compost plants was used in the analysis.	• Collect landfill-specific or facility level data on solid and liquid waste disposal and treatment. • Collaborate with local government authorities in the ten regional capitals in Ghana to improve on the method of data collection especially solid waste disposal.

Cross-sectoral	There is collaboration between economic research, development and environment institutions which facilitated greater exchange of data and experiences on economic forecasts and sustainability options	• Deepen the involvement of research and academic institutions in the economic forecasts and analysis of market potentials of selected technologies. • Collaborate with research and academic institutions to develop methodological tools that take into account the true economic structure of Ghana. • Develop simple to implement QA/QC and uncertainty templates for the sectors.

4.2.3 Mitigation assessment methods and data sources

This section provides information on the methods, data sources, and other resources used for the mitigation assessment. Future mitigation assessment teams can refer to this documentation to determine what methods were used and tools and resources relied upon. It will also help to improve on transparency by explaining how the assessments were developed and above all, reduce the effort required by future teams to develop the mitigation assessments and provide a basis for ensuring consistency in future reports. Table 30 provides an overall summary of the methods used for key mitigation analysis tasks (BAU projection, mitigation scenario analysis, etc.

Table 30: Methods used for mitigation analysis

Analysis Task	Description of Methods	Who conducted analysis?	Key Contact	Comments
Development of BAU Scenario	**Energy and transport** - Based on previous scenarios without measures (WOM) constructed during the national energy planning exercise as part of the strategic national energy planning conducted last year. Developed based on the assumption that government will not adopt any additional policy or programme. **Non-energy sector** – emissions baseline scenarios were developed on the basis that the prevailing base case will continue.	Mitigation assessment working group	Energy and transport team – Mr. Mawunyo Dzobo (Energy Commission)	Assumptions that informed BAU scenarios were consistent with the study that was conducted under strategic national energy planning. The WOM scenario is similar to BAU
Mitigation option development and prioritization (Screening)	Used multi-criteria assessment to screen options based on significance of emission reductions, marginal cost, financial requirements, consistency with national development goals, availability of technology, capacity, and other co-benefits	Mitigation assessment - working group	Daniel Tutu Benefoh, (Environmental Protection Agency)	Dr. Daniel Twerefou, (Economics Department, University of Ghana, Legon) provided technical inputs. Similar screen spreadsheet was used by the Low Carbon development strategy team
Macro-economic analysis	Not conducted due to limited availability of appropriate modeling tools and costs of analysis.			Low Carbon Development Strategy team plans to conduct Macro-economic analysis with support from UNEP DTU
Mitigation scenario analysis (integration)	Simulation (LEAP Model)	Energy team	Mr. Mawunyo Dzobo (Energy Commission)	
	Simulation (COMAP Model)	AFOLU team	Kingsley Amoako (MoFA) and Robert Bamfo (FC)	
	Solid waste (Solid Waste Management tool)	Waste team	Joy Ankomah and Daniel Lamptey	
Development of cost curves	Spreadsheet analysis (Marginal cost curve) for selected mitigation technologies	Mitigation assessment - working group.	Daniel Tutu Benefoh, (Environmental Protection Agency	Third party review of technology and cost inputs to the marginal cost curve.

Table 31-33 provides further documentation on the tools and resources used for specific mitigation analysis tasks, why such tools and resources were used, and comments and suggestions for future analyses.

Table 31: Tools and methodologies used in the energy sector

Analysis Task(s) / Use	**Development of BAU and mitigation scenarios / Modeling tool for Energy sector**
Sector/Scope	Economy-wide (with the exception of afforestation and waste management) – scenario without measures (WOM) and scenario with measures (WM) were developed. WoM represent future scenario with freeze policy (the trend if the existing case remained unchanged in future and none of the proposed or on-going government policies and measures that have mitigation objectives are implemented), WM represents a future scenario where proposed or on-going domestic (government) policies and measures are implemented in order to attain unintended mitigation objectives although its less ambitions than scenario with additional measures (mitigation scenario – where ambitious additional measures are undertaken with international support to attain greater emission reductions.)
Model/Data Source/Tool	LEAP (Long-range Energy Alternative Planning System)
Describe Why this Resource Was Chosen	Simple, flexible modeling tool; adaptable to national circumstances.
Contact	Energy and transport team – Mr. Mawunyo Dzobo (Energy Commission)
Other Comments (e.g. Usefulness, Lessons, Suggestions for Future Analysis)	LEAP allowed changes in the key assumptions pertaining to the present and future economic development circumstances and policy context of major government policies and measures. It was not possible to develop WOM and WM baseline scenarios in LEAP that were not technology dependent. There is need to explore the possibility of linking LEAP to models used by other sectors (afforestation and solid waste management.) This linkage reduced the potential inconsistencies in the assumptions and conditions that informed the baseline. Bringing the models together also allowed for equal treatment of sector analysis at the same scale.

Analysis Task(s) / Use	**Development of Marginal Abatement Cost Curve**
Sector/scope	Economy-wide (except afforestation and solid waste management)
Model/data source/tool	Mitigation screening tool
Describe why this resource was Chosen	Simple, flexible modeling tool; adaptable to national circumstances
Contact	Daniel Tutu Benefoh, (Environmental Protection Agency)
Other Comments (e.g. Usefulness, Lessons, Suggestions for Future Analysis)	Multi-criteria analysis allowed for an objective way of prioritizing technology based mitigation options using qualitative and quantitative criterion. The screening process went through several rounds of scoring and weighting from different stakeholders during national consultation meetings. The final perfect score and weight represent different average iterations.

Table 32: Tools and methodologies used in the Forest Management

Analysis Task(s) / Use	Assessment of Potential Carbon Stock Enhancement Potential for Afforestation/Reforestation
Sector/Scope	Sector (Forest Management)
Model/Data source/tool	COMAP (Compressive mitigation assessment process)
Describe Why this resource was chosen	Best available resource, which allow sector wide mitigation assessment. Less data intensive and available technical capacity to implement the model.
Contact	Kingsley K. Amoako (Ministry of Food and Agriculture) and Robert Bamfo (Forestry Commission)
Other comments (e.g. usefulness, lessons, suggestions for future analysis)	In future, it is important that the selection of parameters into the COMAP model be informed by the scope of the REDD+ forest reference level. At the time this work was done, the REDD+ forest reference level has not been established.

Table 33: Tools and methodologies used in Solid Waste Management

Analysis Task(s) / Use	Assessment of GHG mitigation potential in the Solid Waste Sector
Sector/Scope	Sector-wide (Solid Waste Management)
Model/Data Source/tool	Tool for calculating GHG in solid waste management (SWM)
Describe why this resource Was chosen	Simple, flexible modeling tool; adaptable to national circumstances,
Contact	Joy Ankomah and Daniel Lamptey, (Built Environment Environmental Protection Agency)
Other comments (e.g. usefulness, lessons, suggestions for future Analysis)	Explore opportunities to include GHG mitigation potential assessment for domestic and industrial liquid waste disposal

4.2.4 Mitigation assessment archiving system

4.2.4.1 Review of existing archiving system

Ghana established a simple archiving system during the development of the mitigation assessment. The archive system keeps records of references, chosen methodologies, expert comments, revisions etc. as well as descriptions of the location where these records are kept. The archiving system is a helpful component of the process and encourages sustainability of the mechanism for developing the mitigation component of the national communication. It also helps make the mitigation analysis and assessment transparent and reproducible, and facilitates development of subsequent work by future staff. All records generated during the mitigation assessment, were archived in a single location on the online server hosted at the EPA. The records are in electronic format so that future mitigation teams can have easy access to all relevant files to respond to reviewer feedback including questions about methodologies.

Extra copies of the archived documents have been stored on hard drive in order to reduce the risk of losing all records. All data for the mitigation assessment were collected and processed by the mitigation assessment-working group with technical backstopping from the EPA Some of the data in soft copies were received from the previous team that worked on mitigation assessment under the second national communication. The rest of the data were either collected by the mitigation-working group (non-energy sectors) or were collated during the preparation of the strategic national energy plan (energy sector). All data (processed data, results, and reports) were stored in electronic format in all the three (3) working spreadsheets and one application database. Each spreadsheet was named according to sector and date the files was last saved. The spreadsheet files are (a) FM_date modified, (b) SWM_date modified, (c) mitigation action screening tool_data modified, and (d) leap mitigaition_date modified. Records of all comments, expert judgments, and assumptions are contained in the respective spreadsheets and the leap file.

4.2.4.2 Archive system plan

A description of the Archive System Plan that Ghana plans to follow to ensure a high-quality national mitigation analysis based on an assessment of existing practices is described below.

Archiving contact person's roles and responsibilities

The archiving contact will be designated at the beginning of the next cycle of mitigation analysis. The archiving contact person will be responsible for ensuring that all archiving procedures were performed for the mitigation analysis and all supporting documents and spreadsheets are retained appropriately. He/She will also be responsible for clarifying who is responsible for carrying out archiving procedures at various levels, as well as for ensuring that all team members know their archiving responsibilities, including which documents are worth archiving. These responsibilities require that the archiving contact person:

- Communicates archiving system plan, procedures, and responsibilities to other staff.
- Determines archiving tasks and assigns tasks to staff and creates a checklist of archiving procedures for team members to follow.
- Ensures that the archiving procedures are implemented effectively.
- Serves as the keeper of the permanent archives and responds to future requests to access archival materials.

This task is the general responsibility of the Mitigation assessment leader, who is in charge of compiling the mitigation component for the National Communication for Ghana.

Proposed Archive procedures

The archive plan that will be developed for Ghana by the archive contact person will take into account the following:

A Management of files

- Save files with mitigation sector name and analysis year, and track, the file version by including the date the file was last saved. For example, use a category-year naming convention such as "KEY-CO_2 transport 2020.23_0505_2015.xls."
- Clearly establish and communicate the file management procedures and naming conventions for version control.

B. Data retention - Spreadsheets and other electronic files used to create estimates should be provided to the archiving contact person. The following are essential components of the archive:

- Data and calculation spreadsheets and other electronic files to create mitigation analysis estimates.
- Key sectoral emissions analysis spreadsheets.
- Latest draft and final electronic versions of the mitigation analysis document (for use as a starting point to update the analysis in the future).
- Updated documentation tools, which should be used to list and check references.
- The files listed above must be archived by saving to a CD-ROM or hard disk or other durable media, and should be given to the archiving contact person. If it is not possible to store the data archived in electronic format, files should be printed, catalogued, and placed in the archive. The contents of the CD-ROM disc or the hard disk should be clearly labeled for easy reference.

C. Document retention - Source documents and references used in the mitigation analysis will be collected and provided to the archiving contact person. Vital information from publications, contacts, and other sources must be included in the documents provided to the archiving contact person. This information includes, at a minimum, the title page with the name of the author(s), pages of actual data used, pages explaining data used, and pages describing methodologies used. These documents should include:

- All new reference documents for the current mitigation analysis records file. The files retained in storage from any given analysis year are known as the mitigation analysis archive. The archiving contact person is responsible for reviewing the references cited in the mitigation analysis and collecting all new documents. It is not necessary to include duplicate copies of references that are already in the records file from the previous analyses.
- Draft versions (either electronic or hard copy) used for major internal and external peer reviews, as well as the final submitted versions of the analysis.
- Final version of the National Mitigation Analysis Report (compilation of Key Sectoral Emissions Analysis, Institutional Arrangements for Mitigation Activities, Mitigation Analysis Archiving System, and National Mitigation Plan).

- Documents created to address comments received during any official review periods (or from expert reviews). These documents typically include both, comments received verbatim, as well as the response and subsequent actions taken by the mitigation-working group.

D. Storage mechanisms -Archived mitigation analysis files are stored in the online server.

- The master copies of the archived files are stored in the online server by the mitigation assessment leader.
- Duplicate copies of the archived files are stored in CD or hard drive and lodged with the administrator of the online server at the EPA.
- All archived materials are duplicated (two copies of each document), catalogued and placed in the archive file. An index describing the contents of the archive is placed at the front.

4.2.5 Proposed archive procedures checklist

To ensure a successful archiving system, the archiving contact person will use a comprehensive checklist. Checklists help to ensure that all archiving procedures are followed in a timely and complete manner. The final archiving task list and schedule will show all archiving tasks, corresponding task leaders, and due dates. The archiving contact person will ensure that all tasks are outlined prior to the start of any archiving procedure. The archiving contact person is also responsible for assigning task leaders to accomplish each archive task prior to the due date. Table 33 provides the comprehensive checklist prepared for use by the Archiving contact person for Ghana

Table 34: Archive tasks, responsibilities, and schedule for Ghana

Subtask	Date Due	Task Completed	
		Initials	Date
Archiving contact person			
1. Create official archive located in Environmental Protection Agency on the online server			
2. Communicate archiving plan and set deadlines.			
3. Collect copies of all data references.			
4. Request missing references from sector leads.			
5. Compile electronic versions of spreadsheets used to estimate emissions reductions by sector.			
6. Collect copies of draft versions of mitigation analysis document.			
7. Collect copies of final versions of mitigation analysis document.			
8. Compile electronic versions of final versions of mitigation analysis document.			
9. Collect copies of expert review comment response documents from each category lead.			
10. Catalogue all documents using a unique tracking number and index.			
11. Collect completed Institutional Arrangements for Mitigation Activities and Documentation of Mitigation Assessment Methods and Data.			
12. Compile electronic versions of Key Sectoral Emissions Analysis.			
13. Save all electronic files on archive CD-ROM/hard drives			
14. Distribute electronic files at start of next mitigation analysis update.			
Sector Leads			
1. Send electronic versions of spreadsheets used to estimate net emissions to Mitigation leader using naming convention.			
2. Send final text documents for sector to Mitigation lead.			
3. Send Documentation of Mitigation Analysis and Actions reports for sector.			

4.	Create index of draft documents and files for electronic and hard copy storage.			
5.	Create index of final documents and files for electronic and hard copy storage.			
6.	Compile and send electronic versions of any Key Sectoral Emissions analyses and documents to Mitigation lead (add "key" to naming convention).			
7.	Save all final electronic files on archive CD-ROM/Hard drive. Label as "FINAL" with name of category/sector, date, and contact information, and send copy to Mitigation lead.			

4.2.6 National plan for further mitigation assessment

The Plan for Further Mitigation Assessment presents actions that Ghana has identified to improve its national GHG mitigation assessments. The Plan will guide future efforts to increase the transparency, consistency, comparability, completeness, and accuracy of future inventories. It will address many of the shortcomings of the previous mitigation assessments, and will inform future mitigation teams of needed improvements. These improvements have been identified through an assessment of key sectoral emissions in Ghana's, documentation of existing institutional arrangements, analyses of methods and data, and developing archiving systems. Additional areas for improvements had been identified through feedback from the members of the mitigation assessment-working group who were involved in the planning, preparation and reporting of the mitigation assessment process.

4.2.6.1 Institutional arrangement priorities

The National Mitigation System involves all of the institutional, legal, and procedural arrangements made by a country for estimating emissions reduction, as well as the reporting and archiving of mitigation information. Preparing a mitigation assessment requires establishing, identifying, and documenting all relevant contributors to the assessment. Assessing and documenting the status of existing institutional arrangements for mitigation assessment development will ensure continuity and integrity of the assessment, promote institutionalization of the inventory process, and facilitate prioritization of future improvements. Table 35 lists the priority actions identified in the Institutional Arrangements for Mitigation Activities tool.

Table 35: Priority actions for Ghana management of mitigation assessments

Category	Strengths in management structure of mitigation assessment	Potential improvements in management structure of mitigation assessment
Electricity Supply	Close working relations with the team working on the strategic national energy planning. The leader of the SNEP team is the leader of the mitigation team	Need to include representatives of the public utilities (especially VRA and the independent power producers) in the electricity sector team
Transport		Ministry of transport and Civil Engineering Dept. KNUST must be included in the transport team. The Ministry of transport will focus on shaping the policy context of future work. Civil Engineering Department can help provide data. Reliable data is crucial to making sure that the technical footing of the mitigation assessment is solid.
Residential and Commercial		Collaborate with Ghana Statistical Service to incorporate relevant questions in their regular national living standards surveys
Forest Management	Collaboration with the Forest Services Division of the, Forestry Commission is useful to maintaining access to data. It	Provide continuous training to the Forestry Commission with the aim of fully decentralizing the responsibility of AFOLU mitigation assessment to them.

	also ensures that the Forestry Commission owns the potential abatement options that are identified in this exercise.	
Solid Waste Management	Some capacity within EPA to continue with any future mitigation assessment.	Representatives from private waste management service providers and some local government authorities in the ten regional capitals must be invited into the waste management team in order to bring their perspectives to the waste mitigation assessment.

4.2.6.2 Potential sector improvements

Priority areas for improvement for these and other sectors are identified through the lessons learnt and feedback from the current mitigation assessment. Tables 36 and 37 list the problems and potential improvements for the actions in the mitigation assessment process.

Table 36: Potential Improvements for sectors or actions

Sector or Action	Description of Problem	Potential Improvement
Development of Marginal abatement cost curve	Inadequate data on technology specific fuel consumption, unit cost and lifetime. In cases where such data are missing, team members used expert judgment.	Collect specific data on fuel consumption, prevailing cost and lifetime through household of market surveys.
Construction of baseline scenario	Because models for constructing the baseline scenario differ for energy and non-energy sectors, assumptions may not be applicable to all mitigation action activities.	Conduct seamless economy-wide mitigation assessment for all sectoral activities to reduce uncertainties and ensure greater transparency.
	Industrial processes, avoided deforestation and forest degradation and agriculture were excluded from the baseline for scenario assessment because the model adopted does not cover these sectors.	Search for alternative mitigation assessment models/tool that cover significant number of mitigation activities occurring in the country.
Development of mitigation scenario for non-energy sector	Most national policies in non-energy sectors (forest management, solid waste management) do not provide direct emission reduction objectives.	Collect a more complete dataset in the non-energy sector to help improve the emission projections and the mitigation potential assessment.
Use of default emission factor for baseline and mitigation assessment in LEAP	Default IPCC emission factors were used in the baseline and mitigation assessment for all the activities under energy and transport.	Support country-specific emissions factor development for key categories in order to improve on transparency.
Development of Marginal abatement cost curve	Inadequate data on technology specific fuel consumption, unit cost and lifetime. In cases where such data are missing, team members used expert judgment.	Collect specific data on fuel consumption, prevailing cost and lifetime through household of market surveys.

Table 37: Potential Improvements to the Mitigation Assessment Archive System

Archive System Task	Describe Problem	Potential Improvement
Define roles and responsibility	Lack of clarity on role, responsibilities and reporting chain.	Tasked the mitigation assessment lead to become the archiving contact person. Prepare checklist of archiving tasks for the contact person to follow during the next cycle of mitigation assessment
Storage location	Location of the storage of data and document has not been well described in terms of future retrieval.	Archiving contact person must be tasked to ensure that archived documents are easily retrievable storage location in the short-term

Based on an assessment of the relative importance of improvements identified for key sectors, institutional arrangements and archiving systems identified above, the most critical improvements have been prioritized. By addressing these issues, Ghana can move toward producing a more complete and higher-quality mitigation assessment. Table 38 lists these potential improvements, and identifies the level of priority associated with each (high, medium, or low).

Table 38: National Mitigation Priorities

Priority Level	Improvements Needed
High	Introduce greater documentation and archiving for sectoral and national level assessments
High	Obtaining more reliable data on the following (a) energy - residential and commercial, (b) non-energy – solid waste management and liquid waste disposal, agriculture
Medium	Improve forestry-wide mitigation and ensure linkages with REDD+ forest reference level
Medium	Work more closely with institutions such District Assemblies, Power producers, Ministry of transport, private vehicle garages etc
Low	Consider using other mitigation assessment tools that are more flexible and have wider scope of coverage for different sectoral activities
High	Develop new mitigation potential estimate for agriculture, forestry and other land use
Medium	Develop country-specific emission factors for technologies in key category sectors.

4.3 Mitigation assessment and abatement measures

The section presents the outcome of the mitigation assessment according to energy and non-energy sectors. For the energy sector, the construction of the baseline scenario covered 2010 as the base year to 2040 as the end year. In order to take into account the effects of existing domestic energy policies, two baseline scenarios – scenario without measures (WoM) and scenario with measures (WM) were constructed. The scenario without measures (WoM) depicts a projected future where the emissions in the business-as-usual situation remained unchanged by 2040. For scenario with measures (WM), the effects of existing government energy polices on the projected business-as-usual emissions are incorporated. The mitigation scenario was a projected future emission situation, where Ghana's ability to take up additional measures to reduce GHG emissions are sufficiently plausible. This option was referred to as scenario with additional measures (WAM). The identification and prioritization of the additional measures was through a consultative multi-criteria screening process. Out of the twelve identified additional mitigation actions at the initial stage, five (5) of them were prioritized. The abatement potentials of the five prioritized mitigation actions make up the scenario with additional measures (WAM). The non-energy sectors include forest management (reforestation/afforestation) and solid waste management (SWM). The baseline scenario for forest management and solid waste management was

limited to a business-as-usual scenario where the status quo remained the same from the base year or (2010) to the end year (2040).

4.3.1 Energy sector

4.3.1.1 Baseline scenario (scenario without measures - WoM)

4.3.1.1.1 economy-wide projections

Historical trends and projections of the energy sector, population and economic growth were used to project annual emissions up to 2040 (see figure 27). These projected emissions to 2040 form the reference case that was used as the baseline against which to demonstrate the expected abatement potential in the energy sector. The emissions were then allocated across the energy sector by dividing the energy sector into energy transformation and energy demand sub-sectors. Energy transformation was further divided into electricity supply and charcoal production whereas on the energy demand side, the activities were broken into residential and commercial/services (including agriculture), industry and transportation. The projected reference case was reported in emissions and energy terms. Under the scenario WoM, emissions were projected to rise from 11.83$MtCO_2e$ in the base year (2010) to 332.62 $MtCO_2e$ in 2040 (see table 39). At 332.62 $MtCO_2e$, transport emissions will be the largest source constituting 41.3% of the 2040 projected total emissions. This will be followed by emissions from electricity supply (37.5%), industry (12.2%), residential (4%), agriculture (1.1%) and commerce/services (0.3%). The rising demand for energy resources will drive the expected increases in emissions in the WoM scenario especially in the transport sector. In the scenario WoM, emissions from energy transformation activities (electricity supply and charcoal production) are likely to increase in tandem. The WoM with coal option was used in the analysis of the baselines scenario throughout the assessment.

Table 39: Projected total emissions in scenario without measures (million metric tons CO_2 equivalent)

Mitigation categories	2010	2015	2020	2025	2030	2035	2040	Cumulative Total	% of Cumulative Total
Residential	1.42	1.57	1.69	1.86	2.05	2.28	2.56	13.44	4.0%
Commerce and Services	0.04	0.06	0.08	0.11	0.15	0.21	0.29	0.94	0.3%
Agriculture	0.18	0.24	0.32	0.43	0.573	0.78	1.06	3.56	1.1%
Industry	0.90	1.47	2.32	3.73	6.02	9.78	15.98	40.19	12.1%
VALCO	0	0.02	0.06	0.06	0.06	0.06	0.06	0.32	0.1%
Transport	5.76	8.09	11.35	15.89	22.2	30.97	43.14	137.40	41.3%
Charcoal production	1.1	1.31	1.49	1.70	1.92	2.14	2.36	12.02	3.6%
Electricity Supply	2.42	4.45	8.24	12.76	20.43	31.24	45.18	124.71	37.5%
Total	**11.83**	**17.19**	**25.57**	**36.53**	**53.39**	**77.46**	**110.63**	**332.62**	**100%**

In terms of trends, emissions from transport will remain a predominant source throughout the projected timeframe. The emissions are likely to rise sharply from 5.76 $MtCO_2e$ to 25.57 $MtCO_2e$ in 2020 and further to 137.40 $MtCO_2e$ (see figure 25). A similar pattern of emission trends from electricity generation are expected. The emissions will increase from 2.42 $MtCO_2e$ in the base year to 124.71$MtCO_2e$ in 2040. The possibility of adding nearly 10,000MW of coal fired plant to the electricity generation mix by 2040 accounts for the rise in emissions from electricity supply. Although the likelihood of incorporating coal-fired plant into the electricity generation mix is at an advanced stage of consideration by the government of Ghana, a lot of regulatory work and contract issues are yet to be resolved. Similar emissions increase was projected for residential, commerce and agriculture categories; however, the expected rate of increase will mainly be driven by the changes in the household size, electricity prices and above all, household energy preferences as living standards get better (indexed GDP). Emissions in industry will continue to be higher than emissions from households and commerce put together.

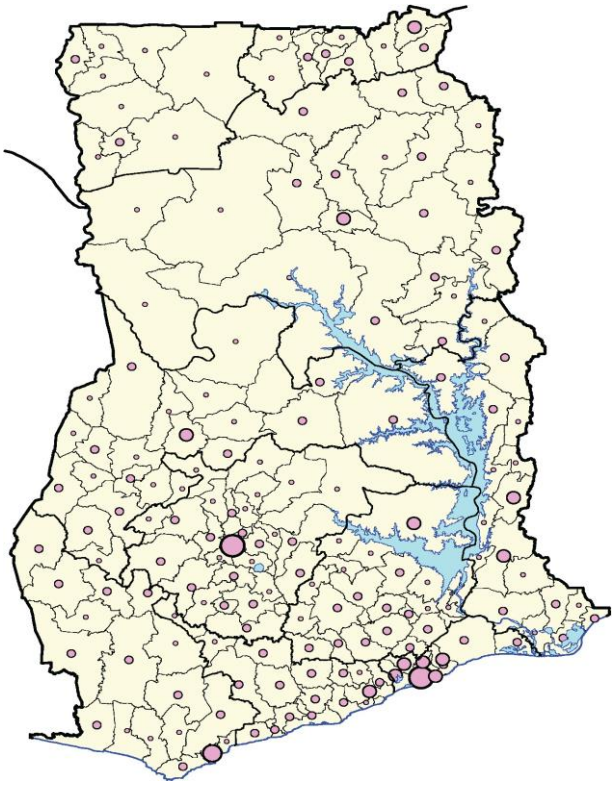

Figure 25: Projected emissions in without measures (WoM) scenario in the energy sector

4.3.1.1.2 Electricity supply

The future emissions under the WoM scenario for the electricity sector were reported with the option of with and without coal in the generation mix. With the coal option, the total installed generation capacity is likely to increase a thousand folds more from 1,950MW in 2010 to 11,195MW by 2040. This increase represent an annual growth rate of 4.6% of installed capacity with the assumption that government plans to constructed coal-fired thermal plant comes on stream by 2020 (see table 40). The technology share of the generation mix was forecasted to shift from hydro to predominantly thermal sources. Renewable (mainly solar) will remain less than 0.1% of the total generation capacity in the WoM scenario. Electricity generation mix from thermal sources will significantly shift from oil based to gas (natural gas and liquefied natural gas).

Table 40: Baseline electricity generation mix (WoM with coal) in Megawatts

Technology options	2010	2015	2020	2025	2030	2035	2040	2010 share	2040 share
Hydro	1085	1430	1430	1430	1430	1430	1430	55.6%	12.8%
Thermal: of which	865	1385	2605	3455	5055	6955	9755	44.4%	87.1%
Oil	*600*	*520*	*0*	*0*	*0*	*0*	*0*	*69.4%*	*0%*
Gas	*180*	*780*	*2120*	*2570*	*3370*	*4070*	*5270*	*20.8%*	*54.0%*
Coal	*0*	*0*	*400*	*800*	*1600*	*2800*	*4400*	*0%*	*45.1%*
Diesel	*85*	*85*	*85*	*85*	*85*	*85*	*85*	*9.8%*	*0.9%*
RE	0	10	10	10	10	10	10	0.1%	0.1%
Total	1950	2825	4045	4895	6495	8395	11195		

Under the WoM scenario, where coal fired thermal plant was excluded from the baseline electricity mix, generation capacity will expand to 6,795MW in 2040 (see table 41). This represented 60.7% lower than 11,195MW of total generation capacity under WoM scenario option with coal.

Table 41: Baseline electricity mix (WoM without coal) in Megawatts

Technology options	2010	2015	2020	2025	2030	2035	2040	2010 share	2040 share
Hydro	1085	1430	1430	1430	1430	1430	1430	55.6%	21.0%
Thermal: of which	865	1385	2205	2655	3455	4155	5355	44.4%	78.8%
Oil	*600*	*520*	*0*	*0*	*0*	*0*	*0*	*69.4%*	*0%*
Gas	*180*	*780*	*2120*	*2570*	*3370*	*4070*	*5270*	*20.8%*	*98.4%*
Diesel	*85*	*85*	*85*	*85*	*85*	*85*	*85*	*9.8%*	*1.6%*
RE	0	10	10	10	10	10	10	0.1%	0.1%
Total	1950	2825	3645	4095	4895	5595	6795		

Similar trends of significant reduction of the hydro share in both cases from 55.6% of generation mix in 2010 to 12.8% and 21% respectively in 2040 are expected

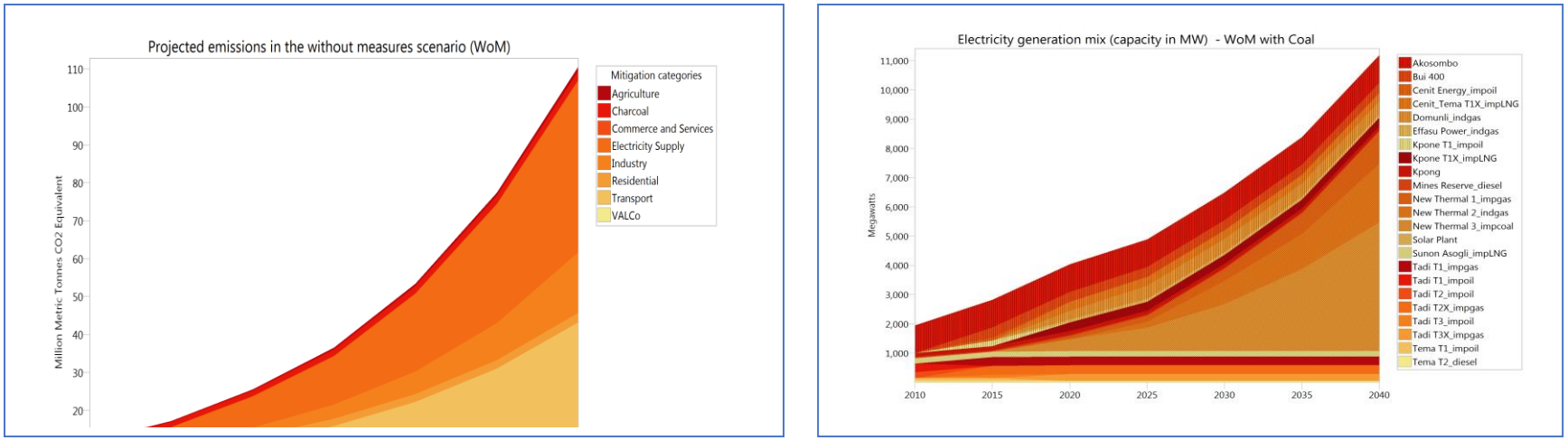

Figure 26: Trend of electricity generation mix in WoM scenario (left – with coal option and right – without coal option).

In the WoM scenario with coal option, additional 32,762.4GWh electricity will be generated by 2040 compared to the without coal option (see tables 42 and 43). Although significant electricity generation will be available in 2040 in the WoM scenario with the coal option, associated emission will be 35.3% higher than the emissions in the without coal option (see table 42).

Table 42: Projected electricity generation in WoM scenario - with coal option in Gigawatt-Hours

Technology Options	2010	2015	2020	2025	2030	2035	2040
Akosombo	5,961.00	7,036.47	6,954.89	7,026.53	7,036.47	7,036.47	7,036.47
Kpong	1,035.00	1,103.76	1,090.96	1,102.20	1,103.76	1,103.76	1,103.76
Bui 400	-	513.08	609.90	745.20	815.99	815.99	815.99
Tadi T1_impoil	1,234.00	-	-	-	-	-	-
Tadi T1_impgas	-	2,233.80	2,207.90	2,230.64	2,233.80	2,233.80	2,233.80
Tadi T2_impoil	1,160.00	-	-	-	-	-	-
Tadi T2X_impgas	-	1,576.80	1,558.52	1,738.59	1,905.30	2,069.55	2,233.80
Tadi T3_impoil	-	818.30	-	-	-	-	-
Tadi T3X_impgas	-	-	1,381.50	1,492.93	1,592.37	1,689.71	1,787.04

Tema T1_impoil	591.00	681.92	-	-	-	-	-
Cenit Energy_impoil	-	381.07	-	-	-	-	-
Cenit_Tema T1X_impLNG	-	-	1,726.88	1,866.16	1,990.47	2,112.13	2,233.80
Tema T2_diesel	28.00	144.41	126.00	144.00	157.68	157.68	157.68
Mines Reserve_diesel	20.00	68.94	70.52	92.44	114.20	127.18	140.16
Sunon Asogli_impLNG	138.00	1,267.28	1,267.02	1,294.65	1,311.08	1,325.68	1,340.28
Kpone T1_impoil	-	615.06	-	-	-	-	-
Kpone T1X_impLNG	-	-	1,558.52	1,712.69	1,888.01	2,060.91	2,233.80
Domunli_indgas	-	-	1,726.88	2,799.24	2,985.70	3,168.20	3,350.70
Effasu Power_indgas	-	-	328.53	552.59	519.60	524.05	450.71
Solar Plant	-	18.98	20.44	21.90	23.36	24.82	26.28
New Thermal 1_impgas	-	-	212.58	812.63	1,711.62	3,344.66	4,957.80
New Thermal 2_indgas	-	-	-	812.63	3,423.24	5,733.69	9,014.18
New Thermal 3_impcoal	-	-	2,943.87	5,948.38	11,913.60	20,848.80	32,762.40
Total	10,167.00	16,459.86	23,784.91	30,393.41	40,726.26	54,377.08	71,878.65

Table 43: Projected electricity generation in WoM scenario - without coal option in Gigawatt-Hours

Technology Options	2010	2015	2020	2,025	2,030	2,035	2,040
Akosombo	5,961.00	7,036.47	6,954.89	7,026.53	7,036.47	7,036.47	7,036.47
Kpong	1,035.00	1,103.76	1,090.96	1,102.20	1,103.76	1,103.76	1,103.76
Bui 400	-	513.08	609.90	745.20	815.99	815.99	815.99
Tadi T1_impoil	1,234.00	-	-	-	-	-	-
Tadi T1_impgas	-	2,233.80	2,207.90	2,230.64	2,233.80	2,233.80	2,233.80
Tadi T2_impoil	1,160.00	-	-	-	-	-	-
Tadi T2X_impgas	-	1,576.80	1,558.52	1,738.59	1,905.30	2,069.55	2,233.80
Tadi T3_impoil	-	818.30	-	-	-	-	-
Tadi T3X_impgas	-	-	1,381.50	1,492.93	1,592.37	1,689.71	1,787.04
Tema T1_impoil	591.00	681.92	-	-	-	-	-
Cenit Energy_impoil	-	381.07	-	-	-	-	-
Cenit_Tema T1X_impLNG	-	-	1,726.88	1,866.16	1,990.47	2,112.13	2,233.80
Tema T2_diesel	28.00	144.41	126.00	144.00	157.68	157.68	157.68
Mines Reserve_diesel	20.00	68.94	70.52	92.44	114.20	127.18	140.16
Sunon Asogli_impLNG	138.00	1,267.28	1,267.02	1,294.65	1,311.08	1,325.68	1,340.28
Kpone T1_impoil	-	615.06	-	-	-	-	-
Kpone T1X_impLNG	-	-	1,558.52	1,712.69	1,888.01	2,060.91	2,233.80
Domunli_indgas	-	-	1,726.88	2,799.24	2,985.70	3,168.20	3,350.70
Effasu Power_indgas	-	-	328.53	552.59	519.60	524.05	450.71

Solar Plant	-	18.98	20.44	21.90	23.36	24.82	26.28
New Thermal 1_impgas	-	-	212.58	812.63	1,711.62	3,344.66	4,957.80
New Thermal 2_indgas	-	-	-	812.63	3,423.24	5,733.69	9,014.18
Total	10,167.00	16,459.86	20,841.04	24,445.03	28,812.66	33,528.28	39,116.25

Table 44 Total emissions for electricity category in $MtCO_2e$

WoM with coal option									
Plant Cluster	2010	2015	2020	2025	2030	2035	2040	2010 share	2040 share
Gas Plants	0.061	2.249	5.48	7.282	9.6	12.424	15.709	2.5%	34.8%
Oil Plants	2.331	2.052	0	0	0	0	0	96.2%	0.0%
Diesel Plants	0.031	0.143	0.135	0.166	0.195	0.209	0.223	1.3%	0.5%
Coal Plant	0	0	2.628	5.309	10.634	18.609	29.242	0.0%	64.7%
Total	2.423	4.444	8.243	12.757	20.429	31.242	45.174	100.0%	100.0%

WoM without coal option									
Plant Cluster	2010	2015	2020	2025	2030	2035	2040	2010 share	2040 share
Gas Plants	0.061	2.249	5.48	7.282	9.6	12.424	15.709	2.5%	98.6%
Oil Plants	2.331	2.052	0	0	0	0	0	96.2%	0.0%
Diesel Plants	0.031	0.143	0.135	0.166	0.195	0.209	0.223	1.3%	1.4%
Total	2.423	4.444	5.615	7.448	9.795	12.633	15.932	100.0%	100.0%

4.3.1.1.2 Residential, commerce/service and agriculture

Total emissions in the three categories was forecasted to increase from 1.61 $MtCO_2e$ in 2010 to 3.62 $MtCO_2e$ in 2040 at 2.74% annual growth rate in the WoM scenario (see figure 27). The rise in the emissions corresponds to the different energy demands in the three categories. Throughout the period, emissions from urban households accounted for an average of 47.1% of the total emissions in the three categories. This was followed by emissions from rural households and energy use in fishing. Expanding household size and the rate of electrification generally determine the level of emissions in the residential category. In the residential category, the use of gas and wood fuel stoves for cooking constitute the largest emission source. Within commerce/service sector, energy demand in schools and eateries (restaurants and chop bars) are two dominant sources of emissions.

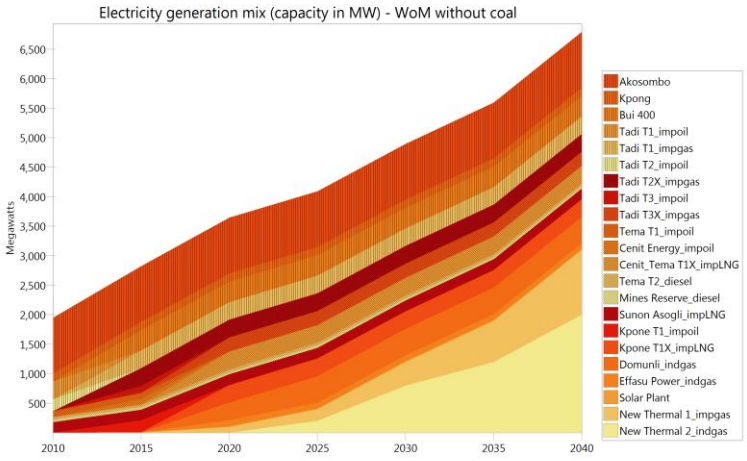

Figure 27: projected total emissions in residential, commerce/services and agriculture categories

4.3.1.1.3 Industries

Emissions associated with future demand for energy use in industry (construction, mining and quarry and manufacturing) was projected to rise from 0.9 $MtCO_2e$ in 2010 to 15.98 $MtCO_2e$ in 2040. A similar trend was forecasted to rise to 0.06 $MtCO_2e$ at an annual average growth rate of 21.68%. Within industry, mining and quarrying will be the main emissions sources making an average of 71.9% of the projected total industry emissions. In VALCO, emissions from residual fuel oil will be an important emission source. The future emissions in VALCO is forecasted based on the assumption that by 2016, 3 pot lines will come on line to reduce the unit cost of production because the operation of one pot line is unsustainable due to high overhead costs per unit output.

4.3.1.1.4 Transportation

Transportation will be one of the most important emission sources in the future. Between 2010 and 2040, emissions were projected to increase from 5.76 $MtCO_2e$ to 43.14$MtCO_2e$. Out of the 2040 emissions of 43.14$MtCO_2e$, passenger transport will account for the majority (93%) while the rest (7%) will come from freight transport. Within the transportation category, emissions from road transport were projected to account for more than 80% of total emissions (see figure 28). The expected rise in road transport emissions in the baseline scenario, was attributed to rising motorization and associated traffic congestions. With more than 60% of Ghanaians expected to live in urban areas and steady growth in the economy, the demand for individual car ownership will significantly drive future emissions in the transport category. Similarly, domestic aviation emissions is expected to increase at 2.27% annually considering current growth trends in the aviation industry in Ghana.

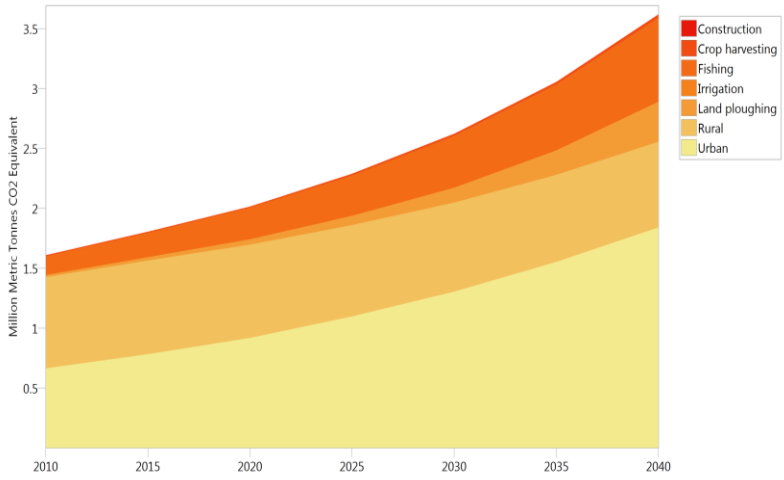

Figure 28: Projected emissions for the transportation category

4.3.1.2Identification and screening mitigation actions

The identification of eleven technology-based mitigation actions was done through a consultative meeting of the mitigation assessment-working group. The identification process took into account the alignment with the following national policy strategy documents: (a) Ghana Shared Growth and Development Agenda, (b) National Energy Policy, (c) SE4ALL Action Plan, (d) National Climate Change Policy and (e) Ghana's 55-list of NAMAs. In doing so, the following list of technologies were identified: (a) Institutional biogas, (b) Efficient industrial motors, (c) Efficient home fridges, (d) Bus Rapid Transit Vehicles, (e) Combined cycle thermal power plants, (f) hydropower plant, (g) solar PV power, (h) afforestation/reforestation, (i) 5% biofuel blend and (j) LPG for cooking. A multi-criteria (MCA) screening tool was used to prioritize the identified technologies into the top-five.

The prioritized technologies were formulated into emissions abatement options. During the screening, quantitative criteria were emission reduction potential, and the direct total cost derived from abatement marginal cost (MAC) curve (see figure 29). On the other hand, the qualitative criteria used for the screening were carefully selected to help in the assessment of the identified mitigation technologies against a set of sustainable development factors. They included; reliance on local technology, reliance on domestic energy sources, potential for poverty alleviation, potential for improving local air quality, technical feasibility, political/social acceptability and potential for capacity development.

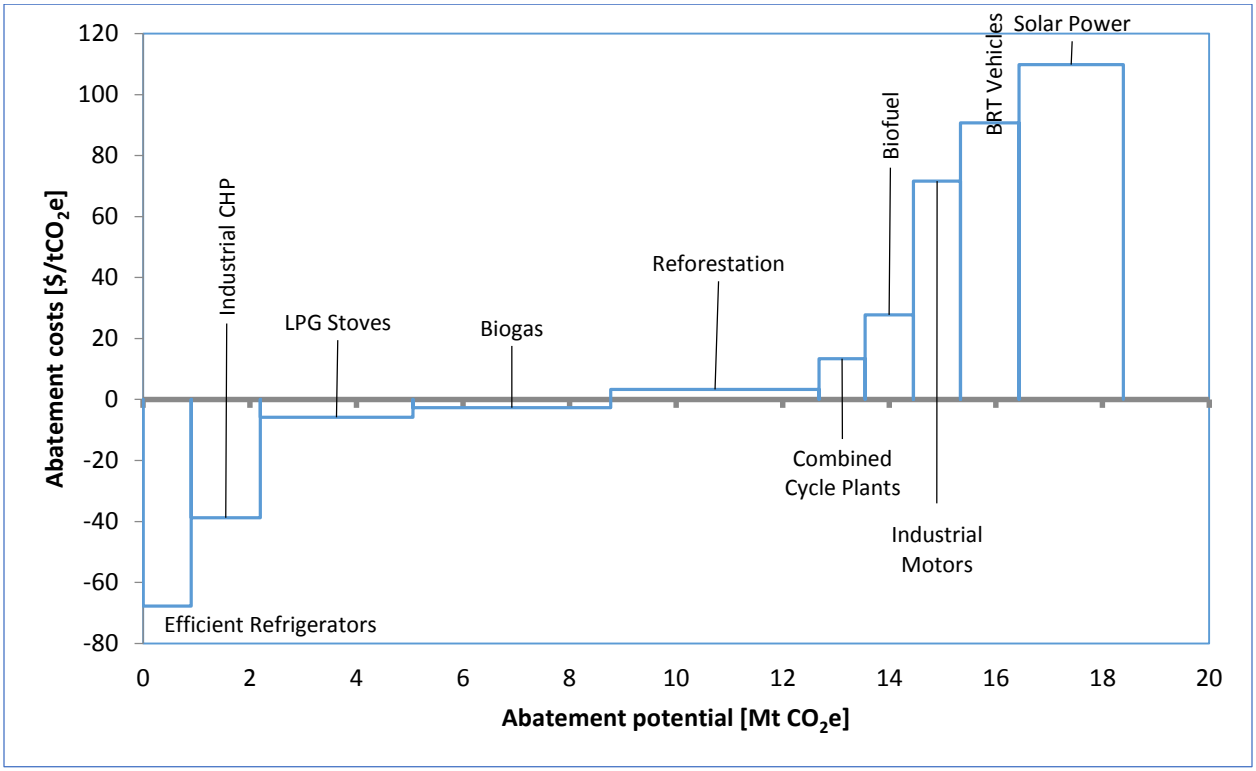

Figure 29: Marginal abatement cost curve developed for the quantitative screening of the selected mitigation technologies

As shown by figure 29, abatement cost of solar PVs, BRT and industrial motor technologies may not be attractive compared to other technologies. This means the high upfront cost associated with the uptake of the three technologies will not make it an option for wider adoption. It would also imply that the chances of implementing abatement measures that depend on these three technologies would not plausible in the foreseeable future. However, the MCA screening does not only rely on the abatement potential and abatement cost factors and other sustainable development criteria were therefore considered in the prioritization. Table 45 shows the results of the MCA screening.

Table 45: Screening matrix for selected mitigation technologies

Criteria	Criteria Weight (Sum to 100 across all criteria)	LPG Stoves	Industrial Motors	Efficient Fridges	BRT Vehicles	Biogas	Industrial CHP	CC Plants	Hydro Power	Solar Power	Reforestation	B_5 diesel
Criteria Taken from Cost Curve												
Mitigation Potential (Million Tons CO_2e)		2.9	0.9	0.2	0.7	3.7	0.00	0.002	0.01	1.96	3.9	0.5
- Mitigation Potential Score (0=lowest, 10=highest)	20	7.3	2.2	0.5	1.7	9.5	0.0	0.00	0.0	5.0	10.0	1.2
Direct Unit Costs ($/Ton CO_2e)		(5.8)	71.6	(67.7)	90.7	(2.7)	(38.8)	13.4	36.8	109.8	3.3	27.8
Direct Total Costs (Mill. $)		-$17	$63	-$13	$60	-$10	$0	$0	$0	$215	$13	$13
- Direct Total Cost Score (0=highest, 10=lowest)	30	10	7	10	7	10	9	9	9	0.00	9	9
Other Criteria (0=bad-10=good)												
Reliance on Local Technologies	8	9	6	6	6	9	4	3	9	4	10	6
Reliance on Domestic Energy Sources	5	9	10	10	10	10	5	10	10	10	10	4
Potential for poverty alleviation	10	9	5	7	10	9	5	6	7	8	8	3
Potential for improving local air quality	7	8	2	8	10	9	6	6	7	6	5	8
Technical Feasibility	8	9	7	8	8	9	7	7	9	8	10	5
Political/Social Acceptability	8	8	7	8	8	9	5	7	8	9	7	4
Potential for capacity development	4	10	8	6	9	6	8	7	8	10	4	10
Totals	100	8.9	5.5	6.8	6.7	9.2	5.6	5.9	6.9	4.8	8.6	5.5
Overall Rank (1=best to 10=worst)		2	10	5	6	1	8	7	4	11	9	3

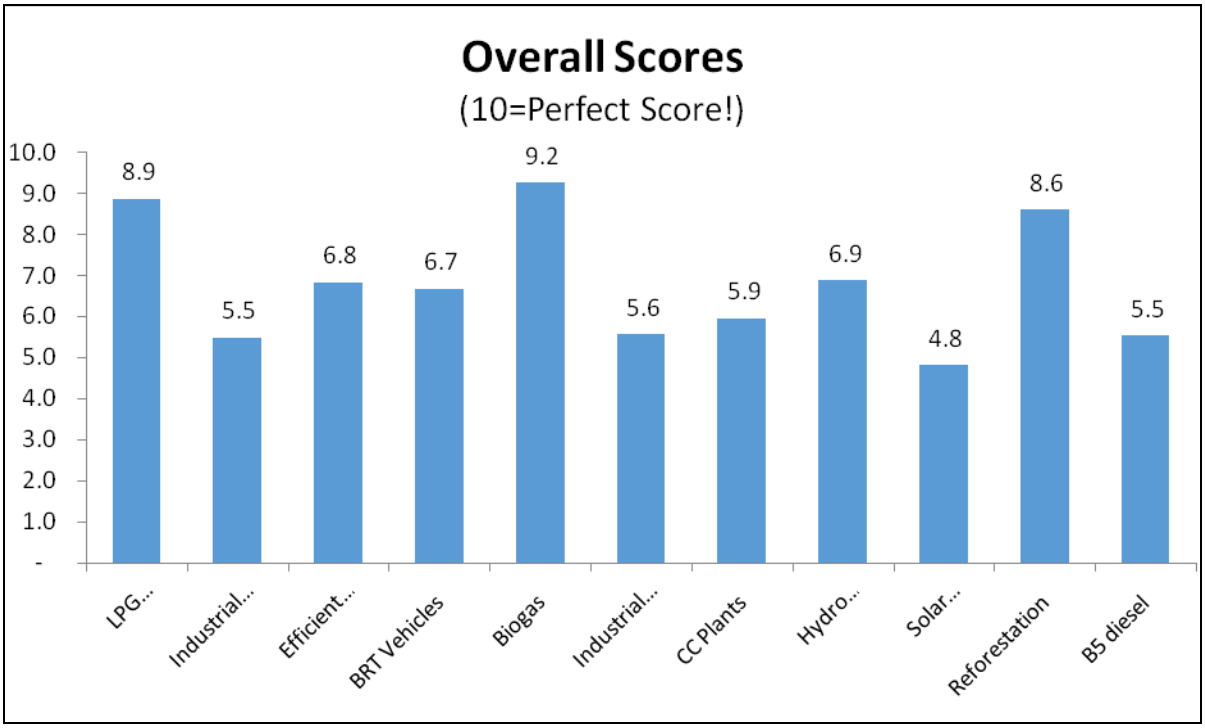

Figure 30: Overall MCA mitigation technology screening results

Based on the stakeholder censuses, any of the mitigation technology that had overall perfect score of more than 6 qualifies to be included in the list of prioritized abatement measures. In total, 6 mitigation technologies that have been prioritized will be formulated into mitigation actions. The overall mitigation potential of the six technologies will be assessed in the mitigation scenario analysis. The list of mitigation technologies that have been prioritized will form the scenario "with additional measures" (WAM). In the mitigation scenario, analysis of the emission savings that is associated with the WAM scenario will be determined relative to scenarios WoM. In order to gauge impacts of already adopted government policies, scenario "with measures" (WM) will be assessed.

4.3.1.2 Mitigation scenarios (scenario with measures (WM) and scenario with additional measures (WAM)

Mitigation scenarios depict projected future emissions that deviate from the expected emissions in scenario without measures (WoM). The degree of deviation from the WoM emissions will depend on the scope of the abatement measures. Any emission savings that will be derived from the abatement measures are determined by the difference between emissions in the (i) WoM scenario and WM scenario and (ii) WoM scenario and WAM scenario. The WM scenario considers a future scenario where the existing renewable energy policies that government is committed to adequately implement and the emission savings thereof are realized. This scenario is considered as the least ambitious option and in order to attain greater emission reductions, additional abatement measures must be adopted in the mitigation scenario. The two renewable energy policies that formed the WM scenario are; (i) 10% renewable energy target in grid-connected electrification and (b) 50% LPG penetration targets in urban and rural households mainly for cooking. However under the WAM scenario, additional abatement measures will be adopted in order to define low carbon trajectory for the energy sector. The broad set of technology options that have been prioritized in addition to the renewable energy measures under the

WM scenarios included: efficient fridges, bus rapid transit, institutional biogas and efficient smoke free cook stoves.

4.3.2.1 .2 Scenario with measures (WM)

In the WM scenario, the abatement potentials of both the 10% renewable energy target in grid-connected electricity supply and the 50% LPG penetration in household policy measures have been determined. In order to determine the abatement potentials for the two policy measures, the scope of the abatement measures translate to:

- *338MW grid-connected renewable energy electricity supply* by 2040. This will lead to (i) the installation of 228MW mini hydro capacity in Hemang, Juale and Pwalugu to deliver 931.1GWh electricity to the national grid and (ii) addition of 100MW wind turbine capacity plant to the national electricity and
- *Promotion of LPG consumption in households* –translate to increase share of gas demand for cooking in urban and rural households. Breakdown of the gas demand are as follows:

    i. Metro urban household gas demand will increase from 41.4% in 2010 to 82% in 2015 and 98.4% in 2040.
    ii. Other urban household gas demand will increase from 23.9% in 2010 to 63.9% in 2015 and 94% in 2040.
    iii. Rural electrified/non-electrified savannah household gas demand will increase from 1.2% in 2010 to 20.7% in 2015 and further to 30.2% in 2040.
    iv. Rural electrified/non-electrified forest households gas demand will increase from 3.2% in 2010 to 25.2% in 2015 and further to 40.2% in 2040 and
    v. Rural electrified/non-electrified coastal households from 2.6% in 2010 to 23.4% in 2015 and further to 41.3% in 2040.

In the WM scenario, the two abatement measures have a projected total economy-wide mitigation potential of -2.21MtCO_2e avoided emissions by 2040 (see table 46). At the household scale, the 50% LPG penetration abatement measure is likely to translate to avoided emissions of 0.43 MtCO_2e by 2040 (see table 45 and figure 31). In the electricity category, under the "without coal option", the avoided emission potential is projected to be 1.12 MtCO_2e by 2040 whereas in the "with coal option", the avoided emission potential is likely to increase to -1.54 MtCO_2e within the same period.

Table 46: Mitigation potential in the scenario with measures

Mitigation Categories	Abatement potential in scenario with measures (MtCO_2e)							
	2010	2015	2020	2025	2030	2035	2040	Total
Economy-wide scale								
Demand	8.31	11.44	15.84	22.07	31.05	44.08	63.01	195.89
Transformation	3.52	5.75	9.74	14.46	22.34	33.38	47.54	136.73
"Avoided vs. With Measures Scenario"	0	-0.41	-0.47	-0.64	-1.03	-1.11	-2.21	-5.87
Household scale (demand)								
Urban	0.66	0.78	0.92	1.09	1.31	1.55	1.84	8.18

Rural	0.76	0.78	0.78	0.76	0.74	0.73	0.71	5.27
""Avoided vs. With Measures" (50% LPG penetration)	0	0.16	0.19	0.24	0.29	0.35	0.43	1.65
Electricity supply scale								
All thermal plants (without coal)	2.42	4.44	5.61	7.44	9.79	12.63	15.93	58.29
""Avoided vs. With Measures""	0	-0.004	-0.018	-0.14	-0.47	-0.49	1.12	-0.007
All thermal plants (with coal)	2.42	4.44	8.24	12.78	20.43	31.24	45.18	124.71
""Avoided vs. With Measures""	0	-0.0041	-0.019	-0.14	-0.47	-0.49	-1.54	-2.67

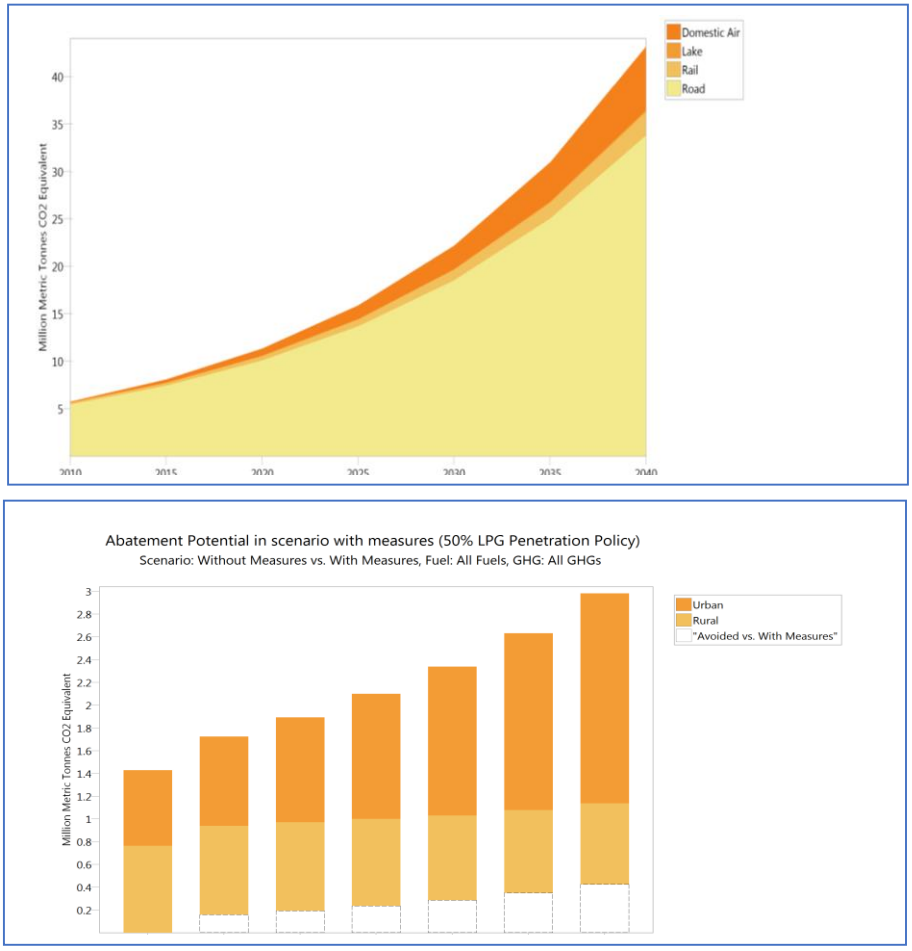

Figure 31: Abatement potential in scenario with measures (left: 50% LPG penetration and Right: 10% renewable energy target)

4.3.1.2.2 Scenario with additional measures (WAM)

In the WAM scenario, projected avoided emissions were estimated at -39.19MtCO_2e by 2040 (see table 47 and figure 32). The breakdown of the contributions from individual abatement measures are as follows: (a) institutional biogas – (-0.024 MtCO_2e), (b) improved cooking stove – (0.331 MtCO_2e), efficient fridges

– (-2.10 $MtCO_2e$), bus rapid transit – (-1.63 $MtCO_2e$), 10% renewable energy – (-1.46 $MtCO_2e$) and 50% LPG penetration – (-37.84 $MtCO_2e$).

Table 47: Mitigation potential in the scenario with additional measures

Abatement **potential in scenario with measures ($MtCO_2e$)**								
Year	2010	2015	2020	2025	2030	2035	2040	Total
Demand	8.31	11.44	15.84	22.07	31.05	44.07	63.09	195.88
Transformation	3.52	5.75	9.74	14.46	22.34	33.38	47.54	136.73
""Avoided vs. with additional measures""	0	-0.50	-3.14	-7.02	-14.55	-25.30	-39.19	-89.70

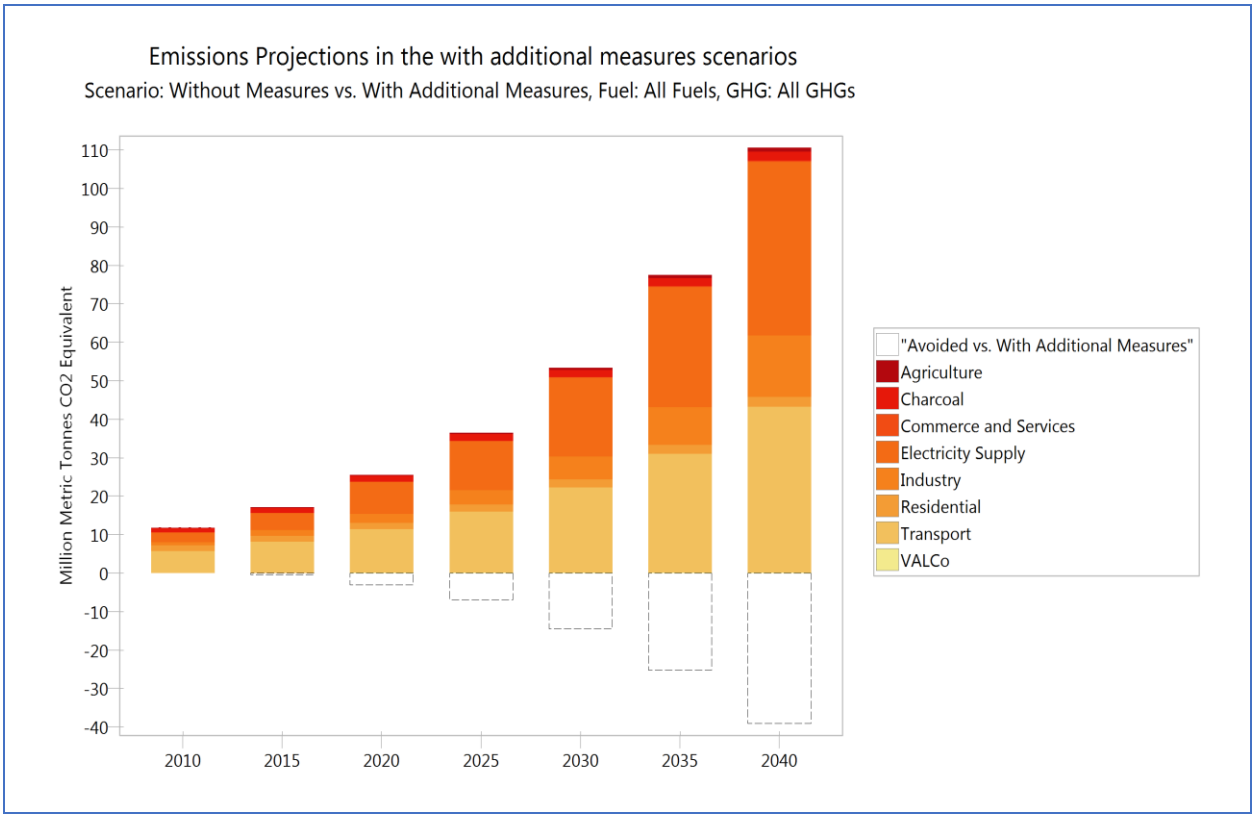

Figure 32: Projected avoided emissions under WAM scenario

4.3.1.3 Description of action plan for mitigation options

The overall objectives for the implementation of the prioritized mitigations measures are to ensure continuous reduction of GHG emissions while ensuring sustainable growth and development. Implementation of these actions will require the mobilization of adequate funding from both local and international sources as well as the facilitation and mainstreaming of these mitigation actions into national, district and sectoral plans and programmes. Table 48 provides an action plan of the prioritized mitigation actions focusing more on the sector, major barriers, investment costs, abatement potentials, sustainable development benefits, lead agency and alignment with national policy.

Table 48: Action plan of prioritized mitigation actions up to 2040

Mitigation Action	Economic sector	Lead Agency	Investment costs for implementation to 2040 ($)	Estimated split between public private sector and consumer investments*	Abatement potential and sustainable development impacts	Priority Barriers	Alignment with National Policy/Programme removing barriers
Improved cook stoves and LPG Cook stoves	Energy and forestry	Energy Commission	US$ 0.65billion Improved cook stoves (UD$0.16billion) LPG stoves (US$ 0.49billion)	Improved cook stoves: about 70% consumer costs and 30% public support costs, LPG stoves: about 80% consumer cost and 20% public support	- Abatement potential to 2040 of 38.1 $MtCO_2e$ - Health benefits from reduced indoor air pollution. - Lower fuelwood demand and deforestation. - Potential cost savings to households	- Inadequate supply of LPG to meet increasing demand. - LPG subsidy policy for cooking unsustainable, not equitable, and prone to abuse. - Inadequate storage, filling and distribution infrastructure. - Weak regulation.	Policy target: 50% LPG penetration by 2020. Reduce wood fuel demand from 72% to 50% by 2020 Programme – SEA4All Accelerated framework
Bus rapid transit (BRT)	Transport, Infrastructure, and local government	Ministry of Transport	(US$ 0.35 billion)	About 70-80% of public investment costs for infrastructure and 20-30% private costs for vehicle stock.	- Abatement potential to 2040 of 1.63 $MtCO_2e$. - Reduced traffic congestion - Improved local air quality - Improved road safety - Job creation	- Difficult to regulate informal transport service providers. - Inadequate funding - Lack of consistent political commitment - Integration of BRT in road development - Lack of clarity in regulation and enforcement	- National Transport Policy - **Policy target:** 80% of all trips in the Urban Area should be - done through public - Mass Transit Systems

Efficient fridges	Energy	Energy Commission	(US$ 0.05 billion)	About 30% public investment through rebate scheme and 70% private costs for efficient fridges	- Abatement potential to 2040 of 2.1 $MtCO_2$. - Improved E-waste management - Reduce household demand and expenditure on energy - Incomes and job across the value chain - Available energy for 0ther productive economic use - Awareness/consciousness on electricity conservation - Phase out of ODS	- Lack of funding for rebate scheme - Lack of Investment in local refrigeration assembly plant - Difficulty in disposing or destruction of ODS	Energy Efficiency Standards and Labelling Regulations 2009(LI 1958) Energy Efficiency Regulation, 2008 (LI 1932) Ensure high market standards and prohibit importation of inefficient range of electronic appliances.
Institutional biogas	Energy, education and health	Energy Commission	(US$ 0.11 billion)	About 55% public investment through rebate scheme 45% private costs for cost institutional biogas	- Abatement potential to 2040 of 0.024$MtCO_2e$. - Reduction in indoor pollution - Improved sanitation - Reduction in out-pocket-expenditure on cooking fuels - Job creation and increase incomes	- Lack of access to improved access to finance, including micro finance. - Limited local professional artisans. - High upfront cost. - Non-existing public capital incentives. - Standardization of biomass plants and registration of firms to ensure efficient monitoring. - There is the need to properly equip the EC and Standards Authority to ensure standards.	SEA4ALL accelerated framework Renewable Energy Act

Table 49: Underlying assumption for marginal cost curves

Item	Assumption			Source
Range of discount rate	19.5% to 20.2%			Bank of Ghana's policy rate.
Global Warming Potential (GWPs)	CH4 = 21 tonnes CO_2, and N_2O = 310 tonnes CO_2			IPCC, TAR
Baseline electricity mix (2010)	Coal = 0% Hydro = 56% Oil (light crude and diesel) = 36% Gas = 8%, RE = 0%			Energy Statistics
Mitigation electricity mix (2040)	Coal = 39% Hydro = 13% Oil (diesel) = 1% Gas = 47% RE = 0.1%			Based on LEAP projections
Emission factors (kg/GJ)	**CO_2**	**CH_4**	**N_2O**	**Price (USD/GJ)**
Fuel oil	77.4	0.0020	0.0006	6.0
Diesel oil	74.1	0.0020	0.0006	4.7
Gasoline	69.3	0.0200	0.0006	4.9
Kerosene	71.9	0.0070	0.0006	4.7
Charcoal	80.0	0.0010	0.0006	2.5
Firewood (Unsustainably Grown)	110.0	0.0040	0.0001	1.0
Biodiesel	-	0.0040	0.0001	6.1
LPG	63.1	0.0010	0.0006	5.5
Natural gas	56.9	0.0040	0.0001	8.0
Coal	94.6	0.0010	0.0014	1.0
Biogas	-	-	-	3.5
Electricity	77.4	0.0020	0.0006	25.0
Hydro/Renewables	-	-	-	-

4.3.2 Non-energy sectors

4.3.2.1 Forest management (Afforestation/Reforestation)

In the forest management category, the Comprehensive Mitigation Assessment Process (COMAP) software developed by the Ernest Orlando Lawrence Berkeley National Laboratory was used to assess the mitigation potential of different abatement measures in forest management. The COMAP model was selected because it is flexible to adopt to fit conditions in the Ghanaian landscape compared to other models such as Agricultural and Land Use (ALU) and ExACT. In addition, the COMAP is less data intensive and allows the assessment to be made at the national scale. Data for the model came from the 2010 land use matrix generated by the Forest Preservation Project (FPP) of the Forestry Commission. For Ghana, three types of mitigation options were considered feasible in the model. This is because other mitigation actions – bio energy for fossil fuel substitution, short rotation forestry and natural regeneration, were not feasible mitigation options for Ghana. The three types are; biomass pool and supply management, forest protection and reforestation. The objective of the assessment was principally to measure the incremental carbon benefit generated by these mitigation actions. The assessment also calculated the cost and benefits of the mitigation action where possible.

Biomass pool and supply management

This intervention was based on the promotion of sustainable supply of land-based products. Its goal is to estimate the changes in biomass (and carbon) stocks from the baseline because of the mitigation action. Specifically, the intervention estimates the supply of biomass under Baseline (BSL) and Mitigation (MIT) scenarios from 2010 to 2040 using the following steps:

a. Identification of the area under different land use categories and biomass density in soil and vegetation,
b. Determination and inclusion of projected and sustainable extraction rates of selected land-based products,
c. Determination of demand and supply of various products.

In terms of the identification of land use category, four types of dominant land use categories were identified for Ghana. Table 50 summarizes the various information on the different land use categories, and biomass densities.

Table 50: Basic information on land categories

Land	Description	Area in 2010 (ha)	Biomass density (t/ha) BSL	Biomass density (t/ha) MIT
Protected Forest Area (PFA)	Wild life protected areas where there is no extraction activity.	1,348,900	13	18
Other Forest Land (OFL)	All other forest types (production forest, off-reserves, plantation) with the exception of protected areas.	7,697,500	130	130
Grasslands (GL)	All other lands that are not classified as annual cropland and fall below the threshold of a forest.	8,149,640	37.98	37.98
Annual cropland (ACL)	Lands classified as used for annual crops.	5,206,270	53.39	53.39

Note: BSL – Baseline, MIT – Mitigation

Biomass density in tons per ha for the various land categories is used by the software to generate the total annual biomass supply for each land category. With regards to the determination and inclusion of projected and sustainable extraction rates of selected land-based products, data from the FPP and expert guest estimates were used. Product extraction rates in tons per ha was used together with growth rate of other socio economic parameters for 2010 and 2040 to generate total annual product demand for agricultural waste, wood fuel, industrial wood, agriculture products and livestock. Using these parameters, the difference in incremental biomass pool between the BSL and MIT scenarios for the period 2010 and 2040, and using a factor of 1 ton of biomass to 0.470 tons of carbon, the carbon savings were estimated.

Forest protection

Forest protection mitigation action focuses on effective management of all Protected Areas (PAs) in Ghana. The mitigation action involves the effective management and enforcement of regulations on PAs to improve biomass volumes. The land area was assumed to be fixed since the government would not acquire additional land as PAs because of the high cost of acquiring and maintaining PAs. This implies that the incremental carbon benefit would be realized through increases in above ground biomass and soil carbon densities. The assumptions were that above ground biomass and soil carbon densities would increase by 5 and 34 tons per ha respectively. Twelve out of the sixteen PAs were used for the analysis since there were no data on the other four. The goal of this action was to estimate carbon abatement potential of forest protection or conservation as well as assessing the cost effectiveness of the option. The methodological steps therefore involved the application of different biomass and soil carbon densities under BSL and MIT scenarios to the area covered by PFA. The Annual Incremental Carbon (AIC) was estimated and using a conversion factor of 1 ton of carbon to 3.7 tons of CO_2, the CO_2 savings were estimated.

Reforestation

The reforestation mitigation action aims at reforesting degraded lands. The action will focus on convalescence areas of production forests. The area under convalescence was estimated at 122,000 ha. The assumption was that between the years 2010 and 2020, 12,200 ha of this area would have recovered and the remaining 109,800 ha of degraded land will be continuously reforested until it gets to zero in 2040. Standing vegetation carbon, carbon density and the addition to stored soil carbon for BSL and MIT were used to estimate the Annually Created Incremental Carbon Pool (ACICP). Streams of cost for reforestation and their respective benefits from reforestation were used to estimate incremental benefits for the mitigation action.

Table 51. Projection of mitigation scenarios emissions

Forest Protection Category	Emissions ($MtCO_2$)		
	Base Year 2010	Year 2020	Intermediate Year 2030
Biomass pool and supply management	0.4	0.23	0.26
Forest Protection	0.053	0.058	0.064
Reforestation	1.4	1.6	1.7
Total	1.853	1.888	2.024

4.3.2.2 Solid waste management (SWM)

In the solid waste category, the mitigation assessment was done for only solid waste management options because it is one of the major contributors to emissions. The rising trend in the emissions is closely linked to population growth, urbanization and changes in lifestyle. With a projected national population of nearly 54.2million in 2040 and per capita waste generation of 0.6kg/day, total solid waste is expected to rise by 11.9 million tonnes every year. The management of such volumes of waste has major logistical and financial challenges especially to city authorities. Similarly, GHG emissions are likely to be more than quadruple compared to the 2010-2012 average of 1.4MtCO_2e by 2040. There are opportunities for avoiding such levels of emissions in the baseline scenario.

The assessment of mitigation potential for variety of solid waste management option was done using the Solid Waste Management (SWM) GHG Calculator developed by GIZ in 2010. The SWM-GHG Calculator allows quantification and comparison of GHG emissions for different waste management strategies at an early stage in the decision making process. Additionally, the SWM-GHG Calculator provides guidance information on the costs associated with different waste management strategies. In order to ensure consistency with the historical emission patterns of solid waste disposal, the main inputs data for the model was sourced from the solid waste data used in the 2012 national GHG inventory that was collected from several national and international sources.

Parameters in the SWM-GHG Calculator model

Technical Parameters

The GHG Mitigation assessment focused on selected number of waste management technologies, which are broadly grouped into different treatments (a) recycling technologies and (b) waste disposal technologies. The method used by the SWM-GHG Calculator follows the Life Cycle Assessment (LCA) method although it does not replace a full LCA of the selected technologies. Waste management strategies have been compared by calculating the GHG emissions of the “different recycled” (paper/cardboard, plastics, metals, and organic waste) and “disposed of waste fractions” over their whole life cycle – from "cradle to grave".

The tool sums up the emissions of all residual waste or recycling streams respectively and calculates the total GHG emissions of all process stages in CO_2 equivalents. The emissions calculated also include all future emissions caused by a given quantity of treated waste. This means that when waste was sent to a landfill, for example, the calculated GHG emissions, given in ton CO_2 equivalent per ton waste, include the cumulated emissions this waste amount will generate during its degradation. This method corresponds to the "Tier 1" approach described in IPCC (1996, 2006). Up to four different waste management systems can be compared using the SWM-GHG Calculator (see table 52). In addition to the baseline, three user-definable scenarios namely mitigation option 1(low ambition), mitigation option 2 (moderate ambition) and mitigation option 3 (high ambition) has been analyzed. Table 52 below provides definitions of the baseline and mitigation (alternative) scenarios.

Table 52: Definition of baseline and alternative scenarios

Management options	Descriptions of scenarios
Baseline scenario as at 2010-2012	Describes a typical situation in Ghana where no appropriate sanitary waste management currently takes place. Recycling of solid waste (mainly plastic and some organic wastes) is on limited scale. Inadequate incentives for the private sector to expand capacity to recycle. Household waste collection is at 70% with increased participation of the private sector through public private partnerships. The majority of the waste is dumped on unmanaged disposal sites under anaerobic conditions resulting in the production of methane. Other parts are disposed of in low heaps ("scattered disposal") under aerobic conditions, producing mainly carbon dioxide. Half of the scattered waste is openly burnt producing extreme air pollution.
Mitigation option 1 (low ambition) scenario in 2040	Improved recycling of plastics and composting of food waste; eliminate scattering of waste in the landscape; reduce open burning of scattered waste; reduce crude dumping of waste and tap gas from existing landfill including sanitary landfills. This is a scenario close to the status quo.
Mitigation option 2 (moderate ambition) scenario in 2040	This scenario is similar to option 1 but greater in ambition and effort. Recycling and composting will further improved; complete elimination of waste scattering; open burning is minimized to its barest minimum; tap more landfill gas and construct new sanitary landfills.
Mitigation option 3 (high ambition) scenario in 2040	This scenario is the most ambitious. Current capacity for recycling of plastic and composting has more than tripled; complete elimination of scattering of solid waste and open burning; reduction of crude dumping to its minimum, reduction of untapped gas landfill, and construction of sanitary landfill with gas collection.

The range of choice threshold of treatment for the baseline (see table 53) was based on the data collected from district assemblies and waste service providers. The treatment capacities range attributed to the 3 mitigation options projected for 2040 was informed by current installed capacities of the waste treatment technologies and how national policy on private sector participation models in solid waste management becomes attractive for the private sector to mobilize additional capital to invest. The projection was, that, current private capital in waste management, will more than double by 2040. In addition, enforcement of environmental standards and regulations on waste disposal by government will be strengthened.

Table 53: Range of options for baseline and the alternative scenarios

Waste Technology		Baseline	Mitigation option 1	Mitigation option 2	Mitigation option 3
1. Recycling management systems					
Recycle		0.11%	10%	15%	20%
Compost		3%	10%	20%	25%
Digestion		0%	0%	0%	0%
2. Disposal management systems					
Unplanned treatments	Scattered waste not burned	1.9%	0.0%	0.0%	0.0%
	Open burning of scattered waste	2.6%	1.7%	0.6%	0.0%
	Unmanaged disposal site	14.8%	9.8%	4.8%	1.0%
Simple treatment technologies	Controlled dump/landfill without gas collection	80.0%	71.9%	60.7%	50.0%
	Sanitary landfill with gas collection	0.0%	10.0%	21.9%	32.6%
	BS + landfill				
Advanced treatment technologies	MBT + further treatment + landfill				
	MBS/MPS + co-processing cement kiln				
	Incineration	0.7%	6.6%	12.0%	16.4%

BS: Biological stabilization MBT: Mechanical-biological treatment MBS/MPS: Mechanical-biological stabilization / mechanical-physical stabilization

Cost parameters of technologies

Typical default cost figures for the different activities was derived from interviews with local private operators and which was then compared with industry prices available in international literature. The values represent average total costs (dynamic prime costs) and may vary considerably according to national and local conditions. The level of technology also has an important influence on the total cost. The cost of establishing collection systems were also required in each scenario and are not taken into account. Table 54 shows the cost range used in the model. Taking into account the current cost of doing business in Ghana, the maximum dynamic cost range was used.

Table 54: Cost of technologies

Dynamic prime costs (DPC)	Min	Max	Euro/t
1. Controlled dump/landfill without gas collection	3	5	5
2. Sanitary landfill with gas collection	12	20	20
3. BS + landfill	15	25	25
4. MBT + further treatment + landfill	40	60	60
5. MBS/MPS + co-processing cement kiln	50	80	80
6. Incineration	90	150	90
7. Recycling of dry waste	0	5	5
8. Composting	20	40	40
9. Digestion	60	90	90

Based on the model (see table 55) more wastes will be treated in 2040 using mitigation option 3, suggesting that if the objective is to increase waste treatment then that option is the optimal. Concerning emission reduction, information from table 34 indicates that mitigation option 3 (high ambition) has the most attractive emission reduction potential compared to the other two options as net emissions will be the lowest at 10.1MtCO_2e per year. The mitigation potential is the difference between baseline and emissions from the three mitigation actions. The option with the highest reduction potential amounts to 7.1MtCO_2e per year resulting from a combination of increased intervention of recycling, composting, elimination of waste scattering and open burning and landfill/sanitary landfills with gas collection taking place.

Table 55: GHG emissions from recycling and disposal of waste (tCO_2e/yr)

		Baseline	Mit Option 1	Mit Option 2	Mit option 3
Recycled	Debits	16,854	172,439	296,342	382,561
	Credits	-18,737	-218,672	-369,157	-478,493
Disposed	Debits	17,175,506	15,589,137	12,386,162	10,199,531
	Credits	0	0	-23,715	0
Total	Debits	17,192,359	15,761,576	12,682,504	10,582092
	Credits	-18,737	-218,672	-392,872	-478,493
	Net	17,173,622	15,542,903	12,289,632	10,103,598

3.2.2Action Plan for Non-energy sectors

Table 56 provides an action plan of the prioritized mitigation actions focusing more on the sector, major barriers, investment costs, abatement potentials, sustainable development benefits, lead agency and alignment with national policy in the non-energy sectors.

Table 56: Action plan for mitigation measures in the non-energy sectors

Landfill with gas collection	Local government, waste, environment	Ministry of Local Government and Rural Development	(US$ 0.51 billion)	About 30% public investment to equity, 70% private capital cost	- Abatement potential to 2040 of 0.4MtCO_2e/yr. - Reduce incidence of fire at landfills. - Additional energy generated - Improve sanitation	- High upfront transaction cost. - No landfill gas collection obligation - Challenges in the operational management of landfills	National Environmental Sanitation Policy - Renewable Energy Act
Reforestation of degraded forest	Lands and forestry	Ministry of Land and Natural Resources	(US$ 0.8– 1 billion)	100% public	- Abatement potential to 2040 of 3.9 MtCO_2 - Biodiversity benefits - Sustainable forest products contribute to improved livelihoods - Job creation and improved personal incomes.	- Poor funding arrangements - Uncertainty about benefit sharing arrangements on off –reserve land. - Poor facilitation of off-reserve land acquisition - Weak regulation -	- National forest plantation development programme. - National forest Programme facility - REDD+ Programme - Forest Investment Programme

Vulnerability, impacts and adaptation assessment




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5. Vulnerability, impacts and adaptation assessment

5.1. Climate Analysis and Scenarios

The review of Ghana's climate projections covered the analysis of past climate trends for the 1980-2010 period. In the analysis of past climate, historical rainfall and temperature records obtained from 22 of Ghana Meteorological Agency' active synoptic weather stations across Ghana were used. The 22 weather stations are spread in the six (6) main agro-ecological zones of the country (see figure 33).

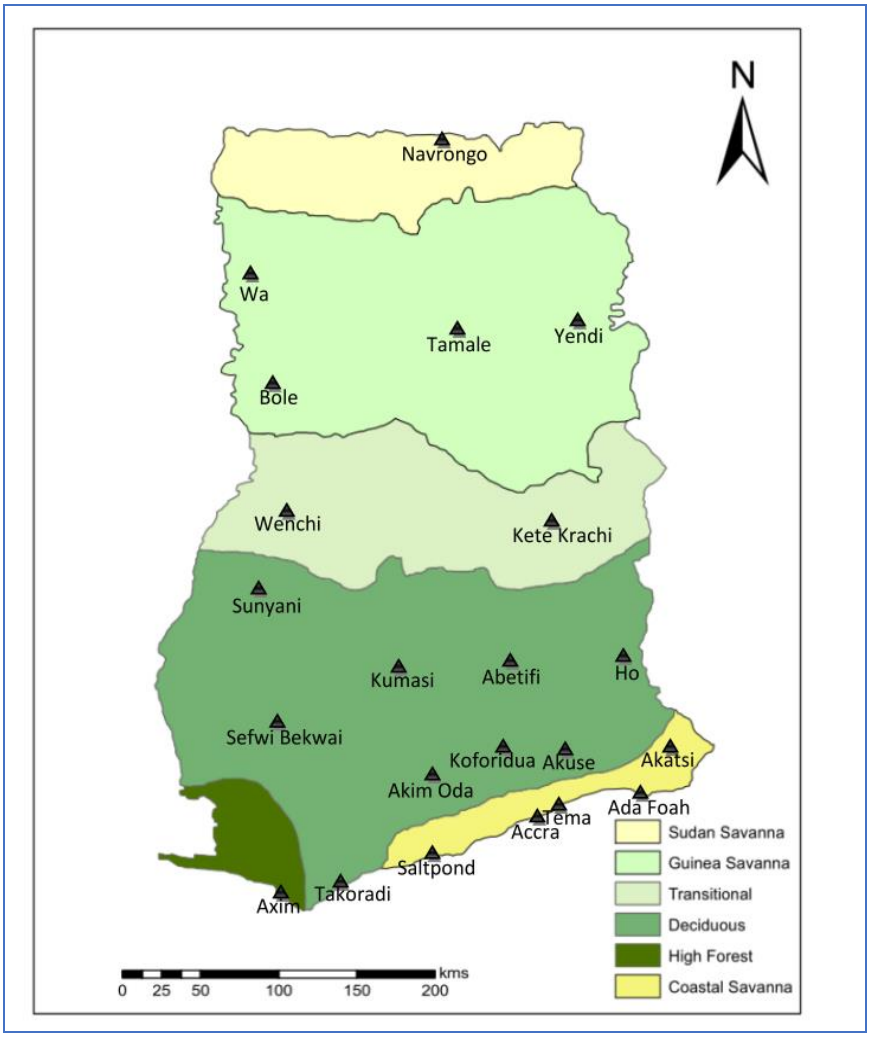


Figure 33: Spatial spread 22 weather stations grouped into six ecological zones in Ghana

The analysis of the rainfall and temperature records covered a 20-year period (1980-2010) and formed the basis for the projection of Ghana's future climate in 2040, 2060 and 2080. The design of the climate analysis framework was guided by the information that emerged from the preliminary assessment of climate modeling and related initiatives. The main purpose was to identify gaps, reduce possible duplication and as much as possible ensure that synergies are forged especially among initiatives that are interrelated in order to derive maximum benefits.

5.1.1 Main findings of assessment of climate modeling and related initiatives

There are a number of governmental and non-governmental institutions that are engaged in different climate modeling and related initiatives. From the assessment, it was realized that there are over thirty climate- modeling initiatives under different stages of implementation by the government of Ghana and in collaboration with international research and academic institutions. Compilation of the initiatives helped in (a) tracking past and on-going climate modeling efforts and (b) understanding the capacity needs.

5.1.2 Climate Projections

5.1.2.1 Description of Methodology

The methodology used for the development of the climate scenarios is described below:

a. *Data collection* – Gauge data from 22 weather stations was used for the baseline analysis for the climate scenario. The data was obtained from the Ghana Meteorological Agency. Climatological variables analyzed were rainfall, and minimum and maximum temperatures. Daily data spanning from 1981 to 2010 was used in the analysis (see table 57).

b. *Simulation* & *downscaling* – rainfall and maximum and minimum temperatures from the 22 synoptic stations were downscaled using quantile-quantile transformation. Nine scenarios (corresponding to nine different combinations of GCMs and RCMs) were generated for each station. The results of downscaled monthly averages of rainfall and temperatures for each station were tabulated and plotted. The monthly averages were calculated for the period 1981-2010, 2021-2040, 2041-2060 and 2061-2080.

c. *Analysis* **–** In the analysis, Ghana was divided into six agro-ecological zones where the data used were distributed. The ensemble means of the nine models of each of the stations in the climatic zones were calculated for 2021-2040, 2041-2060 and 2061-2080. The zonal mean was further calculated by averaging the ensemble means of the number of stations in each climatic zone for the projections 2021-2040, 2041-2060 and 2061-2080. The change in terms of rainfall was calculated by subtracting the baseline mean (1981-2010) from the zonal mean projection. The change was determined in percentage by using the change as a function of zonal mean. However, the change in temperature was determined by deducting the baseline from the projection. The observed and projected data were gridded to produce the individual spatial maps.

The summary of the methodological approach is presented in the table 57

Table 57: Description of methodological approach for the development of climate scenarios

Activity	Description of Activity		Tools used/Source	Remarks
Data collection	Minimum and maximum temperature and rainfall for 22 synoptic stations.		Ghana Meteorological Agency	Records of daily weather observations
Quality control	Identification and removals of: outliers, key entry errors, negative precipitation values		R-Climdex	Improved data integrity
Selection of models	GCMs ECHAM5-r3 ECHAM5 HadCM3QO HadCM3	RCMs Aladin HIRHAM CLM RegCM RCA RA HC REMO	AMMA ENSEMBLES RCM models	Readily available model with dataset over West Africa Robust over West Africa
Selection of emission scenarios	SRES A1B		IPCC (2007)	Robust for West Africa project economic development scenario
Period for scenarios	Baseline – 1981-2010 Scenario years – 2021-2040 2041-2060, 2061-2080			Near to far future policy planning
Downscaling methodology	Quantile-Quantile transformation (statistical downscaling)		High performance computer (HPC)	Allow projections to the local scale
Analysis of the model results	Calibration and validation		Historical data from GMeT	Cancelling out biases and outliers
	Ensemble mean of results		RCMs	
	Analysis of change of climate variable (period and ecological zones)		Spreadsheet	
	Observed data was gridded		SURFUR/ARCGIS	

Analysis of historical and projected future rainfall patterns

The analysis of the 20 years rainfall records from the 22 synoptic weather stations for the six agro-ecological zones, showed variable rates of change in observed rainfall. The rate of change ranges from 333% for the southern (rainforest and coastal agro-ecological zones), 112% for middle (deciduous and transition zone) to 431% for northern parts (Guinea and Sudan savannah zones) of Ghana. Decadal rainfall change was negative for the middle part at -2.8%, but positive for southern (13%) and northern (3.3%) areas. Parts of the change are more intense towards the north than the south for both temperature and rainfall (see figure 34).

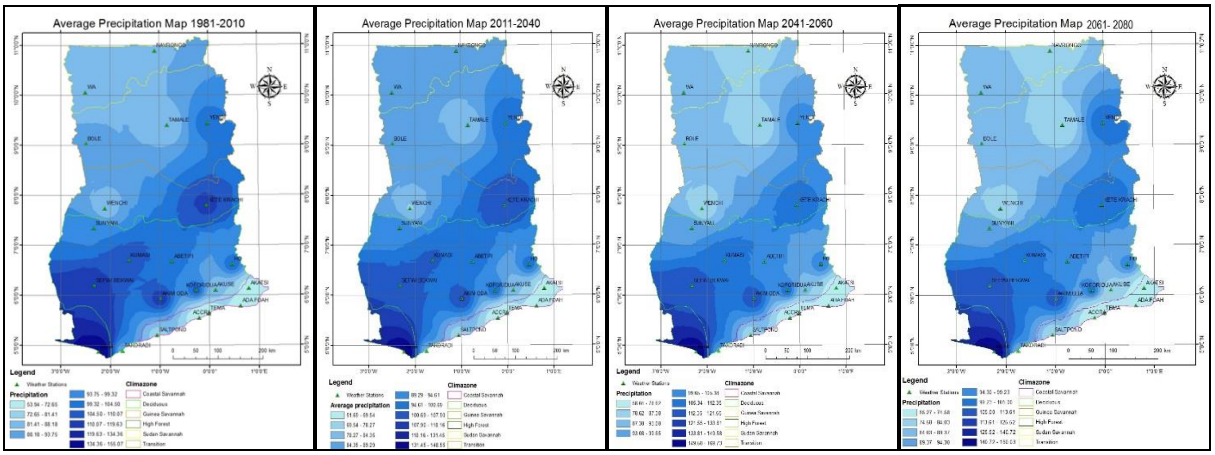


Figure 34: Maps of observed and projected average rainfall 1981-2010 (far left), 2011-2040 (middle left), 2041-2060 (middle right) and 2061-2080 (far right).

Based on the historical rainfall patterns (1981-2010), rainfall across the country has been projected to decrease by 2.9% in the near future (2040). This will be followed by a slight increase in the mid future (2060) by 1.1% and later decrease in the far future (2080) by 1.7%. This observation is a reflection of the uncertainty associated with rainfall. The detailed description of the rainfall for each agro-ecological is provided below. Model results show high confidence that mean annual rainfall totals are likely to decrease by 5% in the Coastal Savanna agro-ecological zone by the year 2040. By 2060, an increase of 6.6% in mean annual rainfall total is expected for the Coastal Savanna Zone. A decrease of less than 1% in the mean annual rainfall total is projected to occur by 2080.

The mean annual rainfall total in the deciduous zone is projected to decrease by 5.8% by the year 2040. An increase of 2.4% is expected in the mean annual rainfall total by 2060. The mean annual rainfall by the year 2080 is projected to decrease by 4.7%. Mean annual rainfall total is projected to record a decrease of 4.4% by the year 2040. By the year 2060, mean annual rainfall totals are projected to increase by 9.2%. By the year 2080, mean annual rainfall totals are expected to increase by 2.9%. Over the Guinea Savanna Zone, mean annual rainfall is projected to decrease up to 3.5% by 2040, 0.9% by 2060 and 3.1% by 2080 (see figure 3 below). Similarly in the Sudan Savanna Zone, the model projected that by 2040 mean annual rainfall total will decrease by 3.2% followed by marginal projected increase of 0.8% by 2060. The mean annual rainfall total by 2080 is projected to decrease by 23% (see figure 35).

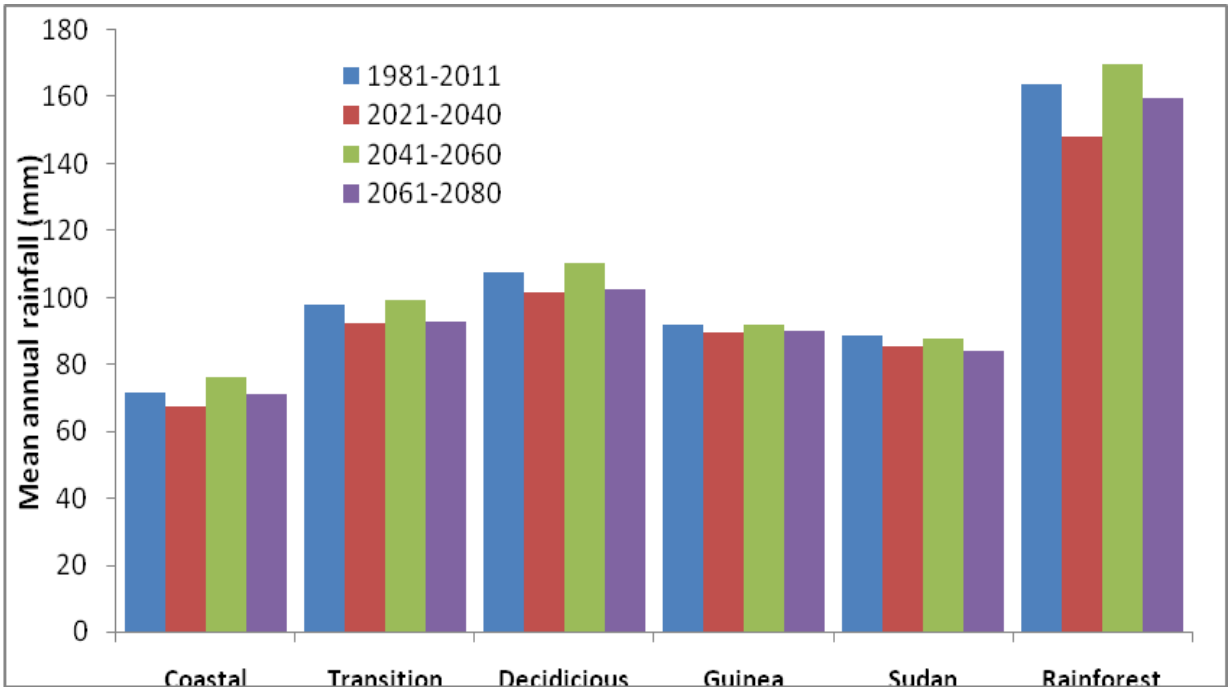


Figure 35: Trend of observed and projected rainfall (mm) in ecological zones of Ghana

Analysis of historical and projected future temperatures

From the analysis of the historical temperature records, the observed rate of change in minimum temperature for the period 1960 to 2010 was 2% for the southern (rainforest and coastal agro-ecological zones) and middle part (deciduous and transition zone) of Ghana and 3.7% for the northern part (Guinea and Sudan savannah zones) of Ghana (see figure 36). The observed decadal changes for minimum temperatures were 0.54%, 0.31% and 20% for southern, middle and northern parts of Ghana respectively. For maximum temperatures, the rate of change was 3.6%, 2.7% and 61% for the southern, middle and northern part of Ghana. Maximum temperatures had higher decadal change of 0.8%, 0.6% and 29.6% for southern, middle and northern part of Ghana respectively.

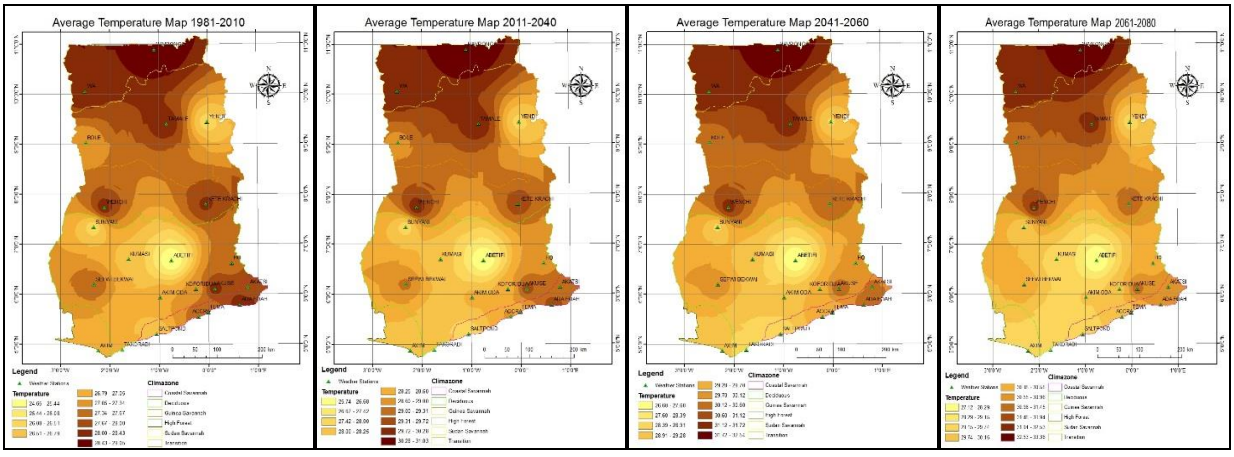


Figure 36: Maps of observed and projected average temperatures 1981-2010 (far left), 2011-2040 (middle left), 2041-2060 (middle right) and 2061-2080 (far right)

The projected mean temperatures for Ghana shows that, mean temperatures are likely to increase in the near future (2040) by 3.8% (1.02^{O}C), slight increase in the mid future (2060) by 5.6% (1.5 ^{O}C) and further increase in the far future by 6.9% (1.8^{O}C) (see figure 29). Mean minimum temperatures over the Coastal Savanna Zone are projected to increase by 1.1^{o}C, 2.5^{o}C 1.9^{o}C, by 2040, 2060 and 2080 respectively. Mean monthly maximum temperature is expected to increase by 1.2^{o}C and 2.1^{o}C by 2040 and 2060 respectively. By the year 2080, the mean monthly maximum temperature is projected to exceed 2.9^{o}C. The mean monthly minimum temperature is likely to increase by 1.1^{o}C by the year 2040 in the Deciduous Forest Zone. By the year 2060, the mean monthly minimum temperature is expected to increase by 2^{o}C. The expected increase in mean monthly minimum temperature by the year 2080 is 2.5^{o}C.

The mean monthly maximum temperature is likely to increase by 4.2^{o}C by 2040. Mean monthly maximum temperature is expected to record an increase of 2.5^{o}C by the year 2060. By the year 2080 mean monthly maximum temperatures are expected to increase by 3.2^{o}C. The mean monthly minimum temperature is likely to increase by 1.4^{o}C by 2040. The mean monthly minimum temperature for 2060 is projected to increase by 2.5^{o}C. Similarly, the mean monthly minimum temperatures are expected to be 3^{o}C by 2080. The mean monthly maximum temperature is most likely to record an increase of 1^{o}C by the year 2040. By the years 2060, mean monthly maximum is projected to increase by an average of 1.9^{o}C. By the year 2080, mean maximum temperature is projected to increase by 2.5^{o}C (see figure 37).

Over the Guinea Savanna Zone, mean annual rainfall is projected to decrease up to 3.5% by 2040, 0.9% by 2060 and 3.1% by 2080. By 2040, the mean monthly minimum temperature is projected to be 1.6^{o}C. By 2060, the mean monthly minimum temperature is projected to increase by 2.8^{o}C. Towards 2080, the mean monthly minimum temperature is projected to increase by 3.5^{o}C and monthly increases are likely to range between 2.3^{o}C and 5.6^{o}C for all months. Over the Guinea Savanna, the mean monthly maximum temperature is projected to be 1.7^{o}C by 2040, 3.1^{o}C by 2060 and 3.9^{o}C by 2080. The mean monthly minimum temperature for 2040 and 2060 is projected to increase by 3.3^{o}C. By 2080, the mean monthly temperature is expected to increase by 4^{o}C. The mean monthly maximum temperature is expected to increase by 2.6^{o}C by 2040, 3.4^{o}C by 2060 and 4.1^{o}C by 2080 (see figure 37).

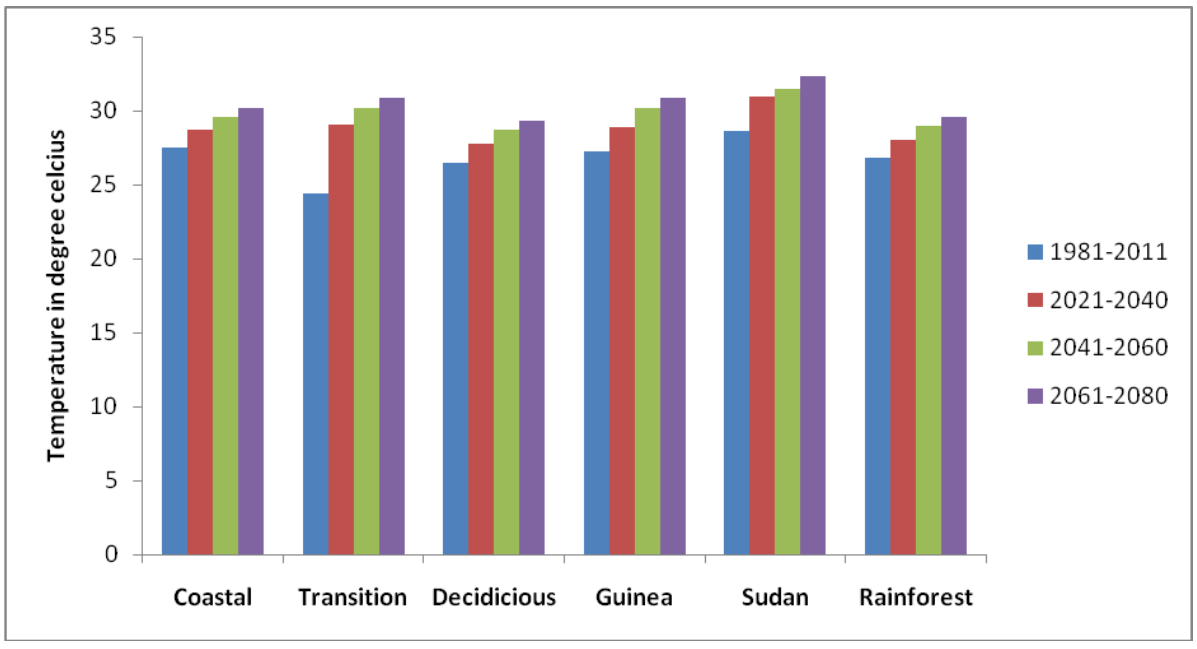


Figure 37: Trend of observed and projected mean temperatures (^{o}C) in the agro-ecological zones in Ghana

Major conclusions

- Projections of temperature and rainfall for Ghana based on observed data from the Ghana Meteorological Agency from 1981 to 2010 indicates a likely warming and increased variability in rainfall by the year 2080.

- The climate in Ghana in the next few decades is projected to be hotter, with a gradual increase in the average minimum and maximum temperature in all agro-ecological zones of the country. Temperatures are projected to increase between 1 °C and 7 °C by 2080 compared with the observed temperatures from 1981-2010.

- There is evidence of statistical change in prevailing weather conditions in the country. The spread of change is more intense towards northern Ghana than the south for both temperature and rainfall.

- The observed changes in a decade for minimum temperatures are 0.54%, 0.31% and 20% for southern, middle and northern parts of Ghana respectively. Similarly, maximum temperature has higher decadal change of 0.8%, 0.6% and 29.6% for southern, middle and northern parts of Ghana respectively.

- The mean annual rainfall in all agro-ecological zones is projected to reduce by about 10%. Rainfall in the major rainfall seasons are also likely to see a decrease of more than 10% in all agro-ecological zones but will increase in the other months by less than 10% in the next 10 to 60 years.

5.1.3. Vulnerability, impacts and adaptation assessment

5.1.3.1 Spatial vulnerability assessment

Spatial flood and drought risk maps were developed for five selected districts in the country. Each selected district represented a distinct ecological precinct of the country and characterized by unique climate and vegetation features except the transition zone. The districts belonged to unique ecological zones and the selection was also made based on the common climate risks and impacts confronting the districts (see table 58 below). The main objective of the flood and drought risk mapping was to contribute to the vulnerability assessment by identifying flood and drought high-risk areas and use the information to support effective community-based flood and drought risk reduction planning. By reducing flood and drought risk, the communities in the districts will build greater resilience to the negative impacts of climate change.

Methodology and approach

The flood and drought risk mapping covers five districts spread across five ecological zones in the country. The districts are (a) West Mamprusi in the Northern Region, (b) Sissala East District in the Upper West Region, (c) Alwen Suaman District in the Western Region, (d) Fanteakwa in the Eastern Region and (e) Keta in the Volta Region (see figure 38).

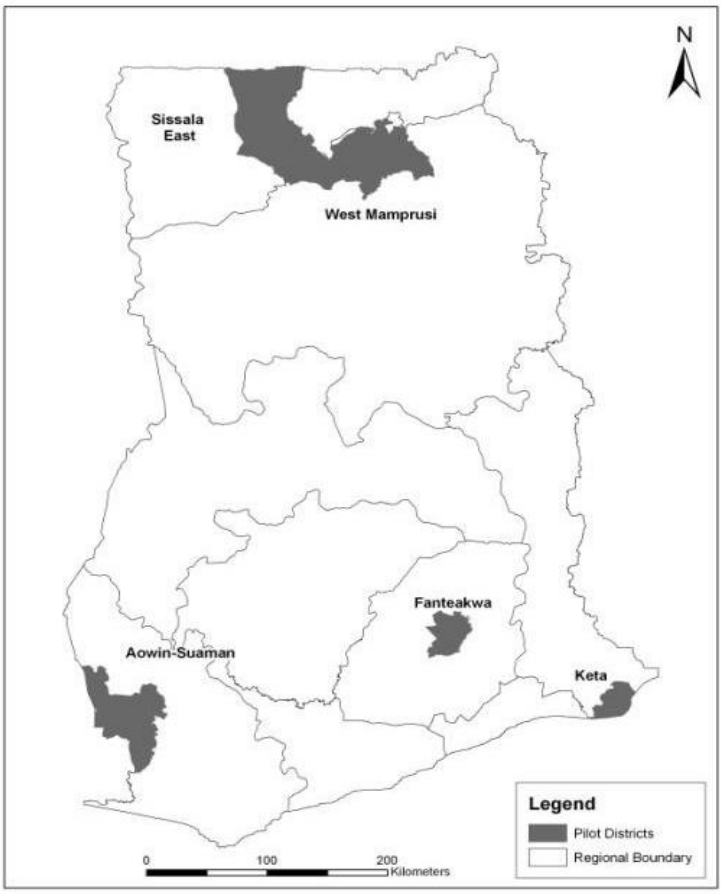


Figure 38: Geographic spread of districts for flood and drought risk mapping

Table 58: Basic Statistics of flood and drought risk mapping districts

District	Region	Capital	Ecological zone	Area (Sq. km)	Population
Sisala East	Upper East	Tumu	Sudan Savannah	4,744	51, 182
West Mamprusi	Northern	Walewale	Guinea Savannah	5,013	117,821
Aowin Suaman	Western	Enchi	High forest	2,638	119,128
Fanteakwa	Eastern	Begoro	Deciduous	1,150	132,488
Keta	Volta	Keta	Coastal savannah	1,086	133,661

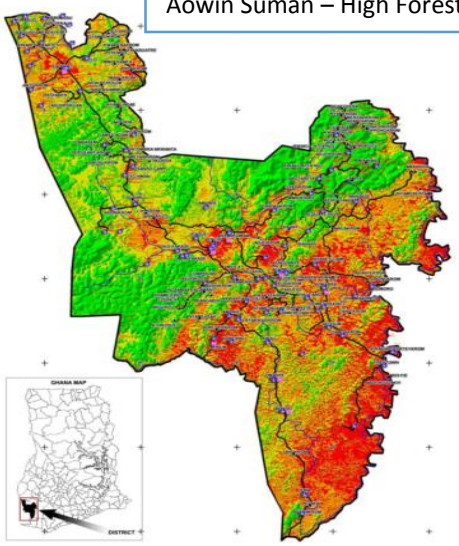
The methodology adopted for the spatial vulnerability assessment included a desktop analysis of the five study areas, GIS-based preliminary flood and drought risk mapping, field verification of the developed preliminary flood and drought maps, vulnerability assessment and stakeholders' validation workshop. GIS layers on climate, land use, vegetation, soil and topography were combined in a multi-criteria analysis to produce the specific flood and drought risk maps. The risk maps were colour coded green-yellow-red indicating low-moderate-high risk areas respectively. The GIS analysis involved the application of geo-statistical techniques in the development and modeling of flood and drought risk maps through the combination of climatic, environmental and other ancillary data layers in multi- criteria evaluation. Ratings and classification for each factor/layer were ranked from low to very high based on degree of vulnerability.

Subsequently, every layer was re-classified based on these ranks, multiplied by their standard weight, and then added to other layers to obtain the output risk maps. The output risk maps for flood and drought for the respective districts are symbolized with a green-yellow- orange-red colour scheme indicating no-risk, low-risk, medium-risk, and high-risk areas. The selection and weighting of different factors for hazard and risk maps were informed by literature and expert input from the National Disaster Management Organization (NADMO) research team. The accuracy of hotspots in the risk maps were validated by stakeholder's workshop undertaken in the 5 districts.

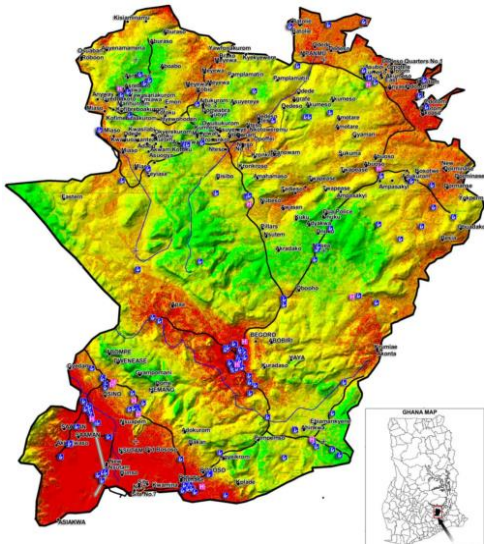
Geographic spread of flood risk

Flood risk is localized and unique to each ecological zone (Administrative Districts). Most of the factors that influence flood relate to severity and frequency of precipitation, structure of the landscape and pattern of planning. In most of the areas identified as flood risk hotspots, the landscape is either gentle or low with relatively unplanned settlements. In all the ecological zones, moderate to severe precipitation was identified as the main cause of flooding followed by poor physical planning and nature of slope. From the maps below (see figure 39), there are more high flood risk areas in the Coastal savannah (Keta) because of the relatively flat landscape. In the high forest and deciduous ecological zones, flood risk is more localized and concentrated in areas that are mainly flat and have sharp slopes. Similar observations are made in the Sudan and Guinea Savannah zones except that in those areas the risk of flooding is rather spread across the district. This is probably due to the relative flat nature of lands in the savannah zones.

Aowin Suman – High Forest



Fanteakwa – Deciduous



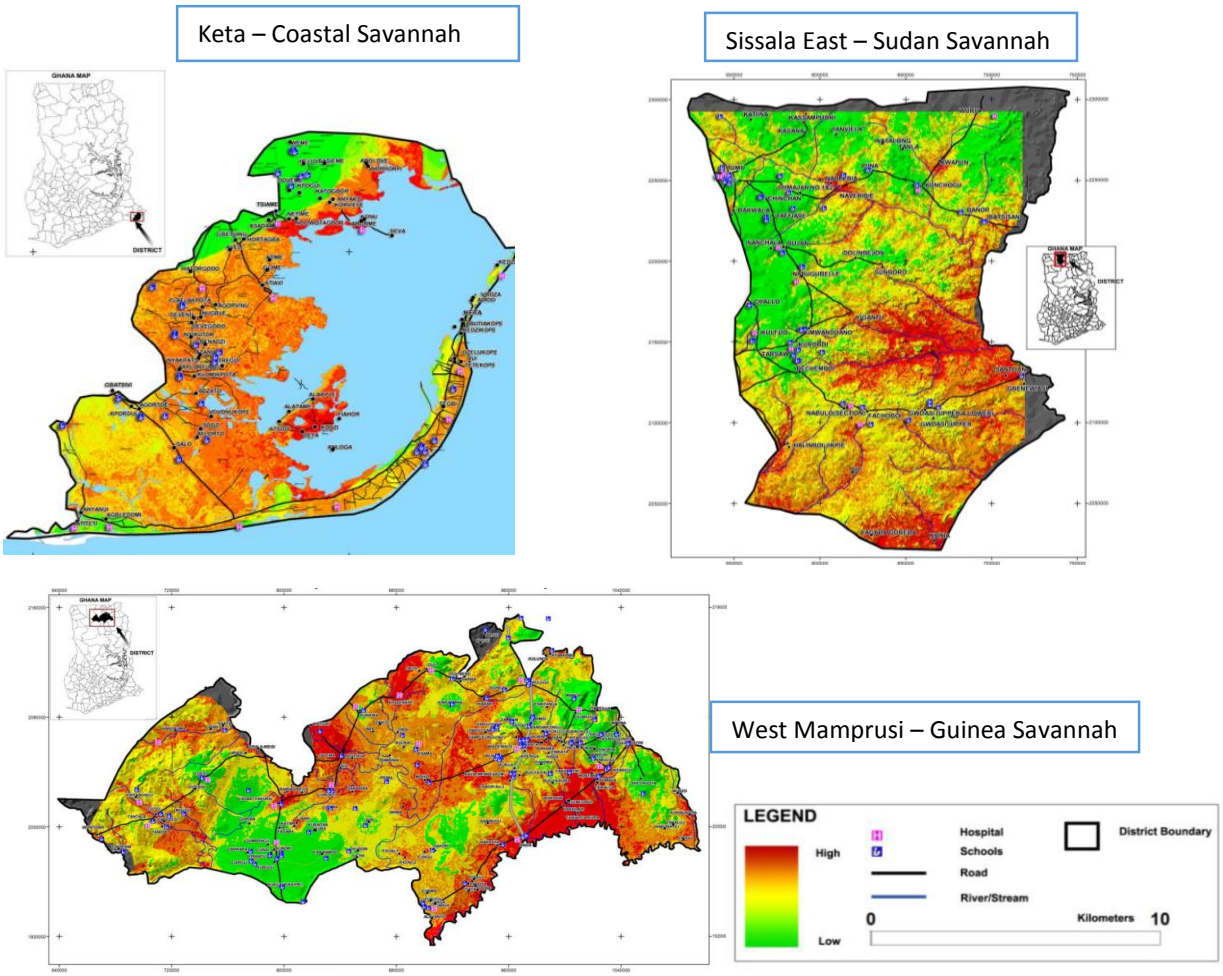


Figure 39: Flood risk Map in ecological zones represented by districts

Geographic spread of drought risk

The factors that influence drought are largely related to length of dry spell, vegetation cover and soil moisture. In general, drought risks are spread widely across the ecological zones, the high forest has the minimum risk to drought whereas areas in the deciduous ecological zone tend to have high risk to drought (see figure 43).

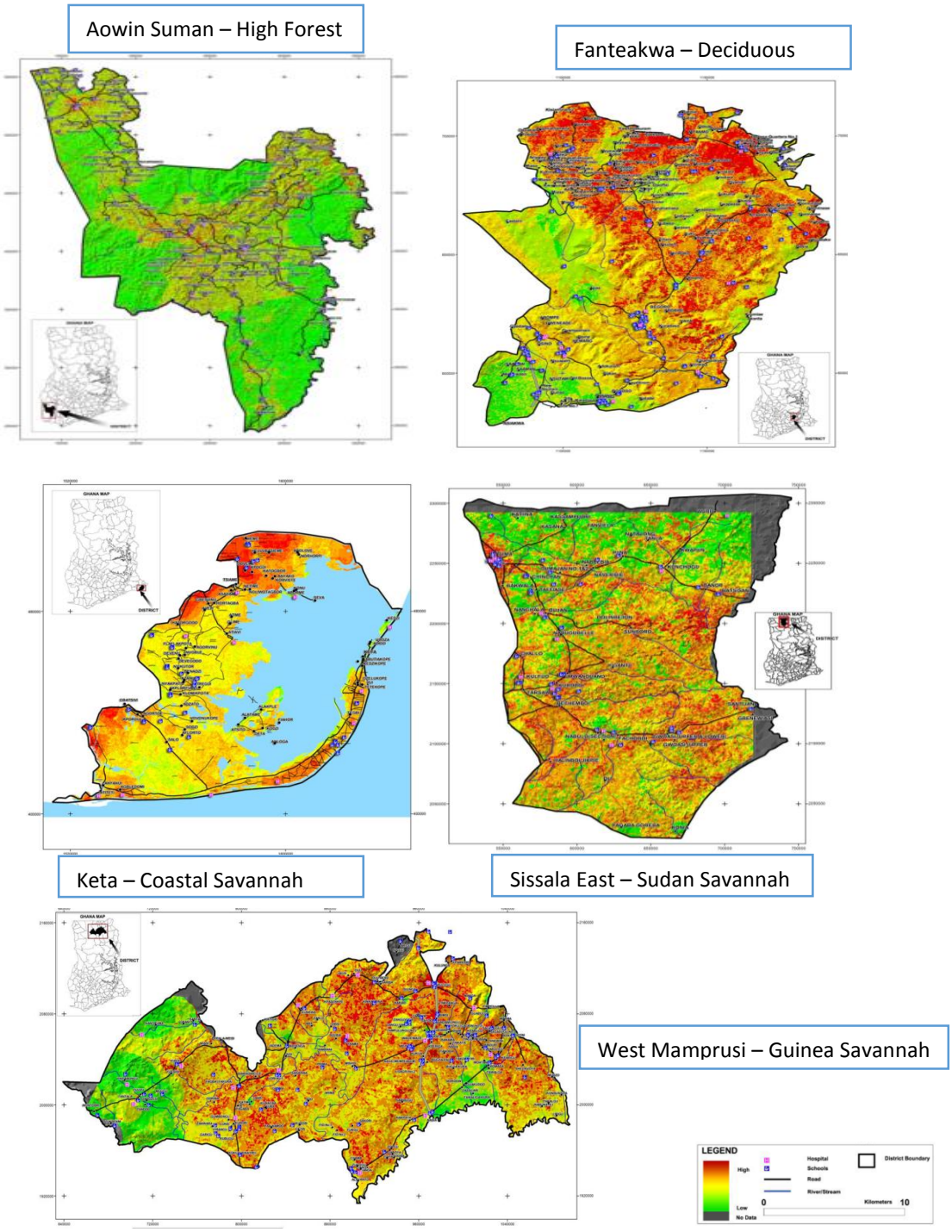


Figure 40: Flood risk Map in ecological zones represented by districts

5.2 Sector vulnerability and impacts Assessment

Climate Change vulnerability assessment was carried out to evaluate how changes in climate affect different segments of nature, the economy and the society. The assessment built on the previous study under the second national communication, which focused on agriculture, water and coastal resources. The current assessment follows up on how identified key impacts in vulnerable economic sectors such as fish production, human health, land use management, linkages between poverty and livelihoods of the

poor, root crop production, women's livelihoods and cocoa production are influencing adaptation planning both at the national and local levels. The vulnerability and impact assessment consisted of analysis of the scope and severity of the potential effects of climate change taking into account different future climate projections. The vulnerability and impacts studies further assessed possible adaptation and policy options that can be taken to prepare for climate change. In addition, the assessment further identified gaps in sectoral vulnerability and impact assessment. The assessment identified scope of issues, gaps and emerging sectors that would be considered in the next national communication. Table 59 presents a summary of the sector impact assessment.

5.2.1 Prioritization of sector impacts

Scoping and impact assessment review study for an integrated approach to broadening climate change adaptation into sectoral development was done to identify priority socio-economic sectors as gaps areas. This was because risk arising from climate change and variability impact cut across broad socio-economic sectors of national development. At the same time, the extent and severity of these effects also tend to vary among the different ecological zones. It was therefore important that attention was focused on the key priority sectors. Accordingly an appropriate set of criteria for selecting the priority sectors was developed in the form of a matrix that qualitatively evaluates the various effects on each of the thematic sectors of the economy. Key climate change risks were identified for each zone based on 330 community level interviews (see table 59). These effects were cross-matched with the various thematic socio-economic sectors in the matrix in table 60 to identify the priority sectors based on the qualitative evaluation of the significance of the effects. Out of the initial 16 key sectors selected, some sectors were merged and others dropped to arrive at 10 key sectors (see table 61). These selected key priority sectors and organizations form the core of the impact assessment study.

Table 59: Climate Change risk in the different ecological zones in Ghana

Ecological zone	Identified risk	Risk level (ranking)**
Coastal Savannah	Sea level rise	High
	Out-migration	Medium
	Weak livelihood support	Medium
	Sea erosion	Extreme
High forest	Erratic rainfall	Medium
	Late start of rains	High
	Early termination of rains	High
	Drought spell	Low
Transition	Low rainfall	High
	Rainfall extremes	High
	Crop failures	High
	Reduced minor rains	Low
Guinea and Sudan Savannah	Long dry spell	High
	Frequent flooding	High
	Out-migration	Extreme
	Erratic rainfall	Medium
	Rising temperature	High

** *ranking score – weight average of score assignment by interview responders at the community level. Score 0 (low) and 10 (extreme) on the graduated risk scale*

Table 60: Selection criteria matrix for key climate sensitive sectors

Sectors	Key Organizations	Climate change effects																	
		Coastal Zone				Forest Zone				Transition Zone				Savannah Zone					
		1. sea level rise	2. migration	3. livelihood	4. erosion	1. erratic rainfall	2. late start	3. early termination	4. drought spell	1. low rainfall	2. rainfall extremes	3. crop failures	4. reduced minor rains	1. drought	2. flood	3. migration	4. erratic rainfall	5. increasing temperature	Perfect score
Agriculture – crops	MOFA	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
Agriculture – fisheries	MOFA	1	1	1		1			1	1	1		1	1	1	1	1	1	13
Agriculture – livestock	MOFA	1	1	1		1			1		1	1		1	1	1	1	1	13
Water resources	MWRH	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	16
Health	MOH		1	1					1						1			1	4
Infrastructure – energy	MOEn	1			1	1			1	1			1	1	1		1	1	10
Infrastructure – transport	MoT (Roads, Port)	1			1	1					1						1	1	6
Infrastructure – housing/human settlement	MWRH / (T &CP)	1	1		1						1				1			1	6
Gender/poverty/vulnerability	MOWAC, NDPC	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
NATURAL RESOURCES – Biodiversity / Land Use Change	MLNR, (FC)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17

Migration and Internal Security	MOI	1	1						1		1			1	1	1			7
Tourism	MOT	1	1		1	1			1		1			1	1	1	1	1	11
Education	MOE	1	1	1	1	1			1		1	1		1	1	1	1		12
Disaster risk	MOI, (NADMO)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
Macro economy	MOFEP, NDPC	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
Coastal Zone Management	EPA WD	1	1	1	1														4

KEY: MOFA=Ministry of Agriculture, MWRH=Ministry of Water Resources and Housing, MOH= Ministry of Health, MOEn=Ministry of Energy, MoT=Ministry of Transport, NDPC=National Development Planning Commission, MOI=Ministry of Interior, EPA=Environmental Protection Agency, MOT=Ministry of Tourism, MOFEP=Ministry of Finance and Economic Planning, MOE=Ministry of Education, WD= Wildlife Division, NADMO=National Disaster Management Organization

Table 61: Final List of Priority Sectors selected for the Impact Assessment Study

Sector	Lead MDA
Agriculture – crops, fisheries, livestock	Ministry of Food and Agriculture
Water resources	Ministry of Water Resources, Works and Housing
Health	Ministry of Health
Infrastructure – transport	Ministry of Transport (Roads, Ports)
Infrastructure – housing/human settlement/energy	Ministry of Water Resources, Works and Housing and Town and Country Planning
Gender/poverty/vulnerability	Ministry of Gender, Children and Social Protection , National Development Planning Commission
Natural resources – biodiversity / land use change	Ministry of Lands and Natural Resources – Forestry Commission
Disaster risk	Ministry of Interior - NADMO
Macro-economy	Ministry of Finance, National Development Planning Commission
Coastal zone management	Environmental Protection Agency and Wildlife Department

Table 62: Sectoral vulnerability and impacts assessment matrix

Sector	Scale/coverage	Methods	Tools	Vulnerability & Impacts Identified	Prioritize Adaptation Measures	Adaptation Programme	Linkages with National Climate Change Policy	Linkages with National Adaptation Strategy
Roots &Tubers	Cassava, Yam and Cocoyam Within the ecological zones (Central, Volta and Ashanti regions for cassava) (Western Region for yam) (Ashanti and Western for cocoyam)	Socio-economic survey for economic and household data Secondary data (production statistics) used for natural yield variability	**Crop model** – DSSATv4 used to evaluate root crops vulnerability , implications for future climatic change and project expected magnitude of impacts Computer aided modeling, Scenario analysis, Simulation gaming Participatory assessment and qualitative assessment used for interactions between impact of climate change on root and tuber crop yields and national policies	Unreliable, irregular and unpredictable rainfall patterns. Indiscriminate deforestation. Poor or degraded soils as a result of intensive and bad cultivation practices. Prolonged drought increases the population of variegated grasshoppers which destroy cassava. Generally low income status of root & tuber famers. Heavy dependence of root & tuber on rainfall. Reduction in production due to high temperatures.	1. Improved Farming technologies or practices - Varieties with different maturity periods. - introduce drought resistant varieties - Integrate nutrient management under the various crops - Afforest degraded forest lands - Alternate cropping 2. Post-harvest technologies. 3. Alternate livelihood especially off farming activities. 4. Irrigation under root crops production	Root and Tuber Improvement and Marketing (RTIMP) - MoFA West Africa Agricultural Product Programme (WAPP) - MoFA Lessons from Conservation Agricultural Practices – CARE International	**Strategic Themes** : Food and Agriculture **Strategic Focus:** **Focus Area 1:** Development of climate resilient agriculture and food systems **Programme Areas** **1.2** Develop and promote climate resilient cropping systems **1.5**. Support to water conservation and irrigation systems **1.6.** Risk Transfer and Alternative livelihood Systems **1.7** Improved Postharvest Management	**Programme Area 7:** minimizing climate change impact and socio-economic development through Agricultural Diversification
Cocoa	National	Informal semi-structured and formal structured surveys (individual interviews.	CASE2 (Cacao Simulation Engine 2)	Generally low income status of cocoa famers due to small size of farms Erratic rainfall patterns in cocoa growing areas	Improved farming practices - drought resistant/tolerant and high yielding varieties - Zero tillage non-burning of vegetation and mulching for conservation of soil moisture	Environmental Sustainability and policy cocoa production Project (ESP) – Ghana Cocoa Board SNV Cocoa Eco-Project	**Strategic Theme:** Natural Resource Management **Strategic Focus:** Increase carbon sink **Programme**	**Programme Area 6:** Managing water resources as climate change adaptation to enhanced productivity and livelihoods

		Key informant interviews, group interviews Focus group interviews) of randomly selected farmers and other stakeholders		Increased degradation of land in cocoa growing areas Increased temperatures leading to drought in cocoa growing areas Generally low and unreliable prices for cocoa Traditional farming practices within the cocoa sector A generally ageing population of cocoa farmers in Ghana	- Planting temporary and permanent shade trees to moderate the microclimatic and edaphic conditions of the cocoa environment - Supplementary water application through irrigation Rehabilitation and restoration of degraded areas Alternative livelihoods - Development of off-farm income generating activities - Alternative land use activities (e.g. planting of other crops such as citrus, livestock farming and fish farming).	Ghana Cocoa Platform (Cocoa Board)	4.4 Conservation of trees through sustainable agro-forestry and on-farm practices	
Fisheries	Marine and inland fisheries	Study fish species: catch, tilapia and sarmollena, phyisical and socio-economic (survey)	Physical (Canoco 4), Biomass Dynmaic Model, Artificial Neural Network (ANN) for meteorological and fishery data	Increasing variability in marine fish stock, reduction in catch rate due to rising seas surface temperature , decreases in freshwater fish landings, generally low income in fishing communities	Aquaculture development, restocking of the fingerlings , reliable extension services including dissemination weather information, monitoring diseases, education	West Africa Fisheries Project (Component Environment and Social Safeguard) – Ghana National Aquaculture Development Plan Ministry of fisheries and aquaculture development	**Strategic Themes** : Food and Agriculture **Strategic Focus:** **Focus Area 1:** Development of climate resilient agriculture and food systems **Programme Areas** Support adaptation and risk reduction in Fisheries sub-sector	**Programme Area 10:** Adapting to climate change; sustainable livelihoods through enhance fisheries resource management
Land Management	Ecological zone specific (upper east) in dry	Rapid field appraisal, information from satellite imagery,		Land degradation and desertification	Agricultural diversification, Livestock-crop integration, i.e., mixed farming, Rearing more goats than sheep and	Ghana Environmental	**Strategic Themes** : (a) Natural Resource Management	**Programme** **Area 3:** Enhancing

	northern Ghana, Jachie in the humid forest zone, Sekesua-Osonson in the semi-humid forest-savanna zone	questionnaires survey and group discussions			cattle, as the goats are easier to feed, Adoption of new crop mixtures and rotations, bunding, agro-forestry, water, Adoption of new crop mixtures and rotations, bunding, agro-forestry, water, Drought tolerant crops, Planting and conservation of trees, Land use intensification, Alternative, off-farm jobs, notably small-scale gold mining, ('galamsey') Harvesting, integrated pest control and other such modern, innovative practices. Moisture conservation, notably mulching, erosion control.	Management Programme (MESTI & EPA), Sustainable Land Water Management Project (MESTI, EPA and MoFA), Climate change Adaptation through Integrated Water Resources Management in the three northern regions of Ghana – Water Resources Commission Land Administration Project (Ministry of Lands and Natural Resources	(b) Food and Agriculture **Strategic Focus:** **Focus Area 1:** Development of climate resilient agriculture and food systems **Programme Area** 1.3. Adaptation of Livestock production systems **Focus Area 4:** Increase carbon sinks **Programme Areas** 4.4. Plantation development (Afforestation, reforestation and forest restoration) **Focus Area 5:** Improve Management and Resilience of Terrestrial and Aquatic Ecosystems **Programme Areas** 5.2. Community-based natural resource management 5.3 Promote alternative livelihood through economic incentive measures	national capacity to adapt to climate change through improved land use management

Climate change and health	Ashanti Region (Southern Ghana), Northern Region - Malaria, Diarrhea, Guinea Worm and Cerebral Spinal Meningitis	Desktop review, questionnaire administration, focus group discussion, key informant interviews and observations, epidemiology survey, household case studies	Multiple regression analysis among climate variable and the three diseases, sustainable livelihood approach for socio-economic health impacts, ANN, MIASMA (Modelling framework for the Health Impact Assessment of Man-Induced Atmospheric changes) MODEL Version 2.0 or LEMRA (Local Eco-epidemiological Malaria Risk Assessment)	4. Measles cases will increase by the year 2080 as a result of increased mean air temperature and reduced rainfall amounts. However, measles is on the decrease under the present climatic conditions. 5. Gradual rise in the incidence of meningitis cases over the range of months where cases of meningitis are high. 6. Risk of increased diarrhea cases due to a reduced rainfall amount and increased mean air temperature.	Breaking the transmission cycle. Destroy breeding grounds of mosquitoes Destroy the larvae in order to break the life cycle. Break the host vector contact and protecting the host. Destroy breeding grounds of Cyclops, Destroy the Cyclops in order to break the life cycle, Break the host vector contact and protecting the host, Management of cases (surgical removal of worms, educating the people, community leaders and village health workers), Reduce Cyclops host contact through; Provision of safe drinking water, Filtration of water to remove Cyclops, Searching for patients with active cases to avoid contact with water, Ensuring that infected persons avoid contact with ponds, Chemical destruction of crustaceans,	UNDP climate change and health Project (Ministry of Health), Climate Change and health in Coastal Community in Accra Project (RIPS)	**Strategic Themes** : Equitable social development Strategic focus **Focus area 6:** Addressing Impacts of Climate Change on Human Health **Programme 6.3** Strengthen disease surveillance and response systems **6.4** Improve public health measures (immunization, improved drainage, sanitation and hygiene) especially in vulnerable communities 6.5. Emergency health preparedness e.g. provision of ambulances in vulnerable areas 6.6. Collaboration and partnership for improved nutrition, water and sanitation	**Programme Area 8:** Minimizing climate change impacts on human health through improved access to health care **Programme Area 5:** Developing and implementing environmental sanitation strategies to adapt to climate change

					Vaccination of high risk groups, Increased input to vaccination campaigns, Proper housing and ventilation, effective case management and Education.			
Poverty Linkages	Nationwide	Use of secondary data. Supplemented by primary sources of data. Data mainly from national government publications and unpublished reports such as Ghana Poverty Reduction Strategy, Ghana Living Standards Survey, Draft national documents, Core Welfare Indicators Questionnaire (CWIQ) surveys (1998, 2003). Informal interviews and consultations were made with	Qualitative and quantitative with the aid of statistical tool, Statistical Package for Social Science (SPSS), Analysis of Variance and Correlation, the use of tables, charts and maps.	Unreliable rainfall patterns. Heavy reliance on rainfall. Inadequate irrigable lands. Harvest failures from improper adaptive strategies. Reduced biological productivity and loss of forest cover. Progressive loss of non-timber forest products.	Reforestation. Cultivation of species in the environment that they are adapted to. Devise flood/drought early warning systems. Provide alternative skill training for fishing communities. Negotiate regional water-sharing agreements; Providing efficient mechanisms for disaster management; Developing desalination techniques;	Africa Adaptation Programme (EPA) Adaptation Learning Programme and community based adaptation - Care International Climate change and food security in the Afram Plain (RIPS) Building Climate resilience through village savings and lending associations (VSLA) – Care International Innovative insurance products for the adaptation to climate change in Ghana –Ghana Insurance Association	Strategic Themes : Disaster Preparedness and Response Strategic Focus: Focus Area 3: Increase Resilience of Vulnerable Communities to Climate Related Risks Programme Areas 3.3. Rapid Response and Disaster Management 3.5 Financial Support and Insurance Schemes 3.6 Provision of Social Support Systems	**Programme Area 2:** Alternative livelihood : minimizing climate change impact for the poor and vulnerable

		key government officials		Increased land degradation and loss of cropable land. Reduction in livestock size and nutrition. Disruption in industry productivity due to possible crises in the energy sector. Disruption in the supply of raw materials e.g. from agriculture, fisheries and forestry. Potential impact on inter-regional trade. Disruption of rainfall patterns will affect Akosombo dam (30% of our energy sources). Higher risk of property insurance. Potential risk from sea level rise such as coastal inundation and erosion.	Planting mangrove belts to provide flood protection; Planting salt-tolerant varieties of vegetation; Improving drainage facilities; Establishing setback policies for new developments; Devising flood early warning systems. The use of setback policies for all underdeveloped areas within the coastal zone. This would prevent the construction of immovable structures within hazard areas. Development of woodlots			

				Salt water intrusion into fresh water resources. Disruption of sources of livelihoods e.g. fishing and agriculture Population displacement	Promote and develop energy efficient technologies Promotion of energy conservation especially in large energy consuming industries. Monitor and control emissions from industries and transport sectors. Promote and develop alternative energy sources such as biomass, wind, biomass, mini-hydro etc.			
Gender (focus on Women livelihoods)	Coastal Savannah Zone of Ghana-Tema, Keta and Kwanyako	Qualitative survey using questionnaires including focus groups to a small group of twenty (20) women in a locality selected from the three study areas	Sustainable livelihood framework The procedure for qualitative survey described by Roger	Unsafe drinking water They experience discrimination under customary law and practice in most parts of the country e.g Land tenure systems and social relations Relatively high fuel wood consumption, which has negative consequences in the rural areas in terms of time spent in collecting or buying firewood;	Facilitating equitable access to land; Security tenure and protection of land rights; Ensuring planned land use; and Developing effective institutional capacity and capability Increase access to health services; Improve the efficiency of health service delivery;	Land Administration Project (LAP)-Gender –MLNR National Health Insurance Scheme to improve financing of the health sector and provide access to quality health services to particularly women. Local level mapping of climate change financial allocation	**Strategic Theme:** Equitable Social Development **Strategic Focus** Focus Area 6: Addressing Impacts of Climate Change on Human Health **Programme area** 6.7 Social protection and improved access to healthcare e.g., NHIS	**Programme** **Area 2:** Alternative livelihood : minimizing climate change impact for the poor and vulnerable

				• Health and environmental effects from smoke particles; difficulty in sitting close to the stove to cook due to excessive heat transfer from the stove to the environment as well as the smoke from the fuel wood; General inconvenience such as increased workload of women and children who collect firewood. Reduction in fishery resources from impacts of climate change Competition from big fishing trawlers Use of chemicals in fishing Inadequate and poor access to financial credit facilities	Foster partnership with other agencies in improving health by: i Addressing inequalities based on gender, poverty and disability; ii Expand water availability, sanitation and the health environment; iii Improve nutritional status.	from a gender perspective (Abantu for Women Development and IBIS Ghana) Gender action for climate change equality and sustainability project		

Key findings from the scoping and impact assessments on water resources are provided in table 63 below:

Table 63: Water sector impact of climate change through changed water resources resulting from the effects of climate change (Dovie, 2011)

Impact area	Impact of changes in water occurrence	Mechanism
Water	Change in river flow regimes	Changes in onset of the rainy season will change surface flow regimes. Higher temperatures of water will change the ecology (e.g. increased eutrophication)
	Water scarcity	Higher temperatures, evaporation and recurrent drought lead to water stress, higher demands, conflict, and biodiversity loss.
	Flooding	Increased intensity of rainfall, coupled with land degradation raises risks of loss of life and property, displacement and damage to infrastructure via flooding.
Health	Malaria	Expansion into breeding areas created by flooding and where resistance may be low.
	Water borne diseases	Flooding is associated with diarrheal disease including cholera epidemics, particularly where sanitation is poor.
	Respiratory diseases	Associated with prolonged dry spells.
Agriculture and food security	Malnutrition and famine	Associated with lower food production and insecurity, particularly with widespread damage brought by floods and droughts.
	Seasonal rainfall change	Erratic onset and cessation of the rainfall seasons. Shorter rains, Crop failure or lower yields of staple foods, reduction in traditional varieties, and more crop diseases.
	High intensity rainfall events	Crop damage, soil erosion, river bank erosion
	Fisheries	Changes in nutrient cycling and loss of spawning brought about by temperature and water level changes will reduce productivity.
Environment	Land degradation and deforestation	Higher wildfire risk in dry periods; pressure on forests when other livelihoods are reduced. Environment assets collapse; salinization and soil erosion.
Infrastructure	Transport links / Settlements	Damage to bridges, roads, telecommunication and buildings during flood and storm events.
	Energy	Changes in reservoir levels reducing flows available for power generation. Higher energy costs and energy poverty with implications for charcoal use, deforestation and land degradation.
Poverty	Multiple	Exacerbated and vulnerability increased.

The scoping assessment also provided a review of existing human and institutional capacities for dealing with climate change risks and opportunities as it relates to water resources. A qualitative assessment of human and institutional capacities to deal with climate change risks and opportunities in the water sector was conducted. The initial assessment was conducted by Dovie, 2011 which was later validated by the targeted interviews during the preparation of the third national communication. The results of the assessment is provided in the table 64.

Table 64: Assessing institutional capacity to deal with climate change risks in the water resources sector based on 2010 extreme events in northern Ghana

Climate Risk	MMDAs	Role	Capacity Score**		
			Rank1	Rank 2	Rank 2
Flooding	NADMO	Preparedness and contingency planning, rescue and relief	2	1	2
	WRC	Trans boundary information dissemination	7	6	5
	GMET	Early warning	4	5	6
	MOFA	Post disaster interventions / extension services	4	5	4
	RCCs / MMDAs	Information dissemination and logistics	3	2	3
	NGOs	Cross-cutting participation	8	8	9
	MoH	First aid, trauma and outreach	4	4	6
	Families / Friends	Safety nets	6	5	6
	NCCE	Education and public awareness	2	1	2
	WSA	Handling of water and sanitation challenges	3	3	4
	HSD	Providing flow data	6	5	6
Drought	MOFA	Extension and appropriate varieties of crops	6	7	7
	GIDA	Harnessing and making irrigation water readily available	3	2	1
	RCCs / MMDAs	Coordination and logistical support	3	2	3
	NGOs	Relief supplies	6	5	5
	Families / Friends	Safety nets	6	7	6
	NADMO	Humanitarian aid / relief	5	4	4
	WRC	Helping to build community resilience through water conservation practices	7	6	5
	GMET	Forecasts of dry local conditions and extent	2	1	3
	HSD	Providing flow data	1	1	3
Reduced Runoff and stream flow	GIDA	Provide sufficient water	3	4	2
	WRC	Monitoring of appropriate water use to avoid over use, ensuring buffer zonation and administering water permits and waste, negotiating upstream release.	6	5	5
	MOFA	Supporting farmers to harness receding flood waters	8	5	6
	HSD	Providing flow data	3	2	3
	Local population	Dry season farming and traditional shallow wells	8	7	9
Changing groundwater recharge and storage	GIDA	Identify and harness the potential of groundwater for large scale irrigation	3	3	2
	MOFA	Making appropriate drought tolerant species and seeds available	6	5	7
Poor water quality	EPA	Monitoring and making information available	2	3	2
	WSA	Supporting the provision of potable water	3	5	4

** Capacity score range from least (0) to highest (10). Three ranking rounds represented in each column.

In addition to water resources, the scoping studies also looked at potential specific impacts on transport infrastructure. The summaries of key findings from the scoping and impact assessments on transport infrastructure are presented in table 65. The transport sector in Ghana comprises of road, rail, air and water (inland and maritime) transport modes. Transport infrastructure comprises the basic physical structures needed for the operation of the transport sector and includes but is not limited to the following;

(a) bridges and tunnels, (b) all road segments, (c) rail (passenger and freight), (d) port and airport, (e) signals and traffic control centers, (f) pipelines and (g) Inland water and sea transport. The priority given to the components of the transport infrastructure depends on factors such as the level of usage, importance within the larger transportation network, class of asset (eg road) and value in emergency situations.The transport sector in Ghana is relatively lacking in terms of both awareness and response to the effects of climate change and climate variability. Table 29 below shows a variety of climate change related risks and impacts associated with the transport infrastructure.

Table 65: Climate change impacts in the Transport sector

Transportation infrastructure	Priority within the national transport context	Climate stressors	Effects of climate change	Ability to withstand stressors
Road	High	Flooding, fog	Accidents, road collapse	Provide good illumination and drainage, appropriate road signs, climate change resilient construction materials, design standards
Airports	High	Fog, turbulence	Visibility problems, plane crash, flight delay and cancellation	Good weather forecasting
Railway	Medium	Fog	Accidents	Good weather forecasting
Seaports	High	Fluctuation of sea level, tides	Shallow berth,	Engineering of seaports to consider CC factors
Pipeline and fuel depots	Medium	Drought and bushfires,	Loss through explosions	Use of fire resistant and climate resilient materials in pipe manufacture and construction

5.2.1.1 Adaptations and interventions for dealing with climate change in the priority sectors

The assessments of the priority sectors identified a number of on-going and/or planned adaptation and/or interventions within the various sectors for dealing with the issues of climate change. These initiatives range from 'soft' items such as institutional and policy interventions (e.g. awareness raising, specific studies, capacity building, etc.) to actual projects on the ground.

Institutional and policy interventions

Analysis of the role of institutions and policy intentions and the contribution in building resilience in the agricultural sector is provided in the table 66. The analysis sought to identify the current sector policy interventions and how it is providing strategic directions in addressing climate change issues in the sector.

Table 66: Institutional and policy interventions in the agricultural sector

Issues	Institutions and current status	Gaps
Development Planning and budgeting	MoFA is the lead government organization responsible for the development of the food and agriculture sector. It does this by formulating appropriate policies, Programmes/plans and regulations. The MoFA is also responsible for providing extension services to operators in the sector in terms of technologies and training. The Ministry regularly goes through re-organization to reflect its development focus. An Environment Unit was established in 2005 for environmental issues. In addition to the Unit, Environmental Desk Officers have been designated for each region to ensure integration of environmental issues into planning and budgeting at the regional and district levels. A sector climate Change Committee was established in 2011 to provide policy recommendations to the Ministry.	The current structure of MoFA is adequate for effectively addressing environmental issues within the sector, but budgetary allocations at the various levels have been far from adequate. There is clear inadequacy of capacity at all levels within MoFA in terms of awareness and understanding of climate change and disaster risk reduction and need for mainstreaming climate change into policies, plans and Programme.
Agriculture Research	Agricultural research is under the Council for Scientific and Industrial Research (CSIR) and Universities. These institutions have over the year's undertaken research and development of technologies to address problems within the sector including important environmental issues such as droughts, pest and diseases. Although the research institutions remain the same, they have at the institute levels, gone through some modifications in response to development needs e.g. CRI and SARI now have socio-economic departments. Approaches used over the years have also gone through a number of processes. At present various methodologies of participatory research are used for technology development and dissemination resulting in better uptake of research innovations.	Despite the developments within the institutes, their response to climate change has not been adequate in terms of data generation and technology development. There is need to enhance capacity of research institutes and universities to enable them respond effectively to the demands of climate change and variability.
Extension Services	The extension service of MoFA is the major provider of extension services in Ghana. Its services are complemented by those of Cocoa Services of Cocoa Board and a number of NGOs. Whilst the MoFA extension services are general in nature, services provided by other providers tend to be specific and focused, depending on the financier, e.g. TRAX operates in the northern parts of the country with emphasis on soil and water conservation. Approaches being used range from technology transfer to Farmer Field Schools (FFS). Currently, a number of NGOs are making efforts at raising awareness on climate change and disaster risk as part of their extension service provision. At the MoFA level, although a number of technologies being promoted provide an entry point for addressing climate change and disaster risk reduction, little or no effort is made to integrate these.	Inadequate capacity of extension service field officers and supervisors for addressing climate change and disaster risk reduction as integral part of service delivery. To effectively deal with climate change as part of extension service delivery, requires innovative methods that require much longer contact hours with clientele, therefore the need for higher numbers of field staff and resources.

Policies	The Ministry of Food and Agriculture is responsible for providing policy direction for the development of the sector. The Food and Agriculture Sector Development Policy (FASDEP II) is the over-acting policy for the sector. The policy seeks to achieve a modernized agriculture sector and increased incomes for farmers. The policy has six objectives which tend to reinforce their outputs as follows: Food security and Emergency preparedness Enhanced incomes for farmer Increased competitiveness for domestic and international market Sustainable Environment and land management Use of Science and Technology for Agriculture Development Human Resource Development Institutional Coordination The FASDEP is supported by sub-sector policies and strategies that define specific strategies and actions towards the achievement of the policy objectives	There is no policy objective of FASDEP that deals directly with Climate Change and Disaster Risk Reduction. This was identified during a Strategic Environmental Assessment of the policy in 2009. The FASDEP policy objectives in supporting agriculture development along the value chain which is necessary for addressing challenges of Climate Change, provides a good entry for mainstreaming climate change initiatives into its implementation. The FASDEP II presents little or no mention of climate change in available sub-sector policies (fisheries, livestock irrigation etc.) and/or strategies hence the lack of needed focus on climate change. This gap could however be addressed during annual planning and budgeting sessions to effectively address climate change issues as they affect the various sub-sectors and agro-ecologies – by developing strategies or framework for mainstreaming climate change issues.

Some projects and interventions currently on-going for climate change adaptation in the agricultural sector are presented are provided in table 67.

Table 67: Adaptation related interventions in the agricultural sector

Adaptation strategies	Location	On-going	Completed
Community Afforestation and forest protection Programme	Volta Region: Jasikan	X	
	Upper East: Sirigu	X	
	Upper West: Nangodi		X
	Western Region: SefwiWiawso, Juaboso		
	BrongAhafo/Wenchi, Techiman	X	
	Eastern Fanteakwa,Kwahu south, Birim central, Atiwa district	X	
	Greater Accra Ga East, Dangme West and Ga South.	X	
Sensitization and awareness creation Radio discussion	Volta Region: Ho	X	
	Eastern Region: Afram Plains	X	
	Upper East: Bolga	X	
	Greater Accra – Radio Ada	X	
Agroforestry Alley cropping Woodlot establishment Taungya	Central Region: Mfantsiman	X	
	Upper East: Bawku	X	
	Western Region: Bia, Juaboso		X
	Volta Region: Jasikan, Denu		X

	BrongAhafo: Asutifi Eastern Region	X	
Land Management	Country wide		
Controlled burning		X	
Cover cropping Zero tillage			
Minimum tillage		X	
Contour bunding		X	
Mulching Erosion control			
Composting Manuring			X
Intensification			
Water harvesting & Management	Volta Region	X	
Flood retention (Proposed)	Upper East	X	
	Central	X	
Flood recession agriculture (cultivation of short season crops)	Northern	X	
Dam construction and rehabilitation	Upper East	X	
De-silting of dams Roof top water harvesting (Proposed)	Upper west	X	
Aquaculture	Volta Region	X	
Cages	Central Region	X	
Ponds	Eastern	X	
	Ashanti	X	
Production of non-timber forest products Grass-cutter, Rabbitery, Snails, Bee keeping, Mushroom	Brong Ahafo	X	
	Greater Accra	X	
	Eastern Region	X	
	Western Region	X	
	Central Region	X	
	Volta Region	X	
Development of improved pastures – controlled grazing	Greater Accra: Amrahya Nungua	X	
	Volta Region: Aveyime	X	
	Northern Region: Tamale	X	
	Eastern Region-Afram plains	X	
Zero grazing	Greater Accra: Amrahya, Nungua	X	
	Volta Region: Aveyime	X	
	Northern Region: Tamale	X	
Hay/Silage making	Greater Accra: Amrahya, Nungua	X	
	Volta Region: Aveyime	X	
	Northern Region: Tamale	X	
Farming system Intercropping Mixed cropping	Country wide	X	
Capacity building for weather forecasting	Upper West region	X	
Integrated Production and Pest Management	Country wide	X	

Institutional capacity building for environment management	Three Northern regions	X	
Bushfire control and management	Savannah regions Volta Brong Ahafo	X	
Small scale irrigation projects	Country wide	X	

It is important to note that majority of the projects indicated above were donor funded so replications and up-scaling have always been the issue offer sustainability. The national climate change policy is seeking to address the issue of sustainability by providing funding to continue implementation of some of the projects.

5.3 Adaptation mainstreaming into national planning

5.3.1 National strategies for mainstreaming adaptation

National strategies for mainstreaming adaptation follows basically the national development planning and budgeting processes. These processes involve national policy formulation, planning, budgeting implementation, monitoring and evaluation. Each of these processes involves very wide and long participation resulting in key documents such as national medium term development policy framework, planning and monitoring guidelines. Table The table 68 summarizes the efforts made so far.

Table 68: Efforts relating to mainstreaming climate change

Scale	Formulation	Planning	Budgeting and Implementation	M & E
National	Climate Change issues have been captured in the Ghana Shared Growth and Development Agenda II which is the current national medium Term development framework (2014-2017) Following from the GSGDA, a National Climate Change Policy has also been prepared to assist the MDAs to do more specific targeting at mainstreaming climate change	Sensitisation programme held for Members of Parliament, Ministers of State, Council of State, Economic Management Team (EMT), Chief Directors of key Ministries, District Chief Executives and Regional Co-ordinating Directors on Climate mainstreaming		Over all national indicators include climate change
Sector	Feedback from the monitoring and evaluation of Sector Plans inform the national policy formulation processes	Sector Planning Guidelines have been prepared including issues of mainstreaming adaptation Training of Ministries, Departments and Agencies (MDAs); on mainstreaming of climate change into planning and budgeting.	Climate Change is a cross cutting issue, all the MDAs are expected to demonstrate, during budget hearings how, climate adaptation issues will be taken care of. Ongoing pilot project at Ministry of Local government and Rural	Each MDA is required to prepare a monitoring and evaluation Plan including indicators to track the progress of climate adaptation

			Development on Climate Change Adaptation Mainstreaming at the Local level.	
Districts	Feedback from the monitoring and evaluation of Sector Plans inform the national policy formulation processes	District Planning Guidelines have been prepared including issues of mainstreaming Training of Metropolitan, Municipal, and District Assemblies (MMDAs) on mainstreaming climate change into planning and budgeting have been done.	Indicators on Climate Change are part of several performance indicators to ensure MMDAs include climate in their implementation efforts.	Each district Assembly is required to prepare a monitoring and evaluation Plan including indicators to track the progress of climate adaptation

5.3.2 Recommendations for improvements

- The main strategy to ensure mainstreaming is to sensitize and work consistently with policy makers such as Ministers of State, Parliament, and District Chief Executives. Chief Directors of key Ministries, and Regional Co-ordinating Directors are also vital in assisting to influence the process. The policy makers are changed periodically and therefore conscious efforts should be made at sensitization as the cycle changes.

- As part of the FOAT under the District Development Fund, more performance indicators on adaptation should be developed to encourage the District assemblies to commit more to ensuring adaptation.

- Research in climate change should be encouraged and supported. Again there should be a conscious effort to link science with climate change interventions in the country.

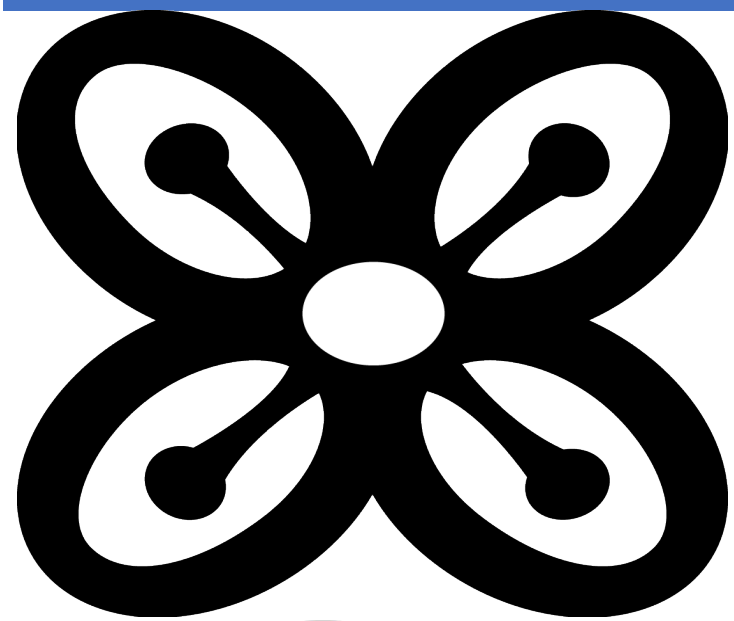
- The National budgeting process should consciously factor climate change into the budgeting process. This should also be replicated at the metropolitan, municipal and district levels.

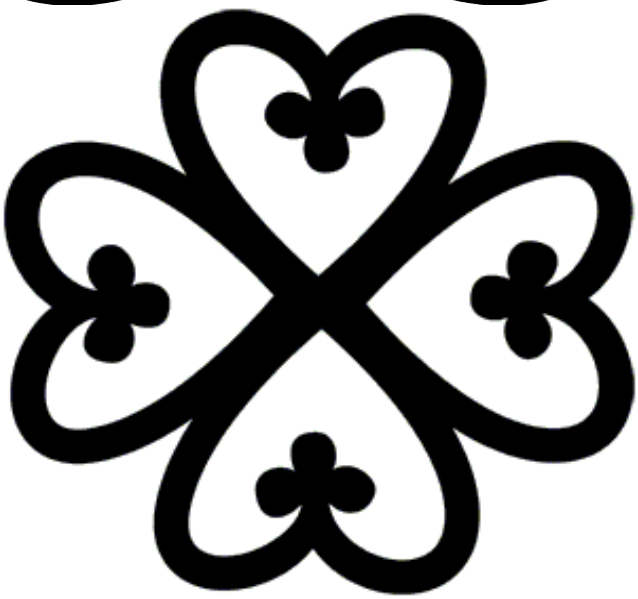
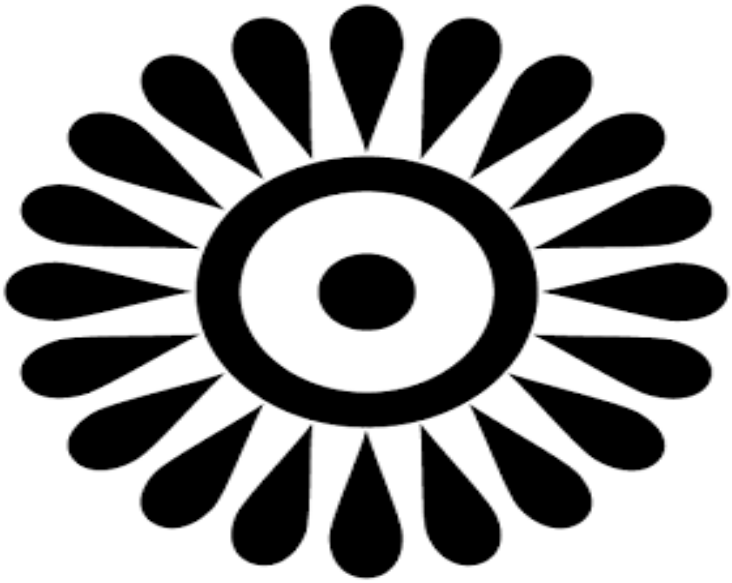
- Besides government, a lot is also being done by NGOs such as Care International and development partners to enhance adaptation particularly at the district level. This should be encouraged so that development partners and NGOs could be partnered to support the mainstreaming process.

- There is need to ensure effective and a consistent monitoring of the implementation of adaptation projects by the MMDAs and MDAs.

- Need effective and a consistent Monitoring of the implementation of adaptation projects by the MMDAs and MDAs.

Other information



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6. Other Information

6.1 Activities relating to Transfer of Environmentally Sound Technologies

6.1.1 Technology need and needs assessment (TNA)

Ghana undertook two TNA exercises to identify select and prioritize technologies that were needed in order to effectively mitigate and adapt to climate change. The two TNA exercises were conducted in 2003 and 2013. The 2003 TNA focused on mitigation technologies in the energy and waste sector whereas the 2013 looked at adaptation technologies in the water and agriculture sectors. The mitigation technologies that were identified in the 2003 TNA were revised in 2014 during the GHG mitigation assessment. In both processes, national stakeholders and experts were involved in the consultation for identifying and prioritizing key technology portfolios. UNDP/GEF and UNEP provided financial and technical support for the two TNA exercises. The adaptation and mitigation technologies that were selected through the TNA exercise and subsequent revisions are shown in tables 69 and 70.

Table 69: Range of prioritized technology portfolios

Technology Portfolio	2003 TNA	2014 Revisions	Comments
Biofuels	x		
Industrial energy efficiency improvement	x	x	
Energy efficiency lighting	x	x	Aligns with 12 prioritized NAMAs
Solar PVs	x	x	Aligns with Ghana's SE4ALL Action Plan and 12 prioritized NAMAs
Natural gas combined cycle and Natural gas distribution system	x	x	
Management technologies and efficiency improvement in transport sub-sector or BRT	x	x	
Wind Energy	x		
Solar Water Heater	x	x	Aligns with Ghana's SE4ALL Action Plan and 12 prioritized NAMAs.
Small and mini hydro	x		Limited potential
Biomass for power generation (Co-generation from sawmill residues)	x		
Landfill methane gas capture for power generation	x	x	
Anaerobic and CH_4 generation technologies for waste water handling (Biogas technologies)	x	x	Topmost priority. Aligns with Ghana's SE4ALL Action Plan and 12 prioritized NAMAs.
Incineration	x	x	Target Public Schools and Hospitals
LPG and Improved Stoves		x	Aligns with Ghana's SE4ALL Action Plan
Efficient Fridges		x	

Table 70: Prioritized adaptation technology portfolios and key barriers based on TNA Action Plan and Project Idea Report

Sector	Technology Portfolio	Technology Description	Target of technology diffusion	Scale/estimated Cost ($)	Technical and Economic Barriers	Comments
Water	Rainwater collection from ground surfaces (RCS).	Collection, storage and use of rainfall that lands on the ground as opposed to collection from roofs with the intention for multi-purpose use in the communities. In many water-poor areas, small-scale runoff collection infrastructure can contribute greatly to the volume of freshwater available for human use and other multi-purpose uses.	Addresses insufficiency of water to support livelihoods of rural communities resulting in poor community health and poor school attendance, particularly for the girl-child	Water-poor communities in Savannah areas and Afram Plains. $ 6,000,000	High construction and maintenance cost. High cost of feasibility. Few technicians and artisans to undertake construction and maintenance of water systems. High production and import cost. Inadequate government incentives. Policy uncertainty.	Contained in TAP & PIR. Selected using consultative MCA. Technology diffusion is projected to take 10 years.
	Post-construction support for community managed water system (PCS).	Facilitates community ownership, management and maintenance of water systems, promotes women participation in their management and improves system performance and sustainability.	Increasing the success and sustainability of community-managed water systems through existing government initiatives.	500 communities nation-wide. $ 8,500,000	Inadequacy of funds available to communities for emergency repairs and general maintenance of their water systems.	Contained in TAP & PIR. Selected using consultative MCA.
Agriculture	Integrated Nutrient Management (INM)	Make efficient use of both synthetic and natural plant nutrient sources to enhance soil fertility towards improving and preserving soil productivity.	Appropriate application and conservation of nutrients and transfer of knowledge to farmers. .	Pilot in selected farming communities nation-wide (100, 000 farmers) $ 9,300,000	High cost of credit. Low farmer income. Inadequate availability of technical information and low access to extension service to end users of the technology.	Contained in TAP & PIR. Selected using consultative MCA
	Community Based Extension Agent (CBEA)	Provide specialized and intensive technical training to identified people in rural communities to promote a variety of technologies and offer technical services with support and review from an extension organization	Training of service providers in climate data collection; analysis and dissemination within their areas of operation to enable communities select appropriate response strategies.	Pilot in 500 farming communities nation-wide $ 4,200,000	Lack of motivation for available personnel. Lack of budgetary allocation to support CBEA because it is not identified as an integral part of the national extension structure	Contained in TAP & PIR. Selected using consultative MCA

6.1.2 Enabling Environment for technology transfer and diffusion

6.1.2.1 Addressing policy and financial barriers

There are a number of policy and financial reforms that are under implementation to help address policy and financial barriers that prevent greater transfer and diffusion of technology. The reforms are broadly clustered into three. These are (a) policy reforms, (b) financial and market reforms and (c) skills and infrastructure development. Table 71 provides an overview of the reforms and how they contribute to address the barriers.

Table 71: Selected policy, technical and financial reforms to enable technology transfer and diffusion

Reform	Type of Reforms	Technology targets	Comments
1. Policy reforms			
Renewable energy law	Renewable energy target	Renewables	Policy target for RE electricity generation share
	Renewable fund		Access to credit
	Feed-in tarrif		Incentives for private sector to generate grid-scale RE electricity
Electricity tarrif rationalization	Automatic price adjustment policy	Grid-scale	Incentive for independent power produces
Standards and Guidelines	Standards for improved stoves	Cook stove market	Development phase by Energy Commission and CSIR
	Appliance standards and labeling	Appliance import market	Ensure quality and energy efficient appliance in the local market
	Ghana Landfill guidelines	Landfill methane capture	Regulate landfill construction and management by EPA
	Law on ban on importation of used fridges and air-conditioners	Refrigeration and Air-conditions	Ban on import of old refrigeration
Investment Promotion Act	Technology Transfer Regulations, 1992 (L.I. 1547)	All technologies	Facilitate technology transfer
Low carbon development strategy	Prioritization and action plan of mitigation technologies	Energy-based technology NAMAs	Contribute policy coherence
Water and Agriculture Technology Project Idea Report	Project idea of water and agriculture technologies	Adaptation based technologies	
2. Skills and infrastructure development			
Skills development fund	Skills development	Technician and artisans	Funding for technician and artisan in RE installation and maintenance (Solar & Biogas)
National Research Endowment Fund	Technology research and development	R& D institutions	National Science, Technology Innovation Policy.
3. Financial and Market reforms			

Free Zone Enclave	Incentives for business to produce at minimum cost for export.	Industrial technology enclave	Relief from double taxation for foreign investors and employees; 100% exemption from payment of direct and indirect duties and levies on all imports for production and exports from free zones.
Ghana Green Fund	Vehicle for technology financing	Environmentally sound technologies	Funding for Environmental Projects through taxes.
Ghana Infrastructure fund		Energy and transport infrastructure	Mobilize private capital and provide credit to business.
Akoben Industry performance disclosure mechanism	Promotion of technology adoption in industry	Environmentally sound technologies	Annual public disclosure of industry performance.
Rebate scheme	Incentive for efficient electronic appliance adoption and market reforms	Refrigeration and air-conditioners	Top up for poor households to buy new efficient Fridges.

6.1.2.2 Capacity building for technology transfer and diffusion

Skills development is crucial for technology adoption at all levels in Ghana. Ghana is therefore making significant efforts to (a) improve capacities of farmers, engineers, technicians and artisans (b) create awareness and knowledge exchange and (c) facilitate lessons sharing on pilot technology adoption initiatives. Ghana believes that up skilling of climate technology adopters is an important step that needs to be taken in order to catalyze technology diffusion. Government of Ghana and its development partners are engaged in a number of capacity development programme. Some of the programmes are described in table 72.

Table 72: Technology related capacity building initiatives in Ghana

Initiative	Type of technology capacity building	Comments
GEDAP	Operational Manual for Matching Grants modified to incorporate in Renewable Energy Business	Capacity building for rural bank staff and solar company's on-going.
Sustainable Land and Water Management Project	Hands-on training on soil and land management technologies	Target – Savannah arid 20 communities.
Skill Development Fund	Training of technicians and artisans on installation and maintenance of Solar PVs	Ghana Technology University College
Human Resource Development for disseminating solar PV	Technical Guidelines for PV Rural Electrification in Ghana, Solar PV Resting Manual, Solar PV system Technical Service Guidelines and Community Agent Manual.	Effort to support tertiary institutions which are already offering courses in renewable energy to build the capacity of students.
Master courses on Renewable energy	Formal training on renewable energy	2 year MSc degree at Mechanical Engineering Department, Kwame Nkrumah University of Science and Technology.
Established University of Energy and Natural Resources	Skilled labour for the energy market	Fully fledged energy training institution to produce high skilled labor on energy technologies.
HND courses on Renewable energy	Technical training on renewable energy	Renewable energy system engineering (Koforidua Polytechnic), Renewable energy & Energy Efficiency (Accra Polytechnic) and Renewable energy and efficient technologies (Kumasi Polytechnic).

Ghana Technology Transfer and Marketing Center (TTMC) – The Ghana Atomic Energy Commission has established the TTMC to enhance collaboration with the private sector for technology transfer activities for the socio-economic development of the country (see figure 41). Among many other functions of the TTMC, those that are deemed relevant to climate technology transfer include (a) conduct analysis on the potential commercial market for each innovation, literature and patent searches to help assess patentability and (b) support scientists and private sector companies to source for funding from existing national funds such as Social Development Fund, Out grower and Value Chain Fund, Export Development and Agricultural Investment Fund and Venture Capital Fund to develop the innovation.

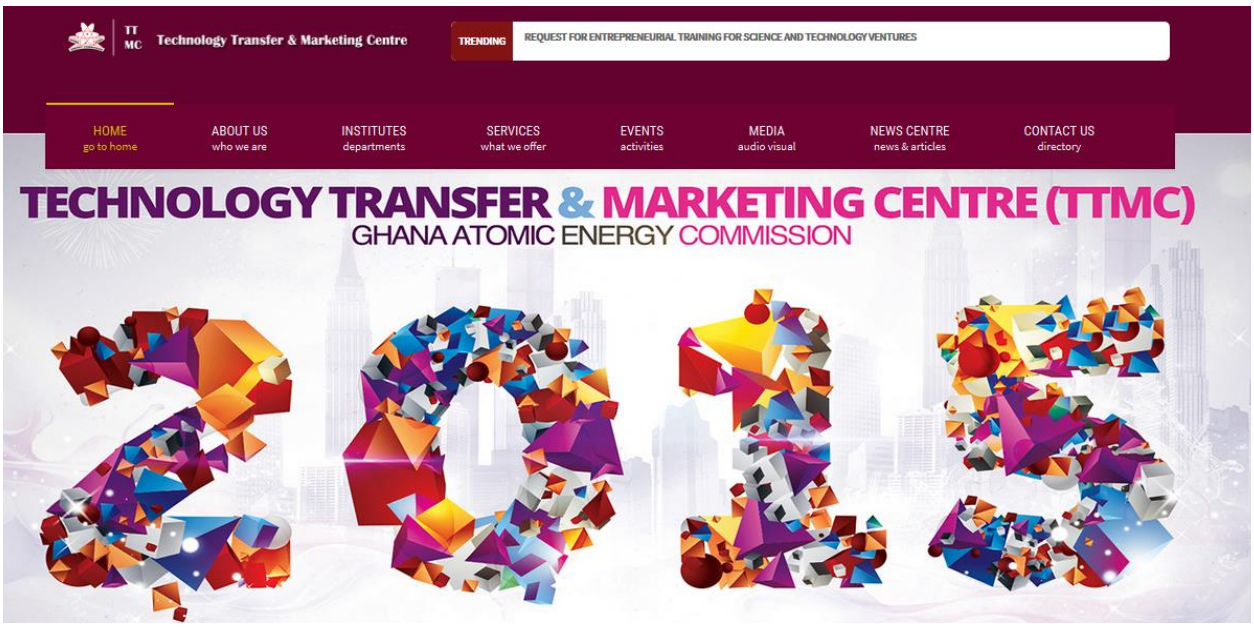

Figure 41: Ghana Technology Transfer and Marketing Center (TTMC)

6.1.3 Mechanisms for technology transfer in Ghana

In Ghana, technology is not only acquired from offshore sources. Certain amounts of conventional and indigenous technologies are also acquired within the country through research and development and farmer innovation. The mode of technology transfer either within the country or from offshore occurs via one or a combination of the mechanisms listed below. It is important to note that the way the transfer mechanism works is mostly defined by the dictates of the markets both at supplier and user's ends respectively. The dominant technology transfer mechanisms in Ghana are described below with examples.

- *South-South Cooperation*– (*China-Ghana South-South Cooperation on Renewable Energy Technology Transfer)* –The cooperation aims to ensure a more holistic transfer of renewable energy technologies from China to Africa through exchange of expertise and technology between China and Ghana, building on China's unique development experience. The partnership support will not transfer hardware per se, but focus on the institutional framework and capacity required to make the local absorption of renewable energy technologies effective.

- The partnership is in collaboration with the Energy Commission Ghana, the Ministry of Science and Technology China, together with the UNDP Country Offices in Accra and Beijing with financial support from the Government of Denmark.

- *Bilateral development cooperation - (Millennium Development Challenge Account Compact 2 – Ghana Power Pact)* – Largest US Government-funded transaction *with* Ghana under the Power Africa Initiative. The Compact intends to invest up to $498.2 million to support the transformation of Ghana's electricity sector and stimulate private investment. The Government of Ghana will invest $37.4 million of its own funds in the initiative making the Compact a total investment of up to $535.6 million.

- *Private sector initiatives - (farmer innovation ICTuse – Isoko)* – ISOKO is a private firm in Ghana using ICT platform to innovate cheap, simple and flexible technologies to help smallholder farmers particularly in the dry northern Ghana to access to commodity market and extension information in real time. Some of the technology products from Isoko are (a) Mobile phone farming (eSoko) – provides agricultural and market information (eg. Market prices, weather, farming methods) through simple SMS via mobile phone to farmers and farmer groups, (b) mFarms – suite of mobile application to effectively deliver market information services (stakeholder communication and monitoring) and (c) e-Extension Platform – ICT based information storage and retrieval system. Communication with Agricultural Agents, online forum and video and audio on demand and Interactive Voice Response.

- *Pilot-Upscale approach- (GEF-Approach)* – The Refrigeration Appliances market transformation project uses GEF funding model of piloting and testing technology to stimulate future market.

6.1.4 Funding received to support technology transfer

6.1.4.1 Funding from Multilateral and Annex II Parties to support technology transfer

Reporting period: 2011 to 2014						
Name	**Type support**	**Source of Funding**	**Channel of support**	**Financial Support Amount (US Dollars)**	**Capacity Support**	**GOG Indicative Co-financing**
Ghana Climate Innovation Center	Grant	Government of Denmark and others	Multilateral (World Bank)	17.6million	Target 500 businesses	-
GEDAP (full name)	Grant, Concessional Loans, non-concessions loans	Multiple sources	Multilateral (World Bank)	235.28 million	-	77.28 million
Promoting of Appliance of Energy Efficiency and Transformation of the Refrigerating Appliances Market in Ghana	Grant	GEF	Multilateral	6.1 million	-	4.4million
China-Ghana South-South Cooperation on Renewable Energy Technology Transfer	Grant	Government of Denmark	Bilateral (UNDP)	2.72 million	-	-
Millennium Development Challenge Account Compact 2 – Ghana Power Pact	Grants	United State Government	Bilateral	498.2 million	-	37.4 million
Facilitating Implementation & Readiness For Mitigation	Grant	Government of Denmark	Bilateral through UNEP-DTU Partnership	0.35 million	Capacity to develop 2 technology-based NAMAs and LCDf	
Technology Needs Assessment	Grant	GEF	Multilateral through UNEP-DTU Partnership	0.07 million	-	-
Human Resource Development for disseminating solar PV	Non-cash support	Government of Japan	Bilateral through JICA	Unknown	Training Materials	-

Sustainable Land and Water Management Project	Grant Loan	GEF World Bank	Multilateral	13.25million	-	4.5million
Forest Preservation Programme	Cash and Technical Support	Government of Japan	Bilateral	8.5million	Spatial Infrastructure and training	-
Ghana Urban Transport Project (BRT)	IDA Credit Grant	GEF & World Bank AfDB	Multilateral	29 million	-	2 million
Ghana Gas Infrastructure Plant	Commercial Loan from China	Government of China	China Development Bank	**1,000 million		
Low Emission Capacity Building Project (LECBP)	Grant	EU Australia	Multilateral through UNDP	0.882million	Capacity to develop 2 technology based NAMAs	-
Community Resilience through Early Warning	Grant	Government of Norway	Bilateral through UNDP	5.2 million	-	-
Total Multilateral				302.33 million		
Total Bilateral				514.62 million		
Total commercial Loans				1,000 million		
Total Grants				816.65 million		
Grand Total				1,816.65 million		125.58million

*** Provisional figures*

6.2 Research and systematic observations (RSO)

6.2.1 Climate change research

The research needs on climate change are significant and the topics vary widely. The topics identified through a survey related to the following: (a) pathways for indigenous knowledge transfer; (b) socio-economic impacts on local communities; (c) documenting past and on-going ecological and social dynamics, (d) policy-research diagnostics etc. That is why the national climate policy has prioritized climate research as one of the strategic pillars for providing evidence for policy and practice. The survey also indicated that majority of on-going climate change research are project-driven and donor-funded, nevertheless Ghana government continues to provide budgetary support to key research and academic institutions.

However, the major challenge Ghana faces with climate change research is inadequate funding from the central government. Because funding from government is not adequate, most of the academic and research institutions that are involved in climate change research tend to rely on external funding sources. The external funding sources although useful in filling the research funding deficit, in most cases the research areas they commit funding to, do not necessarily fit into national priorities. Nevertheless, Ghana believes the plethora of researches that are on-going in the country will go a long way to support capacity development aspirations of the country. In order to derive maximum benefits out of these researches, government has proposed to step up coordination of climate research activities among academic and research institutions. In addition, the government has also given indication of its intention to establish a "National Research Fund" (NRF) in the coming years to streamline funding of research in Ghana. The Ministry of Education is responsible for the formulation and implementation of the NRF initiative. Currently, most of the academic and research institutions are able to mobilize their own funding to augment what they get from government and other external sources. There are a number of on-going researches in Ghana which focus on different aspects of climate change. The overviews of the research are provided below under the following five main clusters: (a) land use and agriculture (b) climate change and society, (c) water and coastal resources, (d) climate modeling and (e) cross-cutting studies.

6.2.1.1. Land use and agriculture

West Africa Science Centre on Climate Change and Adapted Land use (WASCAL)

WASCAL is a large-scale research-focused Climate Service Center mandated to help tackle the challenges of climate change in West Africa with funding is from the Government of Germany. Ghana is among 10 West African nations benefiting from WASCAL and hosts the headquarters (Legon) and the Land use Centre (KNUST). In Ghana, the collaborating institutions of WACAL are: University of Ghana, Kwame Nkrumah University of Science and Technology, Ghana Meteorological Agency, MESTI). WASCAL is organized around three main components namely – (a) Competence center and Observation Network, (b) Core Research Programme and (c) Graduate studies programme. The activities of the WASCAL Core Research Programme are grouped into six research clusters: (a) climate and weather; (b) landscape dynamics,(c) agricultural systems; (d) markets and livelihoods; (e)risk management; and (f) integrated assessment. The research programme cluster has produced extensive datasets and peer reviewed papers on vegetation structure, hydrology, farming systems and innovations, soils, landscape dynamics etc. These products are useful to support evidence-based policy and practice on climate change. WASCAL is running until the end of 2018.

Improving food security in Africa through increased system productivity of biomass-based value webs (BiomassWeb)

Ghana is one of three African countries participating in the BiomassWeb research with funding from the German Government. BiomassWeb aims to provide concepts to increase the availability of and access to food in Ghana through more and higher-value biomass for food and non-food purposes in the next decades. BiomassWeb is structured around the analysis of biomass demand, supply and related value webs, research innovations, and implementation including capacity and network building. In Ghana, the research study sites are located in Ashanti, Brong-Ahafo, Bolgatanga, and Upper East Region. The research partner institutions in the country includes; CSIR-Crop Research Institute, KNUST, WASCAL, University of Cape Coast, Forum for Agricultural Research in Africa (FARA), ISSER, West Africa Regional Office - International Network for Bamboo and Rattan (INBAR). The research is running from 2013 to 2018.

CECAR-Africa - Enhancing Resilience to Climate and Ecosystem Changes in Semi-Arid Africa: An Integrated Approach (United Nations University Institute for Natural Resources in Africa)

The goal of the CECAR-Africa Project is to enhance resilience to climate and ecosystem changes in Semi-Arid Africa, with a particular focus on the northern part of Ghana. UNU-INRA undertakes research and implements capacity development programmes for local residents and professionals in Northern Ghana (social institutions, technical capacity development) in collaboration with UNU-ISP and UDS. Other partner institutions on the project include: University of Tokyo and Kyoto University in Japan and University of Ghana and Ghana Meteorological Agency in Ghana. This 5-year project (2012-2016) is funded by Japan Science and Technology Agency (JST) and Japan International Cooperation Agency (JICA) through a scheme called SATREPS.

CLIMAFRICA – CSIR-Crop research institute

CLIMAFRICA is an EU sponsored research programme in which Ghana is participating with other 10 European and 8 African Countries. The research focuses on developing improved climate prediction on seasonal to decadal climatic scales; assess impacts in the water and agricultural sector of the economy; evaluate vulnerability of the ecosystems and civil population; suggest and analyze new adaptation strategies; develop a new concept monitoring and forecasting warning systems. The research site is the communities around the Ankasa Forest Reserves. The project run for the period 2010 – 2014. The other partners are CSIR Soil Research and Forest Research.

Savannah forest boundary transition in West Africa - Coupling the energy balance and hydrology and carbon cycles across the biome - CSIR-Forest Research Institute (FORIG)

This research is sponsored by the European Union and focuses on assessing the energy balance and carbon fixation regime in savannah vegetation in the forest savannah zone of tension. The research partners are FORIG and Wageningen University.

Does shifting Carbon Use Efficiency determine the growth rates of intact and disturbed tropical forests? Gathering new evidence from African forests - CSIR-Forest Research Institute (FORIG)

This is a joint research between FORIG and University of Oxford with funding from the Government of the United Kingdom through the Natural Environment Research Council. It started in 2011 and ended in 2014. The research sites are Bibiri Forest Reserve and Kogyae Strict Nature Reserve (KSNR).The research aims to address fundamental hypotheses on the relative importance of photosynthesis and autotrophic respiration in determining forest function in intact and disturbed tropical forests.

Payment for Watershed Services on the role forest in generation of rainfall in Ghana - Nature Conservation Research Centre (NCRC),

The research is a collaboration of NCRC, FORIG, WRC and University of Oxford which seeks to assess the ecosystem limits for poverty alleviation. The research is part of the global project on ecosystem service for poverty reduction (ESPA). The government of United Kingdom provided funding.

6.2.1.2 Climate change and society

Building climate resilience through risk communication in Ghana's growing coastal cities - Regional Institution for Population Studies (RIPS), University of Ghana, Legon

The objective of this research was to promote the use of climate change risk factors as common indicators for integrating climate compatible development and policy processes in Ghana. This involved: risk and vulnerability assessments; testing of a vulnerability identity matrix method; evaluating and testing the sensitivity of policy frameworks to respond to community-level climatic risks; understanding specific drivers of risk reduction; and disaster contingency planning. The research also helped to strengthen human capacity in risk assessment and management of key impacts of climate change. The outcome aimed to guide the mainstreaming of climate science, policy and people. Funding was provided by the United Kingdom Government through CDKN Innovation Fund. The project started in 2012 and ended in 2013.

Mapping of Indigenous knowledge in Selected Communities in Ghana (African Adaptation Programme - AAP, Environmental Protection Agency

The AAP conducted research on Indigenous knowledge on climate change adaptation in selected communities in six districts in Ghana. At the end of the research, an Indigenous Knowledge Atlas that compiles local knowledge related to climate and weather was published.

6.2.1.3 Publications on climate change research in Ghana

The number of scientific research publications on climate change has recorded significant increase in the recent years. Majority of climate change research work that took place in the country in most cases produced scientific papers or grey reports. These papers or grey reports are useful to building a body of knowledge on climate change in Ghana as well as contributing to the literature in the scientific community. For most of the scientific papers, the publication is done in journals of varying impacts factors depending on the strength and the focus of the research papers. From the survey conducted as part of the Third National Communication, it was observed that a lot of the papers focused on climate adaptation issues in human and national systems mainly at the local scale. Within the adaptation, the topics ranged from impacts assessment, adaptation strategies and mainstreaming. Few of the publications focused on climate finance and mitigation. Table 73 shows selected scientific and grey literature publications on climate change in Ghana for the period 2011-2014.

Table 73: Selected scientific and grey literature publications on climate change in Ghana for the period 2011-2014

Authors (s)	Title of publication	Sponsor/Collaborators
Ahenkan, A., & I.J. Musah-Surugu, 2014	Financing climate change adaptation and mitigation in Ghana: Challenges and prospects	University of Ghana
Tachie-Obeng, E., P.B.I. Akponikp & S. Adiku (2013)	Considering effective adaptation options to the impacts of climate change for maize production in Ghana. Environmental Development 5 (2013) 131–145.	University of Ghana and EPA
Klutse et al.	Patterns of Rainfall, Temperature and malaria cases in two ecological zones in Ghana (unpublished).	Centre for African Wetlands, University of Ghana
	Farmer's observation on climate change impacts on Maize (Zea mays) production in a selected Agro-Ecological zone in Ghana.	
	Rainfall variability over Ghana: model versus rain gauge observation	
	Changes in the onset and length of rainfall seasons from an ensemble of regional climate models over the Transition and Coastal savannah zones of Ghana	
Egyir et al.	Adaptive capacity and coping strategies in the face of climate change: a comparative study of communities around two protected areas in the coastal and transitional zone of Ghana (unpublished)	
Fosu-Mensah et al.	'Modelling Impact of Climate Change on Maize (Zea mays L.) yield under Rain-fed Condition in Sub-Humid Ghana', UNU-INRA Working Paper No 1/11	UNU-INRA
Afful-Koomson et al.	Governance Challenges for Promoting the Green Economy in Africa' In: J.A. Puppim de Oliveira (ed), Green Economy and Governance for Sustainable Development: Opportunities, Promises and Concerns. Tokyo: United Nations University Press	UNU-INRA
Emmanuel Tachie-Obeng, et. al (2014)	Downscaled Climate Change Projections for WA District in the Savanna Zone of Ghana. Journal of Disaster ResearchVol.9No.4, 2014	University of Ghana
Codjoe, S.N.A. et al. (2015)	Geophysical, socio-demographic characteristics and perception of flood vulnerability in Accra, Ghana. Natural Hazards.	RIPS, Legon
Codjoe, S.N.A. et al. (2015)	Climate change/variability and schistosomiasis transmission in the Ga District, Ghana. Climate and Development.	RIPS, Legon
Codjoe, S.N.A. et al. (2014)	Climate change and cerebrospinal meningitis in the Ghanaian meningitis belt. International Journal of Environmental Research and Public Health, 11 (7), 6923-6939.	RIPS, Legon
Codjoe, S.N.A., et al. (2014).	Climate change and internal migration intentions in the forest-savannah transition zone of Ghana. Population and Environment, 35, 341-364.	RIPS, Legon
Codjoe, S.N.A. et al. (2013).	Economic analysis of climate variability impact on malaria prevalence: The case of Ghana. *Sustainability,* 5(10): 4362-4378.	RIPS, Legon

Codjoe, S.N.A., et al. (2012).	Gender and occupational perspectives on adaptation to climate extremes in the Afram Plains of Ghana. Climatic Change, 110 (1): 431-454.	RIPS, Legon
Codjoe, S.N.A. et al. (2011).	Climate change/variability and food systems: Evidence from Afram Plains, Ghana. Regional Environmental Change, 11(4):753-765.	RIPS, Legon
Twerefou, D. K. and Appiah-Konadu P., (2015)	The Impact of Trade Liberalization on the Environment: Evidence From Ghana, Ghana Social Science Journal, Vol 12, No 1.	Economics Department, University of Ghana, Legon
Twerefou D., K., et al.	The Economic Impact of Climate Change on Road Infrastructure in Ghana	Economics Department, University of Ghana, Legon
Tanner, T., Adelina Mensah, Elaine T. Lawson, Chris Gordon,	Political Economy of Climate Compatible Development: Artisanal Fisheries and Climate Change in Ghana.	Institute of Environment and Sanitation Studies
Emma L. Tompkins, Adelina Mensah, Lesley King, Elaine T. Lawson, Chris Gordon,	An investigation of the evidence of benefits from climate compatible development	
Obuobie, E. et al.	Assessment of vulnerability of river basins in Ghana to water stress conditions under climate change	CSIR-Water Research Institute
Obuobie, E. et al.	Impact of climate change on stream flow in selected river basins in Ghana	
Bawakyillenuo, S., et al. 2014	Exploring the autonomous adaptation strategies to climate change and climate variability in selected villages in the rural Northern Savannah Zone of Ghana. Local Environment: The International Journal of Justice and Sustainability).	Institute for Statistical, Social and Economic Research (ISSER)
Bawakyillenuo, S. et al. 2015.	Local Farmers' Experiences and Perceptions of Climate Change in the Northern Savannah Zone of Ghana. International Journal of Climate Change Strategies and Management. In Press.	
Koforobour K. et al. 2013.	Climate change adaptation mainstreaming at the sub-national level development planning: A Case of the Sekondi-Takoradi Metropolitan Assembly (STMA), Ghana. Journal of Economics and Sustainable Development www.iiste.org ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online) Vol.4, No.11, 2013	Department of Geography and Regional Planning, University of Cape Coast, Cape Coast, Ghana
Klutse, N. A. B., Fred Aboagye-Antwi, F., Owusu, K. and Ntiamoa-Baidu, Y. 2014	Assessment of Patterns of Climate Variables and Malaria Cases in Two Ecological Zones of Ghana Open Journal of Ecology, 4, 764-775	Centre for African Wetlands, University of Ghana
Owusu, K. et al. 2014	Changes in Expectations and Extremes in the Rainfall Climatology of Accra, Ghana, 1895-2005. *Applied Geography* Vol.52, 99-109	Geography and Resource Development, University of Ghana
Francis, N., Klutse, N. A. B., Adukpo, D. C., Owusu, K., Quagraine, K. A., Owusu, A. and Gutowski Jr., W (2014)	Rainfall variability over Ghana: model versus rain gauge observation. *International Journal of Geosciences* Vol 5, 673-683	University of Ghana, Ghana Atomic Agency and others

Klutse, N. A. B., Owusu, K., Adukpo, D,C. Nkrumah, F., Quagraine, K., Owusu A. and Gutowski W. J. 2013	Farmer's observation on climate change impacts on maize (Zea mays) production in a selected agro-ecological zone in Ghana. Research Journal of Agriculture and Environmental Management. Vol. 2 (12) 394-402	
Owusu, K. and Klutse, N. A. B. 201)	Simulation of the Rainfall Regime over Ghana from CORDEX. *International Journal of Geosciences* Vol. 4, 785-791	University of Ghana, Ghana Atomic Agency
Owusu, K. et al. 2013	Identification of historic shifts in daily rainfall regime, Wenchi, Ghana. Climatic Change Vol. 117 (1-2) 133-147	Geography and Resource Development, University of Ghana
Owusu, K, Asiedu A.B., Yankson P.W. K. and Ntiamoa-Baidu, Y. (2013)	An Assessment of Climate and Climate Change Content of Courses and Research at the University of Ghana. NCTE Tertiary Education Series Vol.6 (1) 1-12	University of Ghana
Owusu, K. et al. 2013	The changing rainy season climatology of mid-Ghana. Theoretical and applied Climatology Vol. 112 (3-4) 419-430	Geography and Resource Development, University of Ghana

6.3 Systematic observation

6.3.1 National meteorological observation network

Systematic observation of the climate in Ghana is done mainly through the national synoptic network of meteorological and radar stations. The synoptic automatic weather stations distributed across the country gives coverage of nearly 95% of Ghana's territory for the measurement and monitoring of atmospheric phenomena. The meteorological radar which is located in Accra covers the remaining 5% of the country. The observation network is managed by the Ghana Meteorological Agency (GMeT) which provides climate services to the general public, civil aviation, commercial airlines, military aviation and maritime. The recent addition of radar monitoring station to the system observation network infrastructure has boosted observation capabilities of the GMeT. GMeT is also receiving support from WASACAL to further improve their observation network across the country. Though GMeT has been undergoing institutional reforms for some time now, especially in the areas of data commercialization and overall capacity development, the Agency is still challenged with numerous logistical constraints. Some of the challenges are; (a) inadequate level of funding for the (b) poor or outdated infrastructure for climate information gathering and forecasting, (c) lack of efficient system; (d)unavailability of high computational interconnectivity at synoptic stations to send data to aid forecasting and (e)lack of more automated weather and computation stations..

6.3.2 Centre for remote sensing and geographic services (CERSGIS)

CERSGIS provides support to specialized services on geo-information for observation and monitoring and land and coastal resources. The center has spatial infrastructure and technical capacity for providing services on mapping, acquisition of remote sensing imageries across the country. CERSGIS has a training laboratory, for up to 20 trainees, equipped with modern equipment, resource library. It also has the capacity to provide effective training in its areas of competence. Currently, CERGIS is a partner in the Ghana Agricultural GIS online Platform. The platform gives access to cross-sectional data and GIS data collected by projects including USAID funded ADVANCE and TIPCEE, ADRA Ghana Food Security Programme, the Ministry of Food & Agriculture and GTZ/MOAP projects. Application of GIS technologies in agriculture helps to provide essential information such as locations of smallholder farms, aggregators, processors, tractor service providers, warehouses and weather stations (see figure 42).

Figure 42: Ghana Agriculture Online GIS Platform

6.3.3 Ghana space science and technology institute - Ghana Atomic Energy Commission

The Ghana Space Science and Technology Institute (GSSTI) was established in 2013 to exploit and coordinate space science and technology for socio-economic development of the country. The GSSTI is involved in the establishment, operation and hosting of a space observatory known as the Ghana Astronomical Project (GAP) on the African VLBI to support systematic observation activities in Ghana. The GSSTI has Remote Sensing, GIS & Climate Center to coordinate its programme on geo-information and climate science. The center has been organizing regular capacity building programme on climate modeling for young scientists.

6.3.4 GEONETCast centre – University of Energy and Natural Resources

The GEONET Cast Centre operates GEONET Cast platform which is a near real time, global network of satellite-based data dissemination systems designed to distribute space-based, air-borne and in situ data, metadata and products to various stakeholders. The GEONET Cast applications are useful for water, disasters, health, energy etc. The center has capacity to work within the GEONET Cast domain supported by the Group on Earth Observation (GEO) and is led by EUMETSAT, the United States, China and the World Meteorological Organization (WMO).

6.4 Participation in international Activities

6.4.1 Sub- Regional Activities (ECOWAS Level)

Ghana contributed to a number of climate change related activities in the ECOWAS sub-region. Some of the initiatives Ghana is either contributing to or participating in are provided below:

UNFCCC CDM Regional Collaboration Centre in LOME – The regional office supported Ghana to start the development of a standard baseline in the transport and waste sector. In addition, the center in collaboration with the West Africa Power Pool helped to develop grid emission factors for the countries that share electricity with common transmission infrastructure in the sub-region including Ghana.

Regional Centre for Renewable Energy and Energy Efficiency (ECREE) – Kumasi Institute for Technology and Environment (KITE) is implementing the ECOWAS Renewable Energy Facility (ECREF) funded by Regional Centre for Renewable Energy and Energy Efficiency (ECREE). The project sought to provide grant co-funding for small to medium sized renewable energy and energy efficiency (RE&EE) projects and businesses in rural and peri-urban areas. The project run from 2011 to 2014.

West Africa Gas Pipeline - The West African Gas Pipeline Company limited (WAPCo) is a limited liability company that owns and operates the West African Gas Pipeline (WAGP). The company's main mandate is to transport natural gas from Nigeria to customers in Benin, Togo and Ghana in a safe, responsible and reliable manner, at prices competitive with other fuel alternatives. The gas delivered in Ghana helps to generate electricity from a clean energy source.

Sustainable Greenhouse Gas Inventory in West Africa– Ghana participates in the GHG inventory programme in West Africa with funding from the Australian Government through the UNFCCC secretariat. In the project, Ghana received technical assistance towards reviewing of the AFOLU section of its national GHG inventory report.

6.4.2 Continent wide level (Africa Union Level)

Participation in AMCEN –Ghana is an active member of AMCEN which is hosted by UNEP. During its 14th meeting the Centre for African Wetlands, University of Ghana made presentation on "integrating food security and sustainable agriculture into climate change policies." *African Group of Negotiators (AGN)* - The AGN consists of technical negotiators of every African country. One country is selected to chair the group for a period of two years; the AGN is currently chaired by Sudan. Ghana is an active member of the AGN.

African Climate Policy Centre (ACPC) -The ACPC is a hub for knowledge generation on climate change in Africa. It addresses the need for greatly improved climate information for Africa and strengthening the use of such information for decision making, by improving analytical capacity, knowledge management and dissemination activities. The ACPC is an integral part of the Climate for Development in Africa (ClimDev-Africa) programme, which is a joint initiative of the African Union Commission (AUC), the United Nations Economic Commission for Africa and the African Development Bank. ClimDev-Africa has been mandated at regional meetings of African Heads of State and Government, as well as by Africa's Ministers of Finance, Ministers of Planning and Ministers of Environment. Ghana as a member of the Africa Union contributes to the activities of the ACPC.

6.4.3 International level

UNFFCC and Climate Change Negotiations - Ghana actively participates in the Climate Change negotiations both at the UNFCCC, regional and the sub-regional levels. The country has contributed to the advancement of multilateral structures and mechanisms in the negotiation process. Ghana has contributed immensely to the Africa Group level by leading negotiations on behalf of the Africa Group, especially on Technology Transfer, REDD+ and Climate Change Adaptation. At the regional and sub-regional levels, Ghana has contributed to the formulation and advancement of common African positions on various negotiation issues, as well as participating in activities to develop a common climate change framework for the ECOWAS sub-region. Ghana is also represented on the ECOWAS climate change committee. Ghana has also previously served or d is still serving on the following "groups" of the convention as member or alternate member: (a) Adaptation Fund Board (ADF)–Alternate member, (b) Consultative Group of Experts on National Communications from Parties not included in Annex I to the Convention (CGE) – Member; (c) Expert Group on Technology Transfer (EGTT) – Former Member; (d) Standing committee on Finance.

In addition Ghana contributes to some of the technical activities that the UNFCCC secretariat undertakes. Some of the activities are as follows; (a) Annual review of National GHG Inventory from Annex 1 Parties. So far Ghana has contributed 3 lead reviewers, 3 energy experts, 2 industrial process experts, 1 agriculture expert and 1 waste expert. Ghana also contributes additional experts who also participate in the review of national communications and biennial update reports from Annex 1 parties. In all, 4 national experts are involved in the review of national communications and biennial update reports.

Inter-governmental Panel on Climate Change (IPCC): Ghana is fully represented at the IPCC and has served on a number of working groups and task forces. Under the Fifth Assessment report (AR5), Ghanaian scientists are working in Working Group II (WG II) and Working Group (WG III) as lead and contributing authors. Ghanaian scientists also contributed to the IPCC Special Report on Renewable Energy Resources and Climate Mitigation (SRREN).

7. Education, Training and Awareness

7.1 Information on education, training and public awareness (ETPA)

In Ghana, the implementation of education, training and public awareness Programmes on climate change is coordinated through Article 6 of the convention which is anchored on the environmental education strategy of the EPA In fulfilling the provisions under Article 6, Ghana appointed a national focal person to facilitate implementation of ETPA Programmes. The Article 6 national focal point is hosted at the EPA and works closely with the Environmental Education and Public Affairs departments of the Agency. In addition, a national action plan for the implementation of Article 6 of the UNFCCC has been prepared. In the action plan, strategies for pursuing climate change education, public participation and awareness have been outlined. The Programmes in the action plan that are implemented by the EPA and those undertaken by other bodies complement each other at all levels of the Ghanaian society.

7.1.1 Climate change education and public awareness

Climate change education and public awareness are important parts of the strategies that Ghana undertakes to ensure that the wider society embrace changes that are needed to combat climate change. In this respect, many climate change education efforts that have been implemented targeting formal and informal segments of the society. The education Programme focus on increasing public awareness on climate change, and emphasize behavioral change and community action.

7.1.1.1 Formal education

In most of the public tertiary institutions, climate change and related subjects have either been integrated into existing courses or special graduate courses have been designed. For instance, University of Ghana, Legon and Kwame Nkrumah University of Science and Technology have introduced special graduate courses on “climate change and sustainable development” and “climate science and meteorology”. In addition, the WASCAL project also introduced graduate and post-graduate Programme on climate change. Some of the specialized areas are land use, energy, economics etc. These Programme have produced skilled young natural and social scientists who are capable of contributing to improving the skill-set base of the country. Apart from the specialized climate change Programme, many of the tertiary institutions such as the University of Cape Coast and University of Development studies have revised their bachelor and graduate programme course structures to cover topics on climate change and sustainable development.

At the secondary school level, even though there is a certain level of recognition by the Ghana Education Service and Ministry of Education of the need to incorporate climate change into the school curriculum, not much has happened. The Education Ministry, Ghana Education service and the EPA would continue to explore ways to make the secondary school curriculum responsive to climate change. It is also important to note that, both at the secondary and primary school levels, there are specific subjects on environmental studies and geography that cover climate change. At the secondary level, apart from the fact that some of the subjects have climate change content, activities of most of the environmental clubs incorporate climate change topics which have sufficient relevance to the curriculum. As shown in table 74 there are a number of tertiary institutions in Ghana that teach climate change at the degree level.

Table 74: Overview of climate change and related courses offered by Tertiary Institutions in Ghana

Course/Programme	Institute/Department	University	Comments
MSc and MPhil) in Climate Change and Sustainable Development	School of social sciences, Business School	University of Ghana, Legon	Multi-disciplinary
Bachelor in Geography	Department of Geography and Resources Development	University of Ghana, Legon	Climatology
MSc. Climate Science and Meteorology	Department of Physics	KNUST	
MSc. Environmental, Science, Policy and Management	Department of Urban and Environmental Management	Institute of Local Government Studies, Accra and Tamale	Climate change to inform decision making processes
Post-graduate studies	Institute of Environmental Studies and Sanitation	University of Ghana, Legon	Climate Change Adaptation
Post-graduate studies	Regional Institute for Population Studies	University of Ghana, Legon	
MSc. Renewable Energy	Mechanical Engineering and Energy Centre	KNUST	Climate mitigation
MA in Environment and Resource Management	Faculty of Integrated development studies	University of development studies	Climate change
MA Geography and Regional Planning	Department of Geography and Regional Planning	University of Cape Coast	Climate Adaptation and mainstreaming issues, Climatology
MSc Sustainable Energy Management	Department of Energy and Environmental Engineering	University of Energy and Natural Resources	Low carbon development issues
Dual Degree Programme in Master of Science in Bio-Economy and Natural Resources	Forest Research Institute (FORIG) and KNUST	University of East Finland	REDD+, Carbon Trading
HND Renewable Energy Systems Engineering	School of Engineering	Koforidua Polytechnic	Climate mitigation
HND Renewable Energy and Energy Efficiency	Department of Engineering	Accra Polytechnic	
HND Renewable Energy and Efficiency Technologies	School of Engineering	Kumasi Polytechnic	

7.1.1.2 Informal Education and Public Awareness

The informal education and public awareness Programme usually target the wider section of the Ghanaian society. Majority of the informal education and public awareness Programme on climate change are done through the mass and print media such as radio and TV interviews, jingles, documentaries, community durbars, information vans and dissemination of education materials. Social media has also become a useful tool to communicate with the general public on climate change issues. Table 75 shows selected institutions and their awareness Programme.

Table 75: Institutions, public awareness and training Programme they undertake

Institutions	Public Awareness Programme	Level/Target
Centre for African Wetlands, University of Ghana and Ghana Wildlife Society	Local community fora and stakeholder consultative meetings organized to seek and exchange views with communities concerning climate related issues.	Community and district levels
Crop research institute	CLIMAFRICA; community members around the Ankasa forest reserve were involved in an awareness Programme on identification of climate change coping strategies and development of adaptation strategies.	Community level
Nature Conservation Research Centre	Training, workshops, and capacity building events focused on climate change, REDD+, biomass sampling, biomass mapping, climate smart cocoa, and payments for watershed services.	Community and national level
The Swedish Environmental Institute`, the United Nations International Strategy for Disaster Reduction (UN-ISDR) and UNU-INRA	Regional write-shop for Anglophone African Countries in Accra. This was a training workshop for scientific writing for publishing in the area of disaster risk reduction and climate change adaptation. The write-shop attracted 14 participants from 7 countries, namely Ethiopia, Ghana, Kenya, Malawi, Nigeria, Tanzania and Zimbabwe. UNU-INRA staff served as resource persons at the write-shop.	Sub-Saharan Africa Region
UNU-INRA and ADI/AfDB	Expert Meeting on 'Mainstreaming Energy, Climate Change and Green Economy Mechanisms in Private Financial Institutions in Africa'	Africa Region
UNU-INRA	Education for Sustainable Development in Africa. Develop and test a graduate-level education Programme for professionals to be engaged in sustainable development in Africa.	University of Ghana, Kwame Nkrumah University of Science and Technology, the University for Development Studies, University of Nairobi, Kenyatta University, University of Cape Town and the University of Zambia.
Forest Research Institute (FORIG)	Fifty four communities around the Ankasa conservation area have been trained on forest carbon assessment	Community level
Forestry Commission	Series of sensitization workshops organized for various levels of stakeholders to enhance understanding of climate change issues targeting	Private sector, NGOs, CBOs, local communities and traditional authorities and Government agencies including the frontline staff of the forestry commission.
Environmental Protection Agency	District capacity programme	
	Climate Change awareness in ICT	Second cycle institutions
	Environmental programme in secondary school / Climate change education in Schools programme.	
	AAP high level awareness creation programme	Parliamentarians, Chiefs, Members of Economic management team,
	Number of radio and TV interviews	General public

Ghana Wildlife Society and Environmental Protection Agency, Ghana Education Service and Wildlife Division	Developing manual on outdoor environmental education to complement the national curriculum for primary and Junior High Education with emphasis on emerging environmental challenges including climate change.	Primary and Junior High Education
Ghana Wildlife Society	Periodic training is given to teachers/club coordinators to enhance their teaching of environmental education, organize educational tours for schools/club members and competitions among clubs.	Environmental clubs
	Train teachers in each school as wildlife club coordinators; appoint zonal coordinators to help supervise all coordinators within a town or zone.	Train teachers

7.1.1.3 Monitoring of media reports on climate change and environment issues

Description of steps used for the monitoring

Mainstream media is one of the channels through which the general public gets information on climate change and environmental issues. In order to assess how the general public is informed on environment and climate change, the EPA started monitoring new reporting in the print media. Although environment and climate change news are covered in the electronic and social media, this monitoring is only limited to the print media. The compilation of the news in the print media covers the period 2011 to date and it's archived on an online server with this URL address 192.168.1.126**.** The steps used for the compilation of the news featured in the various print media are:

- Classification of environmental issues leading into thirty-five categories ranging from Agriculture to Wildlife.
- Twenty-eight state and private owned newspapers were identified as newspapers that frequently carry environmental news
- Reading and sorting of content according to environment and climate related topics previously identified.
- Scanning and redesigning newspapers where applicable with Adobe Photoshop and Publisher and conversion to PDF format.

Summary of results environment and climate change new paper reports

For 2014, a total of three thousand, four hundred and ninety (3490) environment and climate change news were reported in the print media. The top seven major categories identified were as follows:

- Mining - 611
- Waste management/Sanitation/Clean-up - 446
- Agriculture - 300
- Oil and Gas - 227
- Gender and Environment - 286
- Climate Change Disasters- 173
- Water- 139

Eight mainstream newspaper publications that carried the most environmental and climate change news are:

- The Daily Graphic - 726
- The Ghanaian Times - 538
- Daily Guide - 376
- Enquirer - 285
- Chronicle - 210
- New Crusading Guide - 171
- Today – 149
- Public Agenda – 104

The Daily Graphic and Ghanaian Times are state-owned newspapers which cover a wide range of issues; they are also circulated nationally. The two are published six days in a week: Mondays to Saturdays. Daily Guide, Enquirer, Chronicle, Crusading Guide and Today are privately owned newspapers. Daily Guide is circulated nationally and gives coverage to a wide range of issues including environment. It is also read widely and published six days a week. The Enquirer is published five times a week; from Monday to Friday.

Areas for Improvements

- Expanding the new reporting monitoring to include electronic and social media reporting.
- Conduct content analysis of the newspapers, electronic and social media report. of environment and climate change news.
- Audience research and opinion pools.

7.1.3 Efforts to promote public participation and access to information

7.1.3.1 Promote public participation in climate change

The Article 6 action plan identifies promotion of public participation as one of the means to generate and sustain public involvement in climate change. It also anticipates that encouragement of public participation is needed to facilitate the involvement of those who are potentially affected by or interested in climate change in the decision-making processes. In this regard, the EPA has set to roll out the following Programmes:

- Organize a bi-annual forum for all organizations working on issues of climate change;
- Initiate an annual climate change youth conference;
- Introduce one public debates/durbars in each of the 10 regions annually;
- Introduce climate change environmental clubs in each basic and second cycle institution;
- Introduce annual environment day competitions in high schools on climate change (tree planting ,drama, exhibitions);
- Initiate annual Miss Climate change Ambassador and integrate climate change discussions on radio and TV and;
- Showcase climate change issues public fairs and exhibitions.

In line with the public participation activities the EPA is implementing the Ghana Climate change education in schools (GCCES) Programme. The GCCES Programme serves as a platform to promote understanding of climate change raise the level of awareness in schools and practical issues of climate change challenges for the purpose of creating a pool of youth in the educational institutions as trainers and agents of change in the environment. The GCCES Programme was launched in 2014 with 10 Second Cycle Institutions.

Through the GCCES, an MOU was signed between EPA and Trans-African Hydro-Meteorological Observation (TAHMO) Project and Delft University of Technology, Netherlands to install and launch Automatic Weather Stations (AWS) in each of the host second cycle institutions. The first AWS was installed in December 2014 at the Accra Academy Senior High School to support the Climate Information Centre on the campus.

7.1.3.2 Promote Access to information

Public access to climate information is essential to promote public accountability and at the same time instill a sense of responsibility in the general public. It is also the right of the public to have full access to publicly available information on climate change. In this respect, the effort by the of Ghana to promulgate a "freedom to information act" will require further strengthening of the existing information sharing platforms in order to facilitate flow of information at all levels of society. Below are some of the initiatives underway in Ghana to promote access to climate change information.

Electronic data sharing platforms

Online climate change data hub – Environmental Protection Agency

The EPA has established an online data hub on climate change. The hub is a one-stop shop which provides access on the latest information to the general public on (a) national greenhouse inventory; (b) relevant climate change policies and measures and (c) registry of climate initiatives in Ghana. The hub has three interfaces which are linked together. These are the GHG database; Dashboard of climate policies and measures (D-PaMs) and Domestic electronic registry system (DERS). The online hub can be accessed through this URL address http://*197.253.69.38/*.

The GHG emissions database contains archived data used for the generation of the national GHG estimates. The database is designed to help improve archiving all data used in the GHG inventory and also ensure that the general public has access to them in near real time. Apart from providing improved access to the emissions data, it also serves as a hub for data sharing among the data providers. The data models are designed in two formats. Part of the database contains all the data files of activity data used in all the GHG inventory sectors from 1990 to 2012. The other part contains primary data inputs from the disaggregated sub-categories to the sector level. Access to different parts of the database is restricted. The general public can have access to the open-source end of the database which contains publicly-available national data in file formats. Access to the primary data section is restricted (see figure 43).

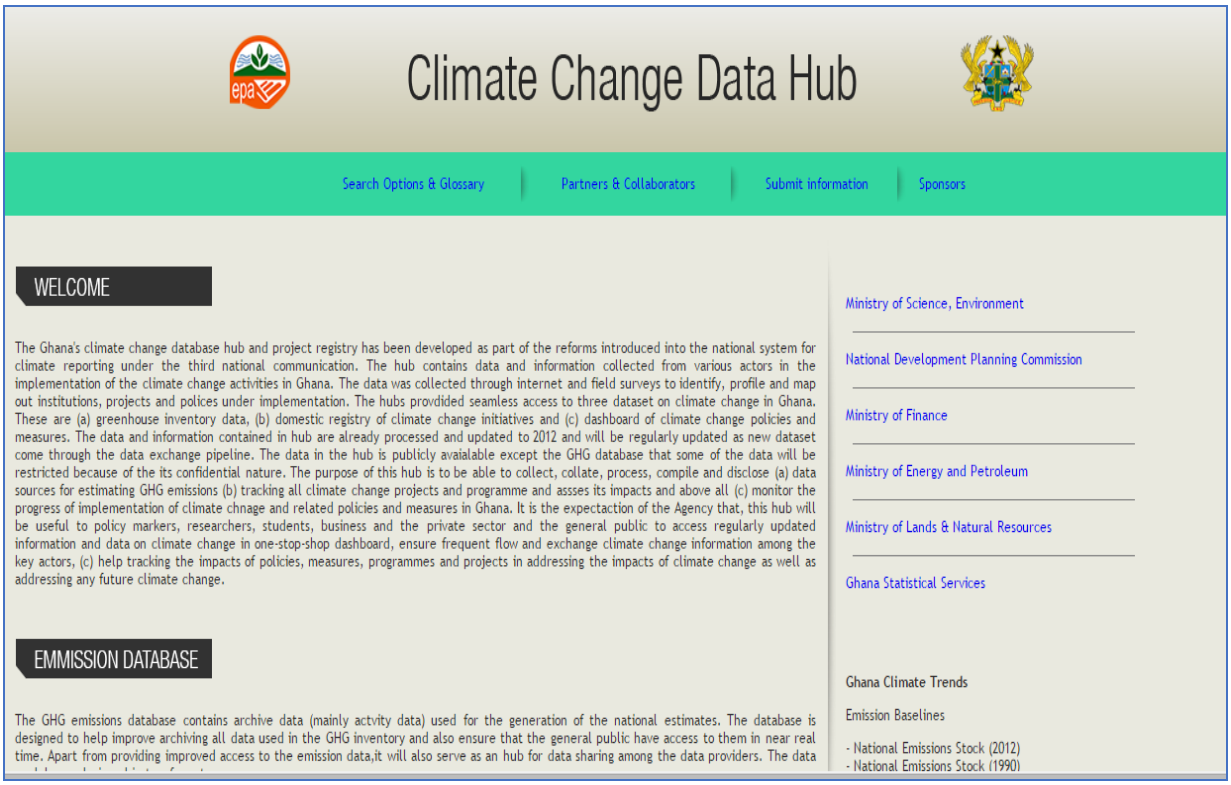

Figure 43: Online climate change data hub

Dashboard of climate policies and measures (D-PaMs) - The D-PaMs is the dashboard of policies and measures of all climate related policies and measures in the productive economic sectors in Ghana. The dashboard has a tracker monitor the progress of implementation towards attainment of its goals. The impacts, achievement and envisaged actions toward archiving its strategic objectives are also contained in the database.

Domestic electronic registry system (DERS) - The DERS is a centralized data point for climate change and related initiatives in Ghana. The database contains information on all climate change initiatives in Ghana that have been implemented or under implementation or being planned. Additional information on the sources of support available to the initiative and monitoring of impacts of implementation are provided in the database. At this initial stage, the DERS is anchored on a simple spreadsheet designed to support: (a) tracking climate change initiative and support in Ghana (b) assess the overall impacts and (c) disclose them to the genera l public bi-quarterly. As the data increase in capacity, the database will be regularly updated to accommodate it.

National Energy data processing and information centre - Energy commission

The National Energy data processing and information centre aims at becoming a one-stop repository of energy data and information on the electricity, renewable energy and energy efficiency, natural gas, and petroleum industries in the country. The web page for the energy data processing and information is under constructed. This initiative is building on the previous Ghana Energy Access Database (GhEA Database). The GhEA database initiative sought to collate and harmonize energy planning and policy data that are located at different organizations in order to support planning for sustainable energy access expansions.

The GhEA database can be access via this web address http://energycom.gov.gh/GhEAdatabase/dataset/. (see figure 44)

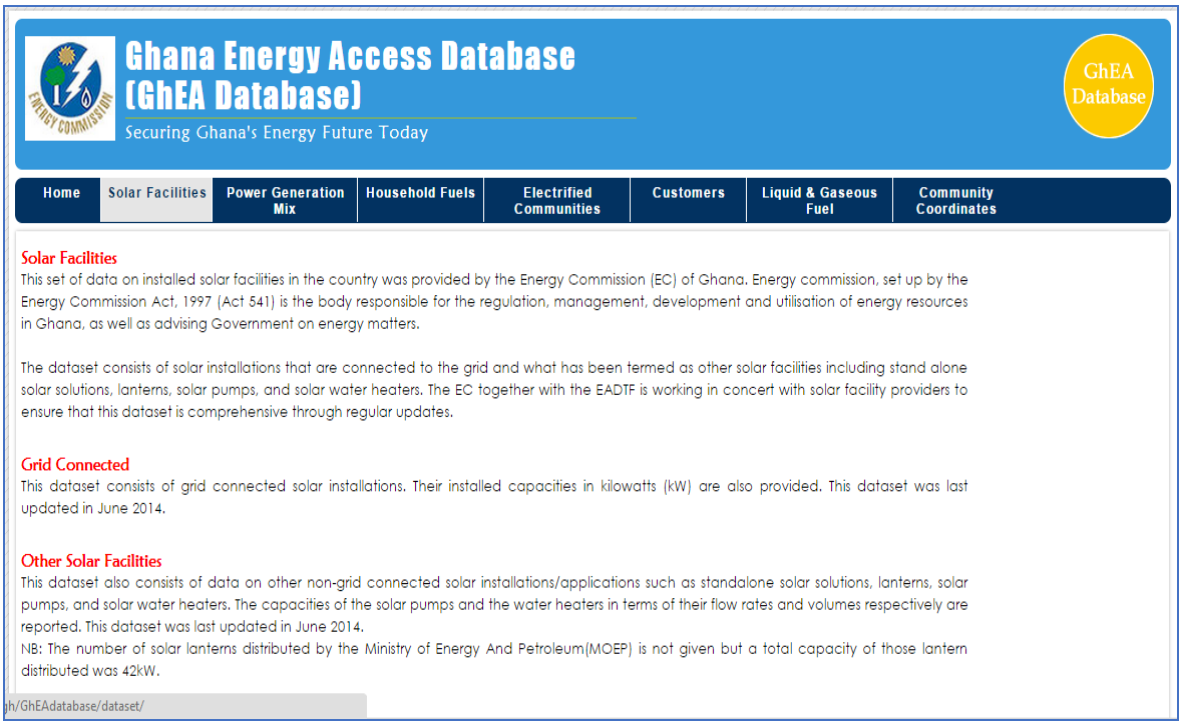

Figure 44: Ghana Energy Access Database

National Forestry Inventory WebGIS Portal - Forestry commission

The Forestry commission has established WebGIS Portal to host national forestry inventory data. The portal is managed by the Resource Management Support Center which acts as the administrator of the web server. The portal was established as part of the Forest Preservation Programme with funding from the Japanese government. The web server has spatial data which serves the public or within FCG for data sharing through web browsers. It also hosts the website for FPP related activities. The customized software for FPP is hosted on this web server which can be accessed through the following web address http://www.fcforestinfo.gov.gh (see figure 45).

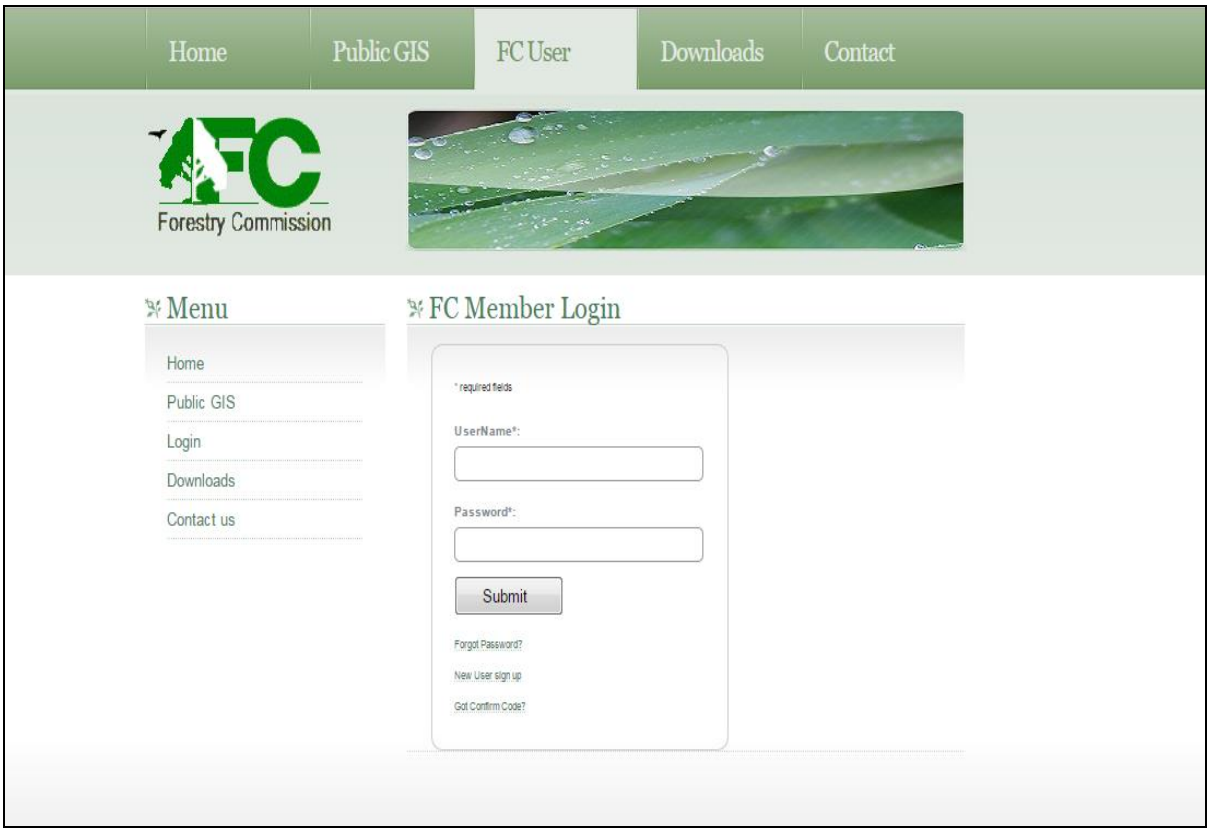

Figure 45: Webpage of Forest Inventory WebGIS Portal

Other initiatives related to promote public access

Ghana-Climate Adaptation Network - Centre for African Wetlands, University of Ghana
The Ghana-Climate Adaptation Network, facilitated by the Building Capacity for Climate Change Challenge (B4C Project), is a medium for interaction between policy makers and practitioners. Data has been collected from climate related research in food security and agriculture, water resources and land use, biodiversity and ecosystems and human health and the results will give insight into the impact of climate change on these areas which can inform policies and initiatives. Local languages are used to communicate especially when local communities are involved.

Access to biomass map online – Nature Conservation Research Centre (NCRC) and Forest Trends
NCRC facilitated public access to national biomass data—Ghana Biomass Map. The map is available on the internet address http://www.forest-trends.org/publication_details.php?publicationID=2837.

Climate Change Agriculture and Food Security Platform – Animal Research Institute
Animal Research Institute is the host of the climate change Agriculture and Food Security platform which was launched in 2013. The platform is made up of research and government institutions and seeks to serve as a climate change and food security exchange platform among key stakeholders in Ghana. The platform is part of the ECOWAS region CGIAR Research Programme on Climate Change, Agriculture and Food Security.

8. Constraints, Gaps, and Related Financial, Technical and Capacity Needs

8.1 Financial, technical and capacity needs

Over the last couple of years the preparation of Ghana's national communications has seen immense improvements. The processes for the preparation of the national communication has not only contributed to building and sustaining capacity in the country, it has also helped to highlight important climate change issues that need the immediate attention of key decision-makers at all levels. Nonetheless the country faces a number of constraints including: (a) implementation of climate change activities envisaged to support convention and (b) preparation of national communication on a continuous basis. One unique characteristic of the national communication process is that it is able to use the networks that have been created over the past ten years, to collect feedbacks on ways to improve the national communication process on a continuous basis. It is also possible to use the existing network to monitor the implementation of activities and measures envisaged under the convention and the challenges confronting them. A national survey was conducted to identify key constraints and gaps on the implementation of climate change activities and ways to improve the continuous preparation of the national communication. The major feedback from the survey has been summarized below.

8.1.1 Financial constraints and gaps including needs

The following were the main financial constraints and gaps that were identified by the stakeholders, as confronting implementation of climate change activities including the preparation of the national communications;

i. *Institutional challenges relating to tracking climate finance* – many institutions receive funds of different forms from all sorts of channels that do not pass through the Ministry of Finance. This had led to a plethora of uncoordinated climate activities in the country that do not help to address the priorities that have been set out in the national climate change policy. The Ministry of Finance and the EPA are putting in place a national climate finance tracking tool that will sufficiently track all climate support expenditure from the Ghana government and donors.

ii. *Duplication of activities and funding* – weak institutional coordination within government and among donors leads to duplication of activities and in most cases resources are not directed to where they are needed. In Ghana, regular sharing of information among donors is already paying off in building synergies and avoiding duplications.

iii. *Lack of transparency on climate finance that have multiple use* – there are institutions in Ghana that receive development assistance that the donor has either rebranded as climate finance or do not make disclosure of the other intended use of the fund. This situation usually leads to underestimation of reporting from the recipient country.

iv. *Insufficient transparency on non-financial support for training and technical assistance*– there are cases where many institutions in Ghana have received training and technical assistance support without much financial disclosure from the donor because most of these support are tapped from global projects that might have different financial contributors. In such situations, reporting is constrained because the recipient countries do not have full access to the funding and accounting information.

v. *Inadequate financial allocation in national budget* –funding for climate change activities including preparation of national communication in the country is largely donor driven and project-based. Domestic financing of climate change activities is difficult to estimate over a given time frame. This is because in the national budget there is no clear demarcation of climate expenditure items and this leads to challenges in tracking actual expenditures during implementation of climate change activities and Programmes. The Ministry of Finance is planning to collaborate with the ISSER to undertake Climate Public Expenditure and Institutional Review (CPEIR) which is expected to streamline how climate change expenditure issues are addressed.

8.1.2 Technical and Capacity constraints and gaps including needs

Climate change capacity needs are widely varied. In 2005, Ghana undertook capacity self-assessment for Global Environmental Management with support from GEF. The assessment informed the selection of priority capacity improvement areas in climate change that required considerable attention. The areas that were identified were used in the subsequent capacity planning in the country. Since then many institutions have received a number of capacity development Programmes (see table 76). Most of the Programmes are either packaged into a bigger project or tailor made to meet specific needs. The challenges that confront Ghana include the following: Inability to monitor capacity and technical assistance regularly. This is because most of the Programmes take place at different levels and unless the Programme is held at the national level, it is difficult to track. This means information on capacity that are reported are not detailed enough to help in future capacity planning. Additionally, there is a problem with retention of enhanced capacity. This usually arises from institutions where individuals who received capacity leave their jobs without transferring the capacity to another person. The country is currently making efforts to reduce the risk of creating gaps in institutions by making sure that at least two or more people benefit from training so that in the event one leaves the other can transit smoothly to take over.

Table 76: Summary of the technical and capacity constraints and gaps

Activity	Capacity Needed	Capacity received	Source of Support
Use of 2006 IPCC guidelines and ALU software for AFOLU GHG Accounting	Data processing and management strategies.	Training on AFOLU data collection and management.	Rainforest Coalition, CD REDD Project,
	Training on ALU and IPCC software on ALU	Hands on -training on the use of IPCC software for AFOLU.	
	Training on 2006 IPCC Guidelines and software	Training on GHG Inventory	GIZ Information Matters project
			UNFCCC CGE Training
GHG National System improvement	GHG Data management and institutional arrangement.	GHG MRV Training	UNEP/GEF, Information Matters project
		Training GHG MRV Management	
	Strengthening national system for GHG	Establishment of online climate change data hub	UNEP/GEF,

		Development of GHG Manual	UNDP, Low Emission Capacity Building Project
		Development QA/QC Plan	
Improvement of GHG Inventory Report	Review of National Inventory Report	Technical review of Energy section of National Inventory Report	GIZ Information Matters project
		Technical review AFOLU section of National Inventory Report	Rainforest Coalition, CD REDD Project, Sustainable GHG Management in, West Africa
		Technical review of entire National Inventory Report	UNFCCC Secretariat
Development of Marginal abatement cost curve	Training on marginal abatement curves	Training on mitigation assessment	UNEP/GEF during preparation of Third National Communication
Improvement in mitigation baseline setting	Training on how to make baseline transparent	Training workshop on baselines	UNEP/GEF during preparation of Third National Communication
			GIZ Information Matters project
Continuous training of GHG Experts	Training new technical expert on GHG at the international level	Training of 6 GHG review experts	UNFCCC GHG Review Training Programme
Development of mitigation scenario for non-energy sector	Training on marginal abatement curves	Training on mitigation assessment	UNEP/GEF during preparation of Third National Communication
Improve forestry-wide mitigation and ensure linkages with REDD+ forest reference level	Training on setting common baseline with REDD+ forest reference level	-	-
Revision of climate statistical using RCMs	Access to computational facility to run downscaling	Statistical downscaling of meteorological data	Dr. Seidou Ousmane, University of Ottawa, Canada
Climate impacts assessment	Use of statistical and dynamic crop and hydrological modeling model	-	-

8.2 The GEF, Annex II Parties, multilateral/bilateral contributions

8.2.1 Data collection

The Government of Ghana and many Donors have committed resources to support Ghana to meet the cost of addressing climate change. As a result, direct and indirect climate change supports had seen significant increases in the last 4 years in Ghana. Most of the supports Ghana received came through several development aid channels. Data on financial contributions from GEF, Annex II Parties and multilateral/bilateral agencies and government of Ghana, have been collected through a national survey and the website of donors. The data collected covered eighty-four climate specific projects (direct climate benefit) for the period 2011-2014. The projects that are not considered climate relevant (having indirect climate benefits) have been excluded because of lack of clarity on definition of scope and sources of funding. In future, Ghana is planning through the Ministry of Finance and the EPA, to put in place an efficient tracking and disclosure database system which will be available online. In the analysis of the data, the following assumptions were made; (a) to ensure consistency in the unit of analysis, non--US dollar denominated projects have been converted to United States Dollars (US$) using averages of exchange rates for each year and for the period 2011 to 2014; (b) projects without adequate funding information are excluded; (c) for projects classified as active, "committed fund" is reported. Actual amounts disbursed may differ; (d) for projects classified as complete, total funds disbursed is reported; and (e) Projects that are less than US$ 30,000 are excluded because of incomplete data.

8.1.1 Analysis of financial contributions

The financial contributions have been analyzed "with" and "without" the Chinese loan Ghana contracted to construct a gas recovery and utilization plant from the Jubilee field. Except explicitly stated, all the financial flows are reported without the Chinese loan in US$. Detailed breakdown of the financial flows are provided in annex 2. However, a summary of the analysis of the financial flows is provided below. Total climate related financial inflows for the period 2011-2014, was US$1,208,746,027 (equivalent of GhC 2,579,483,625) representing 3.7% of GDP (see table 22). When the loan from China Development Bank is included, the total financial inflow was US$ 2,208,746,027 (equivalent of GhC 4,713,499,843) which was 6.7% share of GDP. Grants constituted the largest share (69.2%), followed by loans (19.1%), national budget (6.9%) and result-based payment (4.9%). As shown in table 22, the financial flows through bilateral channels was the largest (49.5%), followed by multilaterals (39%), national contributions (5.1), GEF (3.1%). The remaining 3.2% are co-financing (1.7%), private foundations (1.4%) and private sector (0.15) (see table 77).

Table 77: Analysis of climate change financial contributions from government and Donors (2011-2014)

Description of Parameters	W/China	W/O China
Grand total	2,208,718,027	1,208,718,027
1. Types		
- Loans	1,231,090,000	231,090,000
- Grants	836,854,027	836,854,027
- National budget	82,024,000	82,024,000
- Result-based payment	58,750,000	58,750,000
2. Financial Flow Channels		
- Multilateral	471,799,212	471,799,212
- Bilateral	598,440,553	598,440,553
- Private Foundations	16,921,063	16,921,063
- National funds	62,024,000	62,024,000
- Private Sector	1,001,770,290	1,770,290
- Co-financing	20,000,000	20,000,000
- GEF	37,790,909	37,790,909
3. Climate Relevance		
- Adaptation	40,226,363	40,226,363
- Mitigation	1,989,363,709	989,363,709
- Sustainable Development	50,000	50,000
- Enabling Activities	852,000	852,000
- Means of Implementation (MoI)	178,225,954	178,225,954
▪ *Mitigation MoI*	*140,677,086*	*140,677,086*
▪ *Adaptation MoI*	*16,589,023*	*16,589,023*
▪ *SD MoI*	*20,959,845*	*20,959,845*
4. Implementation Status		
- Complete	143,746,381	143,746,381
- Active	2,046,890,329	1,046,890,329
- Pipeline	18,109,317	18,109,317
5. Recipient Institutions		
- Government	2,151,712,007	1,151,712,007
▪ *Ministries*	*289,228,415*	*289,228,415*
▪ *Implementing. Agencies*	*1,845,162,918*	*845,162,918*
▪ *Regulatory Agencies*	*17,320,674*	*17,320,674*
- Non-Governmental Organizations (NGOs)	5,428,344	5,428,344
▪ *International NGOs*	*4,907,281*	*4,907,281*
▪ *National NGOs*	*521,063*	*521,063*
- Academics	48,105,676	48,105,676
▪ *Research International*	*3,842,000*	*3,842,000*
▪ *Research National*	*10,616,176*	*10,616,176*
▪ *Universities*	*33,647,500*	*33,647,500*
- Private Sector	3,500,000	3,500,000

6. Recipient Sectors		
- Energy	1,000,748,809,727	748,809,727
- Forestry	161,831,140	161,831,140
- Transport	90,000,000	90,000,000
- Environment	31,831,693	31,831,693
- Water	1,364,000	1,364,000
- Agriculture	25,939,048	25,939,048
- Development Planning	7,930,214	7,930,214
- Education	16,519,023	16,519,023
- Finance	117,403,000	117,403,000
- Health	1,918,182	1,918,182
- Interior	5,200,000	5,200,000

Bilateral (50%) and multilateral (39%) channels were the two largest sources of climate finance flows in the period 2011-2014. This was followed by funds from national fund (domestic contributions - 5%) and GEF (3%). The remaining sources were co-financing, private foundations and fund from private sector (see figure 46).

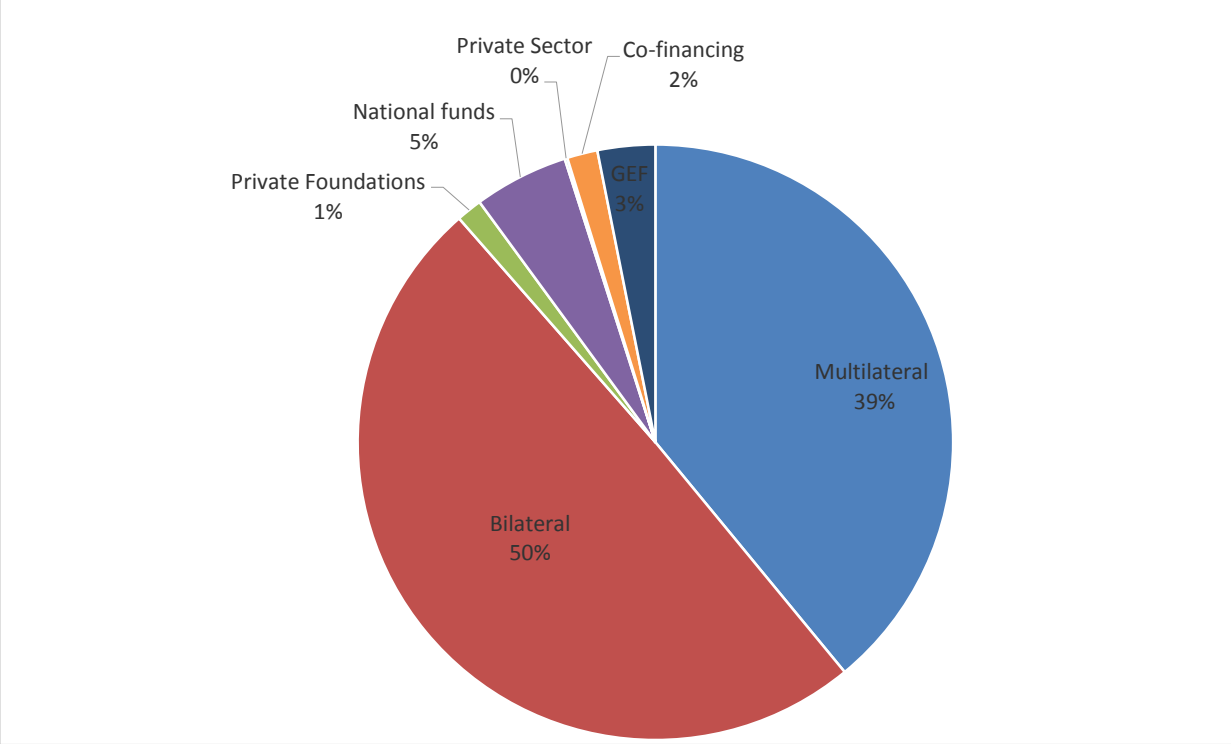

Figure 46: Breakdown of climate financial flows

For the five dominant sources of flow of climate finance, mitigation activities attracted the most funds followed by activities on means of implementation and adaptation. For instance, for bilateral, multilateral and GEF sources, more than eighty per cent of the financing went into supporting mitigation activities. Similarly observations were made for funding from government of Ghana (see figure 47). For bilateral funds that went into mitigation, US$511,260,000 was earmarked for the energy sector while US$12,400,000 funded forest projects.

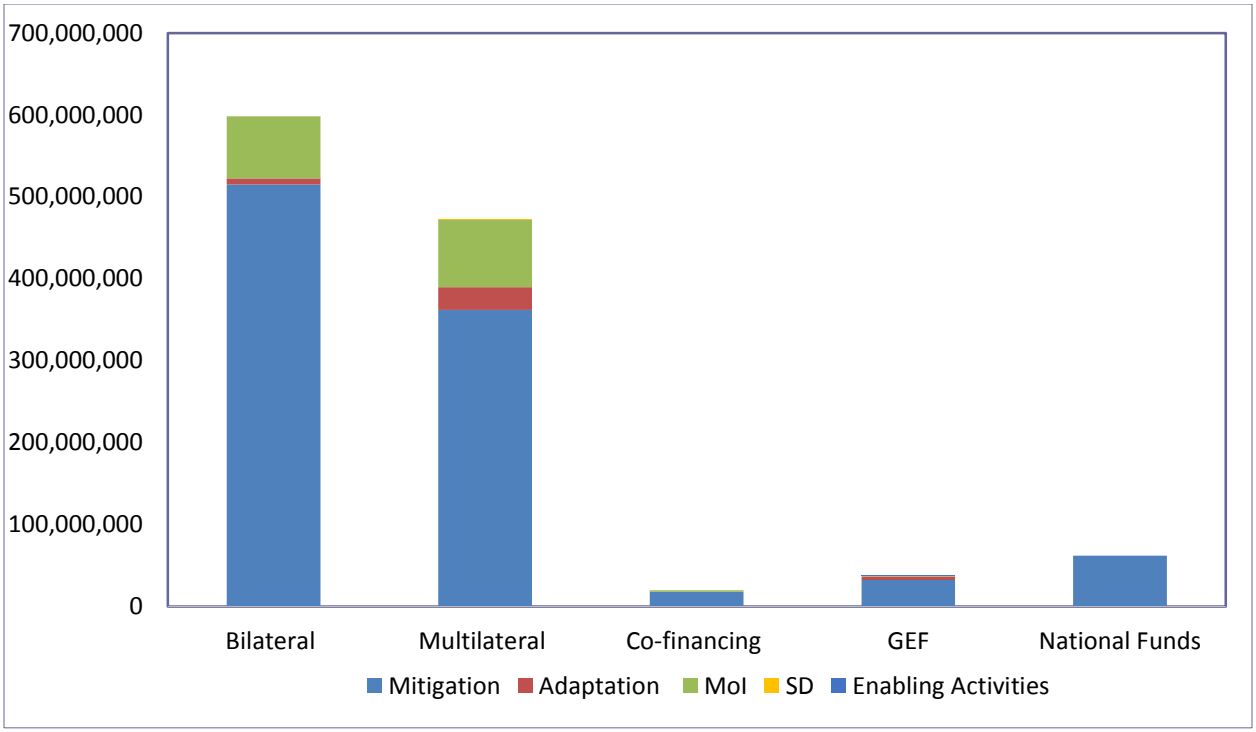

Figure 47: Sources of funds (in US$) according to mitigation, adaptation and means of implementation

Of the funding that were committed to mitigation activities, considerable amounts were classified as grants, loans and national budgets in the order of importance (see figure 48).

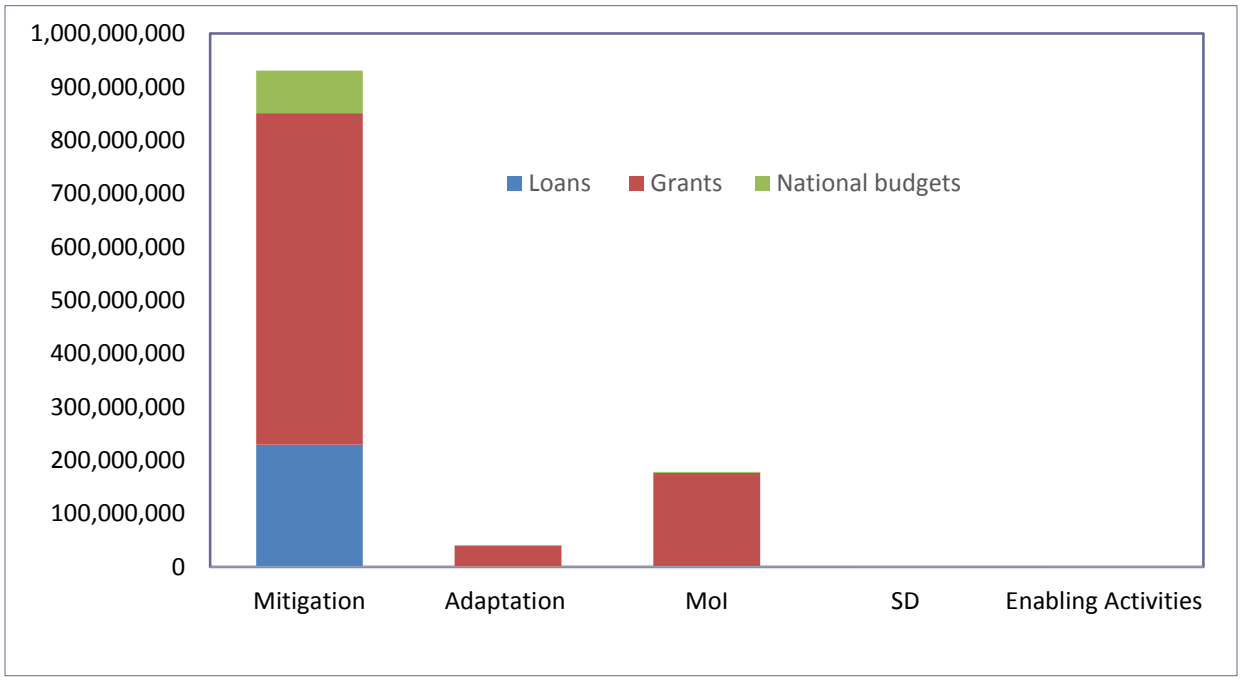

Figure 48: Funds (in US$) that have been committed to different climate activities for the period 2011-2014

9. Annexes

9.1.1 Annex 1: Analysis of bilateral financial flows in detail for the reporting period 2011-2014

Description	Climate relevance	Type of Means of Implementation (MoI)	Recipient	Start Date	End Date	Institution (Country)	Implementing Agency	Amount (US$)	Type	Status
Ghana Energy Development and Access Project GEDAP (formerly) Development of Renewable Energy and Energy Efficiency	Mitigation		Electricity Company of Ghana	2007	2017	Switzerland	WB	11,000,000	Grant	Active
Natural Resource and Environmental Governance Programme (NREG)	Mitigation MoI	Finance	Ministry of Finance	2008	2012	Dutch Embassy, Netherlands		28,739,000	Grant	Complete
				2008	2012	DFID, United Kingdom		6,440,000	Grant	Complete
Ghana Natural Resource and Environmental Governance – DPO				2010	2011	Dutch Embassy, Netherlands		11,160,000	Grant	Complete
Non-legally Binding Instruments on all types of forest in Ghana (UNFF/NLBI)	Mitigation		Forestry Commission	2008	2011	BMZ, Germany	GIZ	400,000	Grant	Pipeline
Forest Preservation Programme	Mitigation MoI	Technical Assistance	Forestry Commission	2012	2014	Japan	JICA	8,500,000	Grant	Complete
Ghana Climate Innovation Centre (GCIC)	Sustainable Dev. MoI	Finance	Ashesi Uni., SNV, EY, UNU-INRA	2014	2019	DANIDA, Denmark	WB	17,206,500	Grant	Active
Millennium Development Challenge Account Compact 2 – Ghana Power Pact	Mitigation		E Electricity Company of Ghana	2014	2019	United States	MiDA	498,200,000	Grant	Active
Innovative Insurance Products for Adaptation to Climate Change (IIPAC)	Adaptation		Ghana Insurance Association	2009	2014	Germany	GIZ	2,925,878	Grant	Complete
Climate Change Adaptation in Northern Ghana	Adaptation		Water Resources Commission	2009	2012	Denmark	DANIDA	884,000	Grant	Complete
Ghana Climate Change and Environmental Governance	Mitigation MoI	Technical Assistance	MESTI	2012	2013	DFID, United Kingdom	DFID	362,246	Grant	Complete

Coastal Sustainable Landscapes Project	Mitigation		USDA/USAID	2013	2016	United States	USAID	3,500,000	Grant	Active
Does shifting Carbon Use Efficiency determine the growth rates of intact and disturbed tropical forests? Gathering new evidence from African forests	Mitigation MoI	Finance	CSIR-FORIG	2011	2014	Natural Environment Research Council, United Kingdom		177,478	Grant	Complete
PEER Science Project	Adaptation MoI	Capacity Building	UFCCC	2012	2014	USAID, United States	USAID	41,000	Grant	Complete
Adaptation of Agro-Ecological Systems to Climate Change	Adaptation		MoFA	2012	2017	BMU, Germany	GIZ	3,901,170	Grant	Active
Mapping forest landscape restoration in Ghana	Mitigation MoI	Finance	IUCN-Ghana	2010	2012	Germany	GIZ	110,533	Grant	Complete
pro poor REDD+ initiative in Ghana	Mitigation MoI	Finance	IUCN-Ghana	2009	2012	Denmark	DANIDA	570,871	Grant	Complete
Scaling up voices for influencing post-2012 climate regime	Mitigation MoI	Finance	IUCN-Ghana	2010	2011	Norway	NORAD	75,000	Grant	Complete
Energy, Poverty and Gender in Agro Processing (EPGAP)	Mitigation		SNV	2014	2015	Netherlands	SNV	600,000	Grant	Active
Developing Sustainable Energy Value Chains in Fish Smoking Markets in Ghana	Mitigation		SNV	2014	2015	Netherlands	SNV	650,000	Grant	Active
Integrated Clean Cook stoves and Biomass Fuel Market Assessment Project	Mitigation		SNV	2014	2015	Netherlands	Sustainable Energy Solutions for Africa	180,000	Grant	Active
Solar Lantern Saving scheme for Ghana	Mitigation		SNV	2014	2015	Netherlands	Sustainable Energy Solutions for Africa	180,000	Grant	Active
Switching from Fuel wood to LPG	Mitigation		SNV	2013	2013	Netherlands	SNV	150,000	Grant	Complete
Energy, Poverty and Gender (EnPoGen)	Mitigation		SNV	2013	2013	Netherlands	SNV	150,000	Grant	Complete
Renewable Energy Capacity Building	Mitigation MoI	Finance	SNV	2013	2013	Netherlands	SNV	150,000	Grant	Complete
Facilitating countries and communities in the design of pro-poor REDD+ Benefit Sharing Schemes	Mitigation MoI	Finance	IUCN-Ghana	2013	2015	Germany		795,839	Grant	Active
Towards Pro-Poor REDD+ Initiative in Ghana II	Mitigation MoI	Finance	IUCN-Ghana	2014	2017	Denmark		636,088	Grant	Active

Advancing REDD+: mobilizing private investment for community-based, carbon-intensive landscape restoration	Mitigation MoI	Finance	IUCN-Ghana	2013	2015	Norway		658,949	Grant	Active
Green Facility	Mitigation MoI	Finance	MESTI	2011	2014	Denmark	UNEP DTU Partnership	96000	Grant	Complete

Annex 2: Analysis of multilateral financial flows in detail for the reporting period 2011-2014

Description	Climate relevance	Type of Means of Implementation (MoI)	Recipient	Start Date	End Date	Donor Institution	Implementing Agency	Amount	Type	Status
Ghana Energy Development and Access Project GEDAP (formerly) Development of Renewable Energy and Energy Efficiency	Mitigation		Electricity Company of Ghana	2007	2017	IDA	WB	100,000,000	Loan	Active
				2007	2017	Africa Catalytic Growth Fund		50,000,000	Loan	Active
				2007	2017	AFDB	AFDB	18,250,000	Loan	Active
				2007	2017	Global Partnership on output based aid	WB	6,250,000	Loan	Active
Solar PV Systems to Increase Access to Electricity Services in Ghana	Mitigation		Ministry of Power	2008	2011	Global Partnership on output based aid		4,350,000	Grant	Complete
Ghana Urban Transport	Mitigation		Ministry of Transport	2005	2015	FDA		20,000,000	Grant	Active
				2005	2015	IDA		45,000,000	Loan	Active
Natural Resource and Environmental Governance Programme (NREG)	Mitigation MoI	Finance	Ministry of Finance	2008	2012	FDA		4,100,000	Grant	Complete
				2008	2012	EU	EU	5,474,000	Grant	Complete
				2008	2012	IDA	WB	40,000,000	Grant	Complete
				2010		EU		Unknown	Grant	Complete
				2010		FDA	WB	1,590,000	Loan	Complete
				2010		IDA		10,000,000	Grant	Complete
Chainsaw Milling Project	Mitigation		FC	2007	2012	EU	EU	2,860,858	Grant	Complete
Forest Investment Programme	Mitigation		MLNR	2015	2020	Strategic Climate Fund	WB	29,500,000	Grant	Active
				2015	2020	Strategic Climate Fund and Africa Development Fund	AFDB	15,000,000	Grant	Active
				2015	2020	Strategic Climate Fund	IFC	10,000,000	Loan	Active
REDD+ R-PP Implementation	Mitigation MoI	Finance	FC	2010	2013	Word Bank, FCPF	WB	3,400,000	Grant	Active
FCPF REDD+ Readiness Additional financing	Mitigation MoI	Finance	FC	2015	2017	Word Bank, FCPF		5,200,000	Grant	Pipeline
Low Emission Capacity Building Project	Mitigation MoI	Finance	MESTI	2012	2016	EC, Germany, Australia	UNDP	888,682	Grant	Active

Community Resilience through Early Warning	Adaptation	Finance	NADMO	2012	2015	Norway		5,200,000	Grant	Active
Africa Adaptation Programme	Adaptation	Finance	EPA	2010	2013	Japan	UNDP	2,760,657	Grant	Active
Integrating Green Economy into Ghana's Medium-Term Development Plan	Sustainable Dev.	Finance	MESTI	2014	2015	Netherlands		50,000	Grant	Active
China-Ghana South-South Cooperation on Renewable Energy Technology Transfer	Mitigation MoI	Technology Transfer	Energy Commission	2015	2018	Denmark		2,720,000	Grant	Active
Institutional Support to the Implementation of the Sustainable Energy for All (SE4ALL) Action Plan	Mitigation	Finance	Energy Commission	2013	2015	UNDP		527,000	Grant	Active
Support for Development and Operation of COCOBOD's Ghana Cocoa Platform	Sustainable Dev. MoI	Finance	Cocoa Board	2013	2015	UNDP/UN-REDD and Mondelēz Cocoa Life.		1,200,000	Grant	Active
Facilitating Implementation & Readiness For Mitigation	Mitigation MoI	Finance	MESTI	2013	2015	Denmark	UNEP/DTU	300,000	Grant	Active
Ghana Cocoa REDD+ Programme	Mitigation		Ghana Cocoa Board and Forestry Commission	2015	2016-2020, 2020-2036	World Bank	WB	58,750,000	Result Based Payment	Active
Green Climate Fund Readiness Programme	Sustainable Dev. MoI	Finance	MESTI	2015	2016	Government of Germany	UNDP/UNEP /WRI	853,345	Grant	Pipeline
Natural Resource and Environmental Governance Programme Technical Assistance	Mitigation MoI	Technical Assistance	Ministry of Finance	2014	2016	World Bank	WB	5,000,000	Grant	Active
CARE Adaptation learning Programme for Africa	Adaptation		Care International	2010	2014	DFID, DANIDA, Ministry of Foreign Affairs Finland,	DFID	7,930,214	Grant	Complete
URAdapt: Managing water in the urban-rural interface for climate change resilient cities	Adaptation		IWMI	2009	2012	International Development Research Centre of Canada, DFID		480,000	Grant	Complete
CLIMAFRICA Project	Adaptation MoI	Capacity Building	CSIR, CRI, SRI &FORIG for Ghana	2010	2014	European Union	EU	78,023	Grant	Complete
Advancing REDD+ in Ghana: Preparation of REDD Pilot schemes in Off-Reserve Forests and Agro-Forests	Mitigation MoI	Finance	FORIG	2013	2014	ITTO	ITTO	366,954	Grant	Complete

Reducing Emissions from Deforestation and Forest Degradation through Collaborative Management with Local Communities	Mitigation	Finance	FORIG	2010	2014	ITTO		760,408	Grant	Complete
Capacity building for CDM forestry in the framework of SFM emphasizing community forests and poverty alleviation in Ghana	Mitigation MoI	Finance	FORIG	2011	2014	ITTO	ITTO	644,382	Grant	Complete
Resilient Landscapes for Sustainable Livelihoods	Adaptation		MoFA, UNU-INRA, UNDP, WFP, FAO	2013	2016	FAO & UNDP	UNDP	3,362,000	Grant	Pipeline
REDD through stakeholder engagement	Mitigation		CSIR-FORIG	2009	2012	ITTO	ITTO	658,716	Grant	Active
Increased Resilience to Climate Change in Northern Ghana Through the Management Of Water Resources and Diversification of Livelihoods"	Adaptation		MESTI	2015	2019	Adaptation Fund Board	UNDP	8,293,972	Grant	Pipeline

Annex 3: Analysis of GEF financial flows in detail for the reporting period 2011-2014

Description	Climate relevance	Type of Means of Implementation (MoI)	Recipient	Start Date	End Date	Implementing Agency	Amount (US$)	Type	Status
Promoting of Appliance Energy Efficiency and Transformation of the Refrigerating Appliances Market in Ghana	Mitigation		Energy Commission	2011	2013	UNDP	5,672,727	Grant	Active
Ghana Energy Development and Access Project GEDAP (formerly) Development of Renewable Energy and Energy Efficiency	Mitigation		Electricity Company of Ghana	2007	2017	WB	6,500,000	Grant	Active
Ghana Urban Transport	Mitigation		Ministry of Transport	2005	2015	WB	7,000,000	Grant	Active
Technology Needs Assessment (TNA) update	Adaptation MoI	Finance	EPA	2012	2013	UNEP/DTU	70,000	Grant	Complete
Third National Communication to UNFCCC	Enabling Activities	Finance	Environmental Protection Agency	2011	2014	UNEP	500,000	Grant	Active
Biennial Update Report to UNFCCC	Enabling Activities	Finance		2013	2014	UNEP	352,000	Grant	Active
Climate Change and Health Project	Adaptation		Ministry of Health	2010	2013	UNDP	1,918,182	Grant	Complete
Sustainable Land and Water Management Project	Mitigation		MESTI	2011	2018	WB	13,250,000	Grant	Active
Promoting value chain approach to climate change adaptation in Ghana	Adaptation		Ministry of Food and Agriculture	2012	2015	IFAD	2,500,000	Grant	Active

Annex 4: Proposed projects for financing

Project idea - Rainwater Collection from Ground surfaces

Project description - Provision of 100 run-off storage facilities (dug-outs and small reservoirs) each of 1 million m3 maximum storage capacity for 100 rural communities to provide water for such multiple uses as domestic, livestock watering, vegetable irrigation, fish production and other income generating activities in the communities.

Targets – 100 mainly farming rural communities and fisher folks in the Savannah regions (the 3 northern regions and the Coastal Savannah regions) of the country

Duration - Ten (10) years

Total Cost - US $ 12.2 million

Proposed funding sources - Government of Ghana, Development partners, Savannah Accelerated Development Authority (SADA)

Project Deliverables

- 100 dugouts/small reservoirs;
- 100 community management committees trained in water systems management and maintenance; and
- 500 artisans trained in maintenance works.

Main activities to implement project

- Project co-ordination setup,
- Selection of sites, feasibility studies and design of the runoff collection systems,
- Construction of 100 Run-off storage facilities,
- Ensuring post-construction management and maintenance system,
- Sensitization and awareness creation in beneficiary communities and district assemblies,
- Setup and training of water systems management committees in the communities,
- Training of artisans for systems maintenance,
- Setup and Training of monitoring and supervisory teams at the district assemblies.

Stakeholder Mapping

- Project co-ordination - MLGRD
- Project monitoring and evaluation (MWRWH as lead; other members from MLGRD, MESTI, WRC, GIDA and EPA)

Other stakeholders

- Beneficiary communities - for direct management, operation and maintenance of the systems.
- District Assemblies – for training, monitoring and supervision of communities

Project idea: Post-Construction Support (PCS) for Community Managed Water Systems

Project description - Empowering rural communities to properly manage operate and maintain their water systems through technical training and capacity building in financial and systems management at the district and community levels.

Targets - Rural communities made up of mainly farmers and fisher folks across the country with active water systems for multi-use.

Duration - Five (5) years

Total Costs - US$ 12.2 million

Proposed funding sources - Government of Ghana, Development partners, Savannah Accelerated Development Authority (SADA)

Project Deliverables

- 500 rural communities trained in the technical and financial aspects of management, operation and maintenance of multi-use community water resource systems;
- Start-up capital provided to 500 rural communities for emergency water systems repairs;
- Monitoring and supervisory teams, setup at the district assemblies to monitor and supervise communities in the use and management of their water systems**.**

Main activities to implement project

- Selection of communities and water systems, identification of training needs of district assemblies, developing technical procedures/manuals for water facility operations and management, developing book-keeping and financial procedures/manuals;
- Training district assemblies and communities;
- Setup of management systems including co-ordination, monitoring and evaluation at all levels – community, district, regional and national;
- Provision of starter capital for the 500 communities.

Stakeholder Mapping

- Project co-ordination - MLGRD
- Project monitoring and evaluation (MWRWH as lead; other members from MLGRD, MESTI, WRC, GIDA and CWSA)

Other stakeholders

- Beneficiary communities - for direct management, operation and maintenance of the systems.
- District Assemblies – for training, monitoring and supervision of communities.

Project idea - CBEA model in Ghana nationwide, training community-based extension agents for transfer of knowledge and innovation into agricultural practices

Target - Crop and livestock farmers, fisher folks and other agricultural producers in rural communities

Duration - Five years

Total Costs - US$ 13 million

Proposed funding Sources- Government of Ghana and development partners

Project Deliverables

- 500 rural communities participating in the CBEA project
- 5,000 CBEA trained in their respective agricultural practices and providing extension services to other farmers in their communities.
- Farmers in the project communities benefiting from the community based extension services.
- Publications on the CBEA project

Main activities to implement project

- Selection of 500 communities in all the 10 regions of Ghana to participate in the project;
- Identification and selection of CBEAs to be trained for the various communities;
- Training of agricultural extension officers in the regions and respective districts;
- Training of CBEAs for the communities;
- Facilitating the extension service provision of the CBEAs in their communities;
- Setting up of project office for co-ordination, monitoring and evaluation at all levels – community, district, regional and national.
- Research and development to support the extension services**.**

Stakeholder Mapping

- Project co-ordination – MOFA (DAES)
- Oversee implementation of the project in communities – District Assemblies
- Research and development – Research team from research institutes and universities
- Organization of targeted agricultural producers – beneficiary communities

Project idea - Demand- and Supply-Side Measures for Adapting the National Energy System to Impacts of Climate Change

Project Context - Ghana's energy supply is vulnerable to climate change. At present, 67% of electricity generation comes from hydropower and by 2020 as much as 41% could still be derived from hydropower. This dependence on hydropower also makes it vulnerable to fluctuations in supply due to changes in annual precipitation and increased evapo-transpiration. At the same time, hydroelectric generation limits the country's vulnerability to oil price shocks as well as its greenhouse gas emissions. This project proposes both demand-side measures, through increased efficiency of electricity use, and supply-side measures, through increased use of low-head run-of-river hydro and other renewable energy sources, to make the national electricity supply more resilient to climate change.

Rationale and Justification - The electricity supply is currently vulnerable to climate change. At present 67% of electricity generation in the country is from hydropower. The vulnerability of the hydroelectric sector to climate change is highlighted by the output of hydroelectricity in 2003, a particularly dry year. The output was 3,885 GWh, or about 60% of the level of 6,610 GWh in 2000, which was a relatively wet year. Emergency supply of thermally generated electricity was brought on line in 2003 to partially compensate for the decrease in hydroelectric generation. If average rainfall decreases, and temperature increases, as is expected under climate scenarios, then runoff will decrease, with consequences for hydroelectric generation. According to the National Energy Plan for 2006-2020, the electricity supply is expected to continue to rely heavily on hydropower into the future, even as demand expands and the electricity supply becomes more diversified. In the scenario where the contribution is lowest, 31% of electricity would be generated from hydropower in 2020. However, the Plan did not take reduced runoff through climate change into account, and instead maintained the installed capacity at a constant level in the simulations. Despite the upgrade of the turbines at the Akosombo hydroelectric dam, which increased output, changes in average annual flow from climate change could make it difficult to meet the National Energy Plans goals**.**

Project Description - The proposed project focuses primarily on small-scale initiatives through off-grid generation and efficiency improvements. These initiatives should lead to an improved economic situation for the potential beneficiary, which raises the question why the beneficiaries have not made the necessary investments themselves. The reason is that both off-grid generation and efficiency improvements represent investments that have multi-year payback periods. Where capital is scarce and access to credit is limited, it is not sufficiently economically attractive to make the necessary investments.

Overall goal and objectives - The overall goal is to enhance the resilience of the national energy systems to climate change impacts through the implementation of demand and supply side measures. Within the pilot communities, the objectives are to:

- Increase the use of off-grid alternative energy resources;
- Increase the use of efficient domestic appliances;
- Develop low-head run on river hydroelectric schemes.

At the national and system level, the objective is to encourage large-scale energy conservation

Development context - This project supports one of the strategic targets in the National Energy Plan for 2006-2020, which is that by 2020 there will be 100% universal electrification, with 30% penetration of rural electrification via renewable energy technologies. The project is geared toward increasing the resilience of both local communities and the national electricity supply through diversification of energy supply and increased efficiency. While the focus is on adapting to climate change, the proposed measures would make the system more resilient to current climate variability, changes in trans-boundary river flow, and fluctuations in global energy prices. The environmental impacts of the proposed activities should be minimal compared to alternative electricity generation options, but are still present

Short-term output - Short-term outputs refer to the outputs produced in the course of the project, which is expected to run for a period of five years

- Run-of-river hydro implemented in five communities;
- Buy-back scheme for inefficient appliances;
- Provide off-grid wind and solar installations;
- Rural energy-efficiency improvement scheme;
- Whole-Country Educational Programme on Energy Efficiency Labelling.

Duration: 5 years implementation-horizon. This is a conservative estimate.

Financial resources - Conservative cost estimates of the project (investment, implementation and transaction costs) ranges between USD 4million and USD 5million.

Stakeholders - Ministry of Power, Volta River Authority, Environmental Protection Agency, Electricity Company of Ghana, Ghana GriDco Company and District Assemblies.