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Republic Of Ghana

Ghana's Second National Communication to the UNFCCC

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Foreword

On behalf of the Government of the Republic of Ghana, I wish to present Ghana's Second National Communication (SNC) to the United Nations Framework Convention on Climate Change (UNFCCC). As a signatory to the UNFCCC, Ghana has an obligation to regularly report to the Conference of Parties (COP) on its Climate Change activities. This SNC report has come about as result of the hard work of many Ghanaian experts who had together reflected the most comprehensive outlook of Climate Change in the Ghanaian context and outlined Ghana's efforts to addressing its impacts. The preparation of this report is yet another milestone to place climate change central on the development agenda of Ghana, particularly, at the time Ghana has set a new development framework (Ghana Shared Growth Development Agenda) from 2010 to 2013 for itself.

Ghana contributes a merely 24Mt Carbon dioxide equivalent to the global greenhouse emissions. Though Ghana's emission is relatively small compared to the global average and emissions from other large developing countries, it has the potential to grow over the coming years under business as usual development pathways. Ghana has therefore resolved to commit itself to pursuing a development model, which will yield multiple folds of benefits; including; socio-economic prosperity, low carbon and climate resilience economy and preservation of environmental and cultural integrity. This SNC indicates that Ghana's major economic sectors are 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, from agriculture to forests, and from health to social safeguards. The SNC further highlighted 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 Millennium Development Goals and to country's inspirational goal of becoming a full-fledged middle-income country.

For these reasons, Ghana has decisively committed itself to pursue harmonised and coordinated actions to reducing Climate Change impacts on most vulnerable people, while continuing to advance national economic development. Therefore, Ghana through a consultative process has developed a National Climate Change Policy Framework (NCCPF) as a major contribution to the Ghana Shared Growth Development Agenda (GSGDA) as well as providing overall strategic direction for coordinating Climate Change activities in Ghana. It is my expectation that the incorporation of the NCCPF 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 total resolve 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.

Hon. Sherry Ayittey
Minister of Environment, Science and Technology
September 2011

Message from the Executive Director Environmental Protection Agency (EPA)

The Environmental Protection Agency (EPA) is happy to have contributed to this important report on Ghana's Second National Communication, which contains most available information on Climate Change between 2000 and 2006. As a living document, Ghana's SNC will be updated regularly as new and additional information on national circumstances, Climate Change impacts, national policies and measures on mitigation and adaptation, greenhouse gas estimates etc. are received. The SNC contains national greenhouse gas inventory for a complete time series from 1990 to 2006 as well as the main findings of studies on impacts, vulnerability and adaptation to climate change on various economic sectors. The report also contains updated information on the various steps being undertaken or envisaged to mitigate climate change and the overall framework for coordinating Climate Change in Ghana.

The SNC report is a combination of sound scientific research and practical recommendations and identifies priority areas, which require targeted actions on climate change at the national level. It could also serve as a useful aid for decision-making across all levels of national planning as well as policy refinement and alignment. This is because the SNC presents valuable feedback on the overall effectiveness of development choices on the environment and in particular on climate change. The report could also be a reliable source of information for different users and readers such as policy makers, researchers, practitioners, students and the general public who are interested in Climate Change issues.

For EPA and its numerous collaborators, the preparation of the SNC had been a long but worthy experience. It was a learning-by-doing exercise. With the preparation of the SNC, greater institutional and human capacities have been built for both frontline and support national institutions. Apart from the specific recommendations regarding Climate Change policies and measures, it is also important to indicate that the preparation of the SNC had a number of challenges. Inadequate funding and adhoc nature SNC process are the two critical factors that deserve attention. It is the firm believe of the Agency that, the major findings presented in this report will contribute to the national effort to addressing climate change in Ghana and at the international level.

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AG. EXECUTIVE DIRECTOR
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List of Acronyms

AML	Abandonment of Managed Lands
BAU	Business as Usual
CDM	Clean Development Mechanism
CERS	Carbon Emission/Removal from Soils
CFOWB	Changes in Forest and Other Woody Biomass
CH_4	Methane
CO_2	Carbon Dioxide
COP	Conference of Parties
CSM	Cerebral Spinal Meningitis
CWG	Country Working Groups
DVLA	Driver Vehicle and Licensing Authority
ENAPT	Environmental Application and Technology Centre
EPA	Environmental Protection Agency
ECN	Energy Research Centre of the Netherlands
FAO	Food and Agriculture Organization
FASDEP	Food and Agriculture Sector Development Policy
GCM	Global Circulation Model
GDP	Gross Domestic Products
GEF	Global Environmental Facility
Gg	Gigagrammes
GHG	Greenhouse Gas
GHGI	Greenhouse Gas Inventory
GHGIR	Greenhouse Gas Inventory Report
GPRS	Ghana Poverty Reduction Strategy
GMeT	Ghana Meteorological Agency
GWP	Global Warming Potential
HIPC	Highly Indebted Poor Country
IEA	International Energy Agency
INC	Initial National Communication
IPCC	Inter-governmental Panel on Climate Change
ISSER	Institute of Statistical, Social and Economic Research
KNUST	Kwame Nkrumah University of Science and Technology

LEAP	Livelihood Empowerment Against Poverty
LNI	Lead National Institution
LPG	Liquefied Petroleum Gas
LUCF	Land Use Land Use Change and Forestry
MDAs	Ministries, Departments and Agencies
MDGs	Millennium Development Goals
MEST	Ministry of Environment, Science and Technology
Mt	Metric Tonnes
N_2O	Nitrous Oxide
NAMAs	Nationally Appropriate Mitigation Actions
NCCC	National Climate Change Committee
NDMO	National Disaster Management Organisation
NDPC	National Development Planning Commission
NHIS	National Health Insurance Scheme
NIR	National Inventory Report
NIS	National Inventory System
PFCs	Perfluorocarbons
QA/QC	Quality Assurance/Quality Control
RFO	Residual Fuel Oil
REDD+	Reducing Emissions from Deforestation and Degradation Plus
SNC	Second National Communication
SNEP	Strategic National Energy Policy
SST	Sea Surface Temperature
TAPCO	Takoradi Power Company
TICO	Takoradi International Company
ToR	Tema Oil Refinery
TRC	Technical Review Committee
TSPS	Transport Sector Programme Support
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

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ES. Executive Summary

ES1. Background

Ghana ratified the United Nations Framework Convention on Climate Change (UNFCCC) in September 1995. As a Party to the UNFCCC and in pursuant to Article 4, paragraph 1, and Article 12, paragraph 1 of the Convention, Ghana prepared and submitted its Initial National Communication (INC) to the Conference of Parties (COP) to the UNFCCC in December 2000. The preparation of this Second National Communication (SNC) is in furtherance to meeting its obligation under the UNFCCC. The main objective of the SNC is to communicate to the Conference of Parties, what policies and measures Ghana has taken and envisaged to implement the convention. The SNC, particularly, highlight Ghana efforts in areas of mitigating climate change and adaptation to the impacts thereof. The report addresses, pertinent issues, finance, technology and capacity building needs as well as gaps, constraints and achievements. Very importantly, the SNC report anthropogenic sources and removals of greenhouse gases not controlled by the Montreal Protocol 1990 to 2006 with 2000 as the base year.

ES 2. National Circumstances

Ghana is a unitary democratic republic with sovereignty residing in the Ghanaian people. The 1992 Constitution declares sharing of power among the Presidency, Parliament, Council of State, and an Independent Judiciary. The President also appoints the Vice President. Ghana's population currently stands at about 22 million with growth rate of about 1.82%. The population of Ghana has the following distribution: 0-14 years, 38.8%; 15-64 years, 57.7%; and 65 years and over 3.5%. Ghanaians have an estimated life expectancy of 58 years. Poverty in Ghana decreased from 51.7% in 1991/1992 to 39.5% in 1998/1999 and further to 28.5% in 2005/2006. Extreme poverty at the same time decreased from 36.5%, 28.5% and 18.2% during the same years. This phenomenon has led to a lowering of the absolute numbers of the poor from 7,931,000 in 1991/1992 to 6,178,000 in 2005/2006. The distribution of poverty in Ghana is, however, not even. There are sharp geographic variations.

From 2000 to 2006 the Ghanaian economy maintained a relatively high average growth rate of 5.1%. The rate for 2006 was 6.2% in spite of the surge in crude oil and other petroleum products prices. The GDP growth rate in 2006 had been largely driven by growth in the agricultural sector. Agriculture continues to be the mainstay of the Ghanaian economy, contributing an average 36% of GDP for the period 2000-2006. The domestic economy continued to revolve around subsistence agriculture, which accounts for 34% of GDP and employs 60% of the work force, mainly small landholders. Ghana has roughly twice the per capita output of the poorest countries in West Africa and still remains heavily dependent on international financial and technical assistance. Gold, timber, and cocoa production are major sources of foreign exchange. Priorities under the $38 million Poverty Reduction and Growth Facility (PRGF) include tighter monetary and fiscal policies, accelerated privatization, and improvement of social services. Receipts from the gold sector helped sustain GDP growth in 2006 along with record high prices for Ghana's largest cocoa crop. Ghana received a Millennium Challenge Corporation (MCC) grant in 2006, which aims to assist in transforming the agricultural export sector, in particular.

With the expanding economy and growing population, Ghana faces major challenges in providing the required energy in reliable and sustainable manner to meet its economic goals. The main energy resources in Ghana are woodfuels, electricity and oil products with wood fuels dominating in energy usage. Total primary energy produced in Ghana in 2000 was 6.2million tonnes of oil equivalent and rose to 7.6 million tonnes of oil equivalent by 2004. The primary indigenous energy comprised of 90-95% woodfuels, 5-10% hydro energy and less than 1% solar energy. Hydro energy is supplied from Akosombo and Kpong hydroelectric dams in the form of electricity. Solar energy is used for sun-drying of selected crops including cocoa, cereals (e.g. maize, paddy rice, sorghum and millet), groundnuts, cowpea, pepper and other exportable commodities. Solar energy for the generation of electricity is relatively negligible; about 150 tonnes of oil equivalent. Ghana is also well endowed with water resources, but the amount of water available changes markedly from season to season as well as from year to year. However, availability of water is decreasing, owing to rainfall variability, rapid population growth, increased environmental degradation, pollution of rivers and draining of wetlands.

ES 3. National Greenhouse Gas Inventory

This report covers greenhouse gas emission and removal from 1990 to 2006 with 2000 as the base year. In 2000, the total direct greenhouse gas emission (including LUCF emissions) in Ghana was estimated at 12.2MtCO_2e (based on carbon dioxide, methane, nitrous oxide and perfluorocarbons). This is 173% above 1990 levels of -16.8 MtCO_2e and 96% lower than 2006 levels of 23.9MtCO_2e (Figure ES 3.1). This change amounted to 242.3% increase from 1990 to 2006. If emissions from LUCF are excluded in 2000, the total GHG emissions in Ghana was estimated at 13.3MtCO_2e, which is about 49.4% above 1990 levels of 8.9MtCO_2e and approximately 38% below 2006 levels of 18.4MtCO_2e. This represented an overall increase of 107% from 1990 to 2006. Ghana's emission represents about 0.05% of the total global emissions and is ranked 108 in the world, which represents a total per capita emission of nearly 1MtCO_2e per person as of 2006.

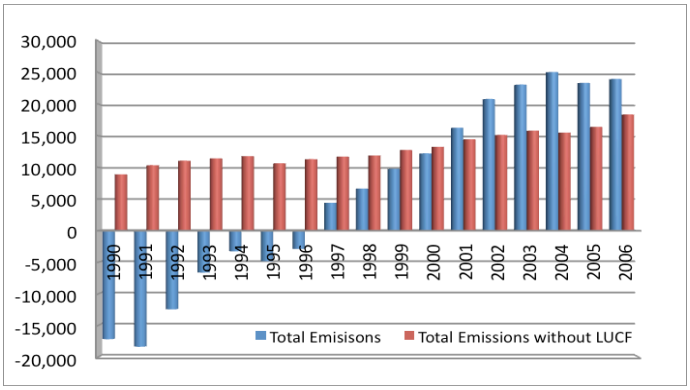


Figure ES 3.1: Trend of total GHG emissions including LUCF (in GgCO_2e)

Though Ghana's emissions is lower than other major developing economies, the trends clearly indicated a strong growing potential in the near to medium term horizon as the economy continues to grow and expand development to new frontiers, dominated by agriculture, forestry and oil and gas industries. The largest contribution to the total national emissions was the energy sector, accounting for 41%. Energy sector emissions increased by 32% above 1990 levels and declined marginally by 2% to 39% of the total emissions by 2006 (Figure ES 3.2) Emissions from transport and residential categories were the largest

emission sources within the energy sector. The general increase in emissions from the sector could be attributed to the increasing fuel consumption in the growing proportions of power generated from thermal sources, increasing fuel consumption and poor fuel efficiency in the road-transport category as well as rising biomass use in the residential sub-category. The second largest contributor to total national emission was from the agricultural sector, amounting to approximately 38%. The general increasing trends of agricultural emissions of about 44.2% between 1990 and 2006 reflect increasing trends in livestock numbers and emissions from fertilizer application. Within the sector, emissions from agricultural soils, enteric fermentation and rice cultivation have had significant impacts on the general emission. Emissions from the waste sector constituted an average of 10% between 2000 and 2006, which is approximately 8% higher than the 1990 levels is the third largest contributor to the national emissions. The main sources of emission from this sector are from disposal of solid waste on land (particularly, waste dump site) and wastewater handling. The sector emissions were driven by the increasing per capita solid waste generation among population especially in the urban areas of Ghana. Disposal of solid waste to land with relatively deeper depth and to sanitary landfill sites is increasingly becoming common practices in urban waste management. This provides suitable conditions for the production of methane, which is not managed in any way in Ghana.

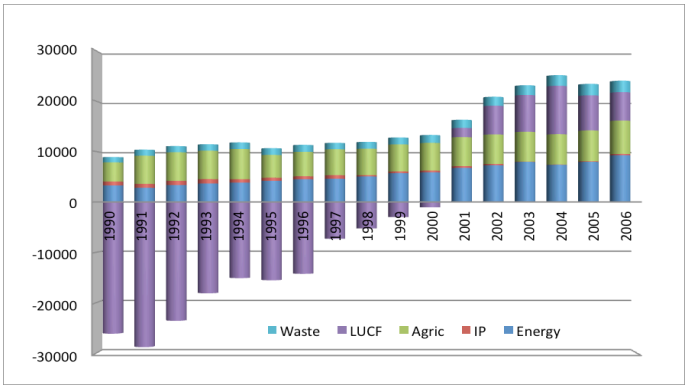


Figure ES 3.2: Trends of Total Emissions by Sectors (Gg CO_2eq.)

Carbon dioxide (CO_2) emissions (including emissions from Land Use Change and Forestry, LUCF) contributed -16.3Mt, 13.3Mt and 22.9Mt of the total greenhouse gases in 1990, 2000 and 2006, respectively. Without LUCF, carbon dioxide was 9.8Mt, 15.8Mt and 18.7Mt of the total greenhouse gas emissions for the same periods respectively. In terms of reported greenhouse gas emissions, carbon dioxide was estimated at -23.9MtCO_2e in 1990 to 2.6MtCO_2e and 10.5MtCO_2e in 2000 and 2006 respectively, including LUCF. Between 1990 and 1999, CO_2 emissions contributed to net removal by sink but experienced a steady inter-annual reduction at an average rate of 24% until 1999. Beyond 1999, net CO_2 emissions increased up to 12.4MtCO_2e in 2004 and decreased marginally to 10.5MtCO_2e in 2006. This decease could be largely attributable to the net positive effect of the national afforestation programmes through the enhancement of forest biomass stocks.

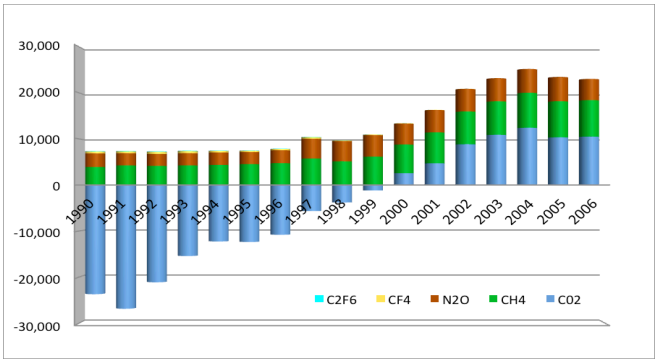


Figure ES 3.3: Emissions by Gases in $GgCO_2e$

Methane (CH_4) emission was the dominant direct GHG in 2000, accounting for $6.2MtCO_2e$ and $0.2MtCO_2e$ increased steadily between 1990 and 2006. The rising trend of CH_4 emissions has been generally driven by the increasing impacts of the following economic activities - domestic and on-site burning of biomass, valley-bottom rice cultivation and above all, enteric fermentation from domestic livestock. Nitrous oxide (N_2O) is the third most important direct greenhouse gas emissions during the period (1990-2006). N_2O emission also increased from $2.9MtCO_2e$ in 1990 to $5.3MtCO_2e$ in 2005 and decreased afterwards to $4.8MtCO_2e$ in 2006. The decrease of nearly $0.5MtCO_2e$ between 2005 and 2006 is due to the general reduction fertilizer application in the agricultural sector. PFCs (CF_4 and C_2F_6) emissions were recorded in small quantities in the time series. Overall, the levels of PFCs decreased by nearly 86% between 1990 and the base year subsequently further by 11.4% by 2006. The decease is attributed to the irregular operations of VALCO (Aluminium Smelter), whose operations serve as a single major source of F-gases in Ghana. Without LUCF, CO_2 emissions dominated through the time series followed by CH_4, N_2O and the PFCs.

ES 4. Policies and Measures Taken and Envisaged to Implement the Convention

In Ghana, attention on climate change is gaining momentum both at the highest political level and across sectors. Climate change is being mainstreamed into the national development framework, particularly in Ghana's Shared Growth and Development Agenda (GSGDA). Additionally, Climate change is among various thematic areas receiving support under the "Natural Resources and Environment Governance" initiative (NREG) among key development partners and the World Bank. The Environmental Protection Agency (EPA) under the Ministry Environment, Science and Technology (MEST) is the lead institution for Climate Change and UNFCCC activities in the country. The EPA is the UNFCCC Focal Point, whilst MEST host the National Climate Change Committee. This committee is made up of representatives from relevant ministries, universities, research institutions, private sector and non-governmental organizations, and has been mandated under a ministerial directive.

The Environmental Protection Agency (EPA) coordinates the implementation of climate change issues in Ghana on behalf of the country. Designated National Authority (DNA) for CDM has been established under MEST to facilitate CDM project development in Ghana. In addition to the institutional arrangement between EPA and MEST, other government agencies have established climate change units. For example, both the Forestry Commission and Energy Commission have also been established climate change units to specifically handle REDD+ and Energy Efficiency issues respecitvely. The Ministry of Finance and Economic Planning (MoFEP) has also created natural resources and climate change desk to oversee, coordinate and manage financing and support in natural resources and climate change activities. With support from the UNDP, the EPA in collaboration with the National Development

Planning Commission (NDPC) and the National Disaster Management Organization (NADMO) are facilitating initiatives to mainstream climate change and disaster risk reduction into national development at all planning levels (e.g. national, regional, district and across sectors). To support such effort guidebook on mainstreaming climate change and disaster risk reduction has been developed. The implementation of the mainstreaming process is being piloted in 10 District Assemblies (DAs) in Ghana. The DAs were selected to reflect regional and ecological balance and above all climate change vulnerability and socio-economic burden or risk.

ES 4.1 Development of National Climate Change Policy Framework

Ghana is developing a National Climate Change Policy Framework (NCCPF) as part of the work plan of the cross-sectoral National Climate Change Committee. The NCCPF aims to "ensure a climate resilient and climate compatible development, while promoting sustainable economic development. The NCCPF is a key contribution to the strategic objective of the Ghana Shared Growth and Development Agenda (GSGDA): to foster high and equitable levels of growth towards middle-income status. It echoes many of the key themes set out in the shared growth and development agenda, including the need for equitable development, coordination and harmonisation. The National Climate Change Policy Framework has three objectives: 1) Low carbon growth, 2) Effective adaptation to Climate change and 3) Socio-economic development. The achievement of these objectives is built on seven systemic pillars:

- Governance and coordination
- Capacity building
- Research and knowledge management
- Finance
- International cooperation
- Communication
- Monitoring and reporting

The crucial next step in the development of our NCCPF is the full engagement of decision makers and stakeholders across the country. Climate change touches on every part of the Ghanaian society and must be engaged for comprehensive and effective response. The implementation of the NCCPF should lead to multiple benefits; including, socio-economic prosperity, low carbon and climate resilience economy and preservation of environmental and cultural integrity. Ghana is actively seeking international support on climate change issues in order to safeguard and accelerate the country's development process.

ES 5. Adaptation Strategy

Development of Climate Scenarios - As part of Ghana's climate change country studies, a national Climate Change scenarios was been developed. Climate Change scenarios for the following climatic variables; mean monthly rainfall amount, maximum, minimum and mean daily temperatures were constructed to cover the whole of Ghana for the years 2020, 2050, and 2080. In additions to the scenarios above, various models and projections have also been applied. Their conclusions vary enormously, but they show clear signs of climate change and confirm Ghana's vulnerability. First, there are clear signals of warming in all models. An increase of 1°C has been seen over the past 30 years. One recent projection estimated temperature increases of 1.7°C to 2.04°C by 2030 in the Northern Savannah regions, with average temperatures rising as high as 41°C. Secondly, there is uncertainty on rainfall – it may increase, or decrease. Ghana's climate is already unpredictable and the country can expect more

intense and extreme weather events, such as torrential rains, excessive heat and severe dry winds as a result of climate change. There is a broad recognition that climate change can significantly impair Ghana's development aspirations.

Sectoral Vulnerability, Impacts and Adaptation Assessment - The 2008 national sectoral climate change vulnerability and adaptation assessments revealed the substantial impacts of climate change on the national economy, with clear evidence that many of the key economic assets – the coastal zone, agriculture and water resources – are negatively affected, as well as social development in terms of poverty reduction, health and women's livelihoods. Ghana has made major progress on poverty reduction in recent decades. Poverty persists, however, in the north and in urban pockets and it is the poorest people who bear the brunt of the impacts of climate change. The poverty situation is exacerbated by climatic stress in northern regions where temperatures are already relatively high. Lower agricultural productivity and periodic flooding are also increasing the pressure on the vulnerable youth from the north to migrate to the south. The main concerns on the potential impacts of climate change include:

- Increased pressure on water, reducing the potential for hydropower
- The impact on agriculture, with reduced yields leading to increased poverty and food insecurity, and the loss of national revenue from cash crops such as cocoa
- Increased rural-urban migration, with increased pressure on urban services
- Deteriorating human health as a result of increased incidence of diseases and reduced access to water and food compounded by the disruption to the delivery of health services, e.g., flooding of health facilities, and the loss of transport infrastructure.
- Severe impacts on land use, leading to loss of biodiversity and soil fertility, land degradation and increased deforestation.
- The negative impact on women, who are particularly vulnerable to the negative impacts of climate change, given their relatively higher levels of poverty and their responsibilities for household water, food and fuel.

Adaptation assessment has been done for the vulnerable and sensitive sectors of the economy including human health, land use, cocoa production, tuber crop production, fisheries, and women. Poverty linkages with climate changes have also been done. What emerged from the impact assessment formed the basis for further multi-sector analysis, which resulted in prioritization of 10 adaptation options. The 10 prioritized adaptation options will be implemented using an integrated programmatic approach. Ghana is also preparing an adaptation strategy to facilitate national response to the impacts of Climate Change, which will be a major input into the National Climate Change Policy Framework.

ES 6. Mitigation Strategy

Abatement scenarios under climate change have been principally focused on three sectors that are major sources of greenhouse gas emissions and removals. Greenhouse gas inventory results showed that the energy sector is responsible for the highest emissions of CO_2 while the forestry and agricultural sectors show increasing trend of greenhouse gas emission, the forestry sector is now becoming a source instead of sink. The following four (4) abatement scenarios have been considered in the energy sector with the assumption that there will be substantial increases in the use of renewable sources of energy:

1. Replacing some biomass with LPG: replacement of fuelwood and charcoal with LPG at the rate of 10% a year from 1995 to 2020.
2. Use of biogas and LPG to replace some biomass from 2010 to 2015 when only LPG and biogas will be used, with the largest proportion of energy for cooking coming from biogas.
3. Gradual penetration of solar PVs to the existing mix: this option integrates the options in scenario two and other options aimed at reduction in the use of petroleum products and electricity. The first option was 5% reduction in the use of petroleum products and electricity from 2000 to 2004, 10% from 2005 to 2010, 20% from 2011 to 2014 and finally 50% from 2015 to 2020.
4. Gradual penetration of biogas for cooking at the rate of 10% of households per year from 2010 to 2020.
5. Massive afforestation or reforestation projects to rehabilitate degraded lands.

The need to develop a low carbon development strategy to contribute to orient Ghana's development to sustainable path has been recognised at the higher political level. This has translated into the inclusion of low carbon growth component as one of the major pillars of the National Climate Change Policy Framework. The process is being facilitated by a set of policy briefs on Low Carbon Growth, Nationally Appropriate Mitigation Actions (NAMAs) and domestic measurement, reporting and verification system (MRV) and emissions from flaring jubilee field gas. Ghana has also responded positively to various international mechanisms on enhanced mitigation actions. After associating itself with the Copenhagen Accord, which emerged as political agreement among selected countries, Ghana submitted a list of fifty-five (55) mitigation actions under its NAMA's to the UNFCCC secretariat as appendix and also elected to participate in the NAMAs mechanism. Additionally, Ghana in collaboration with the ECOWAS secretariat to initiate programmatic NAMAs in the sub-region.

Reducing emissions from deforestation and forest degradation (REDD+) mechanism features strongly in climate mitigation efforts in Ghana. It has been identified as one of the major strategies to facilitate low carbon development as well as building resilience to climate change adaptation. As "REDD+ nation", Ghana is among selected countries participating in the Forest Carbon Partnership Facility (FCPF) with support from the World Bank. As part of the FCPF, Ghana has prepared its REDD+ Readiness Preparation Plan (R-PP). Ghana has also been selected to participate in the Forest Investment Programme (FIP), which is a financing mechanism under World Bank's portfolio of climate investment funds. It supports developing countries' efforts to reduce deforestation and forest degradation (REDD+) including the promotion of conservation and sustainable forest management that leads to the reduction of emissions and the protection of carbon reservoirs.

ES 7. Other Information

ES 7.1 Technology Transfer

Ghana in January 2003 conducted its technology needs assessment (TNA) through a consultative process. Using national criteria, stakeholders prioritized identified technologies. For the energy sector, the decreasing order of priority was as follows:

- Biofuels
- Industrial energy efficiency improvement
- Energy efficiency lighting
- Solar PVs
- Natural gas combined cycle and Natural gas distribution system

- Management technologies and efficiency improvement in transport sub-sector
- Wind Energy
- Solar water heating
- Small and mini-hydro power

For the waste management technologies, the decreasing order of priorities was as follows:

- Biomass for power generation (Co-generation from sawmill residues)
- Landfill methane gas capture for power generation
- Anaerobic and CH_4 generation technologies for waste water handling (Biogas technologies)
- Incineration

Stakeholders further identified the following as barriers common to all technology transfer programmes in Ghana:

- High initial cost associated with the technologies
- Inadequate human and institutional capacities
- Access to technology information (e.g. cost, performance, vendors, etc.)
- Lack of comprehensive technology transfer policy
- Weak local currency
- Inadequate capacities in estimating and certifying potential greenhouse gas reductions associated with the technologies

ES. 7.2 Institutional Framework and Capacities

In Ghana, there are a number of existing national institutions and private organizations whose mandates or activities border on climate and climate change issues. Some institutions have been identified that must be strengthened (both technically and financially), to continuously support research and systematic observation aimed at contributing actively to district, regional, national and global climate research programmes. The institutions include:

- Environmental Protection Agency (EPA)
- Ghana Meteorological Agency (GMeT)
- Centre for Remote Sensing and Geographic Information System (CERSGIS)
- Council for Scientific and Industrial Research (CSIR)
- Kwame Nkrumah University of Science and Technology (KNUST)
- University for Development, Studies (UDS)
- University of Ghana, Legon (UG)
- University of Cape Coast (UCC)

ES. 7.3 Education, Training and Public Awareness

ES. 7.3.1 Ghana's Policy on Environmental Education

Education, training and public awareness have been identified as one of the important components of capacity building in climate change under the convention, and Ghana recognises this important thrust. Therefore Ghana believes that the successful implementation of its environmental policy, including aspects of climate change must be premised on the fact that the citizenry understands the functioning of the environment and the related issues in order to contribute meaningfully to its protection,

improvement and enhancement. To achieve this, continuous and detailed environmental education programs have been implemented at all levels so that every Ghanaian becomes aware of the problems and fully assumes his responsibilities in the protection of the environment. Current climate change programmes on education and awareness creation boarder on the areas below:

- Increasing access to climate change information and knowledge though on-stop Internet portal.
- Development of policy briefs on major thematic climate change topics for high-level policy makers.
- Regular TV and Radio discussions on topical climate change issues.
- Workshop, seminar and interviews for the targeted stakeholders and the general public.

However, the education programmes have the following shortfalls:

- Limited public access to information on climate change and its effects in local languages and at the community level.
- Weak participatory processes for addressing climate change and its effects.

ES 7.3.2 Assessment of Implementation of UNFCCC Article 6 in Ghana

Ghana participated in the assessment of the implementation of Article 6 under the New Delhi work programme. The main objectives of the national survey were to identify and inventory;

- Current national activities and programmes that are relevant to Article 6
- Assess human resources and other assets for implementation and
- Provide the need for greater capacity building and funding

The following were the major findings from the exercise:

- ***Public awareness on climate change*** - The general perception of the Ghanaian general public on changes in climatic elements was clear in all the ecological zones of Ghana, with most of their observations occurring within the last half decade. Ninety percent of the respondent recognised that the changes in global climate are mainly due to effects of human-induced activities.

- ***Public access to information on Climate Change issues*** - access and availability of information on Climate Change was very limited in Ghana. The main sources of information were from newspapers, followed by television and radio. Most Ghanaians considered the Environmental Protection Agency (EPA) and Ghana Meteorological Agency (GMet) as the most possible sources of information on climate change issues. English language in addition to all major languages in Ghana including Akan, GA, Ewe, Dagbani, Hausa and Nzema were chosen for dissemination of information on Climate Change.

- ***Education*** - incorporation of climate change into school curricula at all levels is the surest means to ensure sustained and continued awareness on climate change in Ghana.

- ***Public Participation*** – stakeholder participation could be enhanced by promoting following practical actions:
    - → Provide funds, logistics, expert knowledge and information.
    - → Motivate stakeholders.
    - → Institute training of trainers' programmes.

- → Make available brochures, handouts, fact sheets et cetera. for awareness creation.
- → Support community-based programmes that are relevant to Climate Change.
- → Ensure frequent interaction with various stakeholders
- → Support and incorporate Climate Change activities in public education on open days for awareness creation (farmers' day, students' forum and festivals)
- → Formation of environmental clubs
- → Provision of equipment (forecasting and expansion of forecasting stations, satellite images)
- → Join and support good local initiatives on climate change

- ***Training*** - training of stakeholders is the backbone to sustaining action on climate change. Training should be organized from local, sub-regional, regional and international levels. Training of trainers is therefore considered to be very effective to achieve wider participation in Climate Change training. Targeted workshops and outreach programmes were considered very important forms of training for all stakeholders.

ES 8. Financial and Capacity Needs of Ghana for Efficient Implementation of the Convention

Ghana has attracted some level of multi-lateral and bilateral resources directly or indirectly to support the implementation of the Convention. Particularly, the Global Environment Facility (GEF) through UNDP had been supporting Ghana to execute a number of climate change enabling activities including:

- Preparation of the Initial National Communication (INC).
- Technology Needs Assessment (TNA) and Technology Transfer (TT)
- National Capacity Self-Assessment for Global Environmental Management (NCSA). This project was implemented to assess the capacity, constraints and potentials for implementing the three international environmental conventions on biodiversity, Climate Change and desertification,
- Enabling Activities for the Preparation of Ghana's Second National Communication to the UNFCCC.
- Energy Efficiency for Refrigerating Appliances Project
- Sustainable Land Management in Ghana Project
- Pilot Bus Rapid Transit System Project

However, these areas require additional and sustained support:

- Financial needs:

  - Research Funding –
    - → Comprehensive analysis into the proposed mitigation options.
    - → Development of technology action plan and integration into national development process.
    - → Continued financial support for climate observations as well as support to upgrade computational facilities.
    - → Technology development and innovation centre.

  - Future financial support - The major need is for support to institutionalize the national reporting mechanism under the convention, especially in the wake of the Cancun

agreements. This would require that more resources are made available to develop and mainstream a robust domestic MRV system that is able to meet both international and domestic reporting requirements and at the same time support decision-making processes on accountability and transparency. Financial resources would also be needed to support development of technology action plan for Ghana.

Weaknesses in the Second National Communication

Though in the preparation of the SNC, significant attempt was made to cover the key elements of the SNC in a balanced manner, some topics received detailed coverage than others. For example, the section on climate change mitigation assessment was not adequately dealt with compared to the aspects on climate change adaptation. In the light of this, Ghana would require support to strategically undertake coordinated capacity building programmes on the following topics, particularly in the light of the upcoming commitments under NAMAs and MRV:

- Improvements in the national greenhouse accounting and reporting system as basis for mitigation actions
- Climate change mitigation assessment and marginal cost analysis for major economic sectors.
- Greenhouse gas emission modeling and scenarios setting.
- Capacity building and in climate scenario development and impact and vulnerability assessments.

ES 9. Project Proposals

A summary of the climate change related project proposals are provided below. Full details of selected project proposals could be obtained from the annexes:

ES 9.1 Climate Change Adaptation Projects

- Demand- and supply-side measures for adapting the national energy system to impacts of climate change.
- Managing water resources as climate change adaptation to enhance productivity and livelihoods
- Minimizing climate change impacts on socio-economic development through agricultural diversification.

ES 9.2 Climate Change Mitigation Projects

- Integrated farm model for climate-smart agro-forestry and animal feed management in the transitional agro-ecological zone of Ghana
- Capacity development for GHG emission modeling and climate mitigation assessment

1. Introduction to the SNC

This introductory chapter presents the synopsis of the processes of the Second National Communication (SNC). It further gives an overview of the institutional arrangement and structure of the SNC report.

1.1 Background

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 and has since engaged in policies and measures to facilitate its implementation. In response to Article 4, paragraph 1, and Article 12, paragraph 1 of the Convention, Ghana prepared, published and reported its Initial National Communication (INC) to the Conference of Parties (COP) to the UNFCCC in December 2000 covering the period 1990 to 1996. The preparation of the Second National Communication (SNC) is in furtherance to meeting its obligation under the UNFCCC. The SNC is meant to build on, update and report additional information subsequent to the INC and facilitated by the sets of guidelines contained in the annex to decision 17/CP.8. The main objective of the SNC is to present and communicate to the extent possible to the Conference of Parties, how Ghana is implementing the Convention and in particular, highlighting pertinent issues, gaps, problems, constraints and achievements. The information provided in the SNC

covers between 2000 and 2006. Updates would be provided in the Third National Communication (TNC), which will be launched immediately after submission of the SNC to the COP. The SNC is also considered by Ghana as its flagship drive to shaping climate change policy development, planning and facilitating its integration into sustainable development. The preparation of the SNC had been very participatory, interactive and above all delivered in a systematic manner. The GEF expedited financing mechanism was the main funding source for preparing the SNC; this was, however, complemented by financial resource from the Netherlands Climate Assistance Programme (NCAP). Additional, national counterpart funding complemented it. The SNC processes were generally heralded by a national stocktaking exercise upon which the SNC project proposal was developed and approved. The existing institutional arrangements under the INC was to the extent possible rejuvenated and blended with new set of experts and institutions to ensure continuity and at the same time benefit from building on existing experiences.

The Project Advisory Committee (PAC) and Project Steering Committee (PSC) were the highest bodies responsible for providing guidance and direction in the SNC process. The PAC was made up of the Ministry of Environment, Science and Technology (MEST), Environmental Protection Agency (EPA), Ghana UNDP Representative, Energy Commission (EC), Forestry Commission (FC), representatives from the Universities, National Development Planning Commission (NDPC) and Civil Society Organisations (CSOs) representatives. The SNC had project and assistant project coordinators drawn from the Environmental Protection Agency of Ghana, who were responsible for the administrative and technical coordination of the various working groups (Figure 1.1).

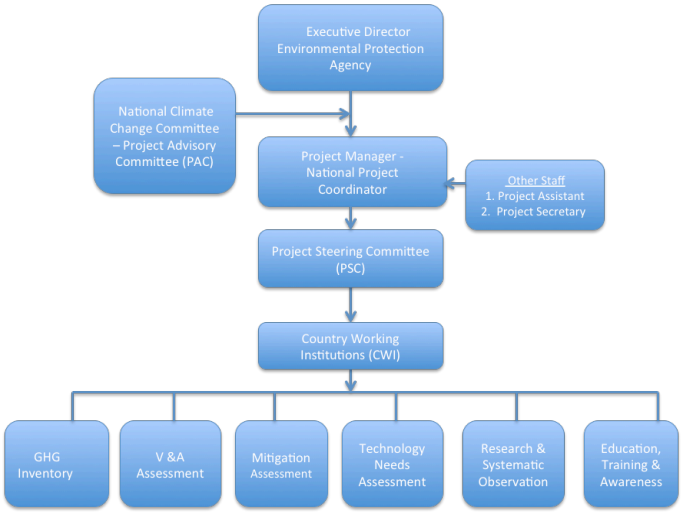


Figure 1. 1 Institutional Arrangements for preparing the SNC

The six (6) existing Country Working Groups (CWGs) were reconstituted based on the key elements of the national communication. Memberships were from relevant private, public institutions and national consultants. The six working institutions were further grouped in the following working groups:

- National Circumstances Working Group (NCWG) led by the Institute of Statistical, Social and Economic Research (ISSER), University of Ghana, Legon.
- Greenhouse Gas Inventory Working Group (GHGIWG) led by ENAPT Centre, a private consulting entity. The GHGIWG also had five sub-technical working teams including Energy, Industrial

Processes, Agriculture, Land Use Land Use Change and Forestry (LUCF) and Waste and supported by coordinators for QA/QC and Uncertainty Management.

- Vulnerability, Impacts and Adaptation Assessment Working Group (V&AWG). The group composed of 12 national experts from public and private institutions as well as consultants, and formed 8 thematic study teams. The eight (8) thematic team were specific to selected vulnerable sectors which were: Fish Production, Cocoa Production, Tuber Production, Linkages with Poverty, Gender and Women's Livelihood, Health, Climate Scenarios, Land Use Management. Impacts assessment on Water and Coastal Resources were reported in the INC. The working group also focused on measures to facilitate and enhance adaptation to climate change.
- Mitigation Assessment Working Group (MAWG). The MAWG was led by the Energy Commission. This group focused on the climate change mitigation assessment in the following economic sectors: Energy, Waste, Agriculture, and Forestry. The team also provided some information on the national REDD+ process and the overall policy framework for facilitating measures to mitigate climate change.
- Working Group on Crosscutting Issues (WGoCI). This group was made up of national consultants and experts who collated and synthesized information on crosscutting issues in the national communication. The crosscutting issues boarded on: technology transfer, research and systematic observation, education, training and public awareness and information dissemination. The EPA led this working group.
- National Communication Compilation and Synthesis Team (NCCAST). This group consisted of drafting and synthesis sub-group and Quality Control/Assurance sub-group, respectively. The compilation of the SNC was led by Environmental Application and Technology Centre (a private consulting firm) with oversight from the PSC of the SNC.

Another important aspect of the SNC was the engagement and participation of the public and relevant stakeholders. At the outset of the SNC process, an inception meeting was held for national stakeholders. The consultation sought to achieve the following:

- Provide platform for sharing and discussing the objectives, agreed strategy, expected outputs and outcomes of the SNC project;
- Provide an opportunity for the stakeholders and partners to provide input into the work plan and to confirm implementation arrangements at the national and/or /community/village levels;
- Established SNC Technical Working Groups to carry out the various tasks relating to the various reporting elements of the national communication.

As part of the processes to review and seek national endorsement of the SNC, two national validation workshops were held for national stakeholders. The first validation workshop brought independent national technical experts together to objectively review the draft SNC and transmit the comments to the SNC compilers for incorporation where appropriate. The second validation workshop constituted the highest level of the consultation process. This workshop targeted senior government officials in relevant ministries, parliamentarians, civil society groups, donor partners, researchers and the media. It sought to solicit broad national consensus and endorsement for the SNC. The SNC report was also subjected to a thorough third-party review by national experts who were directly or indirectly involved in the SNC.

1.2 Structure of the Second National Communication

The Second National Communication contains eight chapters constituting the major reporting elements as elaborated by Article 4 (1) and 12 (1) of the Convention and UNFCCC guidelines for national communication by non-Annex I Parties. Chapter one provides the broad context and rationale of the second communication and summary of the processes for preparing the SNC project in Ghana. Chapter two sets out the national circumstances, and in particular the aspects of the Ghanaian development strategies that relate to the major components of Climate Change Process. Chapter three is devoted to reporting the system, data and methodologies for preparation and compilation of greenhouse gases inventories in Ghana, in accordance with the relevant IPCC guidelines and guidance documents and UNFCCC guidelines for national communication by non-Annex Parties. The chapter also presents results of the GHG inventory in analytical, tabular and graphical forms to aid better understanding. Chapter four provides overview of the steps taken and envisaged to implement the convention in Ghana. It provides a unique opportunity for Ghana to communicate to the COP, its efforts to facilitate the realization of the ultimate objective of the convention.

Chapter five deals with the measures that could be taken to facilitate adequate adaptation to the impacts of climate change in Ghana. The chapter presents information from the various sectoral Vulnerability and Adaptation (V&A) Assessments and the subsequent efforts to mainstream climate change into development planning processes in Ghana. Information on the various measures and policies to facilitate climate change mitigation is presented in chapter six. Apart from providing information on the methodologies and analysis of the various sectoral mitigation opportunities, the chapter, also shares the critical steps undertaken by Ghana to study, assess and develop low carbon development opportunities, to contribute to the future sustainable development prospects of Ghana. Chapter seven is the penultimate chapter, which focuses on the major crosscutting issues relating to the implementation of the conventions, such as technology transfer, research and systematic observation, information dissemination and networking, legislations, stakeholder engagement and projects and programmes. Finally chapter eight makes a detailed assessment of constraints and gaps, and related financial, technical and capacity needs to enhance implementation of the Convention

2. National Circumstances

This chapter presents information on the national circumstances of Ghana. It provides details on national development priorities and objectives that serve as the basis for addressing issues relating to climate change. Information provided on National circumstances is critical for understanding a country's vulnerability, its capacity and its options for adapting to the adverse effects of climate change, as well as its options for addressing its GHG emissions within the broader context of sustainable development.

2.1 Government Structure

Ghana is a unitary democratic republic with sovereignty residing in the Ghanaian people. The 1992 Constitution declares sharing of powers among the Executive, Parliament and the Judiciary. The Presidency, the Council of State, and numerous advisory bodies, including the National Security Council, share executive authority. The President is Head of state, head of government, and Commander in chief of the armed forces of Ghana. The President selects the Vice President as running mate during the national election. The President also appoints cabinet and other Ministers of state, Ambassadors to foreign missions, Municipal and District Chief Executives and heads of certain public institutions in consultation with the Council of State. Ghana has a decentralised local government systems headed by the District/Municipal/Metropolitan Chief Executives. Legislative functions are vested in the National Parliament, which consists of a unicameral 230-member body. Members of parliament are popularly

elected by universal adult suffrage for terms of four years. The structure and the power of the judiciary are independent of all other branches of government. The Supreme Court has broad powers of judicial review; it rules on the constitutionality of any legislative or executive action at the request of any aggrieved citizen. The hierarchy of courts derives largely from British juridical forms. The hierarchy, called the Superior Court of Judicature, is composed of the Supreme Court of Ghana, the Court of Appeal (Appellate Court), the High Court of Justice, regional tribunals, and such lower courts or tribunals as parliament may establish from time to time. The courts have jurisdiction over all civil and criminal matters. The national house of chiefs, without executive or legislative power, advises on all matters affecting the country's chieftaincy and customary laws.

2.2 Geography and Climate

Ghana is located in Western Africa, bordering the Gulf of Guinea, between Cote d'Ivoire and Togo and bordered to the north by Burkina Faso. It lies between latitudes 4.5°N and 11.5°N and longitude 3.5°W and 1.3°E (Figure 2.1) and has a total land area of 239,460 km^2 and 8,520 km^2 of water. Total land boundaries account for about 2,094km (Burkina Faso 549km, Cote d'Ivoire 668km, Togo 877km). Ghana has extensive water bodies including the Lakes Volta and Bosomtwe, which occupy 3,275m^2, while seasonally flooded lakes occupy another 23,350km^2.

Various models and projections have been analyzed to assess the vulnerability status of Ghana with respect to climate change. Although their conclusions vary enormously, they show clear signs of Climate Change and confirm Ghana's vulnerability. First, there are clear signals of warming in all models. An increase of 1°C has been observed over the past 30 years. One recent projection estimated temperature increases of 1.7°C to 2.04°C by 2030 in the northern savannah regions, with average temperatures rising as high as 41°C. Ghana's climate is already unpredictable and the country can expect more extreme weather events, such as torrential rains, excessive heat and severe dry winds as a result of Climate Change.

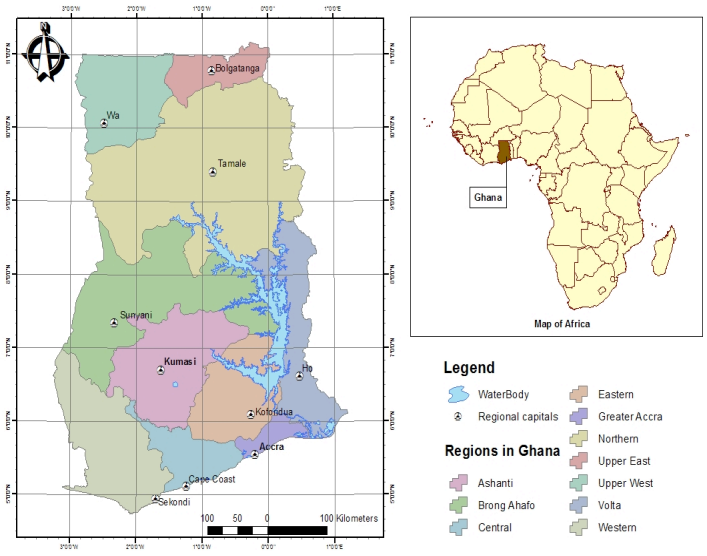


Figure 2. 1 Map of Africa showing the geographical location of Ghana

The territorial waters extend 200 nautical miles out to sea. Ghana's terrain is made up of mostly low plains with dissected plateau in south-central area and elevation extremes of between 0m from the Atlantic Ocean to Mount Afadjato (880m) being the highest point. The country is divided into five distinct geographical regions. Coastal plains stretch across the southern portion of the country, featuring low sandy beaches interspersed with saltwater lagoons. A forested plateau region consisting of the Ashanti uplands and the Kwahu Plateau are located inland, in southwest and south central Ghana. The remaining evergreen rainforest is located in the southwestern part of the country. The hilly Akwapim-Togo Ranges run north to south along the country's eastern border. The Volta Basin takes up most of central Ghana. Finally, high plains characterize the northern third of the country.

Temperatures throughout the country are typically high. The mean annual temperature is generally above 24°C, a consequence of the low latitude position of Ghana and the absence of high altitude areas. Average figures range between 24°C and 30°C although temperatures ranging from 18°C to 40°C or more are common in the southern and northern parts, respectively. Spatial variability of temperature is experienced in terms of the diurnal and annual ranges as a result of distance from the modifying influence of the sea breeze. Generally, rainfall in Ghana decreases from south to north. The wettest area is the extreme southwest where annual rainfall is about 2000 mm. In the extreme north, the annual rainfall is less than 1100mm. The driest area is the wedge-like strip from east of Sekondi-Takoradi, extending eastward up to 40km where the annual rainfall is about 750mm. Two main rainfall regimes are identified: Double maxima regime occurring south of latitude 8°30`N. The two maximum periods are from April to July and from September to November in Southern Ghana. The single maximum regime occurs in the north of latitude 8°30`N where there is only one rainy season from May to October, followed by a long dry season from November to May.

The dry conditions in the southeastern coastal strip are anomalous and are the cause of coastal alignment and upwelling of cold water. The seasonal distribution of rainfall is particularly important to the ecology and land use. Ghana has a warm and comparatively dry southeast coast along; hot and humid in southwest; hot and dry in north tropical. Enough evidence has been gathered in Ghana on the long-term changes and variability in the weather. From a 20-year observed data, temperatures in all ecological zones in Ghana are rising, whereas rainfall levels have been generally reducing and patterns increasingly becoming erratic.

2.3 Geology and Drainage

The geological formation of Ghana (Figure 2.2) comprises the following rock formations:

- The Dahomean formation is the oldest, and underlines the whole of the southeast coastal plains. It constitutes the floor of the Accra plains and the southern part of the Volta Region. The rocks are mainly metamorphic, consisting of gneisses and schists.

- The Birimian formation covers more than three quarters of the closed forest zone and contains all the minerals. The formation is divided into the Lower Birimian, which consists of such metamorphosed sediments as phyllites and schists, and the Upper Birimian, which is the younger of the two and consists of rocks of the Lower Birimian as well as metamorphosed lava. The Birimian formation generally follows a southwest to northeast trend.

- The Tarkwaian formation originally consisted of sediments eroded from the Birimian formation and deposited in a shallow narrow basin, and then folded along the same axis as the Birimian formation. This extends from the township of Agogo to the middle section of the Ankobra River and consists of schists, sandstones, quartzite and phyllites. A few patches of this formation consist of plutonic or volcanic rocks.

- The Togo series consists of sedimentary rocks and their metamorphosed versions (e.g. quartzite, schists shale, and phyllites), which were strongly folded to form the Akuapim-Togo Ranges.

- The Buem formation was formed from material eroded from the Togo series made up of sedimentary rocks together with some volcanic rocks.

- The Voltaian formation covers nearly two-fifths of the surface of Ghana and consists principally of sandstones, shales, mudstones and limestones. With the exception of the eastern margins of this formation, where there has been weak folding, the rocks are generally flat- bedded or horizontal.

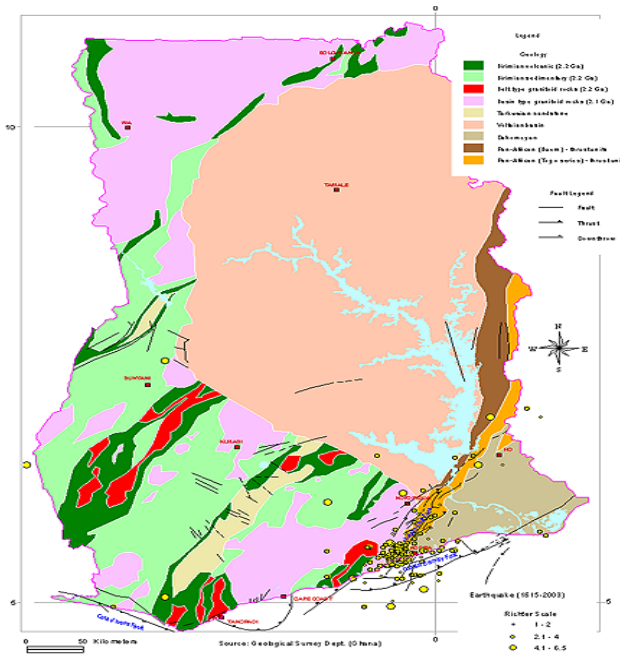


Figure 2. 2 Geology, faults and seismicity map of Ghana

- Upper Cretaceous Rocks are found at the eastern and western extremities of the coast and consist of sandstone, clay shale and limestone.
- The Eocene rocks consist of sediments of sand and gravel and are found at the eastern and western extremities of the coast where they cover, either completely or partially, the upper Cretaceous beds.
- Recent or Unconsolidated rocks consist of clay, loose sand and gravel deposited by rivers at their mouths. The most extensive of these deposits is found at the extreme eastern end of the coast, at the mouth of the River Volta and around the Keta Lagoon.

All the major rivers in Ghana flow into the sea. The only area of internal drainage is found around Lake Bosomtwi, where only streams flow from the surrounding highlands into the lake. River valleys show diverse characteristics. Terraces showing the former width and height of the rivers border the valleys of all the major rivers. Some of the valleys are guided in their direction by relief. For example, the Morago River flows east west along the foot of the Gambaga escarpment or by structure. The two main sources of water supply for the rivers are rainfall and spring. In areas with single rainfall maximum as in the north, the flow of rivers is intermittent. However, in areas with high and well-distributed rainfall within the year, the rivers flow throughout the year. It is also important to add that increasingly, water bodies are either dwindling or drying up across the country.

2.4 Population and Demography

Ghana's population is estimated at about 22,409,572 with a population growth rate of about 2.07% (2006 est.). The population structure of Ghana is estimated as follows: 0-14 years: 38.8% (male 4,395,744/female 4,288,720), 15-64 years: 57.7% (male 6,450,828/female 6,483,781) and 65 years and over: 3.5% (male 371,428/female 419,071) (2006 est.). Ghanaians have an estimated life expectancy of 58 years. The nation has an urban population of about 44% with deaths per 1000 being 10 of the total populations at 2006. In 2000, Ghana had a rural population of 56.2%. The increase in population led to an increase in the demand for more arable land, food and biomass for energy. This also resulted in an increase in crop output. Since agricultural production is mainly rain-fed, the increase in output resulted in the lateral expansion of cultivated lands not productivity. Both extensive cropping and biomass increase has contributed to some land degradation. The increase in population was also associated with increased urbanization. Urbanization puts pressure on the limited resources leading to challenges in dealing with solid and liquid wastes. The increased urban wastes and land degradation have implications for climate change that is discussed below.

2.5 Socio-economic Structure and Climate Change

There is a broad recognition that climate change is a significant development challenge in Ghana. The 2008 national sectoral climate change vulnerability and adaptation assessments revealed the substantial impact of climate change on the national economy, with clear evidence that many of the key economic assets – the coastal zone, agriculture and water resources – were affected, as well as social development in terms of poverty reduction, health and women's livelihoods. Ghana has made major progress on poverty reduction in recent decades. Poverty persists, however, in the north and in urban pockets and it is the poorest people who bear the brunt of climate change. A north-south poverty divide is exacerbated by climatic stress in northern regions where temperatures are already relatively high. Lower agricultural productivity and flooding are increasing the pressure on the youth to migrate to the south. The main concerns on the potential impacts of climate change include:

- Increased pressure on water, reducing the potential for hydropower.
- The impact on agriculture, with reduced yields leading to increased poverty and food insecurity, and the loss of national revenue from cash crops such as cocoa.
- Increased migration from the north with increased pressure on urban services
- Deteriorating health as a result of increased incidence of diseases and reduced access to water and food, compounded by the disruption of the delivery of health services. Severe impacts on land use, leading to loss of biodiversity and soil fertility, land degradation and increased deforestation.
- The impact on women, who are particularly vulnerable to the impact of Climate Change, given their higher levels of poverty and their responsibilities for household water, food and fuel.

- Potential conflicts over use of scare natural resources.
- Loss of human settlements due to sea level rise and coastal erosion.

2.5.1 Economic Overview

From 2000 to 2006, the Ghanaian economy has maintained a relatively high average growth rate of 5.1%. The rate for 2006 was 6.2% in spite of the surge in crude oil and other petroleum product prices. Ghana is making strides towards achieving the MDGs by 2015. The GDP growth rate in 2006 was largely driven by growth in the agricultural sector (Table 2.1). Agriculture continues to be the mainstay of the Ghanaian economy, contributing an average 36% of GDP for the period 2000-2006. The marginal increases in the 2006 growth rates of the crops and livestock and fishing sub-sectors were enough to compensate for the drop in the growth rate of the cocoa and forestry sub-sectors (Table 2.6). However, this increase in the sector is not as much as that of 2004 mainly due to enormous growth in the Cocoa sub-sector.

In 2006, the industrial sector grew by 9.5%, up 1.8% over the 2005 figure. Although all the sub-sectors of industry grew, with the exception of the manufacturing and construction, growth in mining and quarry and electricity and water sub-sectors were high (7 and 11.8% point better than 2005). For the first time since 2002, the services sector recorded appreciable growth; up by nearly 0.7% from 2004 till it reached 6.5% point GDP in 2006. It is interesting to observe that the modest gains in the growth of national output are not reflected in the growth rate of per capita income. One reason is that, output is not increasing sufficiently enough to result in a surge in per capita income, even if the population growth rate is assumed to be constant.

Table 2. 1 Sectoral contributions to national Output, (2000-2006 % of total in 1993 constant prices)

Year	Agriculture	Industry	Services
2000	36.0	25.2	29.7
2001	35.9	24.9	29.9
2002	35.8	24.9	30.0
2003	36.1	24.9	29.8
2004	36.7	24.7	29.5
2005	37.0	24.7	29.4
2006	35.8	25.4	30.0
Average (2000-2006)	36.05	25.15	29.85

Source: Ministry of Finance and Economic Planning, 2005

Well endowed with natural resources, Ghana has roughly twice the per capita output of the poorest countries in West Africa. Even so, Ghana remains heavily dependent on international financial and technical assistance. Gold, timber, and cocoa production are major sources of foreign exchange for Ghana. The domestic economy continues to revolve around subsistence agriculture, which accounts for 34% of GDP and employs 60% of the work force, mainly small landholders (Table 2.2). Ghana opted for debt relief under the Heavily Indebted Poor Country (HIPC) program in 2002, but was included in a G-8 debt relief program agreed upon at the Gleneagles Summit in July 2005. Priorities under its current $38 million Poverty Reduction and Growth Facility (PRGF) include tighter monetary and fiscal policies, accelerated privatization, and improvement of social services. Receipts from the gold sector helped sustain GDP growth in 2006 along with record high prices for Ghana's largest cocoa crop. Ghana received a Millennium Challenge Corporation (MCC) grant in 2006, which aims to assist in transforming Ghana's agricultural export sector.

Table 2. 2 Some Economic Indicators (2006 estimates unless otherwise stated)

Variable	Statistic
GDP Growth rate (2006)	6.2%
GDP per capita (PPP)	US$2,600
GDP Composition by sector:	37.3%
Agriculture	25.3%
Industry	37.5%
Services	10.87 million
Agriculture	60%
Industry	15%
Services	25%
Inflation rate (consumer prices)	10.9%
Budget revenue	US$3.616 billion
Electricity production (2004):	6.489 billion kWh
Electricity consumption: (2004)	7.095 billion kWh
Electricity exports: (2004)	900 million kWh
Electricity imports: (2004)	1.96 billion kWh
Natural gas proved reserves (2005 est.)	23.79 billion cu m

2.5.2 International Trade and Payments

Since 2001, government policy on the external sector focused on building international reserves to levels that can adequately cushion the economy against external shocks. This strategy has involved encouraging exports and foreign direct investment. In 2006, accumulation of international reserves was for a target of 4 months of import cover. Ghana's external sector position continued to be strengthened against the background of high commodity prices, especially crude oil. High export receipts and debt relief under the Multilateral Debt Relief Initiative (MDRI) allowed for the continued build up of international reserves). The trade balance in 2006 was in deficit by US$2,940.2 million, an increase of 15.5% over the 2005 trade deficit of US$2,545.1 million. Both merchandise exports and imports registered an increase in value between 2005 and 2006.

Total export receipts rose by 31.3% from US$2,802.2 million in 2005 to US$3,680 million in 2006. Total import receipts also rose, but at a slower rate of 23.8%, from US$5,347.3 million in 2005 to US$6,620.2 million in 2006 (Table 2.3). Growth in imports in 2006 was mainly due to an increase in oil imports. The year under review saw a lot of volatility in crude oil prices as a result of increasing global demand as well as political factors. Oil imports as a percentage of total imports continued to increase in 2006. From as low as 17.4% in 2003, the share of oil imports increased to 22.8% of total imports in 2006 (Figure 2.3). In 2006, the overall balance of payments, which served as an indicator of current and capital account performance, had a surplus of US$415.1 million, an almost 400% increase over the 2005 figure of US$84.3 million. The improvement is attributed to the strong export performance, growth in remittances, donor resources and debt relief. The current account, including official transfers registered a deficit of US$730million in 2006 compared to a deficit of US$813.5 million in 2005. This improvement in the current account position was due to improvements in the services, income and unrequited transfers. Net transfers increased from US$2,116.7 million in 2005 to $US2, 595.2 million in 2006, an increase of 22.6%. Net private capital flows gained 28.3% over the 2005 figure, rising from US$559.3 million to US$717.8 million in 2006.

Table 2. 3 Summary of Ghana's Balance of Payments, 2002-2006, (US$ millions)

Economic Indicators	2002	2003	2004	2005	2006
Marchandise Exports (f.o.b)	2,015.2	2,562.4	2,704.5	2,802.2	3,726.7
Marchandise Imports (f.o.b)	-2,707.0	-3,232.8	-4,297.3	-5,347.3	-6,753.7
Trade Balance	-691.8	-670.4	-1,592.8	-2,545.1	-3,027
Invisibles (net)	659.9	972.8	1,277.0	1,731.6	2,210.3
Freight & Insurance (credit)	56.0	62.2	70.0	73.4	84.9
Freight & Insurance (debit)	-210.0	-253.8	-335.6	-409.8	-496.0
Investment Income (net)	-174.3	-156.7	-197.8	-187.1	-127.4
Other Services (net)	88.0	-78.18	-90.6	138.4	153.6
Transfers (net)	900.2	1,399.2	1,831.0	2,116.7	2,595.2
Official (net)	220.2	382.0	543.9	566.9	809.1
Private (net)	680.0	1,017.2	1,287.1	1,549.8	1,786.1
Current Account	-31.9	302.3	-315.8	-813.5	-730.0
Government Capital (net)	-115.2	85.8	52.5	141.1	146.9
Long-term Loans (net)	194.3	369.8	402.3	501.3	433.1
Medium-term Loans (net)	0.0	0.0	0.0	0.0	0.0
Gross Inflows	194.3	369.8	402.3	501.3	433.1
Amortization	-309.5	-284.1	-349.80	-360.2	-286.3
Private Capital (net)	105.7	199.9	332.0	559.3	717.8
Direct Investment (net)	58.9	110.0	139.3	145.0	334.5
Divestiture	0.0	26.7	0.0	0.0	0.0
Others (net)	46.7	63.2	192.7	414.3	383.3
Gross Inflows	57.3	91.1	230.9	455.3	444.1
Amortization	-10.6	-28.0	-38.2	-41.0	-60.8
Non-Monetary Short-Term Capital	94.7	45.0	-88.3	106.7	51.6
Monetary Short-Term Capital	-123.8	9.7	-94.6	27.4	-28.7
SDR Allocation	0.0	0.0	0.0	0.0	0.0
Errors and Omissions	110.4	-84.4	103.8	63.4	257.4
Overall Balance	39.8	558.3	-10.5	84.3	415.1

Source: Bank of Ghana, 2007

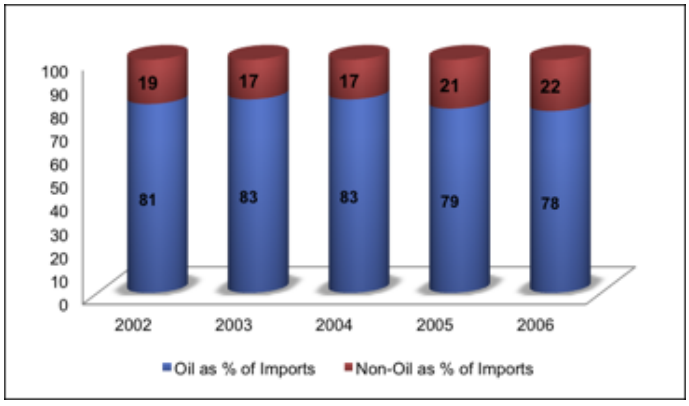


Figure 2. 3 Percentage of Oil and Non-Oil Imports from 2002-2006

Minerals, cocoa and timber continued to be Ghana's main export commodities in 2006 (Table 2.4). As usual, the minerals sector was the country's main export earner, accounting for 37.3% of the export revenue in 2006, an increase from 36.9% in 2005. Over the period 2002 to 2006, it was only in 2004 that the mineral sector was displaced by cocoa as the country's main export earner. However, the amount of foreign exchange that is injected into the economy from the mineral sector is less than 30%. Even though the value of cocoa exports increased from US$908.4 million in 2005 to US$1,187.4 million in 2006, its contribution to Ghana's total merchandise export earnings fell slightly from 32.4% in 2005 to 31.9% in 2006. The value of timber earnings fell from US$226.5 million in 2005 to US$206.7 million in 2006, representing a contribution to total earnings of 8.1% and 5.4%, respectively over the same period.

Table 2. 4 Merchandise Export Earnings by Sector from 2002-2006

Gross Exports (US $m) of which:	2002	2003	2004	2005	2006
	2,015.2	2,562.4	2,704.5	2,802.2	3,726.7
1. Cocoa Total	474.4	817.7	1,025.7	908.4	1187.4
% Contribution	23.5	31.9	37.9	32.4	31.9
2. Minerals Total	753.9	893.6	904.5	1034.8	1371.7
% Contribution	37.4	34.9	33.4	36.9	36.8
3. Timber Total	182.7	174.7	211.7	226.5	206.7
% Contribution	9.1	6.8	7.8	8.1	5.4
4. Other Exports	669.0	739.8	661.6	632.5	968.0
% Contribution	33.2	28.9	24.5	22.6	25.9

Source: Bank of Ghana, 2007

2.5.3 Agriculture

For the first time since 2000, the steady increase in growth in the sector recorded a reduction in 2005 reflecting the drastic decrease in the cocoa sub-sector. As can be observed in figure 2.4, each year had experienced higher growth than the previous year except in 2005 when growth decreased significantly by 45.3% compared to 2004. However, the opposite was the case for both the services and industrial sectors, which grew higher in 2005 than in 2004 (Table 2.5).

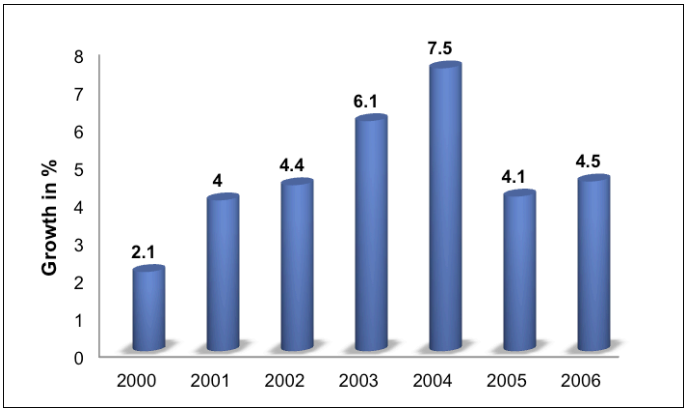


Figure 2. 4 Growth Performance of the Agricultural Sector, 2000-2006

Source: Budget Statement and Economic Policy of the Government of Ghana (Annual Series)

Table 2.5 Agriculture and Other Sectoral Growth Rates, 1998-2006

Year/ Period	Sectors			
	Agriculture	Services	Industry	All
1998	5.1	6.0	3.2	4.7
1999	3.9	5.0	4.9	4.4
2000	2.1	5.4	3.8	3.7
2001	4.0	5.1	2.9	4.2
2002	4.4	4.7	4.7	4.5
2003	6.1	4.7	5.1	5.2
2004	7.5	4.7	5.1	5.8
2005	4.1	5.4	7.7	5.8
2006	4.5	6.5	9.5	6.2
				Average
1990/94	1.1	7.0	4.1	4.3
1995/99	4.4	5.3	4.7	4.4
2000/06	4.7	5.2	5.5	5.1

Source: Budget Statement and Economic Policy of the Government of Ghana (Annual Series)

The main contributor to the impressive performance of the agricultural sector in 2004 was the high growth of the cocoa sub-sector (Table 2.6). In 2005, cocoa performed relatively poorly at 13.2%, a whopping 16.7% decline relative to the 2004 figure of 29.9% (Figure 2.5 and Table 2.6). This shows how unreliable the sub-sector could be in providing the growth needed to push the economy to the required level of acceleration. The decline in the cocoa output could be partly due to the poor rains between August and December 2004, which is important for the development of cocoa pods during the flowering stage. The forestry and logging as well as crops and livestock sub-sectors also experienced a decline of 0.2% and 2.1% in growth as the sub-sector grew only at 5.6% and 3.3%, respectively in 2005. The fisheries sub-sector also experienced a decline in growth in 2005 relative to the 2004 figure but saw significant growth in 2006.

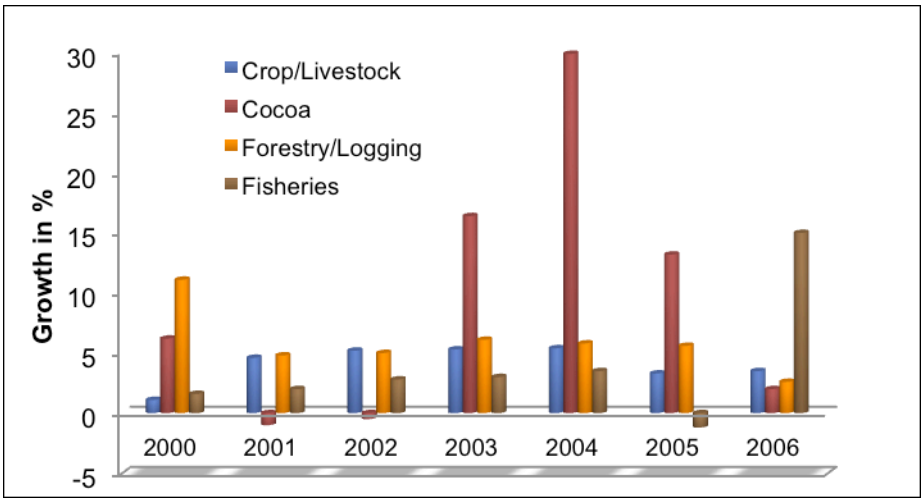


Figure 2. 5 Growth Performance of Agricultural Sub-sector

Source: Ministry of Food and Agriculture

Table 2. 6 Growth Rates in Agricultural Sub-Sectors, 1998-2006

Year/ Period	Sub-Sector				
	Crops/ Livestock	Cocoa	Forestry/ Logging	Fisheries	All
1998	4.4	11.0	10.0	1.8	5.1
1999	4.7	-0.5	6.8	1.0	3.9
2000	1.1	6.2	11.1	1.6	2.1
2001	4.6	-1.0	4.8	2.0	4.0
2002	5.2	-0.5	5.0	2.8	4.4
2003	5.3	16.4	6.1	3.0	6.1
2004	5.4	29.9	5.8	3.5	7.5
2005	3.3	13.2	5.6	-1.2	4.1
2006	3.5	2.0	2.6	15.0	4.5
					Average
1990/94	0.9	1.1	2.5	2.0	1.1
1995/99	4.1	6.3	5.3	1.5	4.4
2000/06	4.1	9.5	5.9	3.8	4.7

Source: Budget Statement and Economic Policy of the Government of Ghana (Annual Series)

2.5.3.1 Agriculture's Contribution to the Economy

The relative share of agriculture in GDP remains the largest. In 2006, 39.3 % of Ghana's GDP came from agriculture compared with 32.9% and 27.8% from services and industry, respectively (Table 2.7).

Table 2.7 Contribution to GDP by Sector, 1998-2005 at Constant 1993 Prices (%)*

Year/Period	Sectors			
	Agriculture	Service	Industry	All
1998	40.6	32.1	27.4	100.0
1999	40.5	31.9	27.6	100.0
2000	39.6	32.7	27.8	100.0
2001	39.6	33.0	27.4	100.0
2002	39.5	33.0	27.5	100.0
2003	39.8	33.4	27.4	100.0
2004	40.4	32.4	27.2	100.0
2005	39.5	32.9	27.6	100.0
2006	39.3	32.9	27.8	100.0
				Average
1990/94	41.6	44.3	14.1	100.0
1995/99	40.6	31.7	27.7	100.0
2000/06	39.7	32.9	27.5	100.0

Excluding indirect taxes **Source:** Ghana Statistical Service, Accra

In 2006, about 42.5% of foreign exchange earnings were agro-based. Even though, there was an increase over the 2005 figure, in terms of percentage contribution, 2005 was higher than 2006 in the share of agriculture in foreign exchange earnings (Table 2.8). In 2005, the share of agriculture in total foreign earnings was US$1,286 million. A total of US$1,589 million was realised from the export of agricultural commodities in 2006 of which US$1,187 million (74.7%) of agricultural export earnings was from cocoa, US$199 million (12.5%) from timber and US$203 million (12.8%) from non-traditional exports (Table 2.8).

Table 2. 8 Foreign Exchange Earned by Agriculture and Non-Agricultural Sectors, 1998-2005 (US$ Million)

Year/ Period	Agriculture						Non-Agric.		Total	
	Cocoa		Timber		Non-Trad.					
	Amt	%	Amt	%	Amt	%	Amt	%	Amt	%
1998	554	30.3	170	9.3	78	4.3	1,028	56.2	1,830	100.0
1999	550	26.2	174	8.3	85	4.1	1,290	61.5	2,099	100.0
2000	437	22.5	175	9.0	75	3.9	1,254	64.6	1,941	100.0
2001	381	20.4	169	9.1	82	4.4	1,235	66.1	1,867	100.0
2002	463	22.4	183	8.9	86	4.2	1,332	64.5	2,064	100.0
2003	818	34.9	174	7.6	138	6.0	1,182	51.5	2,297	100.0
2004	1,071	39.2	212	7.7	160	5.9	1,290	47.2	2,733	100.0
2005	908	32.4	227	8.1	151	5.4	1,516	54.1	2,808	100.0
2006	1,187	31.8	199	5.3	203	5.4	2,146	57.5	3,735	100.0
1990/94	306	30.1	134	13.2	30	2.9	545	53.7	1,015	100.0
1995/99	466	28.1	171	10.3	60	3.6	961	58.0	1,658	100.0
2000/06	752.1	28.94	191.3	8.0	127.9	5.0	1422.1	57.9	2492.1	100.0

Source: Bank of Ghana, 2007

In spite of the decline in the volume of cocoa exports in 2005, about 34% of total export earnings of the economy were derived from the sub-sector. Timber and non-traditional exports also contracted in terms of their absolute contributions to total export earnings and share in the value of export earnings. This is due mainly to unsustainable logging and agricultural practices. The share of non-traditional agricultural exports in total declined from 22.7% in 2004 to about 19.5% in 2005, but increased to 22.8% in 2006 (Table 2.9).

However, the economy earned more foreign exchange from non-traditional agricultural exports in 2005 and 2006 than in 2004. Horticultural products contributed US$75.64 million to non-traditional agricultural exports in 2006 and this represented 37.2% of the total earnings from non-traditional agricultural exports (Table 2.10). This showed an increase of about US$25.3 million over the 2005 figure and a 4% point increase in the percentage share of horticultural products in non-traditional agricultural exports. Fish and other seafood as well as game and wildlife contributed US$67.90 million and US$0.86 million, respectively to non-traditional agricultural exports. There was thus a decline in the value of earnings obtained from of game and wildlife exported, but significant increase in terms of foreign exchange earned by fish and seafood from about US$45.8 million in 2005 to over US$67.9 million in 2006.

Table 2.9 Foreign Exchange Earned by Non-Traditional Agricultural Commodities, 1998-2005 (US$ Million)

Year / Period	Total Non-Trad. ($ Mill.)	Agric. ($ Mill.)	Share of Non-Trad. (%)
1998	401.70	77.80	19.40
1999	404.40	84.50	20.90
2000	400.70	74.50	18.60
2001	459.60	82.00	17.80
2002	504.30	85.70	17.00
2003	588.90	138.10	23.50
2004	705.40	159.80	22.70
2005	777.60	151.86	19.53
2006	892.88	203.36	22.78
			Average
1990/94	77.00	29.90	38.80
1995/99	314.10	59.50	18.90
2000/06	618.48	895.32	20.27

***Source**: Ghana Export Promotion Council, 2007*

Table 2.10 Foreign exchange earned by major groups of non-traditional agricultural commodities 1998-2006

Year/ Period	Horticultural Products		Fish/Sea Foods		Game/Wildlife		Other Agric Products		Total Agric	
	$Mill	%	$ Mill	%	$ Mill	%	$ Mill	%	$ Mill	%
1998	19.77	25.00	21.02	27.00	0.40	1.00	36.61	47.00	77.80	100.0
1999	27.21	32.00	20.94	25.00	0.40	1.00	34.95	41.00	84.50	100.0
2000	28.08	38.00	18.58	25.00	0.36	1.00	27.52	37.00	74.54	100.0
2001	29.99	37.00	23.85	29.00	0.38	1.00	27.76	34.00	81.98	100.0
2002	33.61	39.00	24.48	29.00	1.92	2.00	25.72	30.00	85.73	100.0
2003	29.22	21.00	26.85	19.00	7.36	5.30	74.71	54.00	138.14	100.0
2004	60.52	38.00	52.02	33.00	0.07	0.05	47.18	29.50	159.80	100.0
2005	50.26	33.10	45.76	30.13	1.22	0.80	54.62	35.97	151.86	100.0
2006	75.64	37.19	67.90	33.39	0.86	0.42	58.97	29.00	203.37	100.0

Source: Ghana Export Promotion Council, 2007

An interesting phenomenon emerged in 2005 with regard to non-traditional agricultural exports (Figure 2.6). Considering the top five non-traditional agricultural commodities in terms of their value of foreign exchange earnings, shea nuts contributed over US$28.9 million followed by frozen fish (US$18.4 million), tuna (US$15.0 million), pineapple (US$12.7 million) and yam (US$10.9 million), respectively. Cashew nuts, which featured prominently in 2004 in terms of non-traditional agricultural commodity exports earnings, declined from about US$18.7 million to about US$5.2 million in 2005 (Table2.11).

Table 2. 11 Volume and value of major non-traditional agricultural export commodities, 2004 and 2005

Commodity	Volume (tonnes)			Value ($000)		
	2004	2005	% Change	2004	2005	% Change
						Roots/Tubers/Plantain
Yam	16,169	18,376	13.7	8,399	10,951	30.38
Cocoyam	64	189	195.3	36	96	166.67
Plantain	117	338	188.9	76	202.07	165.88
						Cereal Crops
Maize	16	8,257	51506.3	3.30	703	21203.6
Rice	8	13,907	173737.5	4.00	2,872	71700.3
Millet	2.5	48	1820	0.46	547	118813
Sorghum	0.9	4	344.4	0.17	6.24	3570.59
						Fruits
Pineapple	71,804	46,694	-34.9	22,068.6	12,784.3	-42.1
Banana (fresh)	725	1,116	53.9	208.9	458	119.2
Pawpaw	3,751	3,211	-14.40	1,266.00	1,081	-14.6
Oranges (Fresh or dried)	741	5,845	688.8	93.9	3,865	4016.1
Lime/Lemon	74	103	39.19	31.50	73.00	131.8
						Vegetables
Pepper/Chilies	2,575	1,365	-46.9	987	731	-25.9
Tomatoes	606	N.A	0.00	57	N.A	
Aubergine/G. Eggs	696	124	-82.2	259.9	66	-74.6
						Fish/Sea Foods
Tuna	27,257	19,460	-28.6	24,477	15,023	-38.6
Frozen Fish	15,976	48,823	205.6	19,233.6	18,404	-4.3
Dried/Smoked/salted Fish	1,786	314	-82.4	1,476	384	-73.9
						Others
Cotton Seed/Linters	9,933	11,216	12.9	1,965	5814.8	195.9
Shea Nuts	5,548	165,508	2883.2	2,463	28,968	1,076.1
Coffee Robusta	1,297	514	-60.4	1,587	399	-74.9
Kola Nuts	9,933	816	-91.8	1,965	124	-93.7
Cashew Nuts	51,763	13,831	-73.3	18,757.6	5,235	-72.1
Cocoa Waste	13,474	7,829	-41.9	4,752.4	2,287	-51.9

N.A - Not Available **Source**: Ghana Export Promotion Council, 2006

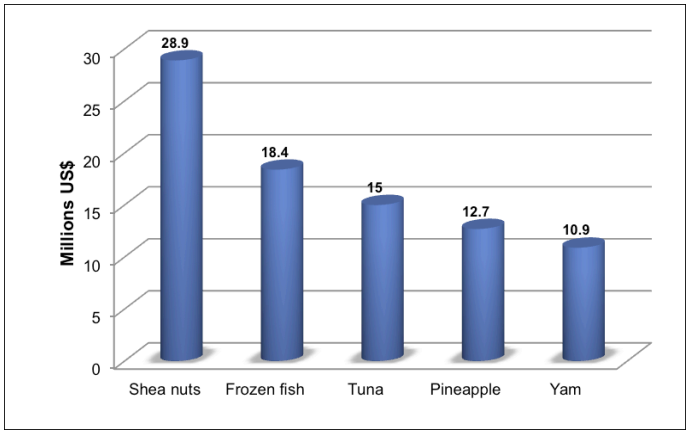


Figure 2.6 Leading non-traditional agricultural export in 2005

Source: Ghana Export Promotion Council, 2006

Table 2.11 reveals that, even though, the volume of frozen fish exports more than doubled in 2005, earnings declined by more than 4.3%. This is because the unit price decreased tremendously from about US$1,200 per tonne to about US$370 per tonne. Similarly, foreign price of pineapple and tuna decreased faster relative to volumes exported. With regard to yam, foreign prices increased faster, relative to the increase in volume exported, while the opposite was the case for shea nuts. Increase in temperature, decrease in rainfall, and its unpredictability, are likely to jeopardize the employment of about 60% of the active population of Ghana, majority of whom are small scale rural farmers. Agriculture and food security are interrelated and thus climate change induced unsustainable livelihoods will result in negative consequences on food security, poverty, health, education, gender equality and environmental degradation. Agricultural production's dependence on rainfall is a significant hindrance to the development of the sector in Ghana. Although an estimated 6,000 farm enterprises nation-wide were using some means of irrigation in 1999, by 2002, the total area under formal irrigation was still around 11,000 hectares whereas the potential area, including inland valleys that could be developed for irrigation, is estimated at 500,000 hectares. This indicates that the use of irrigation to counter the effects of poor rainfall is particularly low across the country. All planning in the agricultural sector is aligned with the FASDEP II (Food and Agriculture Sector Development Policy), which seeks to address the challenges of the agricultural sector. Agriculture is highly sensitive to temperature and rainfall. Ironically, the impacts of climate change have not been factored in any of the six policy objectives of FASDEP II.

2.5.4 Tourism

Ghana's tourism sector focused mainly on two key aims, creating employment and generating revenue. The potential for the sector to contribute meaningfully to economic development led the Ministry of Tourism to carry out key activities throughout the year. Intrinsic in the tourism sector activities throughout 2006 was the target of raising the number of tourist visits to Ghana to 1 million by the end of year 2007 through promotion of Ghana's golden jubilee celebration. The tourism industry in 2006 continued with tourism programmes, capacity building of tourism workers, and institutional strengthening. Key tourism activities continued in 2006 while new potentials were identified. One of the main tourist activities under piloting is Ghana's major tourism attraction activity, The Joseph Project, which was launched in 2007. The Joseph Project seeks to re-unite Africans in the Diaspora with Africans (especially Ghanaians) at home. Also, the hang and paragliding festival entered its second stage in 2006.

Others included tourism fairs, conferences and emancipation day celebration. With regards to identification of new tourism activities and sites, new tourist attractions were identified in 2006. These included the Guoko Sacred Groove, the Presbyterian Cemetery at Osofoman, Mayera and the Samsam Cave & Sacred Groove at Achioto, Samsam. Further, the year saw public-private partnership agreements for the promotion and management of eco-tourism facilities in some of Ghana's major National Parks - Kakum, Mole and Ankassa. These new tourism sites are expected to add to the huge tourism potential in Ghana and also add to the diversity of channels to create tourism-related employment, income and marketing.

Promotion of tourism activities and the identification of new tourist sites and projects will fall short of expectations if there are not enough institutional and individual capacities to support them. In the year under review, a new Tourism Policy was developed. Furthermore, the Ministry of Tourism had created better data collection and monitoring system. Several training programmes were held for private sector tourism personnel such as chop bar operators, drinking spot operators, and hotel staff. Strong encouragement of the private sector to participate in the provision of tourism accommodation is important to increase the number of tourist visits. Majority of Ghana's tourist sites are ecologically based and the impacts of Climate Change in the form of disasters put the sector at a higher risk.

2.5.5 Education

The then Ministry of Education, Science and Sports, in 2006, focused on achieving the targets set under the Education Strategic Plan and GPRS II. These included increasing access to basic education and implementing measures geared towards the attainment of the Millennium Development Goals (MDG) target of Universal Primary Completion by 2015 and Gender Parity by 2008. Various planned enrolment drives were thus carried out in 2006. These included Capitation Grant Scheme and the School Feeding Programme. About GH¢12.95 million was paid as Capitation Grant for pupils in public basic schools. In addition, The School Feeding Programme went through its piloting in various selected districts across the country in 2006. In 2007 alone, the programme was expected to reach 92,000 pupils nationwide. These programmes could explain the sharp rise in enrolment rates especially at kindergarten level. Apart from rising enrolment rates, repeaters have also declined at all levels of basic education. At the kindergarten level alone, gross enrolment increased by 18.7% in the 2004/05 academic year to 75.2% in the 2005/06 academic year (Table2.12).

Table 2.12 Enrolment Rates (%), 2004/05 – 2005/06

Indicators	Boys		Girls		Total	
	2004/05	2005/06	2004/05	2005/06	2004/05	2005/06
Kindergarten						
Gross enrolment ratio	57.2	75.3	55.8	75.1	56.5	75.2
Net enrolment ratio	38.4	50.0	38.5	50.2	49.9	50.0
Repeaters (Public)	7.8	3.8	7.1	3.7	7.4	3.7
Repeaters (Private)	5.4	3.3	5.1	3.3	5.3	3.3
Primary						
Gross enrolment ratio	90.4	88.3	84.5	84.5	87.5	86.4
Net enrolment ratio	60.0	69.6	58.3	68.1	59.1	68.8
Repeaters (Public)	6.8	4.8	6.5	4.7	6.7	4.8
Repeaters (Private)	2.6	1.9	2.4	1.9	2.5	1.9
JSS						
Gross enrolment ratio	74.6	73.8	65.6	66.9	70.2	70.4
Net enrolment ratio	31.3	41.5	31.8	41.7	31.6	41.6
Repeaters (Public)	5.0	3.9	5.5	4.2	5.2	4.1
Repeaters (Private)	2.6	1.3	2.4	1.4	2.5	1.3

Source: Ministry of Education, Science and Sports, 2007

When priority enrolments are analyzed, one observes that the gains of improved access to basic education have trickled down to deprived areas as well. The three northern regions of Ghana are among the most deprived regions. It was observed that progressively, gender parity is being achieved. Enrolments at all levels are increasing for these regions; more girls are being enrolled in primary and basic education levels (Table 2.13). This rise in enrolment has been attributed mainly to the Capitation Grant Scheme and the School Feeding Programme. The significant increase in enrolment necessitated the need for more teachers, especially qualified or trained teachers. To fill this need, the Government of Ghana through the National Service Secretariat, posted a total of 18,900 Service Personnel to teach in basic schools in rural areas while about 2,000 service personnel recruited under the National Volunteer Programme were deployed in schools to increase the supply of teachers in remote areas.

The deployment of teachers, however, has not fully addressed the teacher need of schools across the country. At the national level, the pupil-teacher burden is felt most at the kindergarten and primary levels, where enrolments are escalating. There was only a marginal rise in the number of pupils a teacher handles in primary school and almost no change in the number of pupils a teacher handles in J.S.S (Table 2.14). While effort is being made to upgrade all teacher training schools in Ghana to increase enrolment of teachers, an immediate solution may be the deployment of teaching assistants at the kindergarten level by the National Youth Employment program.

Table 2.13 Priority enrolment indicators, 2003-2006

Indicator	2002/03	2003/04	2004/05	2005/06
Gross Enrolment Ratios in Primary Schools				
National	84.5	86.3	87.5	86.4
Northern Region	70.5	70.5	71.5	83.6
Upper East	76.5	77.1	80.4	90.6
Upper West	70.3	74.1	77.3	100.4
Gross Primary Enrolment Ratio for Girls				
National	82.2	83.1	84.5	84.5
Northern Region	61.8	63.0	65.4	78.7
Upper East Region	76.3	76.4	81.2	92.3
Upper West Region	71.0	74.9	79.2	103.6
Gender Parity Index for Primary (GPI)				
National	0.92	0.93	0.94	0.98
Northern Region	0.78	0.81	0.91	0.94
Upper East Region	0.99	0.98	1.02	1.02
Upper West Region	1.02	1.02	1.05	1.03
Junior Secondary School Enrolment Ratios:				
National	62.3	65.6	70.2	70.4
Northern Region	38.8	45.4	51.4	57.5
Upper East Region	37.4	46.7	51.5	54.4
Upper West Region	43.2	50.3	59.6	67.6

Table 2.14 Pupil-Teacher Ratios in Basic Schools, 2004/2005

Type	2004/05			2005/06		
	Kindergarten	Primary	JSS	Kindergarten	Primary	JSS
National	27	35	18	38	35	18
Public	25	35	19	39	38	19
Private	19	27	15	31	26	15
Northern	35	40	25	62	40	23
Upper East	41	57	25	73	52	24
Upper West	39	49	24	56	45	22

Source: Ministry of Education, Science and Sports, 2007

In spite of the textbook policy ratio of 1:1, national data tends to suggest that primary school children did not have as much access to text books in 2005/06 academic years as they did in 2004/05 (Table 2.15). Since the 2002/03 academic year, textbook ratio share remained at almost 1:1. In 2005/06 however, the ratio has jumped to 1:2. With the exception of the Upper East region where textbook ratios remained 1:1, the other two regions in the north had ratios that were higher than the national target. This situation could have arisen because of poor monitoring by the then Ministry of Education, Science and Sports.

Table 2.15 Pupil-textbook ratio for primary schools, 2002/3 -2005/2006

Regions	2002/2003	2003/2004	2004/05	2005/06
National	1:1.7	1:1.4	1:1.0	1:1.5
Northern	1:1.4	1:1.1	1:0.8	1:1.6
Upper East	1:1.3	1:1.0	1:1.0	1:1.0
Upper West	1:1.5	1:1.1	1:1.1	1:2.3

Note: The ratio represents the number of core textbooks per pupil. GPRS target is 1:1.3.0 for all pupils.

Source: Ministry of Education, Science and Sports, 2007

At the tertiary level, the government continued programmes and projects to expand access to tertiary education. Government policy of allowing private sector participation in tertiary education has increased total enrollment. Trends in Public universities still dominate enrollment. Some institutions at the tertiary level have introduced environmental science programmes, which helps climate change education. Analysis of gender balance in the admission shows that females still lag behind males in tertiary education enrollment (Table 2.16). While efforts are being made to attain universal gender parity by 2008 at the basic education level, it is important to acknowledge that Ghana's development will be accelerated if gender parity is achieved in tertiary education. A further breakdown in tertiary enrolments revealed that public universities admitted more humanities students; private universities admitted more business students while polytechnics had more accountancy students. Emphasizing science education will speed up the nation's development.

Table 2. 16 Tertiary Enrolments, 2002/3 -2005/6

Sex	Public universities		Private Universities		Polytechnics	
	No.	%	No.	%	No.	%
Male	54,929	65.3	5,582	58.8	15,800	70.8
Female	29,149	34.7	3,915	41.2	6,505	29.2
Total	84,078	100.0	9,497	100.0	22,305	100

***Source**: National Council for Tertiary Education (NCTE)*

After twenty years of implementing the current educational system, the need to review the system and adopt key reforms became necessary. To this end, a secretariat and nine sub-committees were formed. These committees drafted a new educational policy expected to be implemented in 2007. Climate Change may affect the education sector directly through the increased frequency and/or severity of extreme weather events. This will result in damage to educational infrastructure and disruption in the provision of educational services. It will also impact the sector significantly through a range of socio-economic impacts. With lands in coastal areas eroding due to rising sea levels, it is very significant to rethink on the location of educational and services facilities and also make such facilities climate-proof.

2.5.6 Health

In 2006, the focus of the health sub-sector was on the attainment of a five-year health sector programme of work, which ultimately seeks to improve the quality of life of the people in Ghana. The Ghana Health Services (GHS) thus sought to:

- Improve coverage of the National Health Insurance Scheme (NHIS), produce, retain and distribute human resources equitably.
- Improve on the delivery of high impact health interventions.
- Expand access to emergency and ambulance services.

Overall, there was improvement in some of the key high impact intervention areas. HIV/AIDS prevalence rates dropped from 3.6% to 3.2%. A total of 20 Anti-Retroviral Therapy (ART) sites were operational and providing service in 2006 at which time there were 600 patients on anti-retroviral drugs. In the case of malaria, the government acquired over 5 million insecticides treated nets (ITNs) for distribution. This resulted in an increase of ITN use among pregnant women and children by 32.7% and 31.0%, respectively. Further, in 2006, the new malaria drug policy was implemented in all districts across the country. Guinea worm infestation did not respond positively to these high impact interventions. By September 2006, total guinea worm cases recorded was 2,968 showing an increase of 21new cases over the 2,947 cases recorded over the same period in 2005 and falling short of the targeted 2,000 cases. These high cases of guinea worm persists in spite of the fact that 100% of 2,167 villages targeted were under active surveillance, and have full household filter coverage. Clearly, the health sector needs to focus more on prevention and eradication of this disease.

The National Health Insurance Scheme (NHIS) continued to reduce the financial burden of households with regards to health care in the year under review. The number of district mutual health insurance schemes nationwide increased to 134 compared to the 124 in 2005. Of this number, 127 provided benefits to registered members. Given the inevitability of the impacts of Climate Change it is important to appreciate the additional burden of diseases and their implications. The climatic conditions are gradually bringing a shift in the known time-frame and geographical boundaries of various diseases and cases of meningitis, diarrheal diseases, guinea worm infestation, etc. are predicted to keep on increasing. There is a need for capital investment, to address the deterioration of existing health

infrastructure, provide staff accommodation and infrastructure in deprived areas, expand and improve the quality of existing facilities to meet increased demand created by the NHIS and environmental education on preventive measures.

2.6 Water Resources

2.6.1 River systems

Ghana is well endowed with water resources, but the amount of water available changes markedly from season to season as well as from year to year. Also, the distribution within the country is far from uniform with the southwestern part better watered than the coastal and northern regions. Due to climate change, rapid population growth, increased environmental degradation, pollution of rivers and draining of wetlands, potential water stress is likely to exacerbate. All of Ghana's major rivers drain southwards to the Gulf of Guinea. The Volta River, with a catchment area within Ghana of nearly 70% of the country, is by far the largest river draining the entire north, centre and east of the country. The remaining rivers, all in the south and southwest, drain about 30% of the country. The major sub-basins of the Volta include the Black and White Volta Rivers, the Oti River and the Lower Volta, including Lake Volta. The South-Western Rivers System comprises the Ankobra, Bia, Pra and Tano, Rivers, while the Coastal Rivers System is made up of, Ayensu, Densu, Nakwa, Ochi-Amissah, Ochi- and Tordzie/Aka Rivers. The Volta River basin is shared with Cote d'Ivoire, Burkina Faso, Togo, Benin and Mali.

The Bia is shared with Cote d'Ivoire, while the lower reaches of the Tano River also forms part of the boundary with Cote d'Ivôire. Impoundments and reservoirs have been constructed for hydropower generation, water supply and irrigation. At Akosombo, 100 km from the mouth of the Volta, the first Volta hydroelectric dam was constructed in 1964, which has created one of the largest man-made lakes in the world, covering an area of about 8,300 km2. A smaller impoundment, the Kpong Head pond, covering an area of about 40 km2, was completed in 1981, when another hydroelectric scheme was commissioned at Kpong, 20km downstream of Akosombo. Other important impoundments are the Weija and Owabi Reservoirs on the Rivers Densu and Offin, respectively. In addition to these, the only significant natural freshwater lake in Ghana is the meteoritic Crater Lake, Lake Bosumtwi.

Surface water quality considerations are becoming increasingly important due to mining activities, urban and industrial pollution problems and agricultural development. Reliable data on water quality is of importance for proper management and thereby the protection and development of surface water resources for the future. Another important on-going concern requiring appropriate hydrological data is the current and future development of urban drainage in a number of Ghana's major cities, for which flood and storm runoff data are needed for proper planning and design.

2.6.2 Groundwater

The occurrence of groundwater in Ghana is associated with 3 main geological formations. These are the basement complex, comprising crystalline igneous and metamorphic rocks; the consolidated sedimentary formations underlying the Volta basin (including the limestone horizon); and the Mesozoic and Cenozoic sedimentary rocks. The basement complex and the Voltaian formation cover 54% and 45% of the country, respectively. The remaining 1% consists of Mesozoic and Cenozoic sediments. Groundwater occurrence in the basement complex is associated with the development of secondary porosity as a result of jointing, shearing, fracturing and weathering. The depths of aquifers are normally between 10m and 60m, and yields rarely exceed 6hm3/hr. In the Mesozoic and Cenozoic formations occurring in the extreme southeastern and western part of the country, the aquifer depths vary from 6m

to 120m. There are also limestone aquifers, some of which are 120m to 300m in depth. The average yield in the limestone aquifers is as high as 180m^3/hr. The quality of groundwater resources in Ghana is generally good except some cases of localized pollution and areas with high levels of iron, fluoride and other minerals. Salinity in certain groundwater occurrences is also found especially in some coastal aquifers.

2.6.3 Water use

The major consumptive uses of water in Ghana are water supply, irrigation and livestock watering. Domestic and industrial urban water supplies are based almost entirely on surface water, either impounded behind small dams or diverted by weirs in rivers. Water supplies in rural areas, however, are obtained almost exclusively from groundwater sources. The various groundwater development programmes have resulted in the establishment of more than 10,000 boreholes countrywide. At present, irrigation development does not play an important role in the overall water resources balance considerations. However, the potential for irrigation has been shown to be considerably larger than the present land area being irrigated. The main non-consumptive uses are hydropower generation, inland fisheries and water navigation. Drinking water coverage in Ghana is very low, 45% of the rural and 70% of the urban population, forcing many communities to depend on underground water for their water supply. On the basis of surface water resources alone, the consumptive water demand for 2020 has been projected to be 5.13billion m^3, which is 13% of the surface water resources. Likewise, the non-consumptive demand can also be met from the surface water available. Rainwater harvesting is increasing and becoming an alternative in many peri-urban areas in Ghana, and has a great potential to increase water availability in certain localized areas. It can be concluded that, if properly conserved and distributed, the surface water resources of the country should be adequate to meet future demands.

2.7 Energy Resources

In the mid 1990's Ghana implemented economic programmes to transform the economy. The drivers of the economic growth are agriculture, manufacturing and services. However, there has been a significant increase in the extraction of minerals, which would require high-energy use. With an expanded economy and growing population, Ghana faces major challenges in providing the required energy in reliable and sustainable manner to meet its economic goals. The main energy resources in Ghana are woodfuels, electricity and oil products with wood fuels dominating in energy usage. Total primary energy produced in Ghana in 2000 was 6.2 million tonnes of oil equivalent and this rose to 7.6 million tonnes of oil equivalent by 2004. The primary indigenous energy comprised 90-95% woodfuels (generally called biomass), 5-10% hydro energy and less than one percent solar energy. The hydro energy is supplied from Akosombo and Kpong hydroelectric dams and light-crude oil fired thermal plant in the form of electricity. Solar energy is used for the sun drying of crops mainly cocoa; maize, paddy rice, sorghum, millet; groundnuts and pepper and other exportable commodities requiring drying. Solar energy for the production of electricity is relatively negligible; about 150 tonnes of oil equivalent.

Net energy import was about 1.9 million tonnes of oil equivalent in 2000 increasing to about 2.6 million tonnes of oil equivalent by 2004. It comprised of 80–83% crude oil and about 15-19% petroleum products. The primary energy production and the net import made up the primary energy supply and totaled about 8.1 and 10.2 million tonnes of oil equivalent in 2000 and 2004, respectively. Biomass was the most dominant primary energy supplied, averaging 69% over the period, followed by oil comprising crude oil and products averaging 25%. The residential or household sector of the economy accounts for over 50% of the country's energy consumption. The significant residential sector share of the nation's energy demand is due to the high usage of woodfuels comprising mainly firewood (almost 76%) and charcoal.

2.7.1 Energy demand

The energy demand sectors of Ghana's economy can be grouped as; Residential (Rural and urban), Commercial and Services, Agriculture and Fisheries, Transport (Road, Rail, Maritime, and Air), and Industrial (VALCO, Manufacturing, Mining, Utilities, and Construction). The available energy sources driving these sectors are petroleum, biomass, and electricity.

2.7.1.1 Residential

The rural and urban communities make up the residential demand side of energy. Total number of households in Ghana was about 4 million in 2000 and is expected to reach between 5 – 6 million by 2020. The energy usage is usually in the form of lighting and cooking with biomass being the predominant energy use for most households especially in the rural communities. About 90% of the rural folk depend on fuelwood for cooking and about 82% depend on kerosene for lighting. The LPG use in the country on the other hand accounted for only 4-6% of the residential sector in 2000. This is concentrated in the urban areas among the middle and higher income groups. Urban households accounted for 88% of electricity usage.

2.7.1.2 Commercial and Services

The Commercial and Services Sector also referred to as the tertiary sector is regarded as the facilitator of economic growth. It has been the fastest growing sector of the economy over the past decade and continues to increase its share in the nation's gross domestic product (GDP). The sector's share of total national energy use has on the average been less than 3% per annum since 2000. The informal subsector comprising chop-bars and street selling or vendor cooking has had the largest share (over 55%) of energy use by the Commercial and Services Sector since 2000, followed by the Tourism (10–11%) and the Education subsector (>5%). Most of the energy used in this sector had come from woodfuels (over 65% in 2000). Electricity follows with about 30% share, and then petroleum products, about 9% share.

Firewood forms the bulk (about 86%) of the woodfuel consumption in the Commercial & Services sector and it explains the relative large percentage share of the informal sector. Vendor cooking/street-selling is responsible for over 85% of the woodfuels consumed by the sector. Restaurants and chop bars on the average have between 3-6% share of the woodfuel consumption annually due to a major shift to LPG as their main cooking fuel in the 1990s. LPG is the main (99%) petroleum product consumed by the Commercial & Services sector. Restaurants are responsible for over 75% of LPG consumed by the sector.

2.7.1.3 Agriculture

In the agriculture sector energy is used for mechanization, irrigation, transportation and preservation. The crops, livestock and fisheries sector contribute to the energy sector immensely by producing and supplying woodfuels. However, the final energy use by the sector is very small, accounting for less than 2% of total energy use in 2000. In the fisheries sub-sector, energy is used for fishing and fish preservation. The main fuels for the Fisheries subsector are diesel and premix gasoline. Trawlers and tuna vessels use diesel. Premix fuel is used both in farming and fishing activities. The fisheries subsector accounts for over 90% of the energy use in the Agriculture and Fisheries sector, followed by Post-harvest processing (3.1%).

2.7.1.4 Transport

The road subsector accounted for about 93% of fuel use from year 2000 to 2004. This was followed by Air (6-7%). Energy use by the Rail and the Maritime subsectors is comparatively negligible, averaging 0.3% and 0.1%, respectively. The transport sector accounted for about 99.7% of gasoline consumption in the economy, with the remaining 0.3% going into industry for general use as solvent in 2000. Almost all the gasoline going into the transport sector was used as fuel for road transport. Most (about 85%) of the diesel supplied to the economy was also taken up by the transport sector, whilst the remaining 9% and

5% went to Industry and the Agriculture & Fisheries sectors, respectively. About 99.3% of the diesel for the transport sector was used by road transport. The rail and the maritime subsectors used the remaining 0.6% and 0.1%, respectively. The fuel consumption by the maritime subsector was mainly for inland or freshwater transport. LPG use in the transport sector during 2000–2004 was relatively negligible. All jet kerosene went to air transport. In recent times, LPG usage has increased in the road transport sector with commercial taxis converting to the use of LPG due to the relatively low price of the commodity.

2.7.1.5.Industrial

The Industrial sector without VALCO had nearly 22% of total national energy share every year since 2000. With VALCO, the industrial sector's total energy share increased slightly to about 23% per annum. The main fuels for industrial purposes are woodfuels, electricity and petroleum products (particularly, diesel and residual fuel oil). In the year 2000, industrial energy shares comprised about:

- 77% woodfuels but increased to 80% in 2004;
- 16% electricity, but dropped to 12% in 2004; and
- 10% petroleum products, but also reduced to 8% by 2004.

Woodfuel is used predominantly in the informal manufacturing subsector and as fuel for baking, cooking and heating in the ceramics, commercial food processing and local textile industries. On the other hand, if only the formal manufacturing subsector is considered, the major industrial energy was electricity (55-56%) followed by petroleum products (averaging 39-42%) and woodfuel (about 5.1%).

2.7.2 Energy Supply

The main sources of energy for the various sectors of the economy are electricity, petroleum and woodfuels. Oil products accounted for about 29% of the total energy used in 2000 with biomass and electricity accounting for about 60% and 11%, respectively (Figure 2.7).

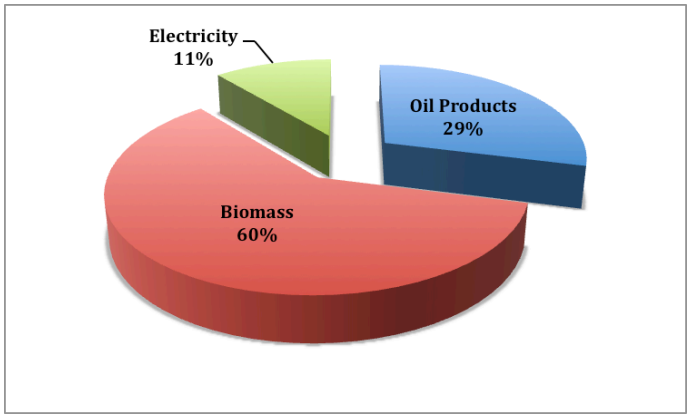


Figure 2. 7 Composition of Fuel in Final Energy Consumption for 2000

***Source**: SNEP, 2006*

2.7.2.1 Wood fuels

Woodfuels provide the bulk of the energy needs for most informal enterprises such as bread-baking, processing of oil-palm, brewing of local drinks, tobacco curing, traditional textiles (tie and dye, batik), traditional soap making, fish smoking, etc. The woodfuel sub-sector is the only energy subsector where cooking appliances and almost all production equipment with the exception of chainsaws, are produced locally. In 2000, the national wood stock for fuel was estimated as 813 million tonnes. Average annual wood production is about 30 million tonnes and the potential woodfuel supply is estimated at 18 million

tonnes per annum. Sources of the wood are from about 87% of the country's landmass of around 24 million hectares with most of them being traced to farmlands and the Savannah. About 90% of the woodfuels are obtained directly from the natural forest and the savannah woodlands. The remaining 10% is obtained from logging, sawmilling waste and woodlots. The transitional and savannah zones of Ghana are the major sources of woodfuels preferred by most Ghanaian homes.

2.7.2.2 Electricity

The existing power plants are the Akosombo and Kpong hydro power stations, the Takoradi Thermal Power Station, the Tema diesel power station and the Ghana (Osagyefo) Power Barge at Effasu in the Western Region. The Akosombo and Kpong hydropower had delivered, on the average, a total firm electricity of 5,815 Gigawatt hours (million units of electricity) annually from 1990–2004. Maximum generation of 6,851 Gigawatt-hours occurred in 1997. The Takoradi Thermal Power Station consists of two blocks of generating plants; 330 Megawatt combined cycle plant and 220 Megawatt open or single cycle plant. The 330 Megawatt plant usually referred to as Takoradi 1 (T1) is registered under the name Takoradi Power Company (TAPCO). The 220 Megawatt plant usually referred to as Takoradi 2 (T2) is registered under the name Takoradi International Company (TICO). The Volta River Authority (VRA) has a 30 Megawatt installed capacity (37.5MVA) diesel station at Tema. The Tema diesel plant was installed between 1961 and 1963 and had run continuously till 1966. Thereafter, it was used as standby till 1979. The station has since been operated as a contingency plant only until 2005 when its pump was completely burnt due to a fire outbreak at the Tema Harbour. The Ghana (Osagyefo) Power Barge constructed in the late 1990s is a 125 Megawatt open cycle plant comprising two modern 62.5Megawatt gas turbines.

The primary fuel for electricity generation had largely been hydro until 1998 when the Takoradi Thermal Power Station at Aboadze commenced operations. The main fuel for the thermal power station at Aboadze is light crude oil (LCO) but it also uses distillate oil for start-up and shut-down of the turbines. Primary electricity generation was about 7,224 Gigawatt-hour in 2000 but dropped to 5,901 Gigawatt-hour in 2003. The electricity production comprised mainly hydro emanating from Akosombo and Kpong hydroelectric power stations. There was, however, a drop in the hydro share from about 91.5% in year 2000 to almost 66%in 2003. Whilst the hydro share of primary energy dropped, the thermal component rose from about 8.5% in 2000 to about 34% in 2003.

Thermal generation is largely crude oil based coming from the Takoradi Thermal Power Station at Aboadze, in the Western Region. Electricity import is primarily from neighboring la Cote d'Ivoire, to the west of Ghana. Ghana exports electricity mainly to Togo and Benin. Solar power systems mostly installed by public institutions in remote areas of the country numbered over 5000 in 2004. The installed capacity of almost one megawatt generates between 1-2 Gigawatt-hour per annum. Some large sawmills and oil palm mills (e.g. the Benso, Twifo, Kwae Oil Palm Mills) also operate Combined Heat and Power (CHP) plants based on biomass wastes to generate essentially steam for their operations and some amount of electricity to supplement their grid electricity supply.

2.7.2.3 Petroleum

Ghana discovered her first large-scale, commercially viable oil field in 2007. The first commercial production commenced in December 2010 and output is expected to ramp up to 120,000 barrels per day in 2011. As at 2006, the only extraction of oil was at Saltpond in the Central Region, yielding between 350-1,000 barrels of crude oil per day. Gas flared at Saltpond fields is about 2 million cubic feet per day. Ghana imports crude oil for the Tema Oil Refinery (TOR), which refines all the crude oil needs of the country, except consignments meant for power generation.

Table 2.17 Product Slate at Tema Oil Refinery

Year					Tonnes
	2000	2001	2002	2003	2004
Crude Oil Imports	1,131,834	1,262,872	1,179,364	1,406,205	1,813,464
Crude Oil Intake at TOR	1,094,860	1,137,278	1,269,568	1,485,106	1,757,936
Refinery Production	1,028,409	1,069,876	1,156,414	1,351,757	1,604,031

Total capacity in tonnes is about 2 million per annum, but on the average, the refinery processes less than 1.5 million tonnes per annum. Crude oil import was about 1.1 million tonnes in 2000, but rose to 1.8 million tonnes in 2004 after a dip in 2002 (Table 2.17 and Table 2.18).

Table 2.18 Percentage share of petroleum products

Year		2000	2001	2002	2003	2004
Percentage share of petroleum products	LPG	0.9	0.6	2.1	3.9	4.0
	Gasoline	23.2	26.8	29.9	32.1	34.7
	ATK	10.5	6.0	7.1	6.3	6.7
	Diesel	34.8	33.0	38.6	37.5	35.4
	RFO	25.5	24.4	16.9	12.1	12.4

Source: Tema Oil Refinery, 2005

Diesel, gasoline and RFO constituted the largest share of fuels produced at the refinery. The large percentage shares of the fuel oil in 2000 and 2001 were due to the fact that the refinery was a simple crude distillation plant (CDU) and thus could not process the Residual fuel oil (RFO) into value-added products. The scenario changed from 2002, when the Residual Fuel Catalytic Cracker (RFCC) was commissioned. The diesel, gasoline and the LPG yields improved whilst the RFO yield dropped. Ghana exports some petroleum products largely Residual Fuel Oil (RFO) and heavy gasoline (naphtha) which have little use in Ghana. Whilst the export share of RFO decreased over the years, the heavy gasoline share increased due to the inability of the refinery to process it efficiently into lighter products of higher market value on the Ghanaian market. The petroleum products required to service a moderately high economic growth scenario are projected as follows (Table 2.19).

Table 2. 19 Moderately high economic scenario for petroleum products

				Moderately High Scenario in '000 tonnes
Year	2008	2012	2015	2020
LPG *	121-134	162-176	223-237	298-300
LPG **	91-100	121-132	167-178	223-275
Kerosene and Jet Fuel	215-219	237-242	283-300	330-350
Gasoline Premium	704-711	822-825	964-970	1,115-1,200
Gasoline Premix	68-70	73-75	76-80	81-85
Diesel	1,030-1,128	1,420-1,470	1,320-1,800	2,030-2,100
RFO#	124-125	134-136	146-147	156-159
RFO##	41-42	44-45	48-50	52-53

- If little or no supply constraints exist **If existing supply constraints largely remain # Demand for fuel oil if potential industries do not switch to natural gas
- ## Demand for fuel oil if most industrial heating switches to natural gas

Source: SNEP, 2006

2.7.2.4 Some Anticipated Impacts of Climate Change on Energy Sector in Ghana

Some of the anticipated impacts of Climate Change in Ghana include rise in average temperature, variability in rainfall, changes in the intensity and pattern of extreme weather events and rise in sea level. Although the impacts of Climate Change on energy would be both positive and negative, the negative impacts are more likely to dominate. The renewable energy resources are likely to be more sensitive to Climate Change since they depend on factors such as hydrology, wind regimes, weather patterns and solar radiation. Frequent rainstorms especially in the northern part of Ghana and Burkina Faso may provide the much-needed water to fill the hydro dams for power generation.

However, very severe rainstorms may threaten the safety of hydro dams with excessive water inflows that will require frequent spillage. The difficulty in weather predictability that will be associated with Climate Change can pose a serious challenge to effective planning of energy supply to the economy and agriculture. Reduced rainfall and iterant droughts on the other hand, may pose danger to the sustainability of mini and small hydro facilities as most of them could dry out completely. Persistent drought could also negatively affect the growth and availability of fuelwood especially in the savannah zones. The expected rise in temperature has the potential to enhance evaporation of water from the surfaces of large hydro-dam reservoirs and result in rapid water loss.

2.7.2.5 Energy Strategy

The main aim of the Government's energy strategy is that of sustainable exploitation and efficient use of the country's energy resources and power production in order to improve on the quality of life of the people. In this regard, the government of Ghana aims to pursue only environmentally friendly policies and measures as part of efforts to meet her obligations under the Climate Change Convention. These include among others:

- Encouraging energy efficiency and conservation practices, for which the Energy Foundation has been set-up by the government to lead in that regard.
- Achieving 15% penetration of rural electrification by decentralized renewable energy complementation by 2015 and expanding to 30% by 2020.
- Reducing the average woodfuel energy intensity per urban household by 30% by 2015 and by 50% by 2020 and also, reducing firewood intensity per rural household by 10% by 2020.
- Achieving 1% penetration of solar energy in hotels, restaurants and institutional kitchens using solar water heaters by 2015 and 5% penetration by 2020.
- Promoting energy efficiency in the transport sector, deregulating the railway system to permit private sector participation in urban passenger and long distance freight railways systems as well as providing incentives for the promotion of nationwide mass transit transport systems.
- Achieving high quality and reliable (95% uninterrupted) electricity supply to the industrial sector per annum by 2015 and improving reliability to 98% by 2020.
- Developing a local market for the industrial use of natural gas when the WAGP project is completed, including displacing residual fuel oil use for heating in most coastal industries by 2015.

It is, however, noteworthy that the oil find in Ghana may change the dynamics of energy demand and supply in country. Also, the Bui hydroelectric dam to be completed by 2015 will add significantly to the renewable energy mix of the energy sector. The West African Gas Project (WAGP) is also expected to supply gas to power the thermal energy component of the energy mix to defray the use of diesel and other petroleum products.

2.7.3 Industrial Sector in Ghana

Industry in Ghana accounts for about 24.7% of total GDP. Ghana's industrial base is relatively advanced compared to many other African countries. Ghana's most important manufacturing industries include light manufacturing, aluminum smelting, food processing, cement, and small commercial shipbuilding. A relatively small glass-making industry has also developed due to the high-quality sand available from the Tarkwa mining area. Other industries include the production of food and beverages, textiles, chemicals and pharmaceuticals, and the processing of metals and wood products. Most products are for local consumption, and most of Ghana's exports are raw materials. Import-substitution industries include textiles; steel (using scrap); tyres; oil refining; flour milling; beverages; tobacco; simple consumer goods; and car, truck, and bus assembly. The industrial sector is one of the high energy consuming sectors in Ghana and also impact negatively on the environment.

2.7.4 Development and Poverty Reduction Strategy

In the last decade, development efforts in Ghana have, to a large extent, focused on Poverty Reduction. However, Climate Change issues are now beginning to gain increasing recognition in Ghana's national development and poverty reduction efforts. According to the Ghana Living Standards Surveys by the Ghana Statistical Service, Poverty in Ghana decreased from 51.7% in 91/92 to 39.5% in 98/99 and to 28.5% in 2005/06, respectively. Extreme poverty at the same time decreased from 36.5%, 28.5% and 18.2% during the same years. This phenomenon led to a lowering of the absolute numbers of the poor from 7,931,000 in 91/92 to 6,178.000 in 05/06.The distribution of poverty in Ghana is, however, not even. There are sharp geographic variations (Table 2.20). Generally, the northern regions have the highest incidences of poverty compared to the southern regions. Central and Eastern regions, with the highest incidences among the southern regions, however, recorded the most significant reduction between the period 1998/99 to 2005/06. The incidence of poverty declined in all regions except Greater Accra and Upper West regions, which recorded increases from 5% to 11.5% and 84% to 88% between the period 98/99 and 2005/06, respectively. Interestingly, these two regions have the lowest and the highest incidences of poverty in Ghana.

In general, poverty is more pronounced in the rural areas than the urban areas (Table 2.20 and Figure 2.8). About 86% of the total population living below the poverty line in Ghana is in the rural areas. Although Ghana has experienced significant decreases in poverty over the period 1991/92 to 2005/06, rural poverty has rather increased from 82.2% in 1991/99 to 83.4% in 1998/99 and 85.7% in 2005/06. One notable dimension of the decreases in the incidences of poverty is related to the attainment of the MDG goal 1 which is targeted at halving extreme poverty. Indeed, statistically from table 2.20, Ghana has attained MDG one as extreme poverty decreased from 36.2% to 18.2% from 1991/92 to 2005/06.

Table 2.20 Poverty incidence by administrative regions

Region	Poverty		Extreme Poverty	
	1998/99	2005/2006	1998/99	2005/2006
Western	27.3	18.4	13.6	7.9
Central	48.4	19.9	31.5	9.7
Greater Accra	5	11.8	2.4	6.2
Volta	37.7	31.4	20.4	15.2
Eastern	43.7	15.1	30.4	6.6
Ashanti	27.7	20.3	16.4	11.2
Brong Ahafo	35.8	29.5	18.8	14.9
Northern	69.2	52.3	57.4	38.7
Upper East	88.2	70.4	79.6	60.1
Upper West	83.9	87.9	68.3	79.0
All	38.5	28.5	26.8	18.2

Meeting Goal 1 of the MDGs shows that Ghana is committed to the MDGs. Clearly, while efforts are being focused on meeting the MDG targets, there is the tendency that attention will be skewed towards the end (what should be achieved) rather than the means or the process (how to achieve) that brings about the change. The mere achievement of the goals, however, should not be a fundamental objective; the crux is meeting the goals sustainably. If the MDG ultimate goal is to uphold the principles of human dignity, equality and equity, then the institutional and governance structures on which poverty reduction and equity depend must equally be addressed. In Ghanaian context, this process relies heavily on the decentralized structures.

Another dimension of the poverty incidence is a food crop farmer. The poverty incidences for food crop farmers have been 68%, 59% and 46% for the years 1991/92, 1998/99 and 2005/06, respectively. The relationship between crop production and Climate comes into play and gives a pointer to the need to consider Climate Change and climate variability in our national development planning efforts.

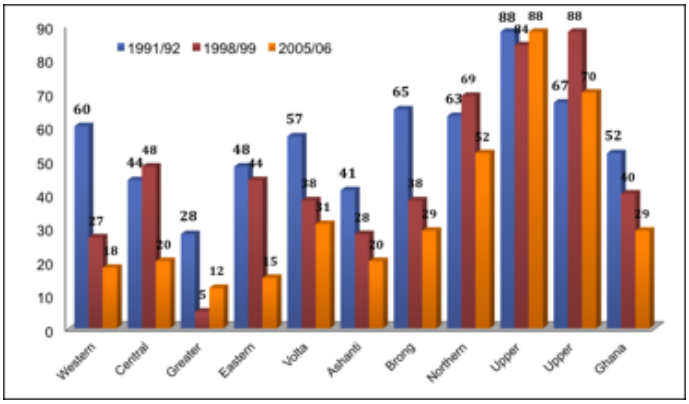


Figure 2.8 Poverty incidence by administrative region, 1991/1992 to 2005/2006 (Poverty line: 370Gh, Cedis)

Table 2. 21 Poverty Information by Regions (GLSS 4, 2004)

REGION	Total Population	Male Population	Female Population	% Poor	Absolute No. Poor	Position by % Poor	Position by Absolute No.
Upper East	919,984	442,492	477,492	88	809,586	1st	4th
Upper West	576,583	276,445	300,138	84	484,330	2nd	9th
Northern	1,820,869	907,177	913,692	69	1,256,400	3rd	1st
Brong Ahafo	1,815,408	911,263	904,145	36	653,547	7th	6th
Ashanti	3,613,101	1,818,216	1,794,885	28	1,011,668	8th	2nd
Eastern	2,106,696	1,036,371	1,070,325	44	926,946	5th	3rd
Volta	1,635,415	790,880	844,535	38	621,458	6th	7th
Greater Accra	2,905,726	1,436,135	1,469,591	5	145,286	10th	10th
Central	1,593,823	760,221	833,602	48	765,035	4th	5th
Western	1,924,577	978,176	946,401	27	519,636	9th	8th

Note: There are more poor people in Northern and Ashanti Regions than any other regions in terms of absolute numbers

Another dimension of poverty in Ghana has to do with the issue of targeting (in other words, where are the poor). It will be noticed that even though the three northern regions ranked the highest incidence of poverty in terms of percentage, they rank differently in terms of absolute numbers. For instance, Ashanti region ranks second in terms of absolute numbers, whilst Upper East and Upper West rank 4th and 9th, respectively (Table 22.1). Targeting of the poor is therefore critical for effective poverty reduction programmes. Given the challenges of poverty, several policies, plans and programmes have been put in place. Some of these are

- **The Ghana Poverty Reduction Strategy I (GPRS I)**, which was a Medium Term Development Framework, comprised of a set of coordinated measures to accelerate poverty reduction. It adopted an integrated and comprehensive approach in the formulation of mutually supportive economic, socio-cultural and natural resource management strategies to achieve growth of the economy, the elimination of hard-core poverty and a sustainable programme of poverty reduction.

- **The Growth and Poverty Reduction Strategy (GPRS II)** which was a continuation of the Ghana Government's coordinated programme for the economic and social development of Ghana from 2006–2009 is aimed at accelerating a sustainable shared growth, poverty reduction, and the promotion of gender equity, protection and empowerment of the vulnerable and excluded within a decentralized democratic environment.

- **Establishment of the Social Investment Fund (SIF)** -SIF has been set up by Government of Ghana to contribute significantly to reducing rural and urban poverty in Ghana. SIF provides targeted assistance to poor/deprived communities in Ghana in partnership with CBOs, Local Government, Civil Society and Donors using a gender-sensitive, flexible, participatory, demand driven and sustainable process for sustainable Community Based Development. The fund supports economic infrastructure and services (e.g. Improvement of feeder roads, extension services), social infrastructure services (Nutrition Improvement, primary health care), urban poverty reduction, micro finance and capacity building (training and technical support),

- **Community Based Rural Development Project (CBRDP)**–Funding for this project was from the World Bank. It aimed at strengthening the capacity of rural communities to improve their productive assets, rural infrastructure and access to key support services from private and public sources, thereby enhancing their quality of life. There are five project components: - Institutional Strengthening and Capacity Building; - Infrastructure for Agricultural Development; - Rural enterprise development; - Infrastructure for Social and Human Development; and - Community-based natural resource management. The project was approved on 29 July 2004 and closed in 2009.

- **Rural Enterprise Project (REP)** – The project was funded by IFAD and was closed in 2002. The Ministry of Environment, Science and Technology was responsible for the project with Monitoring Unit based in Kumasi, Ghana Regional Appropriate Technology Industrial Service, National Board for Small Scale Industries, Department of Feeder Roads, Bank of Ghana, Association of Rural Banks and 15 participating rural banks. UNOPS supervises the loan as IFAD's Cooperating Institution. The objective of the project was to increase rural production, employment and income in order to alleviate poverty through the increased output of small off-farm enterprises. This was accomplished by: facilitating access to new technology and business advice; promoting easier access to financial services; improving the efficiency of existing small

rural enterprises, supporting the creation of new enterprises, and removing communication constraints through feeder road rehabilitation. The project has three components: (i) Support for the Promotion of Rural Small scale Enterprises, which includes the establishment of Business Advisory Centres, the construction of Rural Technology Service Centres, and the development and transfer of appropriate technologies; (ii) Rural Finance Services Support, which included lines of credit to eligible participating banks, supported by training for groups and individual beneficiaries in managing credit, deposit facilities, and a monitoring unit for participating rural banks, under the Association of Rural Banks that also provided training to selected rural bank staff; and (iii) Infrastructure Support, which includes rehabilitation of 100 km of feeder roads and a further 15 km of spot improvements to improve mobility and access to markets.

- **Northern Regional Poverty Reduction Programme (NORPREP)** - NORPREP is funded by IFAD, Government of Ghana, District Assemblies in Northern Region and Other donor partners from 2004 to 2010. The overall objective of NORPREP is to improve the livelihoods and living conditions of poor rural communities with emphasis on women and vulnerable groups in the Northern Region. Specifically, the project sought to build capacity of decentralized local Government, civil society and community organization to better respond to the needs of the poor in the Northern Region. The main components of the project included: Community Development Fund (CDF) - a flexible financing facility channeled to the district and community levels. Capacity building included provision to improve the planning, manage and monitoring capacity of the target group and public and private/ NGO sector agencies supporting poverty alleviation efforts.

- **DACF Poverty Alleviation Fund**– The District Assemblies' Common Fund (DACF) is a pool of resources created under section 252 of the 1992 constitution of Ghana. It is a minimum of 5% of the national revenue sets aside to be shared among all District Assemblies in Ghana with a formula approved by Parliament. The fund is a Development Fund, which enables the use of the nation's wealth throughout Ghana to the benefit of all citizens. The fund is to ensure equitable distribution of the national resources for the development in every part of Ghana; To Improve housing Schemes; To support sanitation management; It is also to strengthen decentralization, and to promote Sustainable self-help development communities, to improve upon primary health care delivery in all parts of Ghana; it is to improve the country's educational facilities, and to ensure quality education and community policing.

- **Livelihood Empowerment Against Poverty Programme (LEAP)** – The LEAP Program is a social cash transfer program, which provides cash and health insurance to extremely poor households across Ghana to alleviate short-term poverty and encourage long-term human capital development. LEAP started a trial phase in March 2008 and then began expanding gradually in 2009 and 2010, and currently (June 2010) reaches approximately 35,000 households across Ghana with an annual expenditure of approximately USD11m. The program is fully funded from general revenues of the Government of Ghana, and is the flagship program of its National Social Protection Strategy.

  It is implemented by the Department of Social Welfare (DSW) in the Ministry of Employment and Social Welfare (MESW). Eligibility is based on poverty and having a household member in at least one of three demographic categories; single parent with orphan or vulnerable child (OVC), elderly poor, or person with extreme disability unable to work (PWD). Initial selection of households is done through a community-based process and is verified centrally with a proxy

means test. An exciting feature of LEAP, unique in the world, is that aside direct cash payments, beneficiaries are provided free health insurance through the new National Health Insurance Scheme, which began in 2004-05. This is facilitated through an MOU between the MESW and Ministry of Health; funds to cover enrolment in health insurance are transferred directly to the local health authority, which then issues cards to LEAP households. Continued receipt of cash payments from LEAP is conditional on a health insurance card.

To a very large extent most of the programmes have been direct government interventions and support from international organisations. Immense efforts have been put in place to involve the District Assemblies but there appears to be still challenges, particularly with regards to sustaining the processes and programmes. The process of planning, implementing and monitoring have all assumed a national dimension with very limited local inputs. Planning, implementation and monitoring of interventions from the national level presents several challenges including; ownership, relevance and sustainability.

3. Greenhouse Gas Inventory

This chapter provides information on the national GHG Inventory system, Methodology used and Results of the greenhouse gas inventory in three sections. The first section provides description of the national system for implementing the entire inventory, covering issues like institutional arrangement, inventory planning and management. The second section gives an overview of methodology used for the inventory estimation. At the third section, results and discussions of the inventory are provided.

3.1 Introduction

The greenhouse gas inventory (GHGI) is one of the reporting elements that Ghana has prepared in response to Article 4, paragraph 1(a) and Article 12, paragraph 1(a), of the Convention, which enjoins each Party to report on national emissions and removals to the Conference of the Parties (COP). The current GHG inventory, reports emissions by sources and removal by sinks for five major sectors, namely: energy, industrial processes, agriculture, land use land use change and forestry (LUCF) as well as waste. The major gases covered include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and perfluorocarbons. The current GHGI builds on the previous GHGI prepared under the initial

communication to ensure time series consistency and where necessary implement recalculation on relevant sectors or categories.

Though, Ghana is required to report on its greenhouse gas emissions for the year 2000 under the second national communication, it has chosen to report on the entire time series from 1990 to 2006. In some cases recalculations have been done for the entire time series from 1990 to 1996 as reported in the initial national communication due to the availability of new dataset and methods. The recalculation reflected better accuracy and consistency in the emission estimates. The methodology used was based on the Revised IPCC Guidelines for National greenhouse gas inventories. IPCC tier-1 methodology was adopted for the inventory except in a few cases such as in the energy and industrial processes sectors, where country-specific methodology was used. Generally, emission factors were derived from IPCC emission factor database, whereas most of the activity data were retrieved from various national sources and complemented with international data from FAO and IEA. Additionally, the preparation and reporting of this GHG inventory provided a number of other benefits to Ghana. These include:

- Provision of a basic framework for the development of low greenhouse gas emission growth plans.
- Provision of useful information for economic development assessment and planning, such as: information on the supply and utilization of natural resources (e.g., croplands, forests, energy resources) and information on industrial demand and production.
- Provision of functional information for addressing other environmental issues (e.g., air quality, land use, waste management, etc.)
- Analysis and capture of information on key categories on GHG emissions for effective prioritization and use of resources.
- Highlight and clarify national data gaps that, if filled, may be beneficial for other sectors and development objectives, e.g., vehicle fleet data, national fuel consumption data, and deforestation rates data.
- Provide basis for evaluating GHG mitigation options based on Ghana's national circumstances while pursuing cost-effective emission reduction/enhancement efforts comprehensively.

This chapter is summary of information provided in the National Inventory Report (NIR), which was produced as a standalone report. The NIR provided detailed information about the preparation and compilation of the national inventory.

3.2 National Inventory system

The national inventory system (NIS) in Ghana defines the institutional set-up and procedures for legitimate data collection, collation, analysis and archiving of all relevant information as was captured during the inventory. The institutional set-up includes; stakeholder institutions (such as government agencies, private and third party entities), assigned mandates and the channel for data provision and management. Though, there is no specific legal regime backing data sourcing from data repositories, official arrangements exist among key data providers within the national system which offer a platform for data sharing on timely basis.

The Environmental Protection Agency (EPA) under the Ministry of Environment Science and Technology is the Lead National Institution (LNI) coordinating all technical climate change activities including the GHGI. The Energy Resources and Climate Change Unit of the EPA is the mandated office coordinating the GHGI process. The Climate Change Focal Point chairs a technical review committee (TRC) that has oversight over the general direction of the greenhouse gas inventory preparation and compilation. EPA

designated the Environmental Application and Technology (ENAPT) Centre to coordinate the implementation of the Greenhouse Gas inventory activities, (including the preparation of the inventory estimates, key source analysis, QA/QC, uncertainty management, documentation and archiving and preparation of the inventory report) in Ghana. An ad-hoc national inventory team, comprising experts from the various inventory sectors (energy, industrial process, agriculture, LUCF and waste) was setup at the centre. The working team members were drawn from the various stakeholder institutions. The mandate of each working team was to conduct a complete inventory of GHG emissions by sources and removals by sink according to the IPCC guidelines and guidance. Each working team had a leader who made sure that the task of each team is undertaken in accordance with the IPCC guidelines and guidance. The various working groups for the sectors were tasked to carry-out identification and sourcing of key inventory datasets; prepare inventory estimates with supporting documents, make important decisions such as determining the appropriate level of disaggregation for data collection, decide which variables may require collection to enhance the input data, whiles maintaining good standard of work at the group level.

In addition to their assigned roles, experts from whose institution's data were being obtained were given additional roles to facilitate the sourcing of the data in-house. Members of the working team conducted data and logistic needs assessment and made requests through their respective leaders to ENAPT Centre. The Centre then forwarded the requests for data and other forms of assistance from the working teams to the EPA for further action. Data requests from EPA were made to the relevant institutions, indicating what form of data is required, timeframes, data format and the intended use of the data in the GHGI. The data collected for the inventory undergo several steps of administrative procedures for serialized documentation. Initial technical and quality evaluation of the activity data is done before transmission to the working teams through ENAPT Centre. First back-up copies are also made at ENAPT Centre.

The EPA has cordial working relationship with some of the data providers and institutions, which makes access to data easier, though such arrangements sometimes tend to be unreliable. In cases where data providers incurred cost in generating data, the EPA is constrained in fully accessing the data. Data providers in certain cases request data protection assurance and acknowledgement of data use in any further publications. Furthermore, in accordance to the Environmental Protection Agency Act, Act 490, 1994 and the Environmental Assessment Regulation, manufacturing companies submit annual report to the EPA. This also serves as good data source for the inventory. Final GHG emission estimates, trends and key categories are presented to EPA for final general quality control and quality assurance (QA/QC) to be carried out.

The QA/QC coordinators facilitate a two-layered review process to assess general correctness of the inventory-estimates, data choices, and emission factors and the consistency with IPCC guidelines and good practice guidance. The first layer of the QA/QC evaluation is an external review of the whole GHG by a third party in the country. The third party reviewers are selected from research and the academic institutions based on their requisite experience in the sector. Feedbacks from the first round of review are incorporated into the final estimates. International experts in GHGI undertake the second layer of the review if considered necessary. The review process is crucial to maintaining rigor and quality of the estimates, background assumptions and the methodologies used. Figure 3.1 shows the organizational arrangement of the national system.

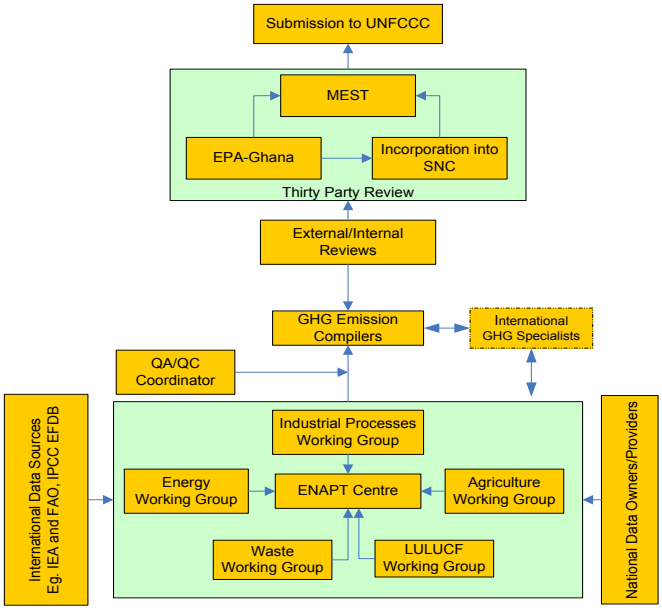


Figure 3. 1 Institutional Arrangement for National System for GHGI

The processes for implementing the national system are interactive and evolving with time. One aspect that has seen major improvements over the years is the increasing institutional awareness and participation. This has contributed immensely to facilitating data access from entities that generate relevant data for the inventory. It is, however, instructive to add that the entire institutional set-up for the GHGI will require legal backing or framework for effective mainstreaming across sectors. To the extent possible, mainstreaming processes must prioritize and address issues such as funding, strategies for capacity enhancement, measures for continuous data collection, collation and archiving systems.

3.3 Analysis of Total GHG Emissions by Sources and Removal by Sinks

3.3.1 Trends in GHG emissions and removals

Five direct greenhouse gases namely; CO_2, CH_4, N_2O, CF_4 and C_2F_6, each with different global warming potentials were covered by this inventory. Though 2000 is the UNFCCC reporting year for the preparation of second national communications by non-Annex I (NAI) Parties (Ref. decision 17/CP.8), Ghana has prepared a complete time series of GHG emission estimates from 1990 to 2006. The analysis of the results of the inventory was done for the year 2000. However, other years excluding the reporting year were also covered in order to provide guidance for policy formulation, among others. In accordance with IPCC guidelines, emission estimates for international marine and aviation bunkers were not included in the national totals, but were reported separately as memo items. Carbon dioxide (CO_2) emissions from biomass consumption were also reported as memo items in conformity with IPCC guidelines. In 2000, the total net greenhouse gas emissions (including LUCF emissions) in Ghana were estimated at 12.2MtCO_2e. This is 173% above the 1990 levels of -16.8MtCO_2e and 96% lower than 2006 levels of 23.9MtCO_2e. The total net greenhouse gas emissions increased by 242.3% from 1990 to 2006 (Figure 3.2). If emissions from LUCF are excluded in 2000, the total GHG emission in Ghana was estimated at 13.3MtCO_2e, which is about 49.4% above 1990 levels and 38% lower than 2006 levels. Without LUCF emissions, the total emissions increased by 107% from 9.3MtCO_2e in 1990 to 18.4MtCO_2e in 2006.

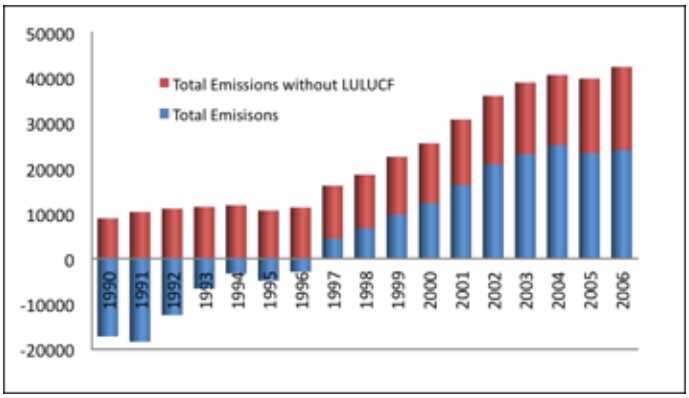


Figure 3.2 Trend of Total GHG Emissions with/without LUCF ($GgCO_2e$)

In terms of gases, carbon dioxide was estimated at 2.6 $MtCO_2e$, accounting for 19% of the total GHG emissions in 2000. This level of carbon dioxide emissions was 111% and 309% below 1990 and 2006 levels respectively. Methane emission was reported at 6.2 $MtCO_2e$ and formed 46% of the total national emissions in 2000 (with LUCF). This is an increase of about 83% from 1990 and nearly 28% lower than 2006 total methane emissions (Table 3.1).

Nitrous oxide emissions recorded 4.5 $MtCO_2e$ and constituted 34% of the total emissions in 2000. This was an increase of 54% from 1990 and 24% by 2006. F-gases (PFCs) emissions accounted for an average of 1.5% of total GHG emissions between 1990 and 2000 and diminished below 0% in 2004 due to the closure of a major aluminum production company in Ghana. Excluding LUCF, carbon dioxide was the highest source of emissions (6.3$MtCO_2e$) and accounted for 44% of the total GHG emissions in 2000. This level is 120% higher than the 1990 levels and 25% below 2006 levels. This was followed by methane with emissions of 4.9$MtCO_2e$ and was 34% of the 2000 total emissions. This increased by 62% and 32% by 1990 and from 2006 respectively. Nitrous oxide accounted for 22% of the total emissions in 2000. Figure 3.3 shows the proportion of GHG among gases.

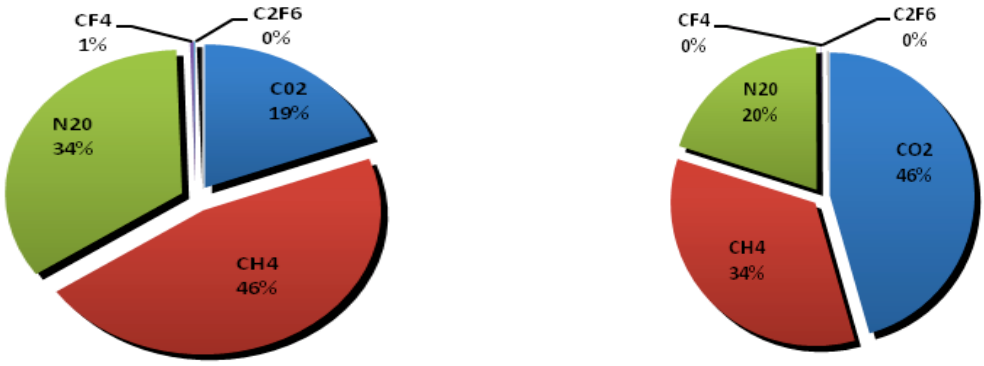


Figure 3. 3 Share of GHG by gases with LUCF in 2000 (chart on left) and 2006 (chart on right)

3.3.2 Total GHG Emissions by Sectors

Total greenhouse gas emissions as indicated by sectors are shown in Figures 3.4, 3.5 and 3.6. In 2000, the largest of GHGs contribution was from the energy sector, which contributed 41% of the total emissions, followed by agriculture (38%), waste (11%) and LUCF (-7%). The energy sector emissions increased from 3.3MtCO_2e in 1990 to 9.2MtCO_2e (Figure 3.5), representing a total increase of 183% between 1990 and 2006.Within this sector; the largest source was from transport followed by residential. Energy Industries, manufacturing industries and construction activities also had major impacts on the emissions from this sector especially in 2000 and 2006, respectively. The general rise in emissions from the sector could be attributed to the increasing fuel consumption in the growing number of thermal power generation plants, increasing fuel consumption and poor fuel efficiency in the road-transport sub-category, as well as rising biomass use in the residential sub-category.

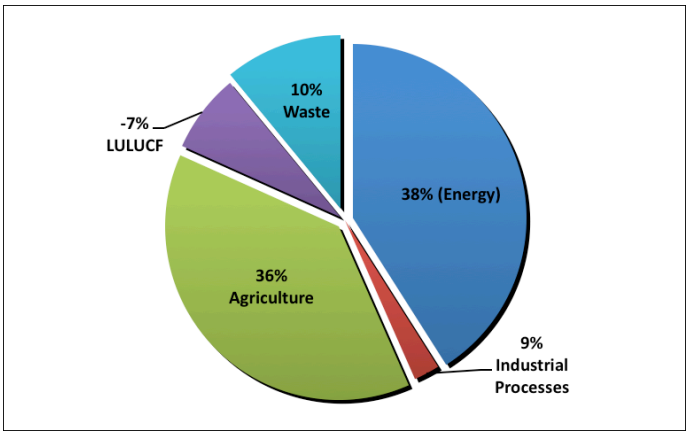


Figure 3. 4 Share of GHG emissions by sectors in 2000 ($GgCO_2e$)

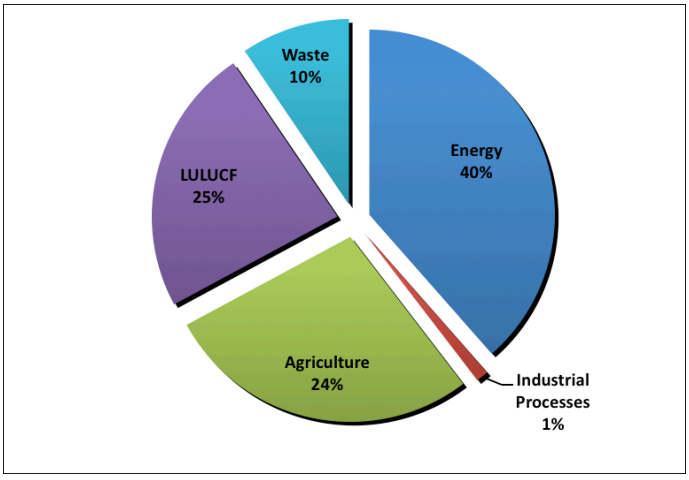


Figure 3. 5 Share of GHG emissions by sectors in 2006($GgCO_2e$)

The next largest source of emissions comes from the agricultural sector. The sector contributed approximately 36% to the total emissions. The emissions from the sector showed an overall increase of 20% from 1990 to 2000, and 44% increase from 1990 to 2006 levels. The general rising levels of agricultural emissions of about 44% between 1990 and 2006 reflects increasing trends in livestock numbers and emissions from fertilizer application. Within the sector, emissions from agricultural soils, enteric fermentation and rice cultivation have had significant impacts on the general emission (refer to the sectors for more details).

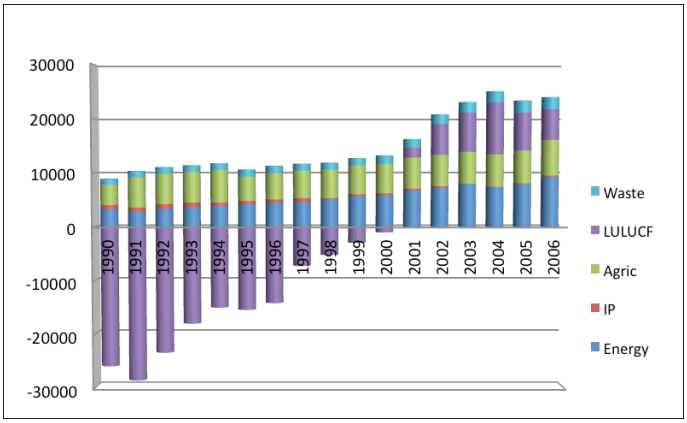


Figure 3. 6 Trends of emissions by sectors ($GgCO_2e$)

The LUCF sector contributed 7% of net removals from the total emissions in 2000. This represented a considerable decline in removals of nearly 66% in 1990 and some 32% below the 2006 levels. In 2001 and beyond, net emissions from LUCF amounted to a net emission source, peaked in 2004 and started to decline in 2005 and 2006. The marginal decline in total emissions generally reflects the sustained gains made in the successive government's reforestation and afforestation policies, and national plantation programmes as well as other sustainable forest management interventions. Within the sector, the increasing rate of forest and grassland conversions through deforestation activities was a major reason for the continuous decline in CO_2 removals from 1990 to 2004.

Emissions from the waste sector accounted for an average of 10% between 2000 and 2006, which is roughly 7% higher than the 1990 levels. The main sources of emission from this sector were from increased disposal of solid waste to deep landfill and wastewater handling systems. The increase in the sector's emissions is being driven by the increasing per capita solid waste generation and population increases especially in the urban areas of Ghana. Disposal of solid waste to landfills with relatively deeper depth and to sanitary landfill sites is increasingly becoming a common practice in urban waste management. The industrial sector contributed 2%, 3% and 1% of the total emissions in 1990, 2000 and 2006 respectively. Within the sector, metal production had been a major source of the total emissions. The general reduction in the emission from the industrial processes sector could be explained by the continued decline in metal production from the main aluminium smelter in Ghana.

3.3.3 GHG Emissions by Gases

3.3.3.1 Carbon Dioxide

The trends of carbon dioxide emissions from 1990 to 2006 by source category are presented in Figure 3.7.The total net CO_2 emissions increased from -23.6MtCO_2 in 1990 to 10.5MtCO_2e in 2006 (including LUCF). In 2000, an estimated 1.4MtCO2e net CO_2 emissions were recorded from three main sectors namely; energy, LUCF and industrial process. This upward trend (from 1990 to 2006) could be mainly attributed to the increases in forest and grassland conversion rates, increased fuel consumption for electricity production from thermal sources as well as increases in fuel consumption for transport. Without LUCF, the total CO_2 emissions were 2.9Mt, 5.1Mt and 7.8Mt in 1990, 2000 and 2006, respectively. In 2000, CO_2 emissions from the energy sector accounted for 55% of the net CO_2 emissions in Ghana (Figure 3.7) followed by 37% CO_2 removal from the LUCF sector and 14% from industrial processes.

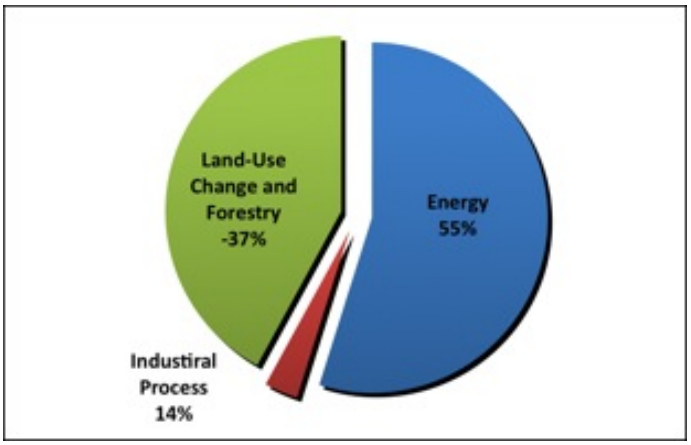


Figure 3. 7 Proportion of CO_2 emissions by sectors in 2000

Carbon dioxide removals from the LUCF sector reduced by 85.8% from -26.5Mt in 1990 to -3.7Mt in 2000 and 2001 (-0.91Mt). Beyond 2001, CO_2 emissions from LUCF increased from 2.8Mt in 2002 to 6.6Mt in 2004 before a marginal net emissions decrease to 3.9Mt and 2.6Mt in 2005 and 2006, respectively (Figure 3.8). The reductions in CO_2 emissions were attributed to consistent implementation of Government policies on national afforestation.

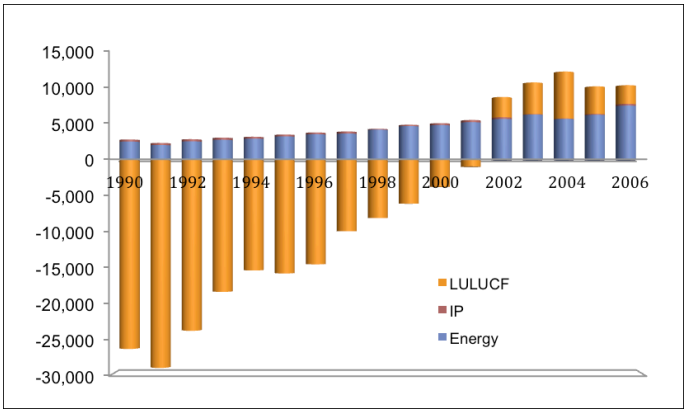


Figure 3. 8 Trends of CO_2 emissions by sector (in GgCO_2e)

CO_2 emissions from the energy sector increased from 2.6 Mt in 1990 to 4.8 Mt and 7.6 Mt in 2000 and 2006 respectively, representing a total increase of 195.8% from 1990 to 2006. It is also important to state that, in 2002 and beyond, both the energy and the LUCF sectors contributed to the sources of CO_2 emissions with the energy sector accounting for the most emissions till 2006, whereas in the LUCF sector, CO_2 emissions were declining. On the contrary, carbon dioxide emissions from industrial processes in 2006 decreased by 16.4% relative to 1990 levels. The decrease was attributed to the reduction in industrial production in mineral and metal products within the inventory period.

3.3.3.2 Methane

Methane emissions are reported from activities in energy, agriculture, LUCF and waste. The trend of methane emissions from 1990 to 2006 by source category is presented in Figure 3.9. Total CH4 emissions increased from 3.4MtCO_2e in 1990 to 7.9MtCO_2e in 2006 (including LUCF). In 2000, an estimated 6.2MtCO_2e of CH_4 emissions was recorded in Ghana. This represented 83.3% above 1990 levels and 27.5% below 2006 levels. This upwards trend (from 1990 to 2006) was attributed to the increases in enteric fermentation from the growing numbers of domestic livestock, rising disposal of waste on deep landfills as well as increases in biomass consumption in the residential and on-site burning of biomass. Without LUCF, the total CH_4 emissions dropped to 3MtCO_2e in 1990. This represented 62% below 2000 levels and nearly 32% below 2006 levels. In 2000, CH_4 emissions from the agriculture sector accounted for the highest (42%) of the total CH_4 emissions (Figure 3.9) followed by 23% from the waste sector, 21% from LUCF and 14% from energy.

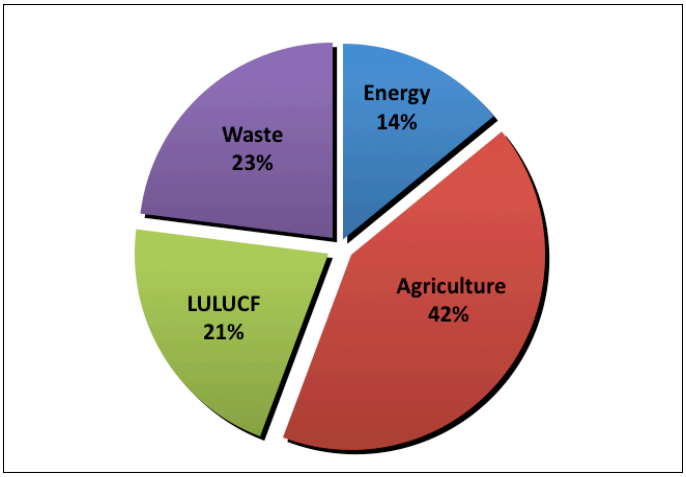


Figure 3. 9 Proportion of CH_4 emissions by sectors in 2000

CH_4 emissions from the agricultural sector dominated emissions from the other sectors from 1990 to 2006. This reflected increases from 0.09Mt in 1990 to 0.12Mt and 0.14Mt in 2000 and 2006 respectively, representing a total increase of nearly 55% of the total methane emissions from 1990 to 2006 (Figure 3.10). Comparatively, methane emission levels from the waste sector were lower, relative to agriculture, but it recorded a steady rise from 0.03Mt in 1990 to 0.07Mt and 0.1Mt in 2000 and 2006 respectively. Figure 3.9 also shows considerable increases in methane emissions from the LUCF sector, which rose by 0.045Mt above the 1990 levels in 2000 and 0.007Mt in 2006. This was due to activities in the forest and grassland conversions.

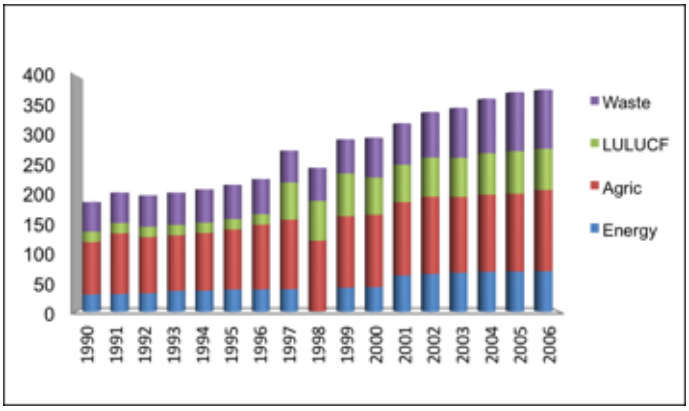


Figure 3. 10 Total CH_4 emissions by sectors

On the contrary, methane emissions from the energy sector saw a gradual increase in the entire time series from 0.029Mt in 1990 to 0.042Mt and 0.068Mt in 2000 and 2006, respectively. However, methane emission from the energy sector in 1998 was anomalously lower than the preceding year 1997 and therefore has been identified as an outlier to the trend.

3.3.3.3 Nitrous Oxide

Nitrous oxide emissions are reported from activities in energy, agriculture, LUCF and waste with the mass of the emissions recorded from the agricultural sector (64%), LUCF (30%), waste (3%) and energy (3%). The trend of nitrous oxide emissions from 1990 to 2006 by source category is presented in figure 3.10. The total N_2O emissions increased from 2.9 $MtCO_2e$ in 1990 to 5.6 $MtCO_2e$ in 2006 (including LUCF). In 2000, the total N_2O emissions amounted to 4.5 $MtCO_2e$. This represented 54% above the 1990 levels and 24% lower than the 2006 levels. There was an increase in N_2O emissions from 1990 to 2006, which was attributable mainly to the increases in applications of inorganic fertilizers to agricultural soils as well as increases in biomass consumption in the residential areas and on-site burning of biomass. The sharp increases from 1997 were the impact of the recalculation implemented in the LUCF sector.

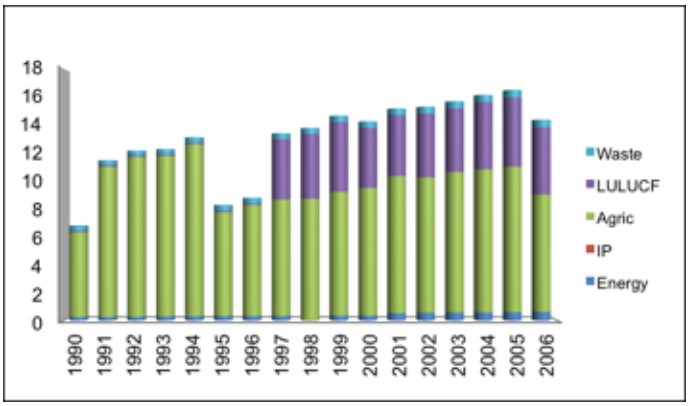


Figure 3. 11 Trends of N_2O emissions by sectors in Gg

Excluding the LUCF sector, the total N_2O emissions dropped by 0.12 Gg in 1990. This was about 49.5% below the 2000 levels and nearly 84% below the 2006 levels. The driving factor for the increases observed in the N_2O emissions without LUCF was primarily attributed to increases in application of inorganic fertilizers to agricultural soils and animal population. In 2000, N_2O emissions from the agriculture sector accounted for 64% of the total N_2O emissions (Figure 3.12) followed by LUCF sector, 30%, with waste and energy sectors recording 3% each.

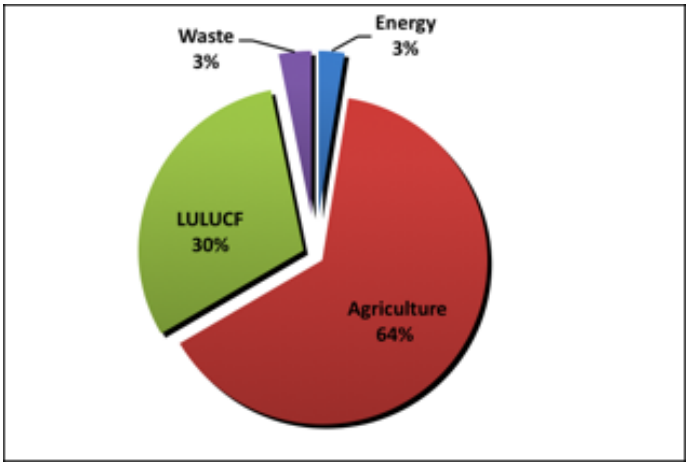


Figure 3. 12 Share of N_2O emissions by sectors in 2000 in Gg

3.3.3.4 Perfluorocarbons (CF_4 and C_2F_6)

Carbon Tetraflouride (CF_4) and Carbon hexafluoride (C_2F_6) emissions emanate primarily from metal and aluminium productions in Ghana. The PFCs emissions constituted 1% of the national total in 2000. The trend of CF_4 and C_2F_6 emissions from 1990 to 2006 is presented in figure 3.13. In general, CF_4 levels were higher than C2F6 throughout the time series. It was also observed that the levels of PFCs (CF_4 and C_2F_6) emissions decreased substantially from 0.5 $MtCO_2e$ in 1990 to 0.07 $MtCO_2e$ and 0.01 $MtCO_2e$ in 2000 and 2006 respectively. The main reason for the reduction in PFCs emissions was the dwindling and irregular production levels of aluminium in Ghana, as a result of decreased energy production from the only hydro power plant from which the aluminium company has contract for the supply of energy. In 2004 the plant was shut down due to inadequate supply of energy. Currently only one pot line is operational.

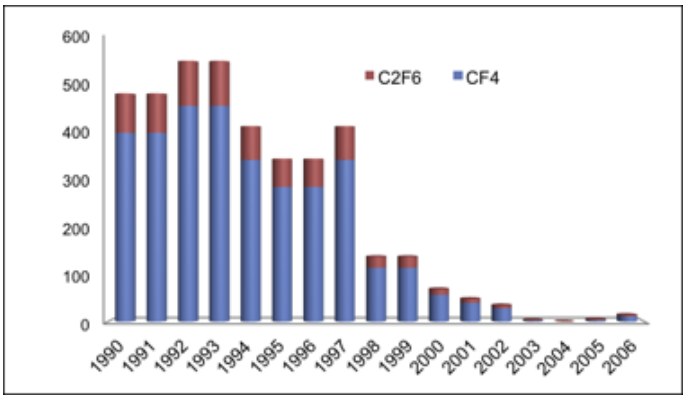


Figure 3. 13 Trends of PFCs emissions from 1990 to 2006 in $GgCO_2e$

3.3.4 Key Category Analysis

Key categories are defined as the sources of emissions or removals that have a significant influence on the inventory as a whole, in terms of absolute level of the emissions, the trend, or both. Key categories are those which, when combined in a descending order of magnitude, add up to over 95% of total emissions (level assessment) or the trend of the inventory in absolute terms. The analysis of key categories was performed on the basis of sectoral distribution, using the Tier 1 approach for level estimates. Trend-based key category analysis was not implemented because of the unavailability of the requisite uncertainty data. Level assessment was undertaken for 1990 and 2000 (reporting years) and 2006. The LUCF sector was included in the analysis of key categories. The results of the key category

analysis for 1990, 2000 and 2006 (including and excluding LUCF) are presented in Tables 3.1, 3.2, 3.3, 3.4 and 3.5.

Table 3. 1 Key categories including LUCF, 1990 (levels)

IPCC Category	Sector	Key Category	Gas	Cumulative level (%)
5A	LUCF	Changes in Forest and Other Woody Biomass	CO_2	60.2
5B	LUCF	Forest and Grassland Conversion	CO_2	76.2
5C	LUCF	Abandonment of Managed Lands	CO_2	82.0
4D	Agriculture	Direct and Indirect Emissions from Agricultural Soils	N_2O	85.1
5.D	LUCF	CO_2 Emissions and Removal from Soils	CO_2	88.0
1A.3	Energy	Mobile Combustion: Road Vehicles	CO_2	90.7
4A	Agriculture	Emissions from Enteric Fermentation in Domestic Livestock	CH_4	93.2

Table 3. 2 Key categories including LUCF, 2000 (levels)

IPCC Category	Sector	Key Category	Gas	Cumulative level (%)
5A	LUCF	Changes in Forest and Other Woody Biomass Stocks	CO_2	43.1
5B	LUCF	Forest and Grassland Conversion	CO_2	85.5
5C	LUCF	Abandonment of Managed Lands	CO_2	88.3
4D	Agriculture	Direct and Indirect Emissions from Agricultural Soils	N_2O	90.1
1A.3	Energy	Mobile Combustion: Road Vehicles	CO_2	91.8
4A	Agriculture	Emissions from Enteric Fermentation in Domestic Livestock	CH_4	92.8
5B	LUCF	Forest and Grassland Conversion	N_2O	93.7
5B	LUCF	Forest and Grassland Conversion	CH_4	94.6

Table 3. 3 Key categories including LUCF, 2006 (levels)

IPCC Category	Sector	Key Category	Gas	Cumulative level (%)
5B	LUCF	Forest and Grassland Conversion	CO_2	43.4
5A	LUCF	Changes in Forest and Other Woody Biomass Stocks	CO_2	84.8
5C	LUCF	Abandonment of Managed Lands	CO_2	87.3
5D	LUCF	Emissions and Removals from Soil	CO_2	89.4
1A.3	Energy	Mobile Combustion: Road Vehicles	CO_2	91.3
4D	Agriculture	Direct and Indirect Emissions from Agricultural Soils	N_2O	92.9
4A	Agriculture	Emissions from Enteric Fermentation in Domestic Livestock	CH_4	94.0
6A	Waste	Emissions from Solid Waste Disposal Sites	CH_4	95.0

Table 3. 4 Key categories excluding LUCF, 2000 (levels)

IPCC Category	Sector	Key Category	Gas	Cumulative level (%)
4D	Agriculture	Direct and Indirect Emissions from Agricultural Soils	N_2O	20.30
1A.3	Energy	Mobile Combustion: Road Vehicles	CO_2	39.10
4A	Agriculture	Emissions from Enteric Fermentation in Domestic Livestock	CH_4	50.20
2A	Industrial Processes	Emissions from Mineral Production	CO_2	58.60
1A.2	Energy	Emissions from Manufacturing Industries and Construction	CO_2	66.50
6A	Waste	Emissions from Solid Waste Disposal Sites	CH_4	73.80
4C	Agriculture	Emissions from Rice Production	CH_4	81.10
1A.4	Energy	Other Sectors: Residential	CH_4	87.50
6B	Waste	Emissions from Wastewater Handling	CH_4	90.70
1A.4	Energy	Other Sectors: Commercial	CO_2	93.20
1A.4	Energy	Other Sectors: Residential	CO_2	95.50

Table 3. 5 Key categories excluding LUCF, 2006 (levels)

IPCC Category	Sector	Key Category	Gas	Cumulative level (%)
1A.3	Energy	Mobile Combustion: Road Vehicles	CO_2	22.56
4D	Agriculture	Direct and Indirect Emissions from Agricultural Soils	N_2O	40.93
4A	Agriculture	Emissions from Enteric Fermentation in Domestic Livestock	CH_4	53.49
6A	Waste	Emissions from Solid Waste Disposal Sites	CH_4	65.39
1A.4	Energy	Other Sectors: Residential	CH_4	75.73
4C	Agriculture	Emissions from Rice Production	CH_4	83.37
1A.2	Energy	Emissions from Manufacturing Industries and Construction	CO_2	90.01
1A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing	CO_2	93.22

Table 3. 6 Total emissions/removals by sectors for the period 1990-2006 ($GgCO_2e$)

Sectors	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Total (with LUCF)	-16,758.38	-19,852.93	-14,232.00	-8,416.49	-5,250.95	-5,321.40	-3,386.89	4,436.2	6,653.3	9,771.7	12,213.2	16,267	20,812.6	23,085.8	25,077.6	23,358.3	23,984.4
Total (without LUCF)	9,292.59	8,851.04	9,271.97	9,639.48	9,805.02	10,160.57	10,819.08	11,726.6	11,893.4	12,766.6	13,259.8	14,441.9	15,127.9	15,811.7	15,500.6	16,412.6	18,370.4
Energy	**3,265.58**	**2,794.20**	**3,335.69**	**3,647.49**	**3,829.87**	**4,185.54**	**4,486.99**	**4,597.95**	**5,043.63**	**5,704.56**	**5,862.31**	**6,736.09**	**7,254.04**	**7,926.83**	**7,353.89**	**7,931.38**	**9,239.81**
Energy Industries	135.25	5.41	0.95	17.79	22.34	15.25	15.25	15.30	18.17	20.59	502.80	893.81	1,927.24	1,689.45	538.98	1,042.71	2,403.82
Manufacturing industries and construction	458.81	557.68	665.59	685.77	746.96	810.86	870.60	886.76	1,008.38	1,126.71	1,069.71	1,085.75	1,115.51	1,092.30	1,227.58	1,246.18	915.39
Transport	1,547.84	1,157.42	1,499.46	1,652.41	1,714.06	1,864.20	2,031.34	2,089.71	2,430.49	2,765.54	2,547.20	2,556.01	1,818.98	2,616.95	3,005.25	3,029.97	3,120.41
Other Sectors	1,123.69	1,073.70	1,169.69	1,291.52	1,346.51	1,495.23	1,569.80	1,606.18	1,586.59	1,791.72	1,742.60	2,200.52	2,392.31	2,528.13	2,582.08	2,612.52	2,800.19
Industrial Processes	**810.57**	**815.19**	**895.74**	**906.84**	**706.63**	**633.41**	**619.92**	**725.70**	**272.71**	**337.30**	**348.57**	**360.07**	**268.53**	**57.69**	**41.31**	**122.69**	**258.29**
Mineral products	14.13	16.85	21.45	23.83	26.49	32.17	32.20	33.47	32.13	35.04	34.74	29.04	30.21	32.94	41.31	92.60	129.75
Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Metal production	796.44	798.34	874.29	883.01	680.14	601.24	587.72	692.23	240.58	302.26	313.83	331.03	238.32	24.75	0.00	30.09	128.54
Agriculture	**4,578.45**	**4,564.12**	**4,391.12**	**4,368.88**	**4,480.38**	**4,680.06**	**4,835.00**	**5,131.47**	**5,242.13**	**5,359.96**	**5,481.66**	**5,723.98**	**5,827.66**	**5,891.89**	**6,001.47**	**6,086.74**	**6,600.52**
Enteric fermentation	1,360.72	1,272.55	1,240.05	1,244.25	1,293.39	1,211.19	1,337.61	1,399.11	1,399.11	1,463.49	1,496.85	1,521.04	1,515.04	1,603.98	1,631.99	1,659.71	1,724.18
Manure management	203.69	155.65	146.99	146.99	144.84	151.37	135.52	145.74	145.74	.41	148.32	149.23	137.43	154.33	153.78	158.21	159.35
Rice cultivation	411.6	797.2	669.5	648.5	672	839.2	884.1	988.7	988.7	982149.8	982.8	982.8	1,142.4	982.8	1,002.9	1,002.9	1,05
Agricultural soils	2,592.00	2,320.00	2,307.20	2,307.20	2,348.80	2,451.20	2,451.2	2,576	2,684.8	2,742.4	2,832	3,049.6	3,004.8	3,123.2	3,187.2	3,238.4	3,642.53
Field burning of agricultural residues	10.45	18.77	27.40	21.96	21.35	27.14	26.56	21.94	23.79	21.86	21.69	21.30	27.99	27.58	25.62	27.54	24.47
LUCF	**-26,050.9**	**-28,703.9**	**-23,503.9**	**-18,055.9**	**-15,055.9**	**-15,481.9**	**-14,205.9**	**-7,290.4**	**-5,240.1**	**-2,994.9**	**-1,046.6**	**1,825.1**	**5,684.7**	**7,274.2**	**9,577.1**	**6,945.7**	**5,614**
Changes in forest and other woody biomass stocks	-33,719	-36,372	-31,172	-25,724	-22,724	-23,150	-21,874	-39,013.8	-39,672.1	-40,195.8	-64,290.4	-63,578.6	-63,956.6	-64,903.5	-65,927.2	-67,137	-66,656
Forest and grassland conversion	9,344.5	9,344.5	9,344.5	9,344.5	9,344.5	9,344.5	9,344.5	34,243.5	36,854.5	39,509.8	66,073.9	67,616.5	71,204.7	72,145.8	76,561.9	74,847.8	73,034.9
Abandonment of managed lands	-3,292	-3,292	-3,292	-3,292	-3,292	-3,292	-3,292	-4,136	-4,136	-4,136	-4,136	-4,136	-4,136	-4,136	-4,136	-4,136	-4,136
CO_2 emissions and removals from soil	1,615.5	1,615.5	1,615.50	1,615.50	1,615.50	1,615.50	1,615.50	1,616.00	1,713.54	1,827.08	1,305.88	1,923.20	2,572.57	4,167.90	3,078.30	3,371.25	3,371.25
Waste	**637.98**	**677.52**	**687.82**	**716.27**	**788.14**	**853.57**	**877.17**	**1,271.46**	**1,334.88**	**1,364.77**	**1,567.25**	**1,621.85**	**1,777.74**	**1,935.28**	**2,103.90**	**2,196.39**	**2,271.75**
Solid waste disposal on land	393.12	425.25	436.80	450.45	515.34	574.98	591.57	713.61	769.72	784.76	985.87	1,033.78	1,173.94	1,325.49	1,487.70	1,558.41	1,633.80
Waste-water handling	244.86	252.27	251.02	265.82	272.80	278.59	285.60	557.84	565.17	580.01	581.38	588.07	603.80	609.79	616.20	637.98	637.95

3.4 Overview of Sectoral Inventories

Information provided in this section has been aggregated to provide synaptic shot of the sectoral contributions to the national greenhouse gas emissions. Specific detailed information relating to methodological, choices include choice activitiy data and emission factor as well as description of recalculation and improvement in the various sectors could be obtained from the NIR, 2010.

3.4.1. Energy

Emissions from the energy sector in Ghana represented the fastest growing source of greenhouse gas emissions. Total greenhouse gas emissions from the energy sector amounted to 5.9MtCO_2e in 2000. This represented an increase of 79.5% above 1990 levels and an overall increase of 182.9% between 1990 and 2006 (Figure 3.14).

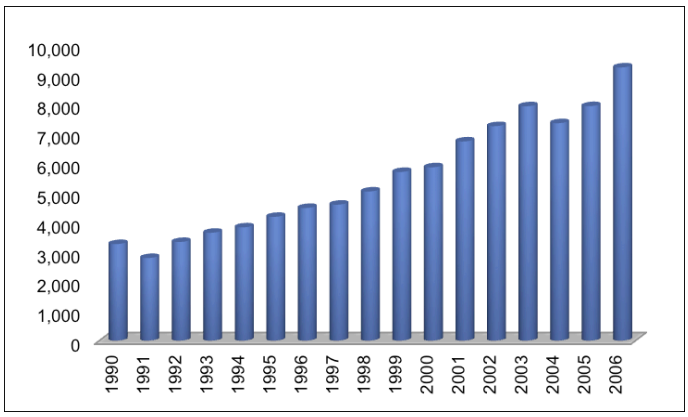


Figure 3. 14 Trends of total emissions in the energy sector ($GgCO_2e$)

Within the energy sector, transport was the largest source of emissions. The proportion of emissions from transport as a fraction of the total energy sector emissions, decreased by 13% from 1990 to 2006 (Figure 3.15. and 3.16). In 2000, emissions from transport accounted for 43% of the emissions from fuel combustion, which was 4% below 1990 levels. By 2006, emissions had also decreased by 11% below 1990. The main driver of the emissions in the energy sector was the increasing fuel consumption for power generation, for transport and other sectors of the economy, particularly mining and agriculture. Increase in fuel consumption within the transport sector was due to increasing vehicle fleets and poor fuel efficiency in the road sector.

However, the total transport emissions reduced by 9% from 2000 to 2006. One of the reasons that accounted for this reduction was the increased importation of fairly new vehicles into Ghana as a result of government policy on importation of used vehicles, which imposed an import duty penalty for 10-year old and over-aged vehicles. Secondly, the government's policy on the promotion of wider use of liquefied petroleum gas (LPG) as a substitute for fuel-wood for household energy, incidentally led to the increased use of LPG as fuel in the road sector, because prices became far cheaper than gasoline. Many commercial drivers rapidly converted their gasoline-based commercial passenger vehicles to LPG-based. The residential sector was the second largest contributor to the total energy emissions between 1990 and 2006, contributing to 32% of the total energy sector emissions. This was due to the increasing population and subsequent increase in consumption of biomass to meet domestic energy needs. In 2000, 18% and 9% of the total energy emissions were observed in the manufacturing, construction and energy industries respectively. In the energy industries sub-category, emissions increased by 5%, from the 1990 levels and further by 17% in 2006 (representing an overall increase of 19% from 1990 to 2006).

Increases in fuel consumption for thermal electricity generation and for refinery operations accounted for the rising emissions in the sub-category.

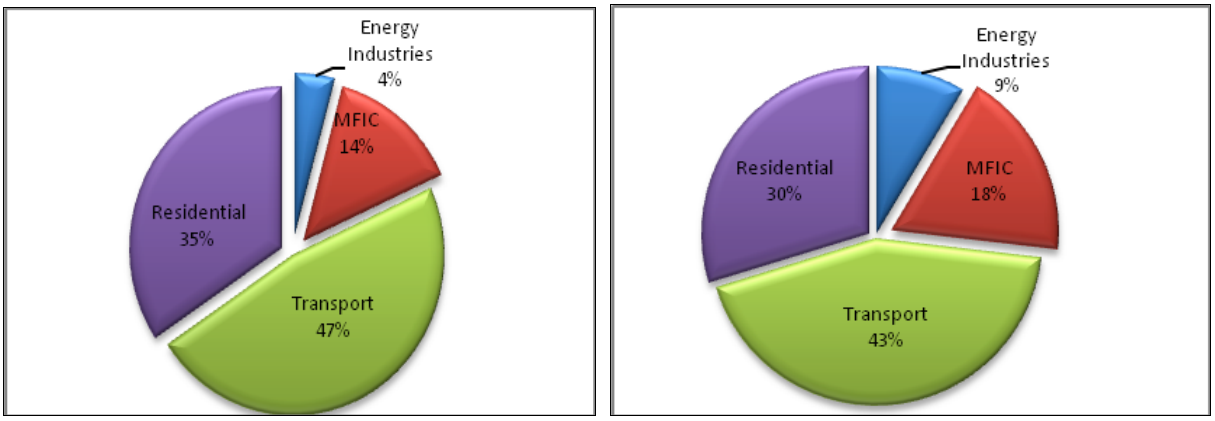


Figure 3. 15 Emissions in the energy sector in 1990 and 2000 ($GgCO_2e$)

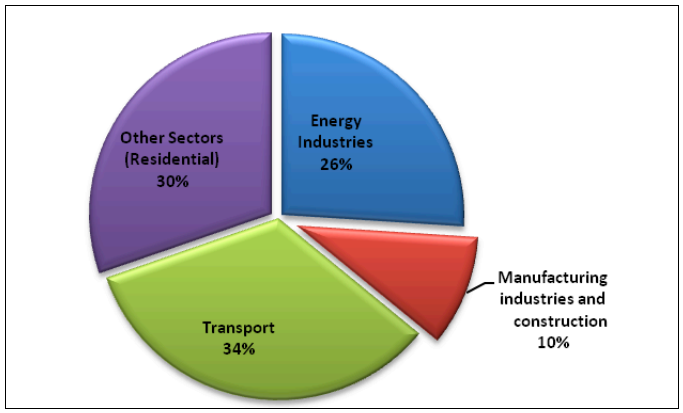


Figure 3. 16 Share of emissions in the energy sector in 2006 ($GgCO_2e$)

CO_2 emissions constituted the largest proportion of greenhouse gas emissions from the energy sector. On average it accounted for 81.3% for the period 1990 to 2006 (Figure 3.16). This was consistently followed by methane and nitrous oxide over the inventory period. In 2000, CO_2 emissions were estimated at 4.9 $MtCO_2e$ compared to 0.9 $MtCO_2e$ of methane and 0.1 $MtCO_2e$ of nitrous oxide. For CO_2, in 2000 this was 2.3 Mt higher than the 1990 levels and 2.7 Mt in 2006 (Figure 3.6). For CH_4, 0.9$MtCO_2e$ was estimated for 2000 and which was 0.3$MtCO_2e$ more than the 1990 levels and 0.6$MtCO_2e$ in 2006. Nitrous oxide also observed a similar trend.

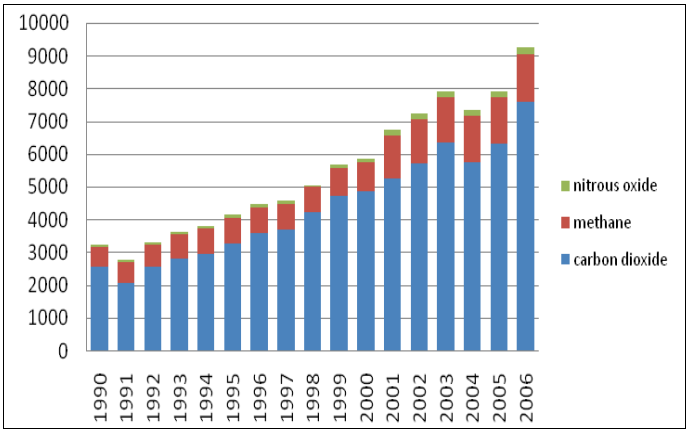


Figure 3. 17 Comparison of gases in the energy sector ($GgCO_2e$)

3.4.2 Industrial Processes

In this sector, emissions from mineral products (limestone use) and metal (aluminium) production were estimated for direct gases such as CO_2 and PFCs (CF_4 and C_2F_6). CO_2 emission was the largest source of GHGs reported during the period 1990-2006. CO_2 from metal production (particularly aluminium production) constituted an average of 74% of total industrial emissions throughout the time series whereas those from mineral products (limestone use) generally formed an average of 26%. In terms of general trends, the total emissions in the sector saw an irregular decline from 1990 to 2006 (Figure 3.18). This was due to a decline in industrial productivity and appropriate allocation of emissions to the corresponding emission source categories.

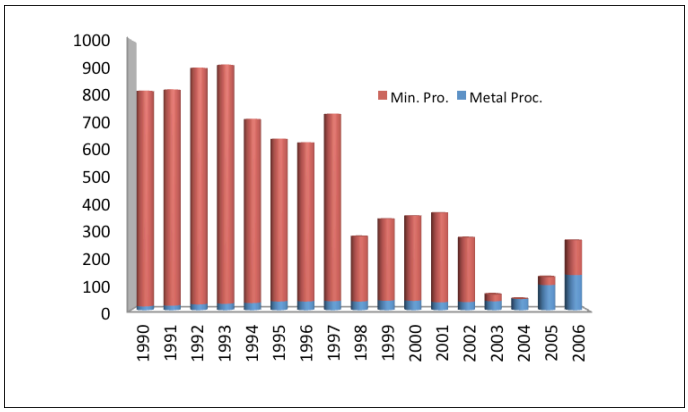


Figure 3. 18 Trends of total emissions by categories in the Industrial Processes sector ($GgCO_2e$)

From figure 3.18, emissions from metal production (aluminium) decreased from about 0.79$MtCO_2e$ in 1990 to 0.3$MtCO_2e$ in 2000 and further to 0.13MtCO2e in 2006. This represented an overall reduction of 89.5% by 2006 compared to 1990 levels. This could be attributed to the steady reduction in aluminium production, particularly in 2003 and 2005 where the only primary aluminium production plant operated

a single pot line and its eventual closure in 2004. The year 2004 had the minimum CO_2 emissions for the industrial processes because emissions came from only limestone use. This was because production of aluminium ceased due to the unavailability of electrical power. On the contrary, total emissions from limestone use under mineral products showed a gradual increase through the time series. In 2000, a total of 34.7GgCO_2e emissions from lime use were estimated. This amounted to 145.8% above 1990 levels and 273.5% increase in 2006 compared to 1990 levels. The rise in limestone use in Ghana has accounted for this change in trends.

3.4.3 Agriculture

In this sector, methane and nitrous oxide emissions from animal enteric fermentation, manure management, rice cultivation, agricultural soils and field burning of agricultural residues were estimated from 1990 to 2006. Nitrous oxide emissions are the largest greenhouse gas from the agricultural sector followed by methane. Total emissions from the agricultural sector increased steadily from nearly 4.6GgCO_2e in 1990 to 5.5GgCO_2e in 2000 and to 6.68GgCO_2e in 2006. This represented an increase of 44% of the whole time series (1990 to 2006), and an increase of some 20% from 1990 to 2000 (Figure 3.19).

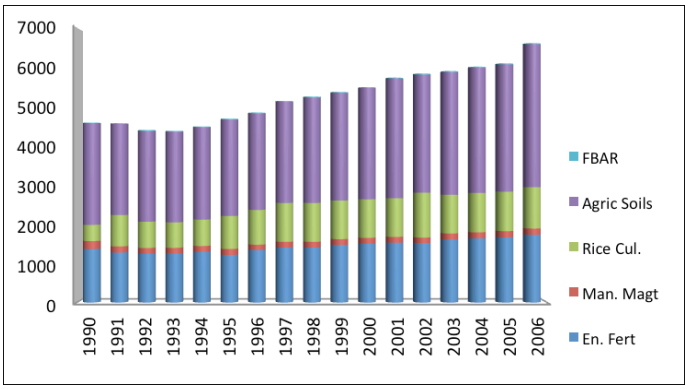


Figure 3. 19 Trends of total emissions by categories in the agricultural sector (GgCO_2e)

Within the sector, the largest source of emissions came from Agricultural soils throughout the time series. This was primarily due to the increases in the application of artificial fertilizers for agricultural production and from pasture, rangelands and grazing. The next largest contributor of agricultural emissions was from enteric fermentation of domestic livestock. The emission levels maintained a continuous but gradual increase from 1990 to 2006. This was followed by emissions from rice cultivation and manure management respectively, and similarly increased marginally over the time series (Figure 3.20). It is noteworthy that, emissions from field burning of agricultural residue were negligible compared to the other sub-sectors throughout the time series.

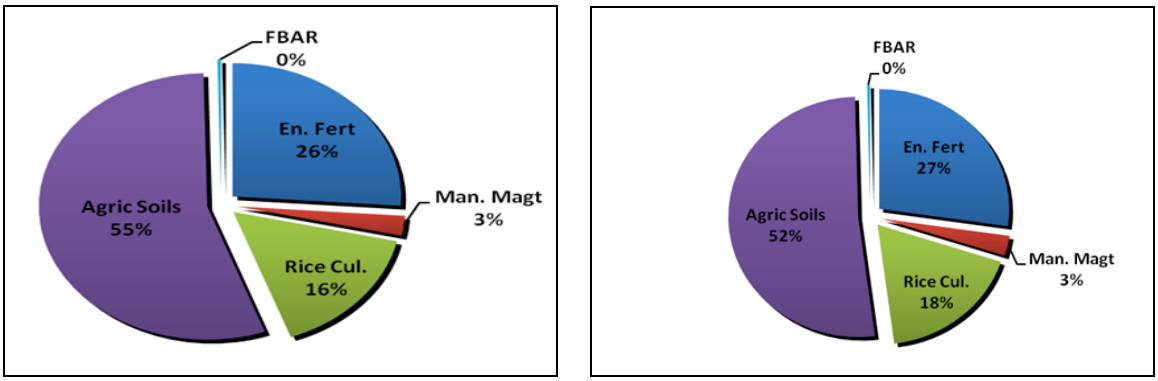


Figure 3. 20 Contribution of emissions from categories in the agricultural sector in 2000 and 2006

In terms of gases, N_2O is the largest from the agricultural sector compared to CH_4 throughout the time series. Between 1990 and 2000, N_2O emissions increased steadily by nearly 19.7% and the overall, N_2O emissions increased by 44.1% from 1990 to 2006 (figure 3.21).

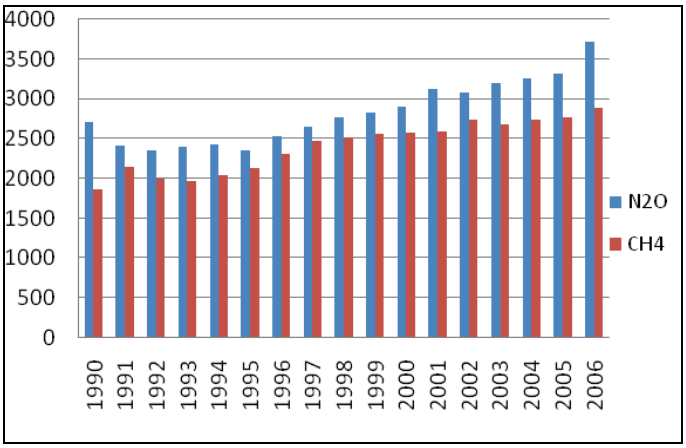


Figure 3. 21 Trends of N_2O and CH_4 in the agricultural sector ($GgCO_2e$)

Agricultural soils are the largest source of nitrous oxide emissions for the period 1990 to 2006. The total Nitrous oxides (N_2O) ranged from 2.9 $MtCO_2e$ in 1990 to 4.5 $MtCO_2e$ in 2000 and 5.6 $MtCO_2e$ in 2006. The contribution from burning of agricultural residues was significantly low. The values of emissions from manure management were next to the values obtained from the agricultural soils, with the highest value of about 6% in 1990. The emissions from manure management followed a consistent downward trend and reduced from 121.6 $GgCO_2e$ in 1990 to 64.00 $GgCO_2e$ (47.4% reduction) in 2006. Methane emissions were recorded from these categories; enteric fermentation, manure management, rice cultivation and field burning of agricultural residues in the agricultural sector, with enteric fermentation from domestic livestock being the largest source. In 2000, methane emissions from the sector were estimated at 2.6 $GgCO_2e$, thus representing 38.2% above the 1990 levels and 16.6% below the 2006 level. Overall methane emissions increased by 54.9% from 1990 to 2006.

Enteric fermentation from domestic livestock was the largest contributor of methane in the agricultural sector during the period 1990 to 2006. This was mainly due to the increasing numbers of domestic livestock such as ruminant animals. Specifically, non-dairy cattle were the major contributors, with the

values ranging from 54% in2006 to 63% in 1996. The contributions from sheep and goats appeared to be similar from 1990 to 1997, with values ranging from 17-20% for sheep and 17-22% for goats. However, contributions of goats from 1998 to 2006 were higher than those of sheep for all the years. Although the difference between the two was only 1% in 2000, this difference had risen to 6% by the year 2006. The observed differences were due to the differential increases in animal population over the years. The contributions from Horses, Asses and Swine were insignificant. Methane from rice cultivation was the second largest source of emissions from the agricultural sector. Emissions are mainly from rice cultivation in flooded fields, which increased by nearly 138% between 1990 and 2000 and by 155% for the period between 1990 and 2006. This finding confirms the claim of increase in local rice production especially for the time series. Methane emissions from both manure management and field burning of agricultural residues were minimal throughout the time series.

3.4.4 LUCF Sector

Between 1990 and 2000, net GHG removals from LUCF decreased nearly by 96% from-26.1 $GgCO_2e$ to -1.04 $GgCO_2e$. It further decreased to 5.6 $GgCO_2e$ in 2006. Net emissions from LUCF constituted a sink from 1990 and steadily depleted to 7% in 2000. After 2000, the sector contributed to emission sources, peaked in 2004 and reduced marginally in 2005 and 2006. Forest and grassland conversion category was the main source of emissions in the period between 1990 and 2006. It increased steadily from 20% of the LUCF emissions/removal in 1990 to 49% in 2000 and further to 50% in 2006 (Figure 3.22). Net emissions/removal from changes in forest and other woody biomass stocks was responsible for the removals. This category constituted -70% of the total net emission/removal from the LUCF sector in 1990 to -47% in 2000 and -45% in 2006.

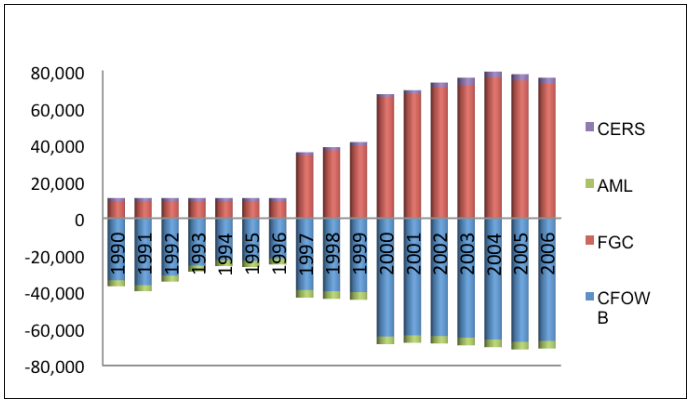


Figure 3. 22 Trends of total emissions by categories ($GgCO_2e$)

Forest and grassland conversion through deforestation activities was the major cause of the decline in CO_2 removal capacity (sinks) and increased emissions in the sector. Some of the activities included; agricultural intensification, predominantly in the middle deciduous eco-zones in the country, illegal logging, expansion of settlements, expansion of surface mining activities, and regular bush burning. Although, the trends of contribution of emissions from the sector increased from 2000 (Figure 2.23), it is important to recognize that increased government and private sector plantation initiatives impacted positively on the increases in the CO_2 removal capacity in Ghana. In addition, other government policies on sustainable forest management and forest conservation also contributed to managing and enhancing carbon stocks in natural and managed areas. This has generally aided in reducing net emissions from the sector since 2004. Removals of GHG through abandonment of managed lands decreased from -7% in 1990 to -3% and -3% in 2000 and 2006 respectively, even though this constituted a marginal portion of

the total of the LUCF emission/removals. The CO_2 emissions from soil averagely made up 3% to 2% of the total LUCF emissions between 1990 and 2000.

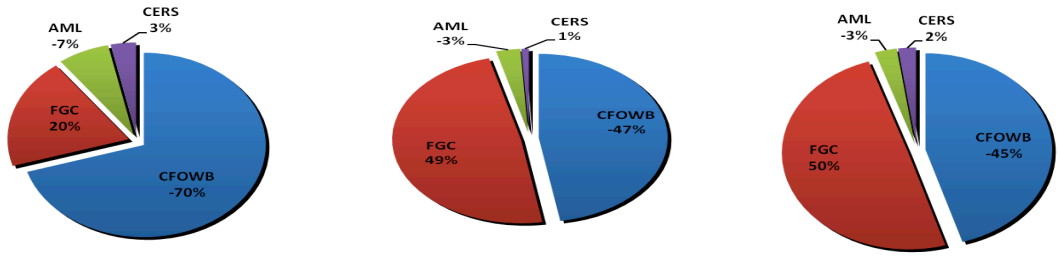


Figure 3. 23 Contributions of emissions from various LUCF activities (1990, 2000 and 2006)

CO_2 was the major source of greenhouse gas emission/removal from the LUCF sector compared to CH_4 and N_2O. In 1990, it constituted -97% (-26.7Mt) of the total LUCF emissions/removals and decreased by 39% to -3.7 Mt and further to 2.6 Mt. Though CH4 and N_2O represented small amounts of the LUCF emissions in 1990, they subsequently increased sharply in 2000 to 21% and further 26% in 2006 (Figure 3.24).

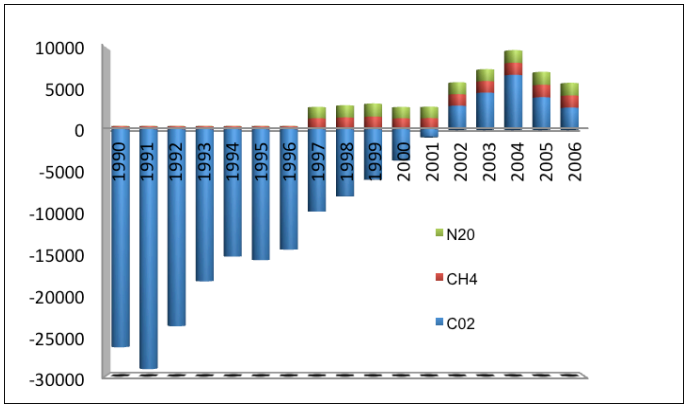


Figure 3. 24 Trends of emissions by gases in the LUCF sector ($GgCO_2e$)

Overall, CO_2 was the dominant emissions/removals in the LUCF throughout the inventory period (1990 to 2006), followed by CH_4 and N_2O. Whiles CO_2 emissions increased sharply over the years from -97% in 1990 to 47% in 2006, CH_4 and N_2O on the other hand recorded marginal increase from 1990 until 1997 when it increased to 26% in 2006. Figure 3.24 also shows the steady trend of reduction in the removal of CO_2 up to 2001 at an annual average of 9.6%.

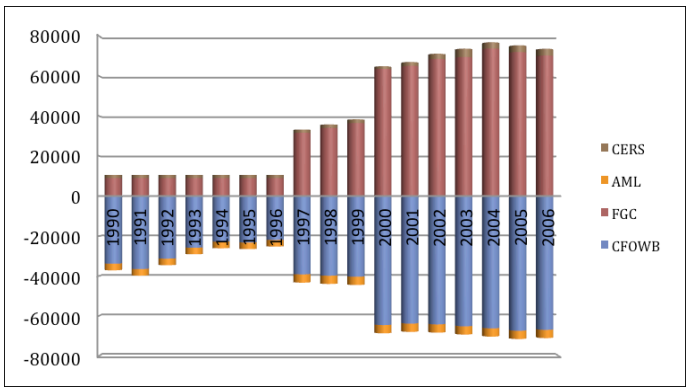


Figure 3. 25 Trends of net CO_2 share among LUCF categories

The two major important drivers of the trend in the CO_2 emissions have been the net increases in forest or woody biomass, and the growing rates of forest and grassland conversions. Figure 3.25 also shows that categories under forest and grassland conversions and CO_2 emissions from soil, respectively, were the main sources of CO_2, CH_4 and N_2O emissions in the LUCF over the inventory period with the former dominating.

3.4.5 Waste

Methane and Nitrous oxide emissions were reported in the following activities in the waste sector;

- (6A) Solid waste disposal: methane (CH_4) emissions and
- (6B) Wastewater handling: methane (CH_4) and nitrous oxide (N_2O).

Total emissions from the waste sector were 0.64, 1.6 and 2.3 $GgCO_2e$ in 1990, 2000 and 2006 respectively. This was 2%, 10% and 10% of the total greenhouse gas emissions in Ghana for the years 1990, 2000 and 2006 respectively. Overall, emissions increased by nearly 115% from 1990 to 2006 whereas in between 1990 and 2000, the emission increased by some 49%. Growing rates of per capita waste generation especially in the urban areas due to population increases and urbanization are generally driving the increases in emissions. Over the years, city authorities have increasingly shifted towards disposing solid waste in deep lands (crude dumping or sanitary landfills) without any policy of methane capture.

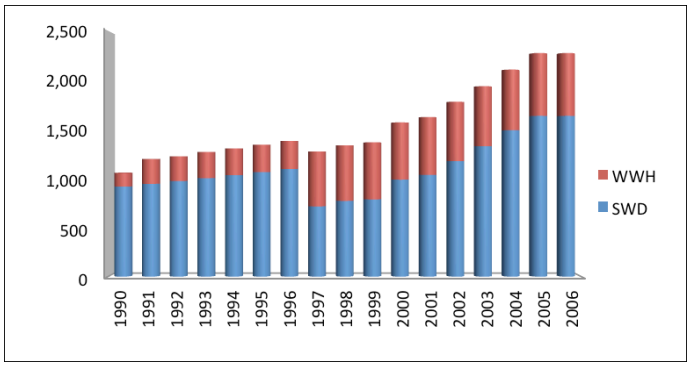


Figure 3. 26 Trends of total emissions by categories in the waste sector ($GgCO_2e$)

Within the sector, solid waste disposal on land was the largest source of emission through the period. In 2000, 1.0 $GgCO_2e$ of emission was estimated from solid waste disposal on land. This was about 150.8% above 1990 levels and nearly 65.7% lower than 2006 levels. Emissions from wastewater handling increased sharply by 317% between 1990 and 2000 and further by nearly 10% in 2006. This trend of emissions could be generally attributed to increases in commercial and liquid waste and the lack of proper systems for their management. Methane emissions were recorded in both 6A and 6B. In 1990, 0.5 $MtCO_2e$ of methane was estimated, which was nearly 0.89 $MtCO_2e$ and 1.6 $MtCO_2e$ below 2000 and 2006 levels respectively. Within the sector, solid waste disposal on lands was the largest source of methane followed by wastewater handling throughout the time series (Figure 3.27)

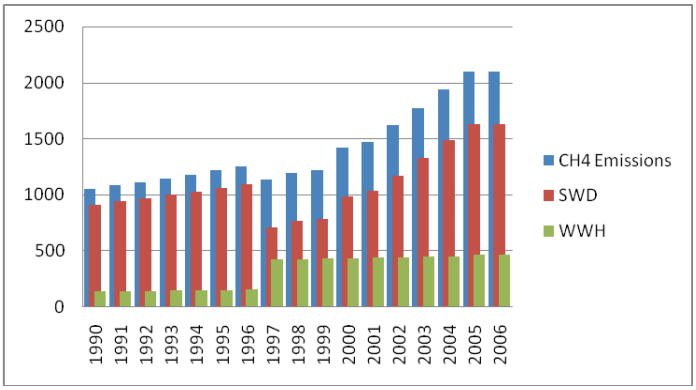


Figure 3. 27 Methane emissions by categories in the waste sector ($GgCO_2e$)

Wastewater handling was the only source of nitrous oxide emissions in the waste sector. It increased by almost 35% from 1990 to 2000 and further nearly 96% in 2006 (Figure 3.28). The levels of nitrous oxide emissions have been considerably influenced by the poor waste disposal practices of domestic and commercial liquid waste especially in the urban areas.

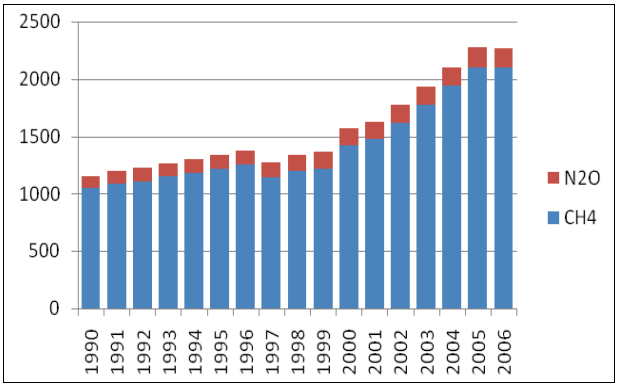


Figure 3. 28 Trends of emissions by gases ($GgCO_2e$)

3.5 Summary of General Information

3.5.1 General Assessment of completeness

An assessment of completeness for each sector may be found in the sector overview section of the corresponding sub-chapters. The following are the aggregated information on completeness.

3.5.1.1 Geographic coverage

The geographic coverage is complete. No region in Ghana has been left uncovered by the inventory.

3.5.1.2 Sectors (sources and sinks)

All sources or removals of direct GHG gases, included in the IPCC Guidelines, are covered in the inventory except some gaps in the following categories: Fugitive emissions from oil and gas (1.B1 and 1.B2) in the energy sector, chemical industry (2B) and other production (2D), consumption of halocarbons and sulphur hexafluoride, waste incineration (6C) and emission estimates from Solvent and

Other Product Use was not carried out due to lack of data. The general gaps in the completeness are mainly due to lack of activity data and the non-occurrence of the activity in Ghana.

3.5.1.3 Gases

Most direct gases are covered by the Ghanaian inventory. However, in the industrial processes sector, CO_2 and PFCs (CF_4 and C_2F_6) were covered except CH_4, N_2O and HFCs.

3.5.2 Information on QA/QC

Quality Assurance / Quality Control (QA/QC) is a key tool for ensuring accuracy, transparency, consistency and completeness in the GHGI. The QA/QC in the national GHG inventory was implemented in two layers. ENAPT Centre and QA/QC coordinator at the EPA implemented the first layer of the QA/QC. The main objective at this stage was to proof-check all GHG estimates, data and methods used in the inventory and ensures compliance to the IPCC guidelines and the good practice guidance. The output of this review was communicated to the sector experts for corrections to be done. At the working team level, experts and the lead group experts ensured that quality control protocols were followed rigorously and in compliance with the IPCC guidelines and the good practice guidance.

QC procedures at the working team level included data inquiry, data correctness and documentation, methodological choice in accordance with IPCC Good Practice Guidance and quality control checks for data from secondary sources as well as record keeping were fed into the first layer of QA/QC. In addition, all background assumptions and documentation about the data and methods were thoroughly verified for consistency. The second level of the QA/QC focused on quality assurance and it involved third party reviewers at the national level. The main activities here were related to different levels of reviews including the review of input data from experts, who were not directly involved in the GHGI. The National Inventory Report (NIR) received extensive international third party reviews. The third-party reviews were by experts from the following international bodies: United Nations Development Programme Office (UNDP), New York; UNFCCC, Bonn; and ECN, Netherlands.

Apart from the international reviews, comments from nearly 50 national experts were solicited through electronic Delphi-panel method. With the support from the UNDP, Ghana country office, a national GHG dissemination workshop was organized for the relevant stakeholders. The workshop afforded the opportunity to collect views and devise strategies for improving on the national GHG systems and the inventory process, and above all create awareness on the inventory among key partners. Though the present QA/QC arrangements are fairly workable to an extent, it is one of the major areas of the inventory that would require improvements, especially in terms of developing an elaborative QA/QC system for the entire inventory. This will contribute to ensuring that the national system is able to function well and deliver GHG estimates that are accurate, transparent, consistent and most importantly repeatable.

3.5.3 Areas of Improvements

3.5.3.1Improvements since INC

Recalculations

A number of recalculations have been performed since the submission of the previous inventory in order to improve on the consistency with respect to the IPCC guidelines. Recalculation was implemented

in the entire GHGI for the whole time series from 1990 to 1996. The recalculation was in three forms: **updating** existing activity data or emission factors (in all the sectors), **expanding** the inventory by including emissions from additional sources (e.g. sub-category 5.D under LUCF sector was added to the inventory in 2000)

Justification for recalculation

The reasons for the recalculations made, can be grouped as follows:

- Changes or refinements in methods. A methodological change occurs when an inventory agency uses a different tier to estimate emissions from a source category (e.g. for key source categories) or when it moves from a tier described in the IPCC Guidelines to a national method. Methodological changes are often driven by the development of new and different data sets. A methodological refinement occurs when an inventory agency uses the same tier to estimate emissions but applies it using a different data source or a different level of aggregation. In this latest inventory, new sets of data were included in almost all the sectors. For example, in the current inventory, emissions from sectoral-approach were included in the reference-approach in the CO_2 and non-CO_2 emissions of the energy sector. In addition, in 5.B under LUCF, new dataset was retrieved from remote sensing imagery on the various land classes and their change matrix. The imagery also helped in picking wildfire areas. The methodology for modeling transport emissions using COPERT III in the transport (1.A3) sub-category also contributed to the general improvement in the estimates.
- Inclusion of new sources. A new source is defined as a source for which estimates (all or some gases) did not exist in previous inventories either due to lack of data or because it has just been identified. Emissions from sub-category 5.D under LUCF were included in 1996 to 2006 due to access to data on carbon emissions from soils. Under Energy, emissions from sub-category 1A (other sectors-residential) were added.
- Re-allocation. This is as a result of changes in allocation of emissions to different sectors or sources/sub-sources. In this current GHGI, emission estimates from Emissions (CH_4 and N_2O) from prescribed burning of savannahs (4E) under the agriculture sector were re-allocated to forest and grassland conversion (5B) for the sake of consistency and availability of data in the LUCF sector.
- Correction of errors. This included errors associated with the calculation of emissions and inconsistencies resolved.

Planned Improvements

The inventory system of Ghana has experienced considerable improvements since the initial national communication. Yet, more need to be done to achieve substantial rigor and robustness. The planned improvements are to be implemented in phases over time. The broad areas identified for improvements over and above those identified in the sectors include:

- Developing relevant higher-tier methodology and emission factors of major key categories by levels and incorporate them appropriately in the subsequent inventories. This would ultimately improve accuracy and reduce potential underestimation.
- Conduct tier-1 uncertainty assessment using IPCC methodology for the entire inventory, all the sectors and in particular key categories in the next inventory. This will also improve transparency of the inventory.

- Conduct and incorporate key category analysis by trends using inputs from the uncertainty analysis.
- Within the national system, effective data management systems strategies (data collection, storage and archiving) will be pursued in the upcoming inventory cycle. In addition, institutional roles and responsibilities among stakeholders will be implemented, formalized and incentivized.
- Data generation and archiving in-between national communications is important to the sustainability of the inventory process. Ghana will vigorously follow this agenda.
- Develop and implement a comprehensive QA/QC plan for the next inventory cycle.

4. Description of Steps Taken or Envisaged to Implement the Convention

This chapter provides information on the description of steps taken or envisaged to implement the convention in Ghana. The information provided cover, in particular, institutional coordination of climate change in Ghana and other major UNFCCC-derived activities.

4.1. The Second National Communication Process in Ghana

The development of this national communication is considered a major step to implement the Convention in Ghana, particularly meeting its requirements under Articles 12 and 4 of the Convention. This second round of national communication builds on the initial national communication, which was completed in 2000. This communication reports on Ghana's efforts to facilitate implementation of the UNFCCC in 2000 to present. The UNFCCC processes also serve as a driving mechanism for making economic development in Ghana more responsive to national needs whiles addressing climate change resilience in a low carbon manner. Support for the preparation of the second national communication was received under "Enabling Activities For The Preparation Of Ghana`s Second National

Communication To the UNFCCC" project through UNDP-GEF funding mechanism. The preparation of the SNC was implemented in three stages (planning phase, preparation stage and compilation phases) and guided by an overarching institutional framework. The existing institutional arrangement formulated under the initial national communication was adequately rejuvenated and blended with new set of experts and institutions to ensure continuity and build on the existing experiences on the national communication process. Under the SNC, the Project Advisory Committee (PAC) and Project Steering Committee (PSC) were the highest body that provided the overall guidance and direction. The PSC was supported by the Project Manager (PM) and Assistant Project Manager (APM) who were also responsible for the administration of the project.

The planning phase was led by the Environmental Protection Agency (EPA) and constituted activities that facilitated the identification and access to information, data, and above all securing funds for the communication. Three main tasks were implemented at this stage. EPA constituted a technical drafting team to put together the second national communication proposal, following a stocktaking exercise that was done as part of the national consultation. Subsequent to the availability of funds from UNDP-GEF, an inception workshop was organised for key national stakeholders to create awareness, solicit institutional support for the SNC process, form various working teams, schedule tasks and responsibilities among working teams and discuss timelines for the SNC. The first stage took nearly 20% of the entire national communication cycle.

The preparation phase was core to the national communication process. It involved processes for collecting requisite data and analysing them as well as generating reports on various elements of the national communication. At this stage, each working team leader was given the responsibility to mobilise technical and financial resources through the Project Management Unit (PMU) for their respective teams. Progress of work among working teams was monitored through UNDP quarterly reporting system and progress reports sent to the SNC Project Management Unit (PMU) for onward submission to the Project Steering Committee. About 65% of the SNC time was spent here. The last stage was the compilation phase, which constituted 15% of the total time spent on the SNC. The main activities at this phase were the preparation, compilation of the composite SNC report and further internal and external third-party review. The review comments were incorporated before submission to the Ministry of Environment, Science and Technology for national authorisation.

4.2. Co-ordination of Climate Change and UNFCCC Activities in Ghana

Attention on climate change in Ghana is gaining leap momentum both at the highest political level and across sectors. At the policy level, climate change is being mainstreamed into the main national development, in particular, into Ghana's Shared Growth and Development Agenda, coordinated by the National Development Planning Commission (NDPC). Additionally, climate change had been selected under the environmental sector, and is receiving support under the "Natural Resources, Environmental Governance" (NREG) programme. The Ministry of Environment, Science and Technology (MEST) is the lead institution for climate change and UNFCCC activities in the country and the host of a functional National Committee on Climate Change (NCCC) (Figure 37). This committee is made up of representatives from relevant Ministries, Universities, Research Institutions, the Private sector and Non-Governmental Organizations (NGOs), and has been mandated under a Ministerial directive among other things to:

1. Formulate a National Climate Change Policy for Ghana that takes into account mitigation and adaptation actions necessary for sustainable national development and endeavour to ensure that the policy is integrated into planning processes at national, regional and district levels.

2. Envision for Ghana, mitigation and adaptation strategies for implementing the Climate Change Policy or otherwise review any existing sector strategies and associated action plan (s).

3. Recommend for the consideration of the Minister, Environment, Science and Technology (MEST), relevant area (s) of study that could provide a sound basis for comparative analyses of climate change adaptation strategies. Identify skills deficiencies within sectors and propose training needs for particular sectors, training modules and institutions for action by the sectors.

4. Evolve harmonized Climate Change programmes from all sectors especially in the key sectors of finance and economic planning, forestry, agriculture, land and water, health, energy and coastal zones management to ensure coherence and building of synergies among these sectors.

5. Source and utilize funding for the implementation of Climate Change mitigation and adaptation activities, and strengthen financial mechanisms for sustainable implementation.

6. Develop a communication strategy for Climate Change related matters in Ghana.

7. Prepare a common Ghanaian position in relation to the on-going Climate Change negotiations. Such a position should as far as possible be consistent and feed adequately into the overall African position, and ultimately the Group of 77 and China but highlighting national areas of difference.

8. Offer strong technical backstopping to the political leadership, Cabinet and Parliament in particular, to share the common African vision on efforts made to combat Climate Change in general and on the African climate platform.

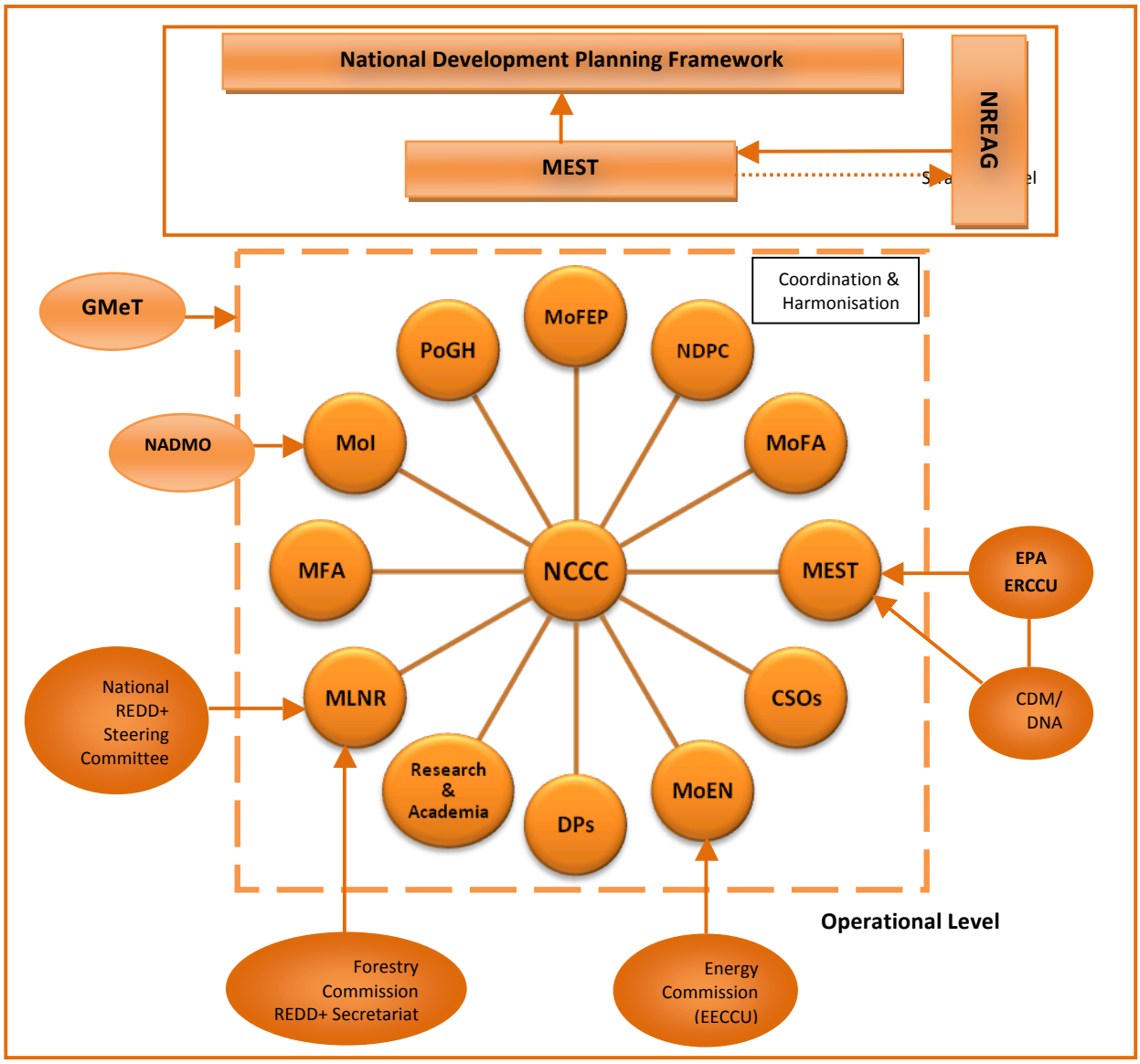


Figure 4. 1 Institutional Arrangement for Coordinating Climate Change Activities in Ghana

Source: *Tutu Benefoh, 2010*

Key*:*

NCCC – National Climate Change Committee, MoFeP: Ministry of Finance and Economic Planning, NDPC: National Development Planning Commission, MLNR: Ministry of Lands and Natural Resources, MoFA: Ministry of Agriculture, MEST: Ministry of Environment, Science and Technology, CSOs: Civil Society Organizations; ERCCU: Energy Resources & Climate Change Unit, EECCU: Energy Efficiency and Climate Change Unit, CDM/DNA: Clean Development Mechanism/Designated National Authority, MoEn: Ministry of Energy, DPs: Donor Partners, MFA: Ministry of Foreign Affairs, PoGH: Parliament of Ghana, MoI: Ministry of the Interior, NREAG: Natural Resource and Environment Advisory Group, GMeT: Ghana Meteorological Agency

Note*: This institutional arrangement does not represent the hierarchical flow of functions and roles within the national development planning process. The various institutions, particularly those involved in the processes of coordination and harmonization are only a representation of their respective institutions and contributions to the national climate change activities.*

The Ministry of Lands and Natural Resources (MLNR) is the lead national entity responsible for overall oversight and direction on REDD+ activities in Ghana. The National REDD Steering Committee, established in 2009 provides support to MLNR. The Ministry is also represented at the National Climate Change Committee. The Ministry of Finance and Economic Planning (MoFEP) is visible in the Climate Change agenda. Apart from their representation at the NCCC, the Ministry has been active in the national processes to mainstream climate change into national development planning. In the light of this, MoFEP has been nominated for accreditation as the National Operating Entity (NIE) to the Adaptation Fund Board. This is to legally enable MoFEP to function as the fiduciary administrator of the Adaptation Fund in Ghana. MoFEP is also leading an inter-ministerial collaboration under the Forest Investment Programme (FIP) initiative by the World Bank to support REDD+ implementation in Ghana. At the implementation level, the EPA is the main Country Implementing Institution (CII) for technical coordination of activities on climate change, the UNFCCC and some other environmental conventions ratified by Ghana. Within the Agency, a specialised unit on "Energy Resources and Climate Change" has been established to perform, inter alia, the following functions:

- Serve as the technical focal point on Climate Change and related issues in Ghana.
- Provide support to the Ministry of Environment, Science and Technology on core technical and implementation issues bordering on Climate Change and related issues.
- Lead in the facilitation and implementation of the various provisions of the UNFCCC.
- Serve as a nucleus for archiving and sharing Climate Change information to aid in national planning.
- Provide technical backstopping to the CDM/DNA

Apart from the Energy Resources and Climate Change Unit at the EPA, Ghana's Energy and Forestry Commissions have established Climate Change Units with special focus on forestry, REDD+ and energy efficiency, respectively. The REDD+ secretariat at the Forestry Commission in collaboration with the National REDD+ Steering Committee facilitated Forest Carbon Partnership Facility (FCPF) process with support from World Bank. The Natural Resource Governance desk at the Ministry of Finance and Economic Planning centrally coordinates the budget support programme under Natural Resource, Environmental Governance (NREG) programme and the Forest Investment Programme Initiatives.

4. 3. Extent of Implementation of the Kyoto Protocol in Ghana

4.3.1 Establishment of DNA

At its twenty-fifth sitting on 26th November 2002, the Parliament of the Republic of Ghana passed a resolution to ratify the Kyoto Protocol. The final instrument of ratification was submitted at the United Nations Headquarters in New York in March 2003 thus allowing Ghana to accede to the Kyoto Protocol and hence becoming a Party to it. The Kyoto Protocol entered into force globally on 16th February 2005. In fulfilling its obligation under Kyoto Protocol and in accordance with Decision 17/CP.7, Ghana established its Designated National Authority (DNA) under a ministerial directive and nominated the Environmental Protection Agency as the host. The EPA has constituted Governing Council for the Designated National Authority for the Clean Development Mechanism (CDM), for the purpose of protecting and improving on the quality of the environment, in terms of the implementation of the Kyoto Protocol. The members of the DNA governing council were drawn from the following institutions:

- Executive Director (Environmental Protection Agency) - Chairman
- Chief Director (Ministry of Environment and Science) - Member
- Chief Director (Ministry of Energy) - Member
- Chief Director (Ministry of Lands and Forestry) - Member

- Director (External Resource Mobilization Division, Ministry of Finance and Economic Planning) - Member
- Chief Director (Ministry of Trade and Industry) -Member
- Climate Change Focal Point (Environmental Protection Agency) -Member, Secretary

The following are the main functions of the governing council;

- Receives projects for evaluation and approval, per the guidelines and general criteria laid down in the relevant rules and modalities pertaining to CDM, in addition to the guidelines issued by the Clean Development Mechanism Executive Board and Conference of Parties, serving as Meeting of Parties (MOPs) to the United Nations Framework Convention on Climate Change. The evaluation process of CDM projects includes an assessment of the probability of eventual successful implementation of CDM projects and evaluation of the extent to which projects meet the sustainable development objectives, as it would seek to prioritize projects in accordance with national priorities.
- Recommends certain additional requirements to ensure that the project proposals meet the national sustainable development priorities, and comply with the legal framework, so as to ensure that the projects are compatible with the local priorities and to ensure that stakeholders have been duly consulted.
- Ensures that in the event of project proposals competing for same source of investment, projects with higher sustainable development benefits and which are likely to succeed are accorded higher priority.
- Carries out the financial review of project proposals to ensure that the project proposals do not involve diversion of official development assistance in accordance with modalities and procedures for Clean Development Mechanism. It also ensures that the market environment of the CDM project is not conducive to under-valuation of Certified Emission Reduction (CERs) particularly for externally aided projects.
- The DNA carries out activities to ensure that the project developers have reliable information relating to all aspects of CDM. These include creating databases on organizations designated for carrying out activities like validation of CDM project proposals and monitoring and verification of project activities, and to collect, compile and publish technical and statistical data relating to CDM initiatives in Ghana.
- The secretary of the Governing Council of the DNA is responsible for the day-to-day activities of the Authority, including constituting committees, sub groups or ad hoc committees to coordinate and conduct detailed examination of the CDM project proposals.

The Governing Council of the Designated National Authority has the powers to:

- Invite officials and experts from Government, financial institutions, consultancy organizations, non-governmental organizations, civil society, legal profession, industry and commerce, as it may deem necessary for technical and professional inputs and may co-opt other members if their services are required.
- Interact with concerned authorities, institutions and individual stakeholders for matters relating to CDM.
- Take up any environmental issues pertaining to CDM or sustainable development projects.
- Recommend guidelines and principles to be followed for CDM projects according to host country approval.

4.3.2 CDM Capacity Development Initiatives in Ghana

National Clean Development Mechanism (CDM) approval guidelines have been developed to assist in assessing how CDM projects contribute to sustainable development. The DNA with support from the United Nation Development Programme (UNDP, Ghana Office) undertook a number of capacity building and CDM promotion programmes for potential project developers, relevant government institutions, businesses, particularly, financial institutions. The capacity building programmes were aimed at facilitating CDM development in Ghana. In terms of international support for institutional capacity development, Ghana has benefited from a number of CDM capacity development initiatives. Ghana was among the list of countries that received capacity development support for Clean Development Mechanism Projects (CD4CDM) currently implemented by the United Nations Environment Programme (UNEP), through its UNEP RISOE Centre in Denmark (URC) with financial support from the Government of the Netherlands.

The project aimed at generating a broad understanding of the opportunities offered by the CDM in participating developing countries, and developing the necessary institutional and human capabilities to formulate and implement projects under the CDM. The DNA, Kumasi Institute for Technology and Environment (KITE) and Energy Foundation (private entities) in Ghana collaborated on this project. Apart from building the capacities of the DNA and other partners, the project supported development, launching and maintenance of CDM web portal for Ghana. Ghana also benefited from the Green Facility Project among a number of African countries where CDM projects are heavily underrepresented. The DNA and ENAPT Centre undertook the Green Facility Project in collaboration with UNEP RISOE Centre (URC) and financial support from the Government of Denmark through DANIDA. Under the phase 1 of the project, two project developers, Zoomlion Ghana Limited and Ghana Water Company Limited, were assisted (technical and financial) to prepare project idea notes (PINs) for two CDM projects on waste to compost in Accra and energy efficiency on the Kpong water supply system in Greater Accra. Phase II of the Green Facility Project is intended to support project developers to further develop the PIN into project design document (PDD) toward final registration.

It supported processes for matchmaking project developers with potential financiers. The DNA and the Energy Commission received training from the government of Austria through Energy Changes Projektentwicklung GmbH to develop and update national grid emission factor in 2008 and 2009, respectively. The training focused on the calculation of combined margin emission factor of Ghana's electric power system according to the UNFCCC Methodological tool (tool to calculate the emission factor for an electricity system). Though some level of success has been recorded in institutional, systemic and individual capacity development, Ghana intends to focus on scaling up involvement of the private sector, increase the technical capacity for project development and above all provide the needed policy and technical environment for CDM projects development.

4.3.3 CDM Projects Development in Ghana

Despite the deliberate national efforts to facilitate CDM development in Ghana, Ghana is yet to register a CDM project, although there are a number of projects at different stages of the CDM pipeline. For example, there is one reforestation project at validation stage, and four afforestation and reforestation methodologies proposed. There are also five CDM projects at the Project Development Document (PDD) stage and many other Project Idea Notes (PINs). According to the World Bank, Ghana has the potential to generate $45 m-100 m worth of carbon revenues per annum especially in the areas of: fuel switch, energy efficiency, avoidance of gas flaring, renewable energy and transport. However, the development

of CDM projects targeting voluntary carbon markets has been comparatively forward-looking across sectors. Ghana faces a number of challenges in the development of CDM. Though the challenges border largely on under capacity, high upfront transaction costs and above all, risks, they could be categorized under: institutional, policy, data management and financial.

4.4 Major Climate Change Enabling Activities in Ghana

In Ghana, climate change is being mainstreamed into Ghana's Shared Growth and Development Agenda which is the highest political and development strategy for government. In this regard, Ghana is completing the preparation of its Climate Change Policy Framework to facilitate climate change mainstreaming.

4.4.1 Development of Climate Change Policy Framework

The Ghana government recognises that climate change affects sensitive economic sectors, and requires a multi-sectoral response. Ghana is now formulating a National Climate Change Policy Framework (NCCPF) as part of the work plan of the cross-sectoral National Climate Change Committee, hosted by the Ministry of Environment Science and Technology (MEST). The NCCPF aims to "ensure a climate resilient and compatible economy while achieving sustainable development and equitable low carbon economic growth for Ghana".

The process of the development of the NCCPF, based on consultation and engagement, is designed to ensure that it is integrated fully into Ghana's main planning processes at national, regional and district levels. The NCCPF builds on feedback from consultations with key stakeholders that began earlier in 2010 and uses illustrative examples to spark robust debate and active engagement on this critical issue across society and the economy. The National Climate Change Policy Framework (NCCPF) has three objectives: 1) low carbon growth, 2) effective adaptation to climate change and 3) social development. The achievement of these objectives must be built on seven systemic pillars:

- Governance and coordination
- Capacity building
- Research and knowledge management
- Finance
- International cooperation
- Communication
- Monitoring and reporting

The next step is the awareness creation of the NCCPF among policy and decision makers and stakeholders. Climate Change touches every part of the Ghanaian society, and every part of society must be engaged for comprehensive and effective response. As well as engaging stakeholders at the national level, the NCCPF is actively seeking international support on Climate Change to safeguard and accelerate the progress of sustainable development in the country.

4.4.2 Integrating Climate Change and Disaster Risk Reduction into National Development, Policies and Planning in Ghana

With support from the UNDP, the NDPC in collaboration with the EPA and National Disaster Management Organisation (NADMO) is facilitating mainstreaming of Climate Change (CC) and disaster risk reduction (DRR) into national development (planning levels in national, regional, district and across sectors). The mainstreaming is being piloted in 10 Districts Assemblies (DAs). The DAs were selected based on regional and ecological balance and above all, Climate Change vulnerabilities and socio-economic burden or risk. The mainstreaming process culminated into the development of a guidebook

for “integrating climate change and disaster risk reduction into national development, policies and planning in Ghana”. The guidebook was intended to facilitate the integration of climate change and disaster risk reduction into national, regional, sector and in particular district plans and programmes. Apart from the guidebook, the twelve (12) thematic policy briefs touching on various subject-areas of Climate Change, including; national development planning, agriculture and food security, disaster risk reduction, coastal resources, education, energy, forestry and bio-diversity, health, human settlement, tourism and transport have been developed to facilitate upstream or high-level awareness on climate change. These “policy briefs” cover some of the key issues in each sector or theme and are not meant to be an exhaustive analysis for an over-arching Climate Change-proofing. The policy briefs are meant to be the start of advocacy for inclusion of these issues for policy review, policy amendment and defining new directions for actions in Ghana, thereby strengthening the on-going work. Generally, the briefs provide overview of sector policies and how they could be made climate compatible within the national development framework.

4.5 Synergies between Climate Change and Other Multilateral Environmental Conventions

Ghana endeavoured to meet its international obligations under various multilateral environmental conventions, treaties and protocols. Ghana has ratified the three Rio Conventions and taken active steps to meet its obligations. Ghanaian stakeholders recently undertook a comprehensive, participatory assessment of the capacities needed to implement the Rio Conventions – the National Capacity Self-Assessment (NCSA). Under the NCSA with support from UNDP/GEF, Ghana conducted capacity self-assessment to meet its commitments under three Rio Conventions, namely the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Convention on Biological Diversity (UNCBD) and the United Nations Convention to Combat Desertification (UNCCD).

The NCSA sought to address the capacity needs of the country along the main building blocks for capacity development – systemic needs, institutional and human resource capacity needs, with emphasis on exploring the synergies between the capacity needs for the three Conventions so as to maximize on the utilization of scarce resources. All the three (3) conventions are influenced by climatic variables and water resources. In-depth analysis of the capacity needs of the three Conventions revealed the following common and crosscutting issues, which offer themselves for complementary and synergistic implementation actions. Listed below are some of the common features.

- The three Conventions stipulate that there should be inter-agency coordination, supported by science through public dissemination of information.
- Implementation of the activities under the Conventions should be subjected to
- Environmental Impact Assessment (EIA) and must build the capacity for effective implementation through training and awareness creation.
- The three Conventions have common obligations with respect to land use, utilization of forest products and sustainable soil management for agriculture and forestry.
- The Conventions deal with demographic characteristics, such as population density, poverty and encroachment of settlements, which can result in natural resource degradation, and emission of greenhouse gases.
- All the three Conventions require the establishment of indicators to monitor and control trends and forecast the occurrences of events that hinder sustainable management of natural resources.

- It is a requirement of all three Conventions to establish a National Secretariat to oversee the activities under the Conventions, such as development of national communications, mitigation and adaptation projects and action plans.
- The implementation of the Conventions requires the participation of stakeholders such as governmental agencies and organisations, local authorities, the private sector, the academic and scientific community, NGOs and civil society and the media.

The recommendations that Government of Ghana assesses the possibility of bringing all multilateral environmental agreements (MEAs) under the proposed national conventions coordinating authority culminated in the UNDP-GEF funded project on establishing an effective and sustainable structure for implementing multilateral agreements.

4.5.1 UNDP-GEF Funded Project for Establishing Effective and Sustainable Structure for Implementing Multilateral Agreements (GECCA Project)

This project "Establishing Effective and Sustainable Structure for Implementing Multilateral Agreement" is funded by UNDP-GEF and hosted by the Ministry of Environment, Science and Technology (MEST). The project is a follow up to the priority recommendation from the NCSA process to assess the possibility of bringing all multilateral environmental agreements (MEAs) under the proposed national conventions coordinating authority. The project objective is to improve the institutional structures and mechanisms for implementing the Rio Conventions in Ghana, so that they generate global environmental benefits and contribute to poverty alleviation. Three key strategic pillars are set to drive implementation of this project.

The first pillar of the strategy is to bring the existing institutional structures for the three Rio Conventions into one structure. Under the leadership of MEST, all on-going initiatives with governmental involvement and related to the Conventions will be brought into a single structure. For example, existing internationally supported projects that target the implementation of the UNCBD and UNCCD have agreed to be brought into this structure. This structure will consist of a single Ghana Environmental Conventions Coordinating Authority (GECCA) and a Secretariat to service the GECCA. The GECCA and its Secretariat will be backed up by a national Law and budget allocation. The GECCA and its Secretariat is envisaged as the entry point for all international, national and local bodies. The GECCA is designed in order to respond flexibly to the political and technical requirements under each Convention, whilst maintaining a coherent structure and synergies across the Conventions. The second pillar of the strategy is 'capacity-building by doing' for the structure and the third pillar of the project strategy recognizes that, ultimately, the most important Convention stakeholders are at the local level.

GECCA was established at the Ministry Environment, Science and Technology in 2009. The Authority is chaired and hosted by MEST and made up of relevant MDAs, NGOs and others that are currently members of the UNCBD, UNFCCC and UNCCD Committees/Commissions. The first year operations had been mostly financed by GEF, and henceforth, will be primarily financed by Government of Ghana. In the future, a detailed business plan will be developed for the Secretariat. This business plan will establish its structure, staffing, activities, targets, financing and monitoring. It is likely that the Secretariat will, by the end of the project, be performing the following tasks and functions:

- Housing the Focal Points for GEF and the three Rio Conventions;
- Taking the lead in mainstreaming Rio Conventions into sectoral activities and practices;
- Overseeing data collection, storing, dissemination and clearing

4.5.2 Ghana's Contribution to International Climate Change Process

Below is a summary of Ghana contribution to the international Climate Change process:

- **Climate Change Negotiations:** Ghana is actively participating in the Climate Change negotiations both at the UNFCCC, regional and the sub-regional levels. Particularly, at the level of UNFCCC, Ghana has contributed to the development of a number of climate solutions and mechanisms, which are aimed at facilitating implementation of the convention. 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 Africa position on various negotiation issues, as well as participating in activities to develop common climate change framework for the ECOWAS sub-region. Ghana is also represented at the ECOWAS climate change committee.
- Ghana had once and 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

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

5. Measures to Facilitate Adequate Adaptation to Climate Change

This chapter addresses Adaptation to Climate Change in three parts. The first part deals with the various attempts to construct Climate Change Scenarios at the national scale over a long-term. The results of the Climate Change Scenario development fed into the sectoral impacts, vulnerability and adaptation assessments in the second part. The assessment covers new sectors that were not dealt with during the initial national communication. Based on the assessments, the various strategies are being developed to facilitate adequate adaptation to Climate Change. This is captured in part three of this chapter.

5.1 Construction of Climate Change Scenarios

5.1.1 Background

Climate Change scenarios were developed for the purposes of assessing the impacts of Climate Change on human health, fisheries, cocoa production, land management- including land degradation, wildlife and biodiversity, in addition to linkages with poverty as well as roots and tubers. Analysis of trends in observed time series of temperature and rainfall, between 1961 and 2000 (base year) have been conducted and presented as graphs. Scenarios for mean daily temperature changes with respect to 1961

to 1990 baseline, as well as projected mean daily temperatures for thirty-year periods for 2020, 2050 and 2080, have been provided for each of the six eco-climatic zones of the country. Similar scenarios for rainfall including mean daily rainfall amounts have also been included. Scenarios of mean sea-surface air temperature changes for offshore area of Ghana have also been provided. Changes in sea level are global values projected with respect to 1990 mean. The scenarios were constructed to cover the whole of the land area of Ghana and over the immediate coastal offshore waters of the Gulf of Guinea, down to the Equator. In particular, scenarios of the climatic variables, monthly mean daily temperatures and precipitation for the six eco-climatic zones of Ghana have been developed. There are also scenarios for the rise in sea level as well as sea-surface air temperature. Thirty-year mean climate scenarios were projected for 2020 (that is 2006 to 2035), 2050 (that is 2036 to 2065) and 2080 (that 2066 to 2095) for the above climatic variables. Figure 5.1 shows the areas for specific scenarios development, selected to coincide with the main ecological areas of the country. In general, the Climate Change scenarios were developed using GCM approaches. However, one of the major problems in the application of GCM projections in regional impacts assessments is the spatial scale of the estimates usually provided. With a typical horizontal grid dimension of over 200 km, most regional features, which are of sub-grid dimensions, cannot be resolved. Several methods have been adopted for developing regional GCM-based scenarios at sub-grid scales. The method after Hulme *et al.,* 1999, in which regional sub-grid observed climatologies are combined with projected changes associated with the GCM grid box within which they lie, was adopted in the scenario development.

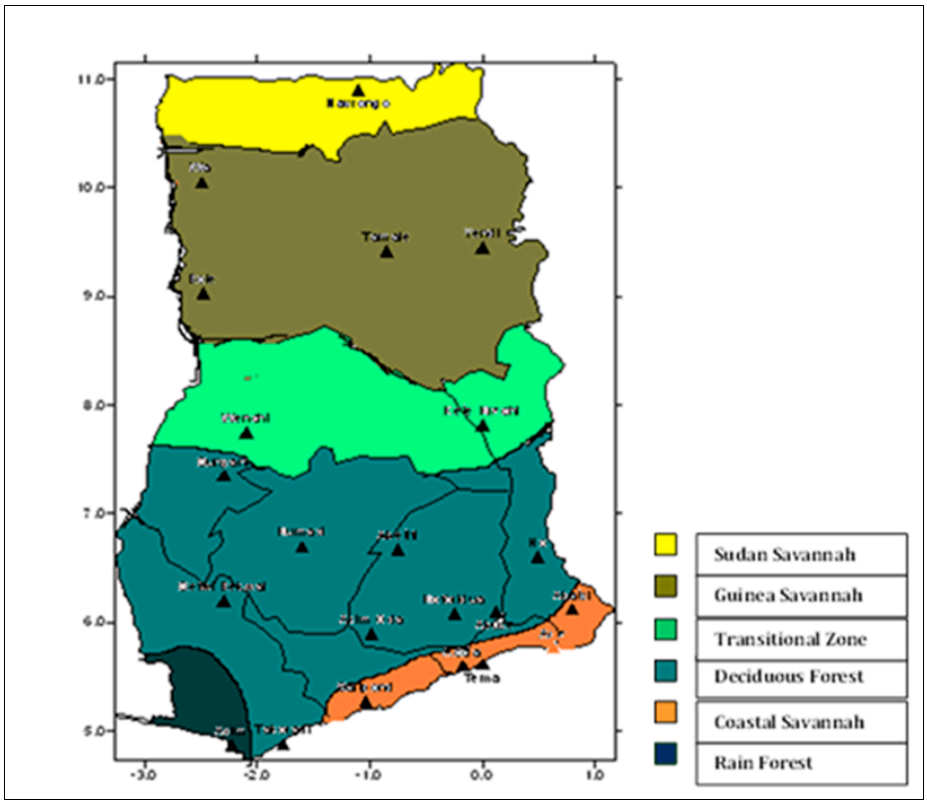


Figure 5. 1 Areas on which Climate Change scenarios were developed

5.1.2 Trends in the observed Temperature and Rainfall series in Ghana

In order to appreciate the changes that anthropogenic interference with the climate system through the emission of greenhouse gases might have on the climate of the country, the observed instrumental time series of temperature and precipitation were analysed for each eco-climatic zone and presented in figures 5.2, 5.3, 5.4, 5.5 and 5.6.

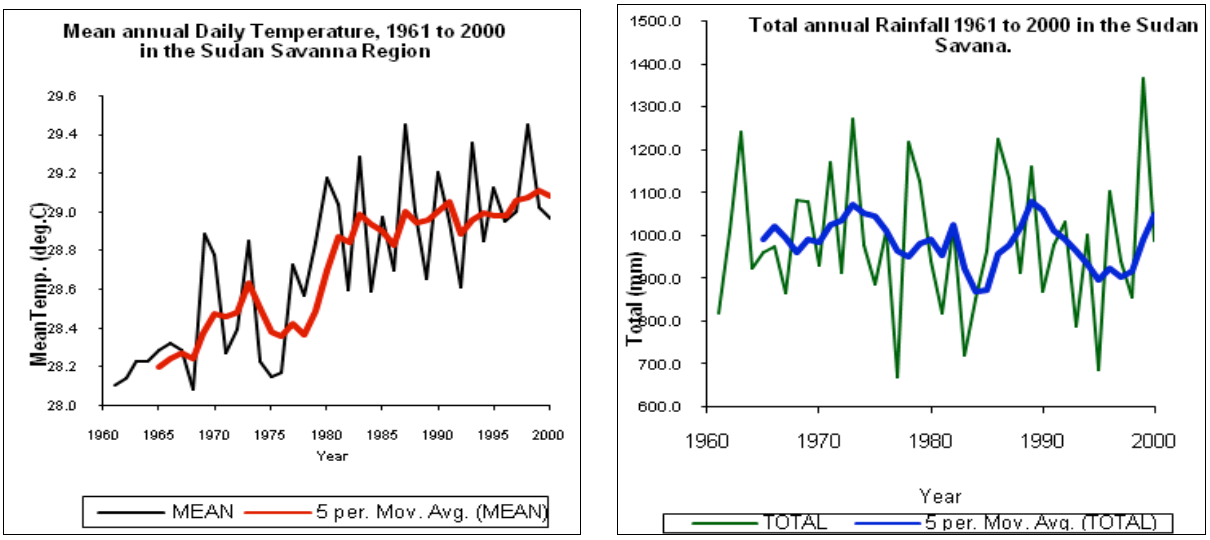


Figure 5. 2 Mean Annual Daily Temperature and Total Annual Rainfall Amount: Sudan Savannah zone

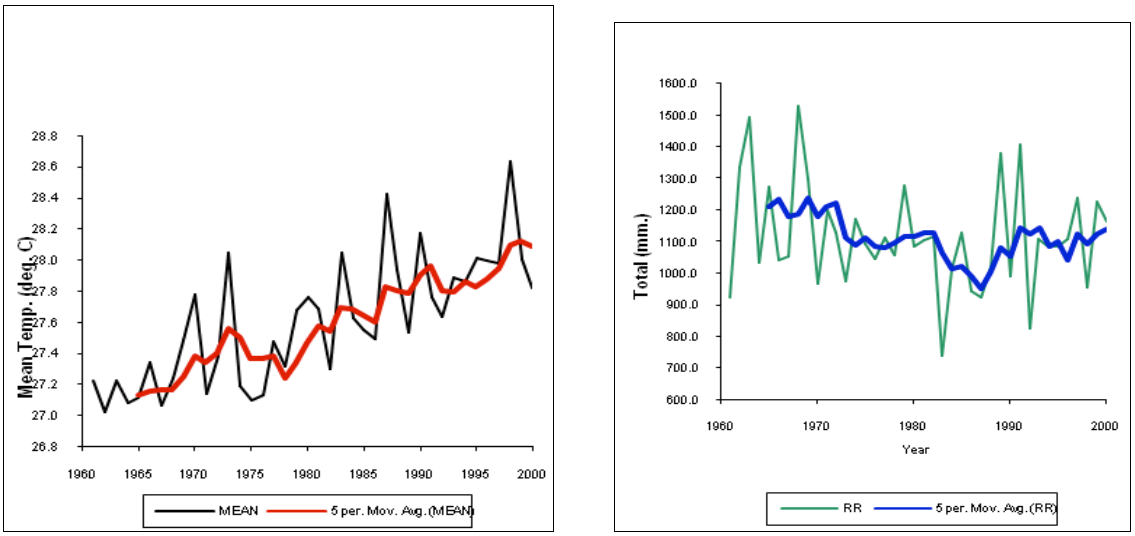


Figure 5. 3 Mean Annual Daily Temperature and Total Annual Rainfall Amount: Guinea Savannah Zone

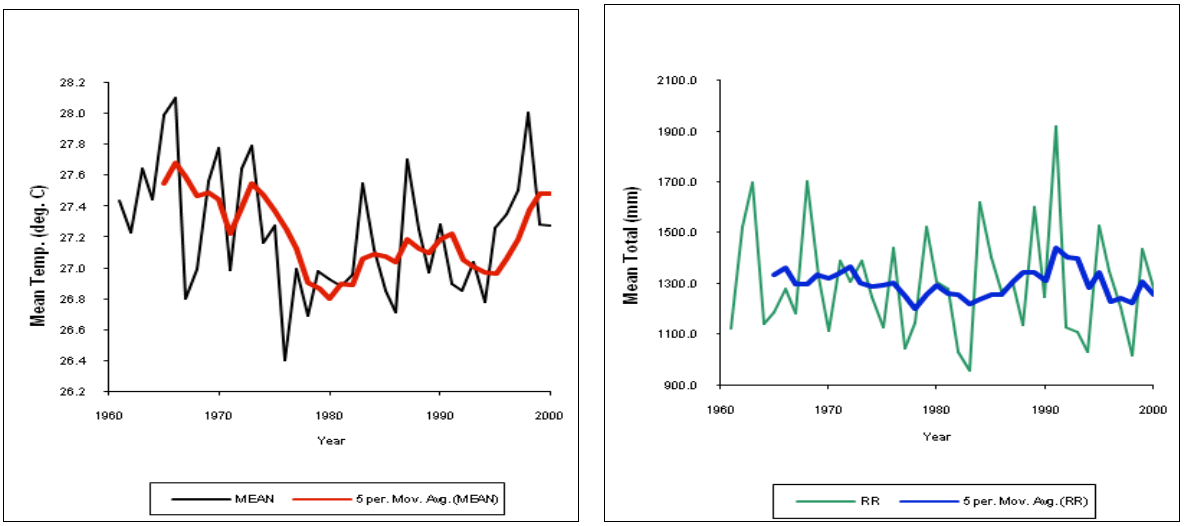


Figure 5. 4 Mean Annual Daily Temperature and Total Annual Rainfall Amount: Transitional Zone

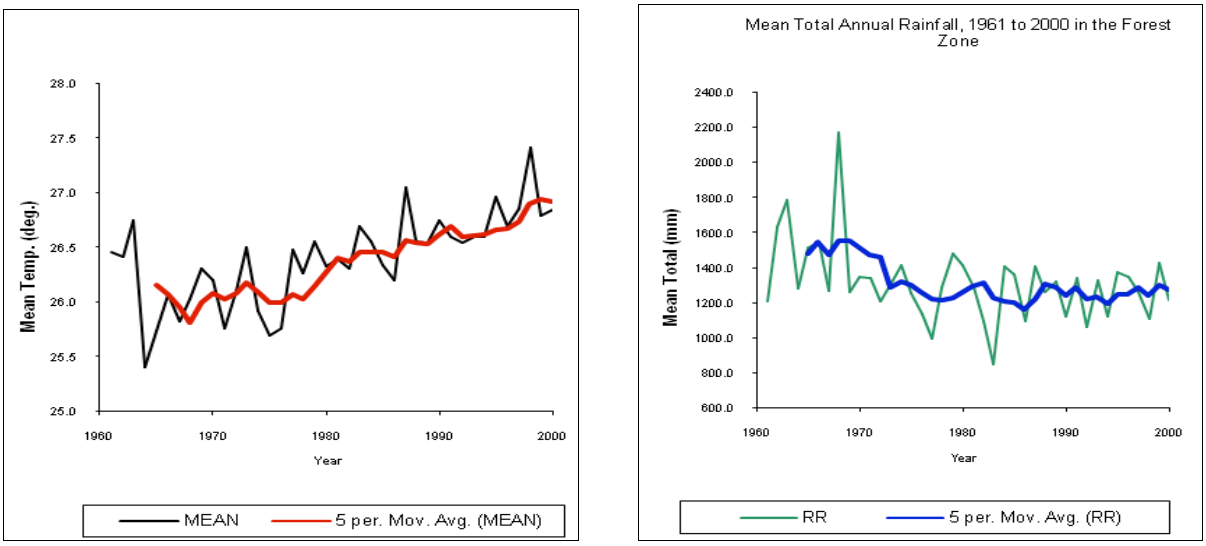
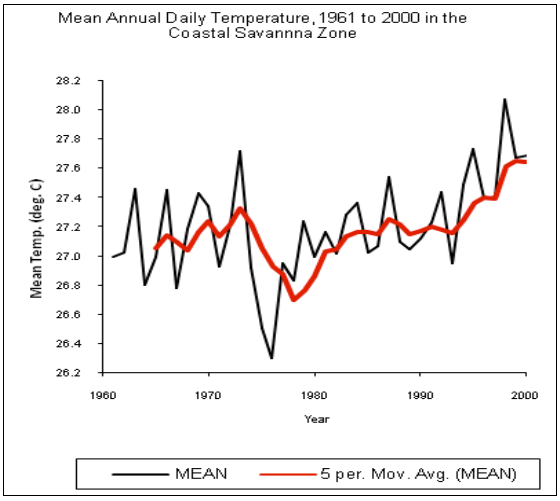


Figure 5. 5 Mean Annual Daily Temperature and Total Annual Rainfall Amount: Forest Zone



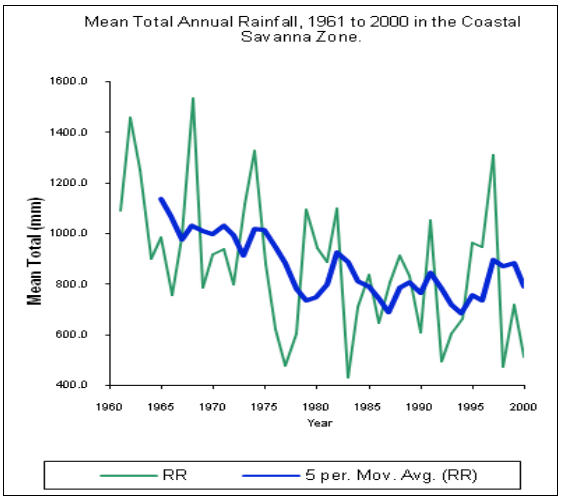


Figure 5. 6 Mean Annual Daily Temperature and Total Annual Rainfall Amount: Coastal Savannah Zone

5.1.3 Results of Climate Change Scenario Development

The sets of scenarios developed for the 30-year mean climate centered on; 2020, 2050 and 2080, for temperature and rainfall for each of the six eco-climatic zones of the country, have been presented below in terms of medium scenarios.

5.1.3.1 Temperature Scenarios

Over 2020, 2050 and 2080 time horizons, temperatures (minimum, maximum and mean) were predicted based on the 1961-2000 observed temperatures. In Ghana, temperatures are generally expected to change by 0.6^{O}C, 2.0^{O}C and 3.9^{O}C in 2020, 2050 and 2080 respectively (Figure 5.7). The hottest months in the year are still likely to be between February and May whereas between June and September temperature will be relatively low.

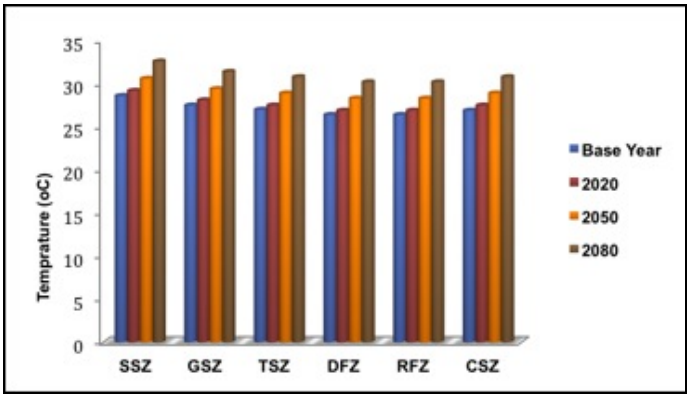


Figure 5. 7 Scenarios for annual mean temperatures

5.1.3.2 Rainfall Scenarios

Based on observed rainfall recordings between 1961 and 2000, scenarios for changes in rainfall were developed for the six ecological zones over 2020, 2050 and 2080 time horizons. From the scenarios in figure 5.8, annual mean rainfall levels are likely to reduce between 1.1% and 3.1% across all the agro-ecological zones by 2020. The highest reduction is expected in the rainforest and the coastal savannah zones. The changes in annual mean rainfall by 2080 is expected to be between 13% and 21% of the observed baseline values. The rainforest zone is still likely to be the wettest areas in Ghana whereas Coastal and Sudan savannahs continue to experience the least rainfall.

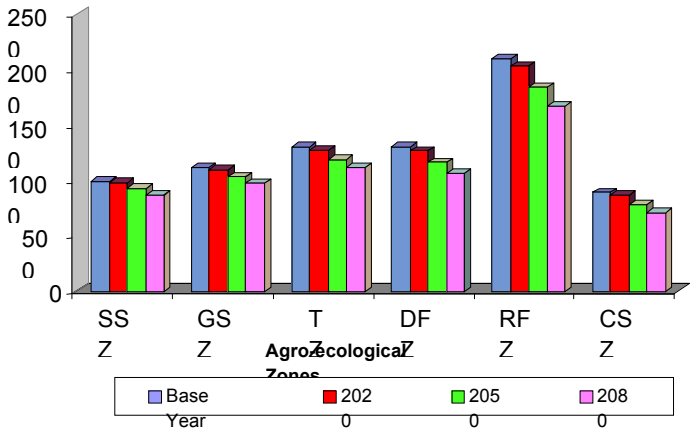


Figure 5. 8 Scenarios for Annual Mean Rainfall (mm)

5.1.3.3 Scenarios for Sea Level Changes

With respect to 1990 mean sea levels, future sea level changes per decade were developed from 2010 to 2080 for the coastal areas of Ghana. Sea levels are likely to rise every decade by an average of 0.3 cm from 3.6 cm by 2010 to 34.5cm by 2080 (Table 5.1 and figure 5.9).

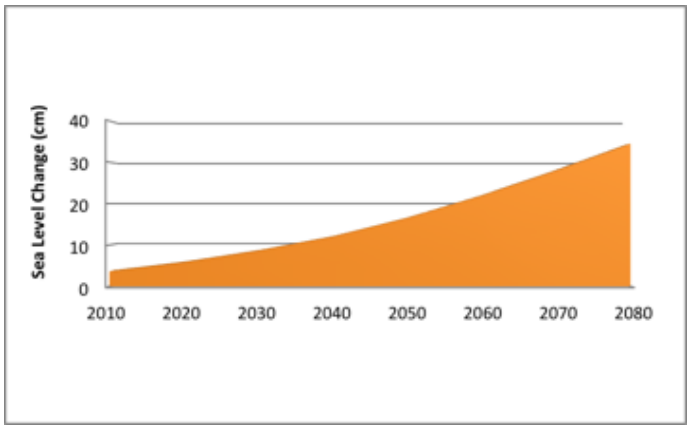


Figure 5. 9 Mean sea level rise for scenario years

Table 5. 1 Scenarios for Sea level change with respect to 1990 mean (cm)

Year	Change (Central Value) (cm)	Change (Range) (cm)
2010	3.6	1.6 to 6.0
2020	5.8	2.6 to 9.8
2030	8.6	3.8 to 14.4
2040	12.0	5.5 to 20.2
2050	16.5	7.6 to 27.6
2060	21.9	10.3 to 36.7
2070	28.0	13.1 to 47.1
2080	34.5	16.1 to 58.4

5.2 Sectoral Impacts, Vulnerability and Adaptation Assessments

5.2.1 Background

The assessment of Ghana's vulnerability to Climate Change was carried out to evaluate how changes in climate may affect segments of the natural and human environment, elements of the national economy and social welfare. The assessment was built on the first study under the initial national communication, which focused on agriculture, water and coastal resources. The current assessment expands to cover the following vulnerable economic sectors: fish production, human health, land use management, linkages between poverty and livelihoods of the poor, root crop production, women's livelihoods and cocoa production. The vulnerability assessment consisted of analysis of the scope and severity of the potential effects of Climate Change, looking at possible temperature rise, decreased precipitation and rise in sea level. The vulnerability studies further assessed possible adaptation and policy options that can be taken to prepare for Climate Change.

5.2.2 Fish Production

Fish plays a major role in the supply of animal protein and represents 65% of the animal protein intake of Ghanaians. This makes it the single most important source of low-cost animal protein in Ghana. Three main fleets exploit it: artisanal (over 70% of total marine catch), inshore or semi-industrial and the deep-sea or industrial, which can be categorized into the large trawlers and the tuna vessels.

Fish species diversity is high with about 447 in the marine waters, 227 in the inland waters and 19 species produced in aquaculture. Aquaculture activities are still low and the inland fisheries constitute only about 16% of the total annual production. The marine fishery is, thus, the mainstay of the sub-sector and has been a significant non-traditional export. The fishery sector has experienced some fluctuations, with the most conspicuous being in the early and late 1970s. However, these fluctuations are still believed to be increasing (Figure 5.10), due mainly to the increase in the population of fishermen. The Anchovy has the highest yield followed by the Round Sardinella and then the flat Sardinella. The small pelages are believed to be over- exploited.

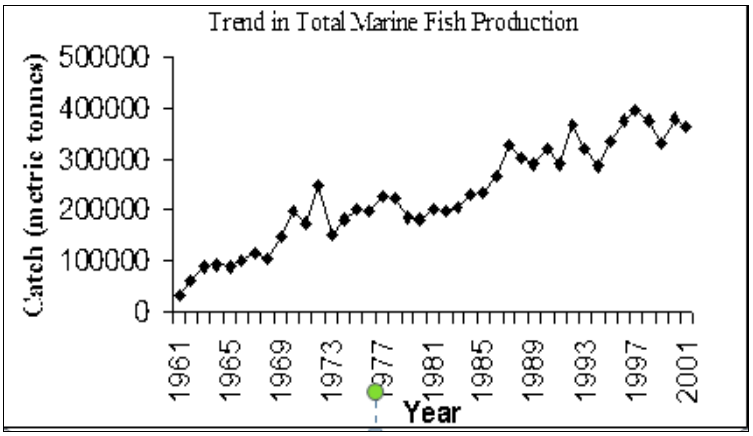


Figure 5. 10 Summary of Total Marine Fish Production (1961-2001)

Source: *MFRD, Ghana*

Based on the observations by Minta and Santos (2003), the following hypotheses are made:

- Climatic conditions affect the distribution of pelagic fish and thereby their catchability
- Climatic conditions affect other aspects of pelagic fish biology e.g. growth rate
- Climate Change could affect the social and economic lives of people employed in the fisheries sector.

5.2.2.1 Methodology

The study was conducted in both marine and inland production areas. The marine area covers 565 km shoreline of Ghana, and in total forms about 7% of the nation's land area. For inland fisheries, the study focussed on the Volta River, Yeji, the Akosombo and Lake Bosumtwi because they have high fishing potential and a lot of fishermen are concentrated in these areas. The target species were Tilapia and Catfish since they are the predominant fish population in the water bodies. Furthermore, it is the most consumed amongst the human population.

The study was conducted using both primary and secondary data. The primary data was based on a socio-economic survey using questionnaires in Tema, Sakumono, Kpong, Apam, Akosombo, Yeji and Lake Bosumtwi fishing communities. Secondary data consisted of rainfall, minimum, maximum and mean air temperature on land (MAT), Sea Surface Temperature (SST), salinity and river run-off. For the fisheries, all records of catch and efforts were documented. The daily records of the minimum and maximum air temperatures from 1960-2000, their projections for 2020, 2050 and 2080 and various climatic scenarios were obtained from the electronic database of GMeT, Accra. Daily records of rainfall and mean air temperatures from 1961 to 2001 were also obtained from the same source. Daily records of SST (1963-2001) and salinity (1968-2001) were obtained from the Marine Fisheries Research Division (MFRD), Tema. Multivariate Statistical Software for Canonical Community Ordination in MS Windows (CANOCO 4), Biomass Dynamic Model and Artificial Neural Networks (ANN) were used in analysing the meteorological and fishery data.

5.2.2.2 Model Results

- The anchovy species showed the highest variability and sensitivity to climate changes
- For the round sardinella, increase in temperatures by 1°C resulted in 4.2% and 102% catch rate.
- Rainfall appears to have a minimal negative effects on catch rates
- The flat sardinella showed the least response to SST and the highest response to changes in rainfall. Thus, distribution of the fish is more dependent on temperature while the population growth rate is more influenced by rainfall.
- Catches in all the three species varied from year to year depending on the magnitude and influence of SST and rainfall.

Stock production and, to a lower extent, catchability were found to be closely tied to Climatological factors. Lower catch rates of the Round Sardinella coincided with years of higher SST and the reverse was true for the anchovy. For the tilapias, catfish and flat sardine, precipitation was found to have the most substantial effect on production and total annual catchability. It was concluded that changes in climate directly affect the productivity of the ecosystem as well as its catchability and most importantly, the population growth rate of the species. For sustainable management of the fishery resources, it is imperative that climatic and hydrological parameters be incorporated into fishery management models.

(The wide inter-annual variations for the individual species confirmed that fishing effort alone did not account for the variations in CPUE. The erratic fluctuations in abundance of the small pelagic were due to differences in the amounts of fish available to the fishermen, which in turn depended on coastal upwelling, rainfall, recruitment and migratory pattern of the fish. The increasing trends obtained for the small pelagic were due mainly to the intensity of upwelling. Hence, an assessment of projections about the fishery sector cannot be made without due consideration to climatic influences. The output of the dynamic production models confirms that the coastal climate as quantified by the SST closely regulates the production of fishery resources. The climate of the current year does not only affect the distribution of fish populations to fishing areas but also regulates to a greater extent, the processes affecting the growth and production. This accounted for the high year-to-year fluctuations. Optimum temperatures enhance spawning and larval growth. Good precipitation and runoff also regulate feeding and recruitment while primary productivity is enhanced by rainfall and river-runoff.

5.2.2.3 Results from Socio-economic Survey

The changing trends are increases in fishing efforts (34%), natural variability (25%), changing climate factors (upwelling, air temperature and others, 17%) and anthropogenic factors. Fisher folks are aware of climatic change indicators and most said the changes have affected fish prices, livelihoods, and employment and changed fishing methods.

5.2.2.3 Fisheries Adaptation Options for identified vulnerable Groups

The study identified the vulnerable to include: rural poor farmers, poor fisher folks, poor women, children and the urban poor and further made the following observations:

- Aquaculture would have direct positive impact on the economic conditions of all the identified vulnerable groups. There is also an indirect benefit to the dependents in meeting their protein needs.
- Cage culture as an adaptation option may be more appropriate to farmers and rural poor who live along the peripheries of inland water bodies. Where women cannot engage directly in cage culture fishing, they can own the cages and also engage in processing and marketing of fish.

- Vulnerable groups involved in fish culture could be encouraged to restock fingerlings into all suitable water bodies within their communities.
- Vulnerable groups have to be educated on water harvesting technologies and also post-harvest management systems.
- Strict observance of traditional and cultural norms and other fishing and environmental protection regulations guiding the exploitation of fish resources should be encouraged.

5.2.3 Assessment of Climate Change Vulnerability and Impacts on Health and Adaptation

5.2.3.1 Background

In its Third Assessment Report (TAR), the IPCC concluded that overall, Climate Change was projected to increase threats to human health particularly, in the lower income population, predominantly within tropical/sub-tropical countries. The TAR further indicated that Climate Change could affect human health directly (e.g. impacts of thermal stress, death/injury in floods and storms) and indirectly through changes in the ranges of disease vectors (e.g. mosquitoes) water-borne pathogens, water quality, air quality and food insecurity. It is envisaged that actual health impacts will be strongly influenced by local environmental conditions and socio-economic circumstances and by the range of social, institutional, technological and behavioral adaptation taken to reduce the full range of threats to health. The main thrusts of the assessment were; identification of impacts of Climate Change on the health of Ghanaians as far as the incidence of common tropical diseases were concerned viz; malaria, measles, meningitis, diarrhoea and guinea worm.

Very little studies have been done on the impacts of climate change on human health such as Malaria, Cerebro-spinal Meningitis (CSM) and diarrhoea. In Ghana, malaria continues to be the leading cause of outpatient (OPD) attendants and admissions in all health facilities contributing to about 44.12% of the causes of the outpatient attendants in 2004 (Tables 5.2 and 5.3). Malaria also contributed to 24.6% of all causes of admission and was the highest cause of deaths in the health institutions with a proportional mortality rate of 17.1%. In 2004, a total of 25,810 malaria deaths were reported in the Health institutions excluding the existing Teaching Hospitals, and 17 million cases reported every year.

Table 5. 2 Cases of 10 top diseases seen at Outpatient Departments in Ghana (Ghana Health Service, 2004)

No.	Disease	% of total
1	Malaria	44.12
2	Acute Respiratory infection	7. 17
3	Diarrhoea	4. 33
4	Skin Diseases and Ulcers	4. 10
5	Hypertension	2. 70
6	Home/Occupational Injuries	2. 32
7	Acute Eye Infections	2. 12
8	Pregnancy Related Complications	1. 89
9	Rheumatic and other joint conditions	1. 86
10	Anemia	1. 69
11	Others	27. 7

Table 5. 3 National profile of diseases under investigation (Ghana Health Service, 2004)

National Profile of Diseases Investigated			
No.	Disease	Rank	% of total
1.	Malaria	1	44. 12
2.	Measles	48	0.03
3.	CSM and other Meningitis	51	0. 01
4.	Diarrhoea	3	4. 33
5.	Guinea worm	52	0. 01

5.2.3.2 Methodology

Epidemiology survey was carried out using the Seasonal Pattern Assessment Questionnaire. Baseline data records on disease incidence at different seasonal periods at various health centres as well as retrospective analysis of total hospital cases (Admissions, Mortality and OPD) over different time periods were also carried out. Multiple regressions analysis was employed to evaluate relationships among climate variables and diseases using simple proportion and univariate and regression analysis. Some Community-based organizations were also interviewed. The Sustainable livelihood approach was employed in the analysis of the socio-economic impact on human health. Major Analyses carried out were:

- Time series analysis of meteorological variables – Mean air temperature, minimum and maximum air temperature, relative humidity, sunshine hours, wind speed, number of wet days, number of dry days etc.
- Time series analysis of outpatient morbidity incidence or mortality due to Malaria, Diarrhoea and Cerebral Spinal Meningitis.
- Regional projections of future climate scenarios and annual levels of meteorological variables.
- Biophysical modeling - current observable relationship between local meteorological conditions and the occurrence of diseases.
- Biological modeling using projected climate data and with sufficient information about the relationship between meteorological variables and the biology of vectors and parasites causing any of the diseases, namely malaria, diarrhoea and Cerebro-spinal Meningitis.
- Statistical modeling: statistical/ empirical models. - Derived artificial neural network models (or a much more suitable model for malaria, diarrhoea and Cerebro-spinal Meningitis can be used.

Modified or adapted existing models such as 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) were used. These approaches were used to assess disease impact, taking into account climate and non-climate effects such as local demography, socio-economic and technical circumstances that could limit transmission.

5.2.3.3 Results

Although temperature, rainfall and relative humidity appear to influence reported cases of malaria, the causal relationship is not very clear since other several factors may come to play. However, the rise in mean air temperatures with reduced rainfall tends to lower the incidence of malaria (figures 5.11, 5.12). Similarly, high incidence of malaria occurs with high rainfall and relative humidity as the mean air temperatures reduce (figure 5.13). High incidence of malaria occurred in June with a mean rainfall amount of 215.2 mm whilst low incidence of malaria cases occurred in February at 54.8 mm, March at 114.9 mm and April at 135.0 mm.

Seasonal distribution of Malaria

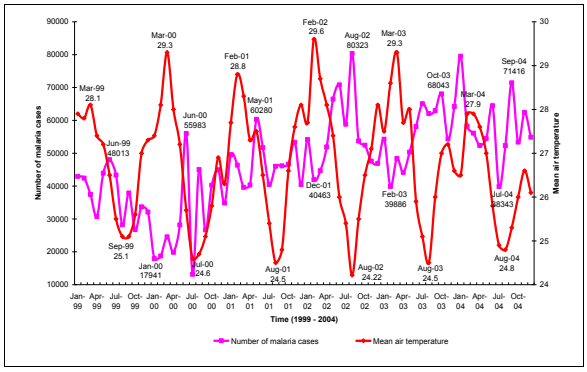


Figure 5. 11 Distribution of number of malaria cases and mean air temperature (1999 – 2004)

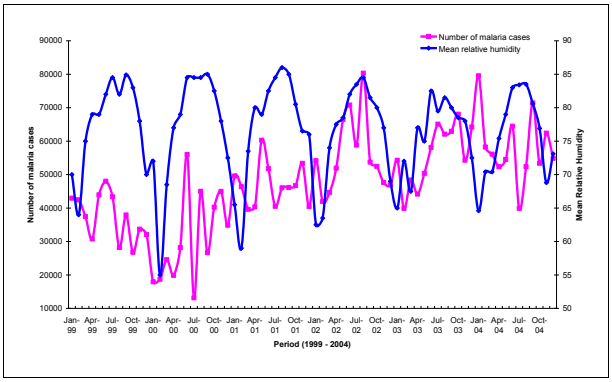


Figure 5. 12 Distribution of number of malaria cases and mean-relative humidity (1999 – 2004)

Seasonal distribution of Measles

Although temperature, rainfall and relative humidity appear to influence reported cases of measles, the causal relationship is not very clear since several other factors may come to play. However, the rise in mean air temperatures with reduced rainfall tends to lower the incidence of measles (figures 5.13). Similarly, high incidence of measles occurs with high rainfall and relative humidity as the mean air temperatures reduces (figures 5.14 & 5.15). The incidence of measles was highest in March and April and lowest in July. The mean air temperatures were 27.9 °C in March and 27.6 °C in April, respectively.

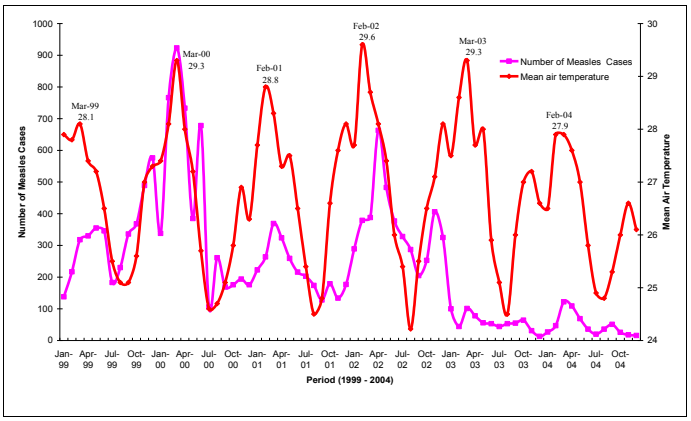


Figure 5. 13 Distribution of measles cases with mean air temperature.

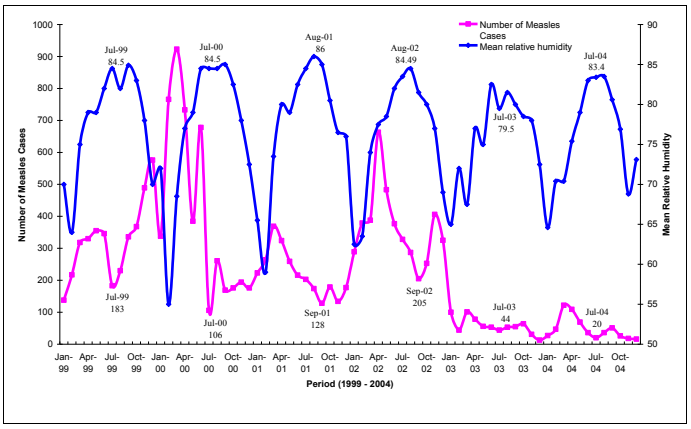


Figure 5. 14 Distribution of measles cases with mean relative humidity

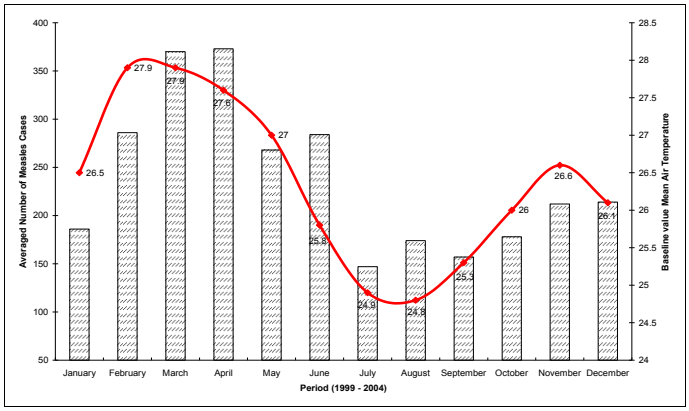


Figure 5. 15 Averaged Number of Measles Cases and Mean air temperature

Seasonal distribution of Meningitis

Although temperature, rainfall and relative humidity appear to influence reported cases of meningitis, the causal relationship is not very clear since several other factors may come to play. However, the rise in mean air temperatures with reduced rainfall tends to lower the incidence of meningitis (figure 5.16). Similarly, high incidence of measles occurs with high rainfall and relative humidity as the mean air temperatures reduce (figure 5.17).

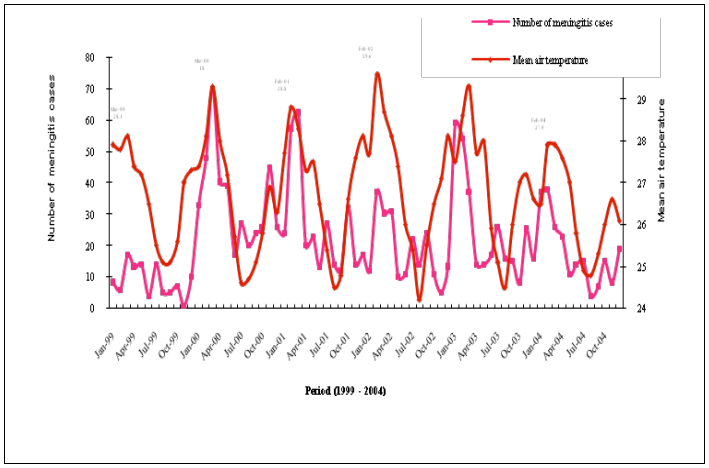


Figure 5. 16 Distribution of meningitis cases and mean air temperature

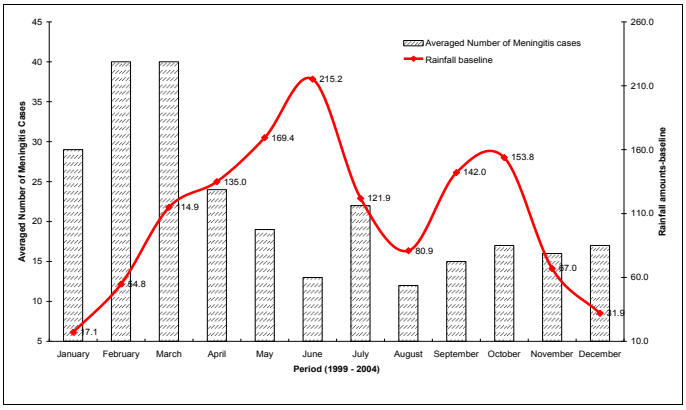


Figure 5. 17 Distribution of number of Meningitis cases (averaged) (1999 – 2004) and rainfall amount – Baseline study

Seasonal Distribution of Diarrhoeal Cases

It was observed that diarrhoea was perennial with very small monthly variation, which could occur at any time of the year. This is not to say that rainfall does not have any influence on the incidence of diarrhoeal cases. However, behavioural pattern of the people, poor sanitation and hygienic conditions are critical factors (Figures 5.18 and 5.19).

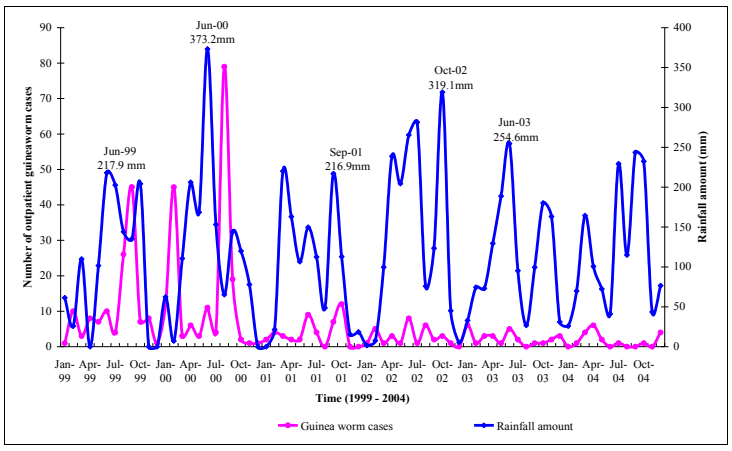


Figure 5. 18 Distribution of Diarrhoea cases and rainfall amount

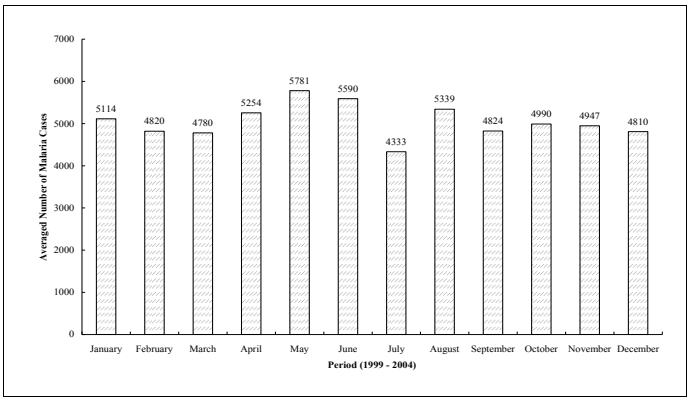


Figure 5. 19 Seasonal variation of the (Averaged) Number of Outpatient Diarrhoeal cases

Seasonal Distribution of Guinea Worm

Although temperature, rainfall and relative humidity appear to influence reported cases of Guinea Worm, the causal relationship is not very clear since several other factors may come to play. However, the rise in mean air temperatures with reduced rainfall tends to lower the incidence of Guinea Worm (figures 5.20). Similarly, high incidence of Guinea Worm occurs with high rainfall and relative humidity as the mean air temperatures reduce.

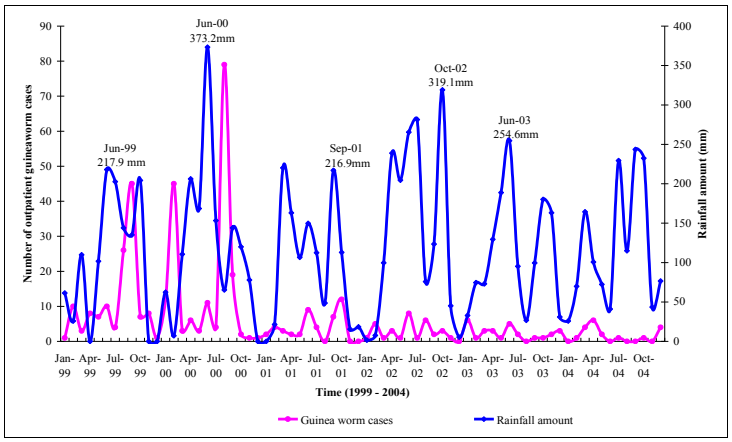


Figure 5. 20 Distribution of number of guinea worm cases and rainfall amount

5.2.3.4 Potential Adaptation Options

Adaptation options for Malaria, Guinea Worm

- Management of cases, for example, surgical removal of worms
- Education of communities and health workers.
- Vector control strategies, such as;

1. Breaking the transmission cycle
2. Destroying breeding grounds of vectors
3. Destroying the larvae so as to break the life cycle.
4. Breaking the host vector contact and protecting the host for Guinea Worm cases, can be achieved through the provision of safe drinking water, filtration of water to remove to Cyclops, preventing people with active Guinea worms cases from getting into contact with water bodies and chemical destruction of crustaceans.

Adaptation options for water-borne diseases such cholera and diarrhoea diseases

- Promote the use of infant feeding bottles that can easily be cleaned
- Proper storage of cooked food
- Promoting personal hygiene e.g. avoid drinking contaminated water,

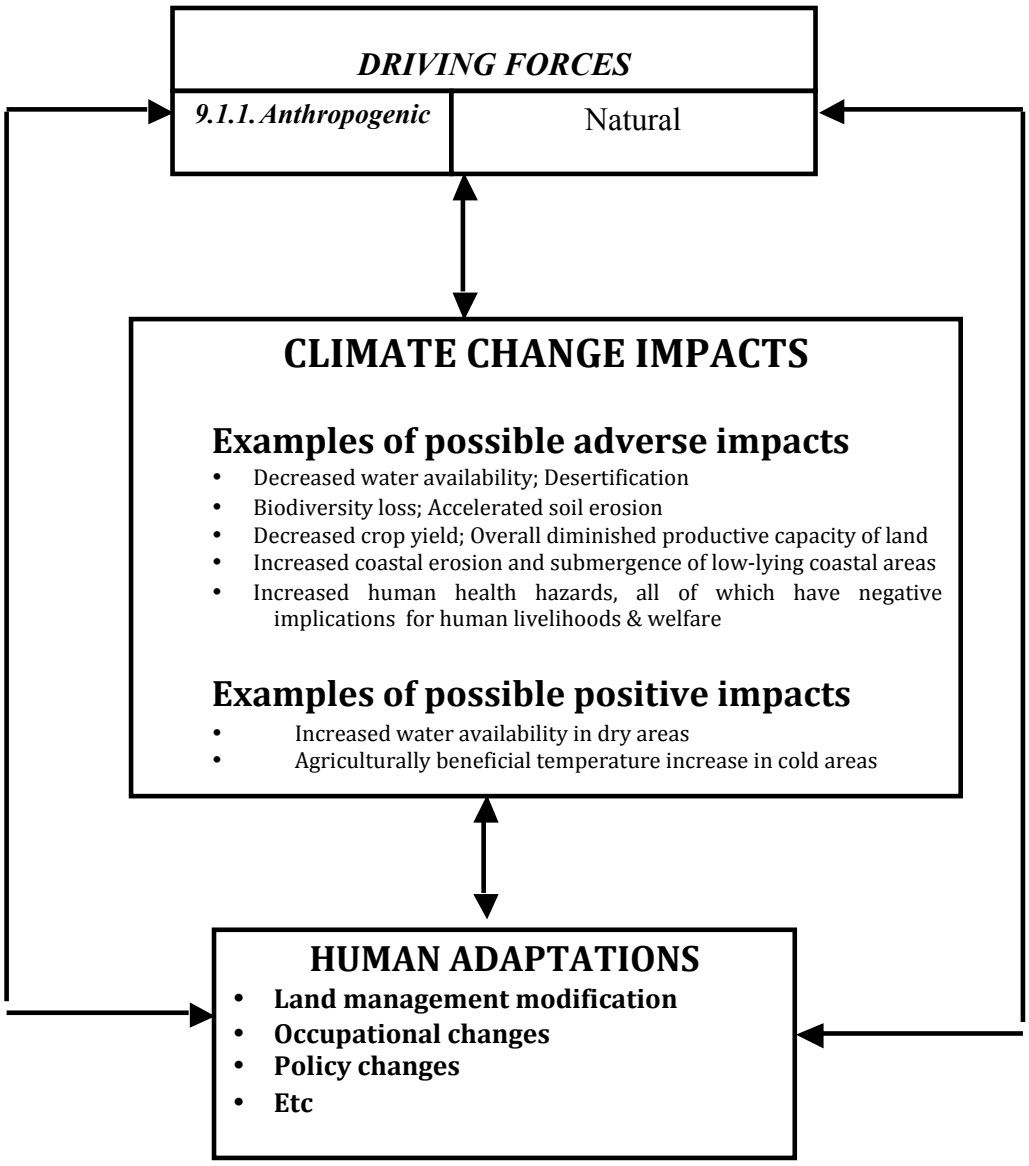
Adaptation options for other diseases (Measles and Meningitis)

- Vaccination of high risk groups, whiles increasing vaccination campaigns
- Provision of well ventilated housing units

5.2.4 Climate Change Impacts, Vulnerability, Adaptation and Land Management in Ghana

5.2.4.1 Climate Change Impacts, Vulnerability, Adaptation

Conceptually, the assessment recognized the elements of Climate Change to include their impacts interlinked through complex feedback loops (Figure 5.21). They are multi-dimensional and crosscutting - disciplinarily and geographically. Therefore, the processes and terrestrial impacts of Climate Change together with human adaptations to them are best tackled multidisciplinary and multi-sectorally across geographical space within a systems theoretical framework.



A simplified diagrammatic representation of Climate Change and possible associated problems and human adaptations

Literature, field studies and group discussions on land management relative to climate variability carried out pointed to land degradation and growing aridity, which are reflected by increased temperatures, accompanied by decreased and erratic rainfall. Generally, farmers are coping through several strategies among which are the following:

- Livestock-crop integration, i.e., mixed farming.
- Rearing more goats than sheep and cattle, as the goats are hardier and can survive harsh conditions
- Adoption of early yielding and drought tolerant crop varieties; adoption of crop rotation, water conservation practices, agro-forestry, Post harvest storage systems, integrated pest and disease management and other modern innovative practices.
- Moisture conservation, notably mulching

- Drought tolerant and improved crops
- Erosion control
- Planting and conservation of trees
- Chemical fertilizers
- Emphasis upon cassava and vegetables
- Land use intensification
- Farm extension into marginal lands
- Cropping moist valley bottoms
- Integration of trees;
- Changing diet
- Out-migration of people
- Alternative, off-farm jobs, notably small-scale gold mining, 'galamsey'.

Desertification and land degradation are two closely interrelated processes. In Ghana, land degradation and desertification are a growing threat. It is manifested by soil erosion; loss of vegetative cover; erosion of biodiversity; breakdown of natural ecosystems; aridity and such other manifestations of adverse changes in the natural environment. Of the country's total land surface, 23% is prone to very severe sheet and gully erosion, 46% to severe erosion and, and 31% to moderate to slight erosion). Soil erosion is common and severe in areas of extensive vegetation removal in all the major ecological zones. However, the most vulnerable zone is the northern savannah, which covers nearly 50% of the country. Hills and steep slopes, particularly those with little or no vegetative cover that experience heavy rainfall, are equally vulnerable.

Loss of vegetative cover is closely associated with the erosion of soils and their desiccation, structural breakdown and loss of productivity. The National Biodiversity Strategy reports a reduction in the country's closed forest cover by 64% between 1938 and 1981. A study carried out in southern Ghana showed that, the forest-savannah mosaic is increasing at the expense of the pure forest; a major consequence of deforestation. The other forms of de-vegetation and associated soil erosion plus the increasingly dry climatic conditions are attributed to desertification. About 30-40 % of Ghana's total land area is estimated to be experiencing desertification. In portions of northeastern Ghana, desertification and land degradation have rendered soils so humus deficient that they no longer respond to chemical fertilizer application.

The causes of the land degradation are varied and closely associated with the particular ecological zone and production system. A leading cause appears to be unsustainable agricultural practices. The progressive reduction in fallow lengths in the predominant land rotation systems of farming, due to high population pressures, ranks foremost among the unsustainable agricultural practices. Others include overgrazing, over-harvesting of fuel-wood and uncontrolled bush fires.

5.2.4.2 Land Use Management

The Land use pattern of Ghana is determined by its environmental resources endowments. Within the framework of unsatisfactory land tenure and land administration operating in the country, there is increasing recognition of soil nutrient depletion, conservation requirements, desertification and urbanization. The main land uses remain agriculture, forestry and wildlife, mining as well as settlement and industrial estates developments. The general pattern of land use is agricultural or non agricultural (Table 5.3).

Table 5. 4 General Land Use Situation in Ghana

Land Use	Area ('000 Sq. km)	% of Total
Savanna Woodland	71	30
Bush fallow and other uses	60	25
Unimproved pasture	36	15
Forest Reserves	26	11
Tree Crops	17	7
Annual Crops	12	5
Wildlife reserves	12	5
Unreserved forest	5	2
Total	239	100

Source: Ministry of Food and Agriculture (1990)

5.2.4.2 Soil erosion problems

In Ghana, natural hazards causing damage to food crops are floods, line squalls, drought, soil erosion and bush fires. The level of erosion hazards ranging from slight, moderate to severe geographical locations are shown in Figure 5.22. The erosion levels in the study areas ranged from (MTVS to MTS. Information on the impacts of these hazards on crops are limited. Of these hazards, the most widespread ones are drought, soil erosion and bushfires. Droughts of varying duration have affected Ghana in the past. The most recent occurrences were those of 1970, 1975, 1977 and 1983. The northern savannah areas are the most at risk. The impact of soil erosion is not dramatic, but widespread in all areas of the country with the increasing rate of deforestation. Bush fires occur annually in the dry areas of the country, and are due mostly to human and cultural factors than to natural factors. The impact is widespread and severe during drought years. Line squalls occur during the start of the rains between March and May each year. Floods are localized and limited to low-lying areas during wet periods.

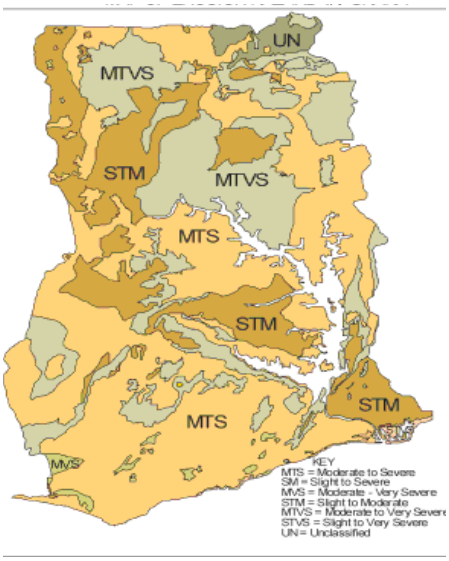


Figure 5. 21 Map of erosion hazard in Ghana

5.2.4.3 Conclusion

Farmers and other local people are aware of temporal trends in climate and the status of land, and that their views on climate variations and qualitative changes in land are similar to those of scientists. On the whole, they perceive that the climate is getting drier and the land is degrading. Apart from these adverse climatic trends, other negative factors influencing environmental degradation include; annual migration of Fulani herdsmen, sand winning, small-scale gold mining, extensive wood harvesting and charcoal production. These adverse factors combine to degrade the land and diminish water availability to the detriment of farmer livelihoods. In response, farmers have resorted to adopting new, shorter duration varieties of crops, cultivation of maize, cassava and where possible, vegetable farming by irrigation in the dry season. They also rear goats, which are less demanding in terms of feeding than sheep and cattle. Chemical fertiliser application is the measure largely used by farmers to improve yields on their degraded land. This is combined with various soil and water conservation practices. The integrity of the environment is related to the efficient use and management of available land. The need for efficient management of land is more urgent in the face of an ever-increasing population and the growing demands in all the various land-based activities. Land resources and the processes of their development and use, however, have varying consequences on the environment and specifically land becomes more vulnerable to climate variability, which subsequently affects productivity.

5.2.5 Linkages between Poverty and Climate Change: Adaptation for Livelihood of the Poor in Ghana

Despite the lingering scientific uncertainties surrounding the impacts of Climate Change, there is increasing recognition that a clear understanding of Climate Change /variability is crucial for poverty reduction strategies and national development planning as a whole. However, the persistence of the high incidence of poverty in Ghana appears to have created a more urgent place for poverty reduction compared to Climate Change in national development efforts. Viewed to be remote from the immediate concerns of poverty, Climate Change is usually considered a secondary issue. Indeed, the uncertainties surrounding Climate Change impacts make it appear abstract, futuristic and justifiably call for long-term solutions. How can urgent issues such as poverty reduction be balanced with seemingly long-term issues of Climate Change especially when the change is so indeterminate? An assessment of the linkages between Climate Change and national development planning especially poverty reduction is therefore vital in this context.

Accordingly, this study explored the linkages between Climate Change and poverty reduction in Ghana. It focused on the potential impacts of Climate Change/variability with respect to the livelihood systems of the poor and vulnerable communities. The study demonstrated that whereas poverty and Climate Change might appear at the extreme ends of the tunnel, the attainment of poverty reduction goals, both nationally and globally, would hardly be realised without due consideration for mainstreaming Climate Change/climate variability into national development and poverty reduction programmes. Thus, based on carefully identified gaps and focussing on adaptation measures including governance issues, the study proposed strategies to facilitate the process of mainstreaming Climate Change issues into national poverty reduction planning. The study was underpinned by a number of factors.

The Ghana Poverty Reduction Strategy (GPRS) addresses environment and poverty linkages; however, it hardly tackles the potential impacts of Climate Change and climate variability. While it is acknowledged that Climate Change issues can hardly be separated from the environment, appreciating the cardinal role of the environment does not necessarily deal with the fundamental issues of Climate Change. This phenomenon, in part, arises because Climate Change appears abstract to many policy formulators, planners and decision makers, who often have to grapple with the “urgent” issue of poverty rather than increases in global warming, which on the face value seem negligible. In this light, the studies sought to

deepen and create awareness about the potential impacts of Climate Change and convince policy makers and the private sector about the critical role of Climate Change in national poverty reduction efforts. Ghana is heavily dependent on climate sensitive sectors such as agriculture and forest. Majority of the population dwell in rural areas where agriculture is the main source of livelihood. The limited use of irrigation facilities and high dependence on favourable climatic conditions for the realisation of good harvest tend to introduce huge instability in the standards of living of the people. Rural communities are characterised by: relatively higher incidence and depth of poverty; higher fertility rates; higher biomass usage; inadequate infrastructure and facilities; lower educational status and lower health status, among others. The interplay of these features has made rural communities disproportionately vulnerable since they are most exposed to hazards such as bush fires, flooding, etc. and are certainly least capable of adjusting or coping with such hazards. Thus, the poor remain most susceptible to the potential damages and uncertainties associated with Climate Change. This study therefore examined the linkages between poverty and Climate Change and the potential consequences of Climate Change and climate variability. It also assessed the coping mechanisms of the poor to such potential effects.

In Ghana just like other African countries, the life of 'the poor' is a life of vulnerability, which reflects the deeper problem of insecurity. The poor depends heavily on environmental goods and services. Their livelihoods are punctuated by dependence on agriculture, fisheries and forestry (which revolve on the use of land and water resources), and on the capacity of ecosystems to provide the services vital for environment balance without which food production and other productive activities cannot be carried out on a sustainable basis. This trend puts the poor at risk relative to the rich. In both rural and urban Ghana, the poor are indeed highly vulnerable to environmental disasters and environment-related conflict and it is believed that the depth of vulnerability is correlated with the pace of environmental degradation including Climate Change. Droughts, forest fires, and floods hit the poor in rural and urban areas more and these are on the increase.

Although some progress has been made especially with regards to the vulnerable in the society, there are some traces of doubt about the far-reaching impacts of climate change /climate variability on the livelihoods of the poor. While in the very long term it is important that attention is focused on stabilising greenhouse gas emissions, for some developing countries such as Ghana, some amount of adaptation is recognised as inevitable. Adaptation measures are more costly and may affect poor people who have more limited coping mechanisms. This is coupled with the fact that the requisite financial, technical capability and social safety nets to cope with climate change and climate variability are often lacking in most African countries including Ghana. Often resource response systems are limited to prepare for early warning systems and disaster prevention. This study identified and proposed adaptation mechanisms that can safeguard the interest of the poor and vulnerable. Finally, in an era where the modern world is transforming into a "global village", economic growth, poverty reduction and environment issues are gradually becoming a unified concern of nations at large. Initiatives such as New Partnerships for Africa's Development (NEPAD) and the Millennium Declaration are therefore critical in the search for solution for a development dilemma facing this single world. Certainly, it is important that strategies are adopted to convince stakeholders about the importance of integrating environmental including (climate change issues into national poverty reduction planning.

5.2.5.1 Climatic Happenings in Ghana

In Ghana, temperatures throughout the country are generally high and meteorological evidence reveals increases in temperature over the coming years. The mean annual temperature is generally above $24^{O}C$. The consequences of the low latitude position and the absence of high altitude areas have resulted in average temperature figures ranging between $24^{O}C$ and $30^{O}C$. Extreme temperature conditions are experienced in some areas, for instance, temperatures ranging between $18^{O}C$ and $40^{O}C$ or more are common in the southern and northern parts of Ghana, respectively. Rainfall in Ghana generally decreases from the south to the north. The wettest area is the extreme southwest where annual rainfall is about 2000mm. In the extreme north, the annual rainfall is less than 1100 and the driest area is the wedge like strip from east of Sekondi-Takoradi, extending eastward up to 40km where annual rainfall is about 750mm. These marked differences in climatic conditions manifest in various forms and reveal symptoms of climate change and climate variability. Evidence of some extreme weather conditions and climate variability that the country has experienced over the years are as follows:

- Floods
- Drought
- Bush fires
- Unpredictable rainfall patterns
- Sea level rise along the eastern coast
- Increased desertification/land degradation
- Consistent loss of forest cover
- Loss of some biodiversity

Increasing Surface Air Temperature and low Rainfall

Mean annual temperatures from 1960-2000 for six major ecological zones revealed evidence of increasing surface air temperature for Ghana. Mean annual temperatures for two of the ecological zones (Sudan and coastal savannah) increased greatly over the 40-year period (1960-2000). The Sudan savannah increased from $28.1^{O}C$ in 1960 to $29.0^{O}C$ in 2000 and that of coastal savannah from $27.0^{O}C$ in 1960 to $27.7^{O}C$ in 2000. Even though such increase may appear negligible, a temperature increase of 0.1 has serious implications for the survival of some plant species, animals and cropping patterns compared to rainforest where mean temperatures increased from $26.5^{O}C$ to $26.9^{O}C$ over the same period. Both rainfall intensity and seasonal distribution has changed in many parts of the country. Annual totals of rainfall amount in Ghana have decreased over the years.

The country experienced extreme weather events (drought) in 1983. This resulted in severe hunger, which affected the poor and reduced gross domestic product for that year. This phenomenon demonstrates the potential impact of climate change on Ghana's development. Rainfall is not only decreasing in some areas but also unpredictable and unreliable. This makes it difficult for the poor farmers to determine the rainfall pattern for crop production. As a result, farmers in Ghana are gradually loosing the skills of predicting major and minor rainy seasons. The irregular pattern and scanty nature of rainfall in some parts of the country have affected the flow rates of many rivers like the Volta and other water resources. The implication of dwindling rainfall has led to observed changes in water levels in the Akosombo dam. Presently the Akosombo dam, which used to supply 70% of the country's energy, can now supply only 30% of Ghana's energy due to the low water level.

5.2.5.2 Poverty Incidences in Eco-Climatic Zones

In Ghana poverty is more endemic among rural communities who depend on subsistence agriculture that lacks significant input such as irrigation, market, inputs and credits. Climate change leading to less rainfall is likely to result in extensive agriculture and thus land degradation. This leads to reduced productivity and therefore less income. In these areas, climate change is likely to exacerbate poverty levels. In addition these communities have limited off-farm economic activities to generate additional income.

5.2.5.3 Poverty Diagnostics in Ghana

According to the GLSS 4, 40% of the Ghanaian population has incomes below the Upper Poverty Line, while about 27% (slightly more than a quarter) of the population has incomes below the extreme poverty line. This forms nearly a third of the population of Ghana (about six million) who are unable to meet their basic nutrition needs, even if they devoted their entire consumption budget to food. Poverty is still predominantly a rural phenomenon with the rural areas accounting for more than 70% of the poor. Five (5) out of the ten (10) regions in Ghana had more than 40% of their population living in poverty. The worst affected being the three northern savannah regions (the Upper East, Upper West and Northern Regions). Nine out of ten people in the Upper East or 88%; eight out of ten in Upper West or 84%; and seven out of ten in Northern Region or 69% of their populations lived below the poverty line.

Out of every ten people in the Central Region five or (48%) were classified as poor. Eastern region had 44% of the population below the poverty line while other regions fell between the Greater Accra (5%), which has the lowest incidence and the Volta Region with 38% of the population living below the upper poverty line. Another group vulnerable to climate change in Ghana is the urban poor. This group usually live in unplanned settlements (slums and densely populated areas) on marginal lands. The likely climatic impacts to be faced by this group are flooding, sea level rise and health related diseases such as malaria and CSM.

5.2.5.4 Environment in the GPRS

The GPRS recognises a causal link between the environment and the poor. Accordingly, it focuses on the use of environmental resources in the creation of wealth while making sure that the environment is not depleted. Safeguarding the environment is an essential strategy in the GPRS process to ensure sustainable development and improve quality of life. Generally, environmental issues in the GPRS are categorised into two types. These are the natural and the built environment. The natural environment constitutes natural conditions and resources including eco-systems that support life i.e. water bodies, land, forests, flora and fauna, air and the atmosphere. On the other hand, the built environment constitutes the human settlements and infrastructure created by man in pursuit of his economic, social and cultural fulfillment. However, the GPRS stresses deforestation, water and air pollution, inadequate sanitation and waste management, urban degradation, land degradation and soil and coastal erosion as well as the use of natural resources in the creation of wealth sustainably.

5.2.5.5 Regional Initiatives and Climate Change

NEPAD and Climate Change

The New Partnership for Africa's Development (NEPAD), which is a long-term vision for Africa, is an initiative by African leaders to eradicate poverty and to place their countries both individually and collectively on a path of sustainable growth and development. The main objective is to provide an impetus to Africa's development by bridging existing gaps in prioritizing sectors to enable the continent catch up with developed parts of the world. The long-term objectives and goals of NEPAD are to:

- Eradicate poverty in Africa and to place African countries both individually and collectively on a path of sustainable growth, and thus halt the marginalisation of Africa
- Promote the role of women in all activities
- Achieve and sustain an average gross domestic product (GDP) growth rate of above 7% per annum for the next 15 years
- Ensure that the continent achieves the agreed International Development Goals such as MDGs.

The NEPAD initiative recognises global warming and desertification as priority interventions and emphasizes monitoring and regulating the impact of Climate Change and integrating fire management projects. This is a step in the right direction. In addition, the Maputo Declaration of NEPAD recommended that African Governments allocate 10% of their budgets to agriculture. However, given the poor' dependence on the immediate environment for their livelihood strategies, and the vulnerability status of the poor, there is the need to rank high climate change issues particularly adaptation measures in national and regional poverty reduction programmes. Achievements of the long-term vision and goals of NEPAD specifically the 7% annual GDP growth rate calls for integrating climate change at the planning, designing, implementing and monitoring of anti-poverty strategies and programmes at national and regional levels.

5.2.5.6 Key Findings

- The complex cause-effect relationship between climate change and poverty hampers the ability to assess the magnitude and direction of climate change. Coupled with the absence of proper and effective data and information, the process of integrating Climate Change into the GPRS is constrained.
- There is a strong relationship between climate and poverty levels. Districts that fall within ecological zones with high temperature and low rainfall such as Sudan Savannah, Guinea Savannah and transitional zone tend to have high incidence of poverty. The implication is that harsh climatic conditions are likely to worsen the poverty levels of these districts and the nation at large.
- There is no doubt that there is a causal relationship between environment and poverty. However, the fact of the Coastal Savannah having comparatively low rainfall and high temperatures and yet lower incidences of poverty suggest that climate is not the sole factor, there are multiplicity of factors.
- Ghana's economy depends on climate sensitive sectors such as agriculture, forestry and energy. Climate variability/climate change therefore have a high potential to make more than 60% of the Ghanaian population vulnerable as they depend directly on these sectors.
- Changes in precipitation, enhanced evaporation and severe drought have impact on the large reservoir of the Volta Lake. The Akosombo dam, which used to provide 70% of the country's energy need presently, produces only 30% due to low level of water in the dam. This has serious implications for industrialisation and private sector development.
- Malaria (vector-borne diseases) could be on the ascendancy given an increase in extreme temperature in the face of poor drainage facilities. In addition, cholera and cerebro spinal meningitis and water related diseases have potential to increase.
- The MDGs, NEPAD and the GPRS provide very little focus for Climate Change, though they all recognise the importance of the environment for reducing poverty. Thus, the strong linkages and the recognition for adaptive measures for the vulnerable are not well articulated in all of them.

- There is evidence of consistency of the GPRS and the MDGs, and in fact the targets and indicators set up for both appear to show that meeting the GPRS goals and targets will work in consonance with the attainment of the MDGs. The challenge here is how to overcome the assumption that meeting the GPRS targets will automatically realise the MDGs. It is one, which simply goes beyond the point of integrating MDGs at the national level or into the GPRS. Insufficient attention to the practical realities on the ground (local level) could result in neglecting the concerns of the vulnerable and the adaptive measures that could be instituted to address their concerns.
- Addressing Climate Change issues as a vital focus of national development planning and poverty reduction will result in rippled benefits not only for achieving the GPRS and the MDGs, but maintain trends to ensure sustainable development

5.2.6 Climate Change and Root and Tuber Crop Production in Ghana

The root and tuber crops such as cassava, yam and cocoyam are important sources of energy in our daily diets and constitute a major part of the rural Ghanaian staple diet. With an estimated per capita consumption of 151.4kg of cassava, 43.3kg of yam and 56kg of cocoyam, they account for 58% of the per capita food consumption; making them a major source of food and savings on revenue. Scientific research has shown that root crop yield response to Climate Change vary widely, depending on the species or cultivar, soil properties, incidence of pests and diseases. The need to assess the effects of climate change on root crop demand, farm incomes, and prices is therefore critical. Climate Change scenarios generated indicated an increase in both the minimum and maximum temperatures in all the ecological zones of Ghana. The mean base year temperature ranges from 26.4^{O}C (Forest) to 28.6^{O}C (Sudan) and the scenarios gave a possible mean temperature change from 0.6, 2.0 and 4.0 for 2020, 2050 and 2080 respectively. A positive correlation exists between temperature and root crop yield; this relationship gave a correlation less than 40%. Scenarios for rainfall amounts in the various ecological zones differed; the rate of change in total rainfall will increase from -1.1% to -20.5% from 2020 to 2080. This means that less amount of rainfall should be expected in future.

The status and trends in root crop production was assessed using Crop model – DSSATv4. Climate factors identified and perceived to be stressors within the limits of the study included temperature and rainfall. Using the projected climate scenarios and the crop model CROPSIM-cassava and CROPGRO (ARGRO980)-tanier; yields of cassava and cocoyam are expected to reduce with the rise in temperature and changes in intensity of solar radiation. Cassava productivity or yields are expected to reduce by 3%, 13.5% and 53% in 2020, 2050 and 2080, respectively, whiles reduction in cocoyam productivity will be 11.8%, 29.6% and 68% in 2020, 2050 and 2050, respectively. Farmers on their own do have options that help them cope and share losses or modify threats. Agricultural extension services and relevant agencies in the sector provide appropriate technologies and improved varieties. The study identified the following as adaptation/coping options for climate change:

- Improved farming technologies which includes planting more than 2 types of varieties of root crops on the same piece of land, planting improved varieties that are nutrient efficient and drought tolerant, adjustments to planting dates, fertilizer applications and supplementary irrigation.
- Post harvest technologies – This option provides insurance against local supply changes through storage which tends to store the crop for a longer period and also guarantees a good price for

the commodity. Alternate livelihood development especially those that give fast income such as bee keeping, poultry production, piggery, snail rearing, and mushroom cultivation.

- Marketing policies that encourage root crop production

The vulnerable groups most likely to benefit from these adaptation strategies are the farmers and rural folks, women and the urban poor in a decreasing order of severity.

5.2.7 Women and vulnerability to Climate Change

In the Ghanaian system, women have the primary responsibility for childcare, ensuring sufficient resources to meet children's needs for nutrition, health care and schooling. In the rural areas and in female-headed households, they are also the main managers of essential household resources like water, fuel for cooking and sometimes food for domestic animals. In addition to performing their household chores, women participate in land preparation, planting, weeding, fertilizer application, harvesting and transportation of produce. They also undertake the cultivation of vegetables in the dry or minor rainy season. Some of the women process both food and cash crops for home consumption and for sale. Given the variety of women's daily interactions with the environment, they are the most keenly affected by its degradation including Climate Change. Women face greater difficulties in accessing formal financial services than men because of their lower status and other cultural barriers in the communities. Lack of acceptable collateral; lack of familiarity with the land administrative processes due to illiteracy and lack of information are also part of the limitations that confront women. With restricted access to credit, women farmers resort to informal sources such as moneylenders, relatives and friends, who are unreliable, and in some cases expensive, resulting in more hardships.

Climate change will systematically affect women due to their reliance on subsistence farming activities. These changes will affect soil conditions and therefore would have adverse impact on food production. Women's income from their livelihoods and other economic activities will become critical thus making them poorer. This reinforces the importance of the environment and particularly climate change in women's lives. Given the opportunity, women may well have a predisposition to practice sustainable agriculture and maintain overall land quality, because of their strong reliance on natural resources. The Ministry of Food and Agriculture (MOFA) established the Women in Agricultural Development (WIAD) directorate in 1989, with the objective of improving access of women and other target groups to information on improved agricultural and post-production practices. They also facilitated access to resources towards an increase in production, improved nutrition, health and food security. These activities include transfer of technologies on food production, nutrition and food utilization, food processing, preservation and storage, while still maintaining the home management and other income generating activities to enhance the production capabilities of women in the agricultural sector.

A gender strategy on agriculture development has also been developed by MOFA. The outlined interventions have not taken into account the impacts of climate change. There is the need to recognize the importance of placing women at the heart of sustainable development. It will be a mistake to solve climate change impacts without integrating women in the process, or improve their status and economic empowerment since women's management of local natural resources is crucial. In Ghana, women constitute about 51% of the total population and about 30% are heads of households according to the 2000 population and housing census. With climate change and recurring droughts particularly in the northern parts of the country, and chronic water shortages, the poor, especially women and children usually spend more resources for water. They pay more in cash to buy small amounts of water

and they expend more in energy carrying water from long distances. Women and children are most vulnerable to hunger-related deaths and illness, which would be indirectly exacerbated by climate change through food and water shortages. Cases of cholera, diarrhoea, malaria, malnutrition, and heat-related deaths may increase depending on varied climate scenarios. The two major issues that emanated from the study were lack of knowledge on the causes and impacts of climate change and inadequate capital for the women in their economic activities. Discussions with the women revealed that much as they have experienced the changes in the climate, the vast majority of them do not have any idea about the causes. Therefore, any fruitful discussions on the impacts and policies to mitigate climate change must consider the differential knowledge of women on developmental issues and the need to create awareness to the general public. Sustainable development demands recognition and value for the different ways in which women's lives are linked with environmental realities including climate change. Women's involvement must extend to the availability of simple and relevant information; access to appropriate technological innovations; extension and resource management services. As key stakeholders, women could enhance their roles in national development on the basis of scientific and technological upgrading of their activities. The fundamental concept is that strategic extension of innovations to women will improve their contributions to national development and promote national welfare. Although, climate change may affect women more negatively than men, adaptive options must target both women and men in order to understand and harness their complementarities for achieving effective and equitable development.

5.2.8 Impacts of Climate Change on Cocoa Production in Ghana

Cocoa is highly susceptible to drought and the cropping pattern is related to rainfall distribution. The annual total rainfall in the cocoa growing regions of Ghana is within a range of 1200 mm and 2000 mm. The rainfall distribution pattern is bi-modal from April to July and September to November. There is a short dry period from July to August during which the relative humidity is still high, with over cast weather conditions. There is a main dry season from November to February-March. During prolong droughts, there is soil water deficit leading to loss of cocoa seedlings during the establishment phase. In fruiting plants, the existence of the short dry season during pod filling can affect bean size if it is sufficiently severe. In old plantations, water deficits result in lower yields and an increase in mirid (capsid) infestation.

Cocoa has a low light saturation point (LSP) of 400µEm-2s-1, and a low maximum photosynthetic rate (7 mg dm-1 h-1) at light saturation. The photosynthetic rate of the crop decreases if the photosynthetic apparatus is exposed to light intensities exceeding 60% of full sunlight that is 1800µmol m-2s-1, while prolonged exposure to high light intensities damages the photosynthetic mechanism of the leaves. However, suppressed flower production results in light levels less than 1800 hours year-1, which further results in a considerable depressing effect on production. Cocoa can only be profitably grown under temperatures varying between 30-32^{O}C mean maximum and 18-21^{O}C mean minimum and absolute minimum of 10 °C. Temperature has been related to light use efficiency with temperatures below 24^{O}C having a decreasing effect on the light saturated photosynthesis rate.

Black pod disease is the most destructive of a number of diseases, which attack the developing or ripening cocoa pod. The disease is closely related to weather and climate. It is more prevalent in damp situations and is most destructive in years when the short dry period from July to August is very wet. Mirids (capsids) are sucking insects that feed on cocoa and make them difficult to establish. On mature cocoa, capsid damage can cause tree death. The insects are usually most active and destructive from

September to March, particularly when moisture deficit is severe. They are favoured by high light intensity and humidity in the cocoa microenvironment. Cocoa is highly sensitive to changes in climate from hours of sun, to rainfall and application of water and particularly to temperature due to its effects on evapo-transpiration. Climate Change could also alter stages and rates of development of cocoa pests and pathogens, modify host resistance and result in changes in the physiology of host pathogen/pests interaction.

The most likely consequences are shifts in the geographical distribution of host and pathogen/pests, altered crop yields and crop losses which, will impact socio-economic variables such as farm income, livelihood and farm-level decision-making. The climate change scenarios for the semi-deciduous forest and evergreen rainforest zones of Ghana constructed using process-based methods that rely on the General Circulation Models (GCM) in conjunction with Simple Climate Models (SCM), indicated that projected mean annual rainfall values in the semi deciduous forest zone of Ghana will decline by -2.8, -10.9 and -18.6% in year 2020, 2050 and 2080 respectively. In the evergreen rainforest forest zone, mean annual rainfall will also decline by -3.1, -12.1 and -20.2% respectively. Mean annual temperature changes will rise by 0.8, 2.5 and 5.4 and 0.6, 2.0 and 3.9°C respectively in the semi deciduous and evergreen rainforest zones in 2020, 2050 and 2080. These projected climatic changes will exacerbate soil moisture conditions during the dry season (November to March) and aggravate the vulnerability of cocoa production to adverse climatic changes. Since cocoa is highly sensitive to drought in terms of growth and yield, it is reasonable to anticipate consistent decreases in projected output from 2020 to 2080.

Estimated solar radiation is expected to rise by 1.9% in 2020, 3.2% in 2050 and 4.4% in 2080 compared with the year 2000 baseline value. On average, the daily average solar radiation will rise by 0.5 MJm-2d-1 by 2080. Vapour pressure will increase above the 2000 value in 2020 but show a downward trend in 2050 and 2080. The CASE2 (Cacao Simulation Engine 2), a process oriented computer model, is a physiological model that simulates cocoa growth and yield for different weather and soil conditions and cropping systems. The model was used to assess the impact of climate change on cocoa production. Results of the simulation showed that the projected yield of dry cocoa beans for 2020 and 2050 were 14 and 28% lower respectively, compared to the baseline year of 2000. A simulation run for 2080 was not possible because the projected annual rainfall figure for 2080 was below the minimum of 1250 mm year-1 required by the model for successful simulation. This indicates that moisture levels in 2080 would not be adequate for profitable cocoa production. Multiple regression analysis was also used to analyze impact of Climate Change on cocoa production. The analysis showed that over 60% of the variation in dry cocoa beans produced could be explained by the combination of the preceding year's total annual rainfall, total rainfall in the two driest months and total sunshine duration. The relationship is defined by the equation:

$$Y = 2447 - 1.41(x1) + 32.4(x2) + 0.66(x3)$$

Where:

Y= Annual dry cocoa beans production;

X1 = total annual rainfall;

X2= total rainfall in the two driest months of the year and

X3= total annual sunshine duration.

The over 800,000 farm families, comprising farm owners, sharecroppers and their dependents, who are directly engaged in cocoa production and whose livelihoods directly depend on cocoa, constitute the most vulnerable group in the sector. Other vulnerable groups are the rural poor and women. Other players in the cocoa production chain, such as the Licensed Buying Companies, Agrochemical Companies and inputs distributors, may also be considered vulnerable since cocoa is the focus of their business enterprise and any distortion in the cocoa production chain may affect their profits and livelihoods. These groups could lose their incomes and livelihoods in 2080 and beyond if adaptive strategies are not implemented to mitigate the effect of Climate Change on cocoa production. Cocoa production benefits farmers who use judgment or discretion in adjusting their behaviour; such non-routine decision-making can be thought of as an important part of the skill requirement of cocoa farming. The skill requirement of cocoa growing arise because cocoa is disease-prone and sensitive to temperature and moisture variation and because fermenting and drying methods carried out are critical to taste. High quality cocoa production thus requires motivation and skill to use best practices.

Given the low incomes of most farmers, the low motivation to further invest in cocoa and the lack of formal credit, most farmers cannot adopt recommended practices to mitigate the impacts of Climate Change on cocoa production and hence their high level of vulnerability to Climate Change effects. The success or failure of the State to foster labour supply; assure a sufficient return to intensive cocoa cultivation; provide transportation and other key infrastructure; buffer farmers from ruin in the commodity market; push for long-term investment; and advance quality production is crucial in mitigating the impact of Climate Change on cocoa production and the vulnerable groups in the sector. It is also crucial in sustaining the present level of income/revenue accruing to the State from the cocoa trade.

5.2.8.1 Adaptation Options for the Cocoa Sub-sector

The following policy actions may be put in place to deal with adaptation of the cocoa sector to the impacts of Climate Change:

- Rehabilitate and restore degraded and moribund cocoa farms and forestlands previously cultivated to cocoa. Encourage farmers to adopt efficient farming practices. For instance, relatively easy acquisition of credit, stabilization of farmers incomes through effective pricing policies, effective land tenure systems
- Manage drought policy through information systems about changing climate conditions and patterns, preparatory practices and options to deal with eventuality of drought, and farm insurance programmes, must be set in place.
- Promote the establishment of irrigation systems in cocoa farms through the provision of infrastructure, education and training.
- Encourage tree planting and maintenance of shade on cocoa farms. Shaded cocoa cropping system is a sustainable agricultural land use system that provides relatively high values of environmental services. The ecological and environmental benefits of this system include habitat conservation, Climate Change mitigation, hydrological cycling and watershed protection.

The Cocoa Research Institute of Ghana, in collaboration with MoFA and COCOBOD, in anticipation of future Climate Change, and taking cognizance of the debilitating effect of drought on cocoa production is continuously developing drought tolerant, high yielding and disease resistant cocoa planting materials and improved agronomic practices to sustain cocoa production and farmers' livelihood. Farmers and other vulnerable groups in the cocoa sector have sought alternative livelihoods in view of current difficulties in cocoa production. This is an anticipatory adaptive measure against loss of livelihood as a

result of loss of income from cocoa. Farmers are quite conservative and therefore require a very effective extension and credit systems to assist them to accept innovations, and new technologies. Policy actions to deal with adaptation and anticipatory adaptive strategies already in place have been synthesized into three major proposed adaptation options for implementation to mitigate the impact of climate change. These are summarized as follows:

Improved farming practices. This option involves the use of drought resistant/tolerant and high yielding planting materials; Zero tillage; non-burning of vegetation and mulching for conservation of soil moisture; 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. This would involve the use of appropriate agro-forestry technologies to reclaim degraded lands and replant cocoa using best practices. To stop deforestation, encourage afforestation, protect watershed and conserve biodiversity.
- Alternative livelihoods. Development of off-farm income generating activities (e.g. artisanal work and petty trading); Alternative land use activities (e.g. planting of other crops such as citrus, livestock farming and fish farming, beekeeping, mushroom cultivation etc.).

The rehabilitation and restoration of degraded areas envisaged among other actions to stop deforestation, encourage afforestation, protect watershed and conserve biodiversity. The loss of biodiversity through deforestation and land degradation has been estimated as 10% of the Gross Domestic Product. Biodiversity benefits for farmers and other vulnerable groups include timber and non-timber products, hunting opportunities, and protection from pest and disease outbreak through biological control mechanisms.

5.3 Multi-sectoral Climate Change Impacts Analysis

5.3.1 Context and Justification

Ghana is developing Climate Change adaptation strategy in support of the Ghana Poverty Reduction Strategy based on the Climate Change sectoral impacts studies. The strategy cuts across sectors, and involves the participation of sector experts who have done a combination of field and analytical work to create sector-specific adaptation plans. The challenge is to combine the individual sector plans into a coherent integrated plan. Of particular concern is the likely presence of complementary strengths or conflicts among sector plans. It is clear that representatives from each sector need to sit together and talk. However, a logistical problem presents itself. For the seven sectors– fisheries, land, root crops, cocoa, health, poverty, and gender – each of which proposed between three and ten Climate Change adaptation activities. For example, if an average of seven activities were chosen for each sector, the total number of activities is 49. Discussing the possible interactions between each of the activities on a case-by-case basis would require a total of 49 x (49 - 1)/2 = 1,176 discussions, while taking into account the combined impacts of different sector plans would involve 77 = 823,543 discussions. This is prohibitive, and a method is required to simplify the task of identifying interactions between activities in different sectors. Thus the Akropong Approach was employed.

5.3.1.1 "Akropong" Approach

The approach adopted in the cross-sector impact analysis aims to reduce the number of discussions by identifying those activities where an in-depth discussion would be most useful, using a comparatively rapid activity, while avoiding detailed discussion of activities that are likely to be independent of one

another. The approach was refined and formalized during a workshop held in Akropong Akuapim, Ghana, and has been named by the authors as the ‘‘Akropong Approach.’’ At the core of the approach is a modified cross-impact analysis. In the full approach, the cross-impact activity is combined with other methods—Logical Framework Analysis (LFA), Multi-Criteria Analysis (MCA), and scenario analysis. The components that make up the Akropong approach are shown in Figure 5.23. The starting point is a logical framework analysis for each sector, and the final output is a cross-sector project plan; in this case an action plan as a component of a national adaptation strategy. The main output from the sector LFAs are sector-specific plans.

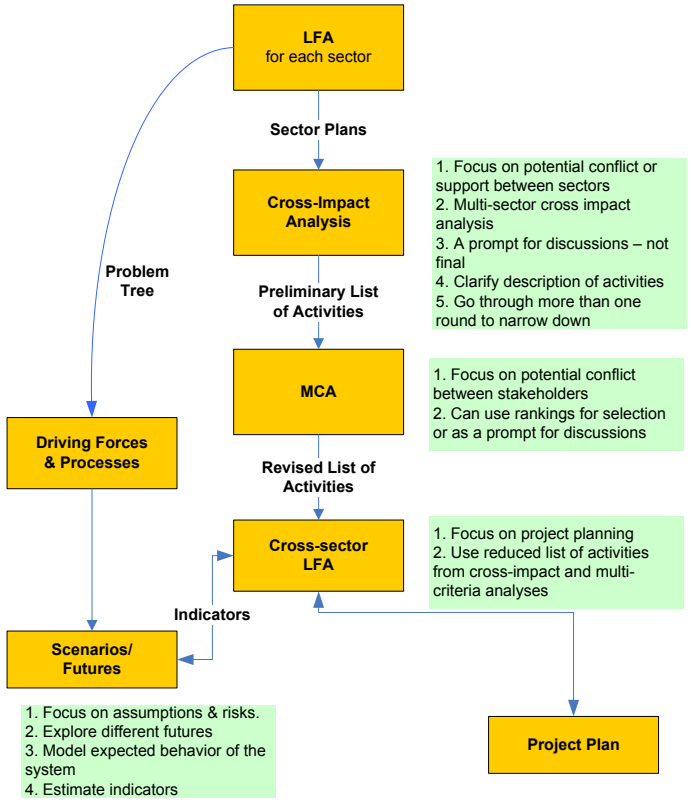


Figure 5. 22 Tool for multi sector climate impact analysis (Akropong approach)

Logical Framework Analysis is a technique for objective-based project planning. It consists of the following steps: (1) analysis of the project context; (2) stakeholder analysis; (3) problem analysis/situation analysis; (4) objectives analysis; (5) plan of activities; (6) resource planning; (7) indicators/measurements of objectives; (8) risk analysis and risk management; (9) analysis of assumptions. In this approach, stakeholders discuss the relative importance of different criteria for judging possible activities. Criteria are assigned weights according to the relative importance of each criterion as well as the degree of consensus. Activities are assigned scores for each of the criteria and an overall score is calculated for each activity as the weighted sum of the scores across all of the criteria. The overall scores are then used to rank the activities. Subsequent to the application of the “Akropong Approach” to the processes of prioritizing sectoral adaptation options, ten adaptation projects were identified and packaged into programmatic adaptation plan, which fed into national adaptation strategy.

The ten (10) projects include:

- Increasing resilience to climate change impacts: identifying and enhancing early warning systems.
- Alternative livelihoods: minimizing impacts of climate change for the poor and vulnerable.
- Enhance national capacity to adapt to climate change through improved land use management.
- Adapting to climate change through enhanced research and awareness creation
- Development and implementation of environmental sanitation strategies to adapt to climate change.
- Managing water resources as climate change adaptation to enhance productivity and livelihoods
- Minimizing climate change impacts on socio-economic development through agricultural diversification.
- Minimizing climate change impacts on human health through improved access to healthcare
- Demand- and supply-side measures for adapting the national energy system to impacts of climate change.
- Adaptation to climate change: sustaining livelihoods through enhanced fisheries resource management.

Implementation of the prioritised adaptation options are designed in a programmatic fashion to ensure wider resilience building benefits to most vulnerable natural and human systems. The options under early warning systems and health are being implemented with support from the Government of Japan and UNDP-GEF respectively.

5.4 Policies and Measures to Support Adaptation to Climate Change

Ghana is embarking on programmes to facilitate adaptation to Climate Change in various sectors and across the various national planning levels. The choice of policies and measures are closely linked to the overall priority impacts sectors, which emerged from the cross-sector impact analysis. At the upstream level, Ghana is developing the National Climate Change Adaptation Strategy (NCCAS) with support from UNDP (Ghana Country Office) and the Climate Change Adaptation and Development Initiative (CCDARE) to provide strategic linkages among prioritised impact sectors. This is to ensure packaged delivery of Climate Change adaptation programme at the project level, which emerged from the multi-sectoral impact analysis.

Mainstreaming Climate Change into national development has commenced and piloted in 10 district assemblies in Ghana. The mainstream processes were supported by the UNDP country office and culminated in the development of a "guide or tool" for integrating Climate Change and disaster risk reduction into national development, policies and planning in Ghana. At the downstream level, two of the ten-point programmes that emerged from multi-sector impacts analysis attracted funding from the Japan Government and UNDF-GEF for implementing resilient-building project in early warning system and health. The two projects are underway.

5.4.1 National Climate Change Adaptation Strategy (NCCAS)

Ghana is developing a national Climate Change strategy to contribute to the mainstreaming processes of Climate Change and disaster risk reduction into national development planning as well as facilitate effective adaptation across sectors and at various planning levels. The preparation of the adaptation strategy has been principally influenced by among other reasons; (1) Ghana's commitments under the UNFCCC to ensure that Climate Change issues are adequately considered in national development

planning, (2). The country's responsiveness to the Hyogo Framework for Action (HFA) 2005-2015 (comprehensive and action oriented response to international concern about the growing impact of disaster on individuals, communities and national development, which aims to reduce substantially loss of life as well as the social, economic and environmental losses caused to communities), (3) the extent of added vulnerability to the Ghanaian economy attributed to the current and expected impacts of Climate Change on the entire society makes the preparation of the NCAS more appropriate. Initial funding for the preparation of the funding was sought from the Environment and Natural Resources Governance budget support programme and later complemented by resources from CCDARE.

5.4.1.2 Scope, Guiding Principles, Objectives and Strategies

The following key principles generally guided the formulation and implementation of the NCCAS:

- Adaptation policies must be addressed as part of a broader context of National Development Policy Framework.
- Stakeholder participation is central to ensure national ownership.
- Promotion of sustainable development and poverty reduction is focus areas of the adaptation strategy.
- Long term impacts of Climate Change is the principal means for considering adaptation
- Gender sensitivity and reduction of vulnerability are extensively adopted.
- Flexible and iterative.
- Cross-sectoral and integrative but not necessarily sector wide.
- Implementation of the document shall ensure learning by doing.

Thus, the basic goal of the NCCAS is to increase Ghana's resilience to Climate Change impacts now and in the future through improved awareness, effective mainstreaming and consistent efforts to reduce vulnerability in natural and social systems. This would be achieved by building Ghana's capacity in the area of infrastructure and knowledge to deal with Climate Change impacts and reduce vulnerability in key sectors, ecosystems, districts and regions of the country.

5.4.1.3 Approaches and Processes

The preparation of the NCCAS has been driven fundamentally by participatory approaches anchored on transparent processes. The process has evolved from the assessment stage (impact, vulnerability and adaptation assessment and multi-sector impact analysis), on the basis of which this strategy has been prepared. Subsequent to drafting, the strategy was subjected to wider consultation among key stakeholders. The strategy would be further subjected to national approval processes to seek buy-in from the highest political authority possible in Ghana. This process is crucial to assert legitimacy, authority and ownership of the strategy. The entire approach is presented in the figure 5.24.

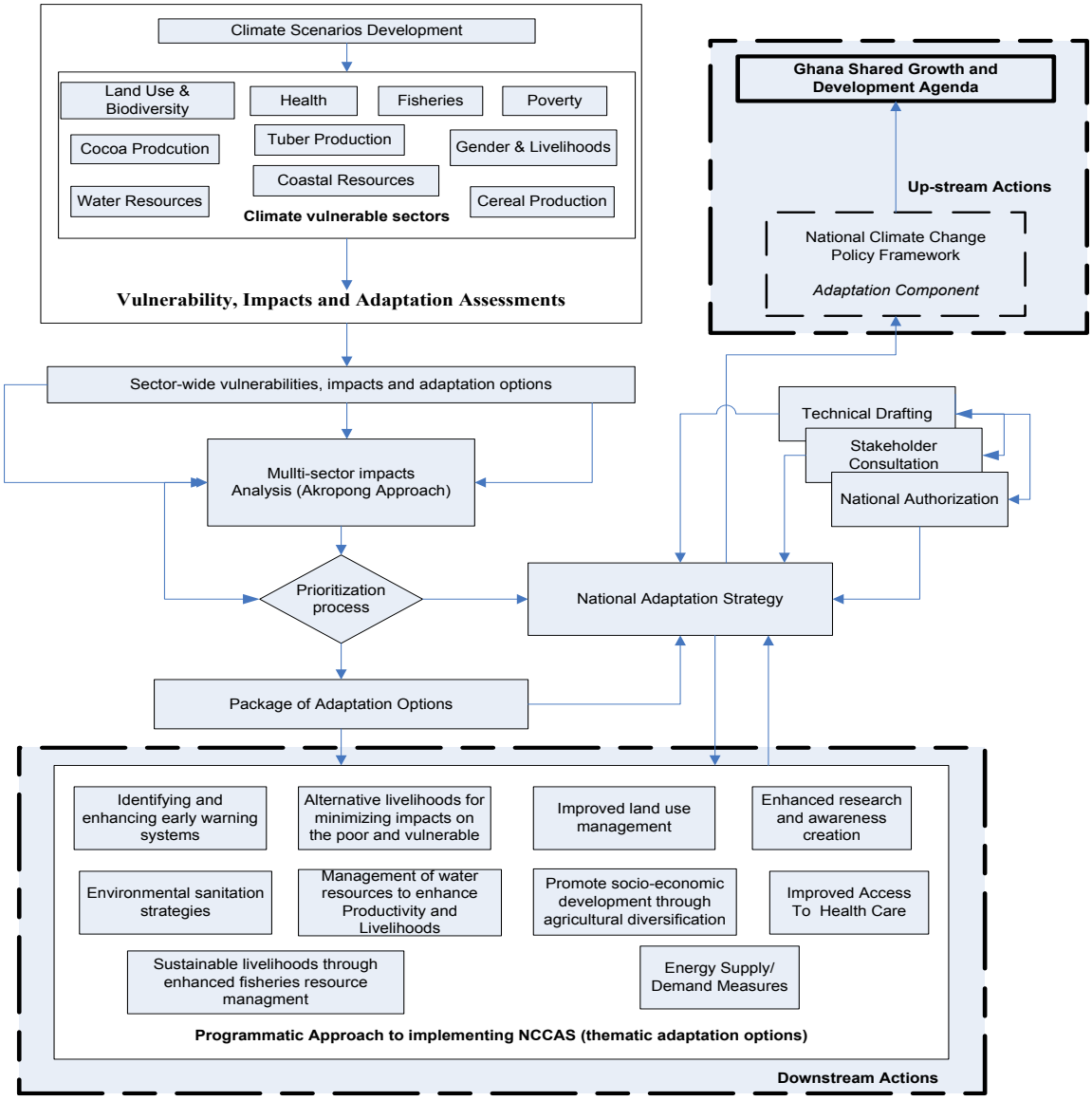


Figure 5. 23 : Overview of the process-based approach to Climate Change adaptation planning in Ghana

Source: *Tutu Benefoh, 2010*

5.4.2 Mainstreaming Climate Change and Disaster Risk Reduction into National Development, Policies and Planning

There has been high-level commitment from the government of Ghana to tackle Climate Change, which has translated to a range of activities including assessments and tools for mainstreaming Climate Change and Disaster Risk Reduction (CC and DRR) into district and national development plans. The UNDP has provided continued financial support to facilitate piloting of mainstreaming of CC and DRR into districts development plans in ten (10) District Assemblies. Each district was selected based on risk and vulnerability levels by spatial location, poverty levels, accessibility to resources and above all extent of extreme climate events. To facilitate the process better, a CC and DRR mainstreaming guidebook has been developed to aid in building capacities of the various District Planning and Coordination Units of the District Assemblies. The guidebook specifically intends to;

- Create and deepened awareness about the critical role of Climate Change and disasters in national development efforts
- Ensure that Climate Change and disaster issues are fully integrated and sustained in the national planning processes.
- Assist pilot districts to integrate Climate Change and disaster risk in their District Medium Term Development Plans

The exercise is expanding to cover newly created District Assemblies. So far, five District Assemblies out of the initial ten pilot districts are implementing community-level Climate Change adaptation projects.

5.4.3 Africa Adaptation Programme (AAP)

AAP is a strategic initiative funded by the government of Japan and is aimed at creating an environment for more informed and capable adaptation decisions and practice in each Country. AAP provides financial support to 21 African Countries to implement adaptation initiatives. The national projects are designed to further develop country capacities to successfully implement adaptation and disaster risk reduction in line with national development goals. In Ghana, the project is being implemented by the Environmental Protection Agency in collaboration with Ghana Meteorological Agency (GMet), National Disaster Management Organisation (NADMO), Ministry of Finance and Economic Planning (MoFeP), National Development Planning Commission (NDPC). The Regional UNDP Office in Dakar provides technical support to the national projects.

The project objective is to ensure broadened and improved institutional capacity and financing mechanisms for addressing climate risks, and demonstrating positive impacts in linking disaster risk reduction and Climate Change through the implementation of early-warning systems. The project is expected to achieve the following:

- Strengthen long term planning to manage both existing and future risk associated with Climate Change.
- Strengthen leadership and institutions to manage climate risks and opportunities in an integrated manner at the local and national levels
- Implement policies and measures that are durable in nature and can withstand Climate Change impacts in priority sectors.
- Expand financing opportunities to meet national adaptation costs at the local, national, sub-regional and regional levels.
- Build knowledge management systems and promote information sharing across all levels.

The AAP also considers tangible downstream projects vital. In this direction, the project is working closely with 5 pilot districts to fund practical adaption projects in Ghana. The Districts are: Aowin Suaman, Fanteakwa, Keta, Sissala East and West Mamprusi. The District Assemblies selected their projects, particularly to build adaptive capacities of social groups whose livelihoods are threatened by the impacts of Climate Change and extreme events. In general, the AAP has generated enough positive resonance both at the strategic and community levels to support any scaled-up action across sectors and at the various planning levels.

5.4.3 Climate Change and Health

Reducing climate-related health vulnerabilities is one of the adaptation thematic options that emerged from the cross-impact analysis. The adverse impacts of Climate Change on health risk are compounded by a current and significantly large disease burden. Climate is a primary determinant of whether a particular location has suitable environmental conditions for the transmission of malaria, meningitis,

and diarrheal diseases. Current interventions to support the health sector do not take the risks of Climate Change into account. To date, Ghana's approach to Climate Change in relation to human health vulnerability has been a reactive response, and is characterised by an absence of a well-defined strategic and policy intervention plan for both the medium and long terms. Besides financing shortages, the absence of a policy framework for addressing Climate Change related health risks; absence of technical and institutional capacities at local and national levels make the need for corrective interventions even more urgent.

Ghana is receiving support from the UNDP/GEF to implement a project on "Integrating Climate Change into the Management of Priority Health Risks in Ghana". The Ministry of Health will implement the project with support from the Environmental Protection Agency. The project will entail institutional strengthening, capacity building, and raising awareness under a programmatic approach to Climate Change sensitive health risk management. Three critical components underpin this initiative: (1) Strengthening technical capacities to manage climate change -related health risks; (2) climate change health risk mainstreamed into decision-making at local and national health policy levels, and (3) Information management and effective dissemination of climate change health risk knowledge. Demonstration activities will also be implemented in selected pilot areas identified to be at particularly high health related risks due to climate change. The project objective is to identify, implement, monitor, and evaluate adaptations to reduce current and likely future burdens of malaria, diarrheal diseases, and meningococcal meningitis.

The project will generate adaptation benefits by building local and institutional capacity to manage adverse Climate Change impacts on human health, especially among vulnerable sub-groups such as women and children. The results of the project will be relevant to decision-makers in other parts of sub-Saharan Africa and in regions of the world where climate sensitive diseases such as malaria, diarrheal diseases, and meningococcal meningitis are prevalent. It will complement the governments' present initiatives such as the Roll Back Malaria programme, and Integrated Management of Childhood Illness (IMCI). The project will address long term adaptation to Climate Change needs by supporting the development of local capacities and institutions to explicitly factor in Climate Change risks on key disease burdens and various national level plans and programmes that are designed to manage their expected spread and impact on development.

5.4.4 Analysis of Financial Needs to Implement Climate Change Adaptation Measures

Following Ghana's participation in the National Environmental, Economic and Development (NEEDS) for Climate Change project, analysis of financial needs for implementing climate change adaptation measures have been done. The NEEDS Project was launched in response to SBI 28 mandate to request information on the assessment of financing needs of non-Annex I Parties to implement mitigation and adaptation measures (FCCC/SBI/2008/8). The main objectives of the NEEDS Project are to support the participating countries including Ghana in:

- Selecting key sectors for climate change mitigation and adaptation measures, on the basis of priorities identified in the national communications and in national development plans;
- Assessing the financing required and received to implement mitigation and adaptation measures in the key sectors selected and identifying appropriate financial and regulatory instruments to support these measures;

- Raising awareness and facilitating informed consensus among government agencies on the policy actions required to mobilize finance and investment in mitigation and adaptation measures.

5.4.4.1 Methodology for Estimating Cost of Investment in Adaptation Scenarios

The methodology for calculating the cost estimation in the various sectors earmarked for adaptation to Climate Change followed the same procedure used for mitigation measures. While the mitigation scenario incorporated measures to lessen Greenhouse Gas (GHG) emissions, the adaptation scenario incorporated new measures to respond to the potential impacts of Climate Change on health, agriculture and coastal zones. Investment in the base year was used in estimating time horizons 2020 and 2050. Government budgetary allocation for the Health and Agricultural sectors in 2006 were appropriately discounted and used for estimating the adaptation cost in 2020 and 2050. Scenarios were made using the Business-As-Usual figures. In the case of malaria, the cost estimations were based on costs per episode and the prevalence rate for the Business-As-usual. The cost estimations for adaptation to Climate Change in the coastal zone was done using investment alternative proposed by the Ada Coastal Protection Works and Volta River Estuary Report (2007). Appropriate discounting was undertaken for the Business-As-Usual case as well as the Climate Change scenario. In total, Ghana will need about US$ 697.2 million by 2020 and US$ 701.7 million by 2050 to implement adaptation measures to contain the effects of Climate Change (Table 5.4).

Table 5. 5: Incremental Cumulative Investment by sectors - Adaptation in Climate Change (Constant US Dollars)

Sector	B-A-U	CC Scenario	Amount Needed
Health (Whole Sector)**			
2006	3,026,296,286.27	2,874,981,471.96	151,314,814.31
2020	6,994,167,839.42	6,644,459,447.45	349,708,391.97
2050	7,042,217,556.47	6,690,106,678.65	352,110,877.82
Malaria*			
2003	66,556,045.48	63,228,243.20	3,327,802.27
2020	151,042,279.36	143,490,165.39	7,552,113.97
2050	150,818,247.73	143,277,335.34	7,540,912.39
Agriculture (Whole Sector)**			
2006	2,892,473,220.30	2,747,850,675.87	144,622,544.43
2020	6,684,882,753.24	6,350,641,190.39	334,241,562.85
2050	6,726,013,733.67	6,389,715,633.50	336,298,100.16
Coastal Zone Management***			
2006	49,763,250.00	47,275,087.50	2,488,162.50
2020	115,009,400.87	109,258,930.83	5,750,470.04
2050	115,717,064.60	109,931,211.37	5,785,853.23

Note:

* estimations based on costing of malaria in 2003 by Asante et al (2005).
** estimations based on government budgetary allocation in 2006 for the sector.
*** estimations are based on Ada Coastal Protection Works Report (2007).

Discount rate (37.5%) = Bank of Ghana prime rate (18%) + Commercial Bank's margin (11.5%) which together forms the bank's base rate + margin on lending (8% - ceiling) charged by commercial banks. Discount factor = (1/1+0.375)n, Average interbank rate for 2006 (US$ to GH) = 0.9131, B-A-U= Business-As-Usual scenario, CC= Climate Change.

Limitations in Estimating Adaptation Costs

Estimation of the cost of adaptation under various scenarios is fraught with uncertainties, which include differences in adaptive capacity; the fact that most adaptations will not be solely for the purpose of adapting to Climate Change; the uncertainties associated with any readily available methods to estimate adaptation costs; and the existence of an adaptation deficit. There is uncertainty about adaptive capacity of people and societies in responding to stresses related to Climate Change. Therefore all scenarios used in this study leave many key aspects of adaptive capacity undefined. Also most adaptations to Climate Change will most likely not be made solely to adapt to Climate Change. This implies that most activities that need to be undertaken to adapt to Climate Change will have benefits even if the climate does not change. Thus, it will be difficult to attribute all benefits of adaptation measures to scenarios under Climate Change.

5.4.4.3 Cost of implementing Adaptation Measures

Health

In the health sector, Climate Change is projected to increase the burden of climate-sensitive health determinants and outcomes with the impacts being manifested in changes in the location and incidence of infectious and diarrhoea diseases, increases in air and water pollution, and increases in risk of heat stress. The adaptation scenario suggests specific measures that can be taken to reduce vulnerability to Climate Change and these could include improved monitoring systems to detect the arrival or presence of infectious diseases and also investment in heat-watch warning systems to warn the population about heat waves. The incremental cost of adaptation in Climate Change in the health sector will be about US$ 350 million by 2020. This figure will go up to about US$ 352 million by 2050. Scenarios are discount at rates of 25% and 20%. Malaria treatment forms about 50% of outpatient care in public hospitals. The Health expenditure on malaria in Ghana comes from both the public and private sectors. It is a fact that government spending is a major expenditure item in malaria treatment in Ghana but the payment by the private sector in treating malaria is significant. Government expenditure mainly goes into operation of health facilities that treat malaria while the families of those affected pay for the cost of treatment although this trend is expected to change in the adaptation scenario due to the sustained operation of the National Health Insurance Scheme (NHIS), which has helped in lifting this burden off the shoulders of many households. The estimations do not include the costs of setting up new infrastructure (such as new hospitals). Additional investment in controlling malaria will be about US$ 7.6 million/yr. in 2020 and US$ 7.54 million/yr. in 2050. This additional investment is needed to avoid an episode of malaria.

Agriculture

The agricultural sector will require about US$ 334.24 million in 2020 and US$ 336.30 million in 2050 for adaptation to the impacts of Climate Change. The investments will mainly be in research into production of drought tolerant crops, change in management of crops and fisheries, moisture and irrigation management, extension and training, pest and disease management, fire management in crop production, among others.

Coastal Zones

Climate Change will result in rising sea levels, increased intensity of coastal storms and the destruction of coastal wetlands. The combination of these and continued expansion of human settlements in coastal areas is likely to lead to an increasing need for protection from coastal hazards. Protection of natural ecosystems such as wetlands can increase the resilience to Climate Change. The major abatement scenario for adaptation is that of protection, which is to reduce the risk of the effect of Climate Change by decreasing the probability of the occurrence of sea-level, rise. The major suggestion in this adaptation scenario is the development and integration of coastal zone management institutions and processes. This could increase the efficiency of adaptation to Climate Change and sea level rise with respect to protection of the coastal zone in Ghana. Additional investments needed for adaptation at the Ada Coastal Zone by 2020 will be US$5.7 million and this will increase to US$5.9million in 2050.

6. Polices and Measures to Mitigate Climate Change

This chapter presents a summary of policies, measures and efforts to facilitate Climate Change mitigation in Ghana. The topics are generally addressed in three sections. The first section addresses mitigation assessments for key sectors such as energy, transport and agriculture and forestry. The assessment builds on the assessment conducted during the initial national communication. Drawing from the assessment in the first section, the second section provides an overview of upstream efforts to facilitate mitigating climate change especially in sectors that contribute significantly to national GHG emissions and removals. The third section reflects various supported national efforts to translate mitigation measures into implementation at the project level.

6.1 Sectoral Mitigation Assessments

6.1.1 Background

For the purposes of improving on the robustness of the assessments, the complete GHG emission time series (1996-2006) was used as the basis. The emission trends revealed that the largest and rapidly growing sectors for emission and removals are energy, agriculture and forestry sectors. Thus, emphasis was put on these sectors in the planning of mitigation measures. However, this does not suggest that other sectors such as waste, industrial process were excluded. The various authors justified the use of various models (e.g. LEAP, ADAGE and G-cubed) and methodologies to estimate future trends GHG emissions and removals under different mitigation scenarios. Therefore, the assessment focuses on

energy, forestry and agriculture. Based on the results of the complete GHG emissions time series analysis, different GHG emission and mitigation scenarios were developed.

6.1.2 Projections of GHG emissions at 2020 and 2050 under the Business-As-Usual

The energy sector in Ghana is currently the largest emitter of GHG. Projection of GHG emissions indicates that CO_2 equivalent emissions would increase from 7,278 Gg to 118,405 Gg between 1994 and 2020, move up to 234,135 Gg by 2030, and then to 519,826 Gg by 2050 (Table 6.1).

Table 6. 1 Projections of CO_2 Equivalent GHG Emissions under the Business-As-Usual Scenario

Year	1994	1996	2000	2004	2008	2020	2030	2050
Biomass consumed TJ	233033.1	2975551	485163.7	791046.6	1289780.5	5590583.6	10515000.2	22828048.9
CO_2 emissions from fossil fuels (Gg)	3048.40	3892.50	6343.62	10348.00	16872.14	73132.68	146263.63	328505.93
Methane emissions from biomass (Gg)	155.80	198.94	324.37	528.87	862.31	3737.72	7475.29	16789.35
Nitrogen oxide emissions from biomass (Gg)	0.80	1.02	1.67	2.72	4.43	19.19	38.38	86.20
CO_2 equivalent of CH_4 (Gg)	3817.00	4873.93	7946.81	12957.06	21126.15	91571.78	183140.05	411328.81
CO2 equivalent of N2O (Gg)	256.00	326.89	532.98	869.01	1416.90	6141.57	9125.76	20382.38
Business-As-Usual CO_2 equivalent	7278.00	9093.32	14826.41	24174.07	39415.19	118404.87	234135.02	519825.62

6.1.3 Abatement scenarios at 2020 and 2050 time horizons

Abatement scenarios under climate change have been principally focused on three major sectors that are potential sources for GHG emissions and reductions. The GHG inventory results showed that the energy sector was responsible for the highest emissions of CO2 while the forestry sector emerged as the potential for increasing the country's carbon sink base.

6.1.3.1 Abatement scenarios under Energy Sectors

Four abatement scenarios have been considered in this sector and these are as follows:

- Replacing some biomass with LPG: replacement of fuelwood and charcoal with LPG at the rate of 10% per annum from 1995 to 2020 (Scenario 1).
- Use of biogas and LPG to replace some biomass from 2010 to 2015 when only LPG and biogas will be used with the largest proportion of energy for cooking coming from biogas (Scenario II).
- Gradual penetration of solar PVs to the existing mix: this option integrates the options in scenario two and other options aimed at reduction in the use of petroleum products and electricity. The first option is 5% reduction in the use of petroleum products and electricity from 2000 to 2004, which then moves to 10% from 2005 to 2010, 20% from 2011 to 2014 and finally 50% from 2015 to 2020 (Scenario III).
- Gradual penetration of biogas instead of a huge penetration as in the second and third scenarios: this option was an adjustment of the third option by just a gradual penetration rate for biogas for cooking by 10% of households per year from 2010 to 2020 (Scenario IV).

Estimated CO_2 reductions from the abatement scenarios above are 494,506 Gg, 700,044 Gg, 712,515 Gg and 543,778 Gg for scenarios I, II, III and IV with their projected cost savings of 33.22 $/Gg, 27701.56 $/Gg, 6932.22 $/Gg and 9448.86 $/Gg respectively (Table 6.2).

Table 6. 2 Emissions reduction and cost savings under different abatement scenario

Options	CO_2 Reduction (Gg)	$/Gg
I	494,506	33.22
II	700,044	27,701.56
III	712,515	6,932.22
IV	543,778	9,448.86

6.1.3.2 Abatement Scenarios under Forestry Sector

The forest protection abatement scenario is generally geared towards increased surveillance of protected/managed permanent forest and wildlife reserves and involvement of stakeholders, especially local communities in their protection. As a result, an additional 42,000 ha of unreserved high forests above the baseline situation (which is expected to protect 3,000 ha) would be maintained and managed as productive dedicated forests by communities and landowners. In the end, total carbon density would increase from 213tC/ha in 2001 to 272tC/ha in 2020 in the high forest zone and from 55tC/ha to 62tC/ha in the savannah woodland zone over the same period.

Another abatement option is the reforestation abatement scenario, which will ensure that an additional 112,000 ha of land is reforested, largely as industrial plantations by private enterprise (small, medium and large scale). This area is approximately equivalent to the unreserved high forests that would be deforested and lost even under the forest protection option outlined earlier. Consequently, the incremental carbon that would be sequestered is estimated at 6,060ktC. The cost of the reforestation option would amount to US$ 93.6 million between 2001 and 2020 for the 112,000 ha of land to be reforested with an initial establishment cost of US$ 836/ha. This also translates into about US$ 15.45/KtC sequestered. It also used a net present benefit approach with a discount rate over a 20year rotation and this was estimated at US$ 330/ha or US$ 6.10/KtC. The estimation was based on indicative costs and benefits developed for private sector industrial forest plantation programs in Ghana.

6.1.4 Analysis of Cost of Implementing Mitigation Measures

6.1.4.1 Energy

The major assumption under the mitigation scenario in the energy sector is the implementation of strong policies that seek to increase energy efficiency significantly to provide the same services with 15% less energy and shift the energy supply to more climate friendly technologies. It is also assumed that increased energy efficiency will limit the rate of growth of electricity demand under the current mix by 2020 and 2050. The scenario also assumes a substantial shift in electricity generation in Ghana, with significant investments in nuclear and renewable energy. Finally, the mitigation scenario suggests that energy subsidies especially on the price of LPG should be incorporated into the cost of petroleum product build-up. The logic is that the subsidies on LPG prices can reduce emissions by curbing

deforestation when households (especially rural and to a large extent urban) switch from firewood and biomass burning (charcoal) to LPG. The energy sector will require additional investments of about US$ 286 million in 2020 and US$ 287 million in 2050. These investments will be needed in energy-efficient equipment that is ultimately expected to reduce emissions by 5%. Additionally, the electricity subsector will need investment flows up to US $ 21.9 million by 2020 and US $22 million by 2050. Emissions due to electricity generation mainly from thermal electricity generation are projected to increase by 2.73% by 2020 and 7.31% by 2050 in the Business-As-Usual scenario from 2004.

6.1.4.2 Transport

The mitigation scenario in the transport sub-sector is based on increased use of bio-fuels and investments in fuel-efficient vehicles, by both Government and private stakeholders by 2020 and 2050. These measures will need to be driven by policies and must be enforced. In this scenario, the subsector will require additional investment to the tune of US$ 6.58 million in 2020 and US$ 6.55 million in 2050.

6.1.4.3 Forestry

The financial flow needed to reduce deforestation/ degradation is estimated as the opportunity cost of converting forest to other land uses. The mitigation scenarios advanced for the forestry sector are a reduction in deforestation; better management of productive forests (proper forest management); and forestation to increase the forest area (afforestation and reforestation). Additional investment in the forestry sector is mainly geared towards reforestation, which eventually will reduce GHG emissions by sinks. Therefore, additional costs needed would be about US$ 3.9 million in 2020 and US$ 81.1 in 2050.

6.2 Methodology for Estimating Cost of Investment in Mitigation Scenarios

The cost of implementing mitigation measures due to Climate Change in 2020 and 2050 has been estimated using a discount rate of 37.5%. Investments by private as well as public sources in the base year have been calculated for time horizons 2020 and 2050. This rate is the opportunity cost of capital for investments and is based on the Bank of Ghana's prime rate and charges on lending by commercial banks. This rate has been used because there is no explicit public discount rate established by government Ministries, Departments and Agencies (MDAs). The costs have been estimated based on assumption that there will be additional investment in the various sectors, which will see implementation of mitigation measures. The major sectors for mitigation include energy and forestry. The estimations in the forestry sector were based on cost of plantations and maintenance of reforests by the forestry commission of Ghana while that of the energy sector was based on government budgetary allocation in 2006.

The estimations of the transport subsector were based on investment flow and operations and maintenance costs of Metro mass Transit Ltd (a public-private entity) in Ghana. The transport sector is responsible for about 60% of all petroleum consumed in Ghana with 1990 as the base year. This means that this subsector is a major contributor of GHG emissions in Ghana and therefore included as a standalone subsector. Estimations of investment flows and operations and maintenance flows needed in the electricity generation subsector were based on figures from the Takoradi combined cycle plant (this plant uses both fossil fuel and/or natural gas to generate electricity) and the main sources of funds have been a combination of both private and public sources. The results also indicate that (Table 6.3) additional investments that will be needed to mitigate effects of Climate Change relative to the Business-As-Usual scenarios. On the whole, Ghana will need about US $ 340.6 million by 2020 and US$ 422.7 million by 2050 to execute mitigation measures (mainly in the energy sector and forestry subsector).

Table 6. 3 Incremental Cumulative Investment by sectors - Mitigation in Climate Change (Constant US Dollars)

Sector	B-A-U	Mitigation Scenario	Amount Needed
Energy (Whole Sector)**			
2006	2,467,339,219.04	2,344,008,456.34	123,330,762.69
2020	6,170,139,519.43	5,861,724,081.97	308,415,437.46
2050	6,263,953,049.11	5,950,848,947.30	313,104,101.81
Transport*			
2003	58,362,691.80	55,516,820.39	2,845,871.41
2020	134,642,518.96	128,065,336.68	6,577,182.28
2050	133,584,576.74	127,031,741.84	6,552,834.90
Electricity			
2004	189,379,644.81	179,944,689.76	9,434,955.05
2020	437,679,960.80	415,874,475.83	21,805,484.97
2050	440,540,600.16	418,590,437.08	21,950,163.08
Forestry- Reforestation***			
2006	14,355,817.84	13,638,165.67	717,652.17
2020	77,259,104.33	73,397,179.79	3,861,924.54
2050	***154,501,687.42	73,401,214.35	81,100,473.07

Note:

* Estimations based on investment and O&M cost by Metro Mass Transit Ltd,
** Estimations based on government budgetary allocation in 2006 for the sector.
*** Investment is required to establish new plantations since forest plantations have average lifespan of about 30 years.

Discount rate (37.5%) = Bank of Ghana prime rate (18%) + Commercial Bank's margin (11.5%) which together forms the bank's base rate + margin on lending (8% - ceiling) charged by commercial banks. Discount factor = (1/1+0.375)n, Average interbank rate for 2006 (US$ to GH₵) = 0.9131, B-A-U= Business-As-Usual scenario, CC= Climate Change .

6.3. Policies and Measures to Mitigate Climate Change

Ghana is implementing policies and measures that would inure to the ultimate benefits of climate mitigation and above all contribute to sustainable development. At policy level, Ghana has set the pace to formulate a low carbon development strategy, which will feature prominently in the National Climate Change Policy Framework. To facilitate buy-in, a number of policy briefs are being developed under the directive of the National Climate Change Committee.

6.3.1 National Efforts to Develop Low Carbon Growth Strategy (LCDS)

The need to develop a low carbon development strategy as a blue print to contribute to orienting Ghana's development to a sustainable path has been recognised at the higher political level in Ghana. This has translated to the inclusion of low carbon growth component as one of the major pillars of the National Climate Change Policy Framework. The process is being facilitated by a set of policy briefs on Low Carbon Growth, NAMAs and MRVs; emissions from flaring jubilee field gas. With support from the Dutch government through Energy Research Centre of the Netherlands, Ghana is also setting up a methodology for designing an LCDS using the phased approach. This phased approach consists of simultaneously a) assessing the institutional and technical capacity needs, b) step by step building the

necessary fact base and c) creating awareness and developing capacity within the different Ministries and sector representations. In Ghana, the LCDS methodology will focus on the following objectives:

- Clear description of the current situation regarding institutions, major emissions sources, and policies and efforts related to climate change and development.
- Analysis of the issues surrounding data collection and management, both of which are essential for any form of scaled up and rigorous climate change related effort - the project will assess capacity needs and provide recommendations for improvement.
- An exploratory assessment of issues related to Nationally Appropriate Mitigation Actions (NAMAs) and the related systems for Monitoring, Reporting and Verification (MRV) to show how LCDS can be operationalised for a specific sector using two concrete Ghanaian NAMAs as case descriptions.
- Providing three short, clear and accessible briefing notes on the above points targeted at parliament and cabinet ministers to build the political awareness required for broad support.

6.3.2 Responses to the International Mechanism on Enhanced Mitigation Actions

Ghana has responded positively to various international mechanisms on enhanced mitigation actions. After associating itself to the Copenhagen Accord, which emerged as a political agreement among selected countries, Ghana submitted a list of fifty-five (55) NAMAs to the UNFCCC secretariat as appendix. Indications are that Ghana will continue to participate in the NAMAs mechanism as agreed during COP 16 in Cancun, Mexico in 2010. The large number of NAMAs would require some prioritization before developing them in concrete proposals for implementation. In addition, Ghana also collaborated with the ECOWAS secretariat to initiate a programmatic NAMA in the sub-region. The collaboration is meant to explore possibilities to leverage opportunities in sectors that are promising to demonstrate and implement NAMAs successfully at the sub-regional scale. The initiative is beginning to resonate strongly among member countries following an inception meeting to evolve a roadmap for the exercise. In the end, the roadmap is expected to translate into NAMA framework (ECOMA), which will be a sub-regional blueprint on enhanced mitigation actions.

6.3.2.1 Analysis of Ghana's List of NAMAs

Following the COP decision on the NAMAs from Cancun, the list of NAMAs are being prioritised using the following set of criteria among others: emission reduction potential, alignment with national development policy framework, contribution to sustainable development, market and technology feasibility, indicative cost and scope of implementation. Below is the summary of assessment of the alignment of the NAMAs to Ghana's Shared Growth and Development Agenda (GSGDA). The study was conducted with technical support from Energy Research Centre of the Netherlands.

The interpretation of alignment between GSGDA and the NAMAs is based on a case-by-case best judgment. For 39 of the NAMAs, the mitigation is ranked low, medium or high, based on existing quantitative analysis and expert judgment. Furthermore, there is a category "negative impact" for actions that are wholly development focused. Thus, these actions would neither qualify as NAMAs, nor be eligible for international support within the climate change -funding context. For 13 of the NAMAs, there is insufficient information to assess the mitigation potential. The GSGDA is examined for policy objectives and specific strategies that might contribute to implementing that NAMA. In most cases, there is no perfect match between a specific NAMA and a GSGDA strategy/policy but in several cases, elements in the GSGDA either directly or indirectly support specific NAMA. Table 6.4 shows different sectoral NAMAs compare to GSGDA.

Table 6. 4 Degree of Alignment of NAMAs with GSGDA

Sector	NAMAs	Alignment with GSGDA	Non-alignment with GSGDA	Increased Emission
Energy	33	19	11	3
Industry	1	-	1	-
Agriculture	8	6	2	-
Land Use (LUCF)	8	7	1	-
Waste	5	4	1	-
Total	55	36	16	3

Source: Policy Brief – NAMAs and the Ghana Shared Growth and Development Agenda (2010-2013)

The majority of the NAMAs are energy related, covering electricity generation, transport, residential use, industrial use and fuel storage. Eight (8) of the energy NAMAs that are not found in the GSGDA are in three specific sub-sectors such as transport fuel use, industrial manufacturing and oil and gas production. The majority of NAMAs that are considered to have high mitigation potential (12 out of 14) are aligned with the proposed development strategies, including actions such as:

- Fossil fuel switching to natural gas,
- Renovating the transmissions system,
- Improving public transport
- Improving charcoal production, and
- Improving forest management and conservation.

These NAMAs target sectors that are important from emission reduction point of view (electricity production, deforestation and transport) and also yield development benefits (energy equity, health, biodiversity, or economic growth.

6.4 REDD+ Mechanism and Forest Investment Programme

REDD+ mechanism features strongly in climate governance in Ghana. It has been identified as one of the major strategies to facilitate low carbon development as well as building resilience to climate change adaptation. As a REDD+ nation, Ghana is among selected countries participating in the Forest Carbon Partnership Facility (FCPF) with support from the World Bank. As part of the FCPF, Ghana has prepared its REDD+ Readiness Preparation Plan (R-PP). The R-PP aims at assisting Ghana to prepare itself for Reducing Emissions from Deforestation and forest Degradation (REDD+), and become ready for the implementation of an international mechanism for REDD+. The R-PP addresses various aspects of REDD+ including: stakeholder consultation and participation, strategy issues, setting reference scenarios, monitoring, reporting and verification system and finance. Following approval to participate in the facility, activities to facilitate implementation of the R-PP are underway. For example, call for projects have been made to solicit for potential demonstration projects from prospective project developers.

Ghana has been selected to participate in the Forest Investment Programme (FIP), which is a financing mechanism under World Bank's portfolio of climate investment funds. It supports developing countries' efforts to reduce deforestation and forest degradation (REDD+) and promotes sustainable forest management that leads to emission reductions and the protection of carbon reservoirs. FIP achieves this by providing scaled-up financing to developing countries reforms and public and private investments, identified through national REDD+ readiness or equivalent strategies. FIP will supports:

- Investments that build institutional capacity, forest governance and information;
- Investments in forest mitigation efforts, including forest ecosystem services; and
- Investments outside the forest sector necessary to reduce the pressure on forests such as alternative livelihood and poverty reduction opportunities.

FIP investments also mainstream climate resilience considerations and contribute to multiple co-benefits such as biodiversity conservation, protection of the rights of indigenous people and local communities, and poverty reduction through rural livelihoods enhancements. Following Ghana's selection to partake in the programme, the Ministries of Lands and Natural Resources and Finance and Economic Planning are conducting preliminary consultations in order to take off.

6.4.1 Supported Climate Change mitigation-related initiatives

At the downstream, a number of low carbon growth related initiatives continue to receive support from multilateral and bilateral donor agencies. The projects are presented in the table 6.5 below:

Table 6. 5 Overview of Climate Change Mitigation Initiatives in Ghana

Status	Keywords	Description	Recipient	Start Date	End Date	Funding Institution	Amount	Currency
Completed	Renewable energy	Renewable Energy-Based Electricity for Rural, Social and Economic Development in Ghana (RESPRO)	Ministry of Energy	01-Feb-99	30-Mar-01	Government of Ghana	600,000	USD
						GEF	2,472,000	USD
						Total funding:	3,072,000	USD
	Energy efficiency	Transformation of lightning market from incandescent to CFL bulbs	Energy Commission	01/01/2007	31/12/2007	Ministry of Energy	15,200,000	USD
	Forestry and land use	A Review of Forestry and Wildlife Policies and Laws	Forestry Commission			NREG		
	Forestry and land use	Growing Forest Partnership (GFP)	IUCN					
	Forestry and land use	Peoples' Diagnostic Study	IUCN	01-May-09	31-Jul-09	GFP		
	Forestry and land use	Community Resource Management Areas (CREMA)	Forestry Commission			NREG		
	Forestry and land use	Forest Resources Use Management Project (FORUM)	Unknown		31-Dec-08	GTZ	12,500,000	EUR
	Transport	Vehicle emissions programme	EPA	01-Jun-05		DANIDA		
	Carbon finance	Capacity building for CDM in Ghana	Unknown		31-Aug-09	UNDP		
On-going	Forestry and land use	Ghana Readiness Preparation Proposal (R-PP)	Forestry Commission		31-Jan-10	FCPF	786,000	USD
	Energy efficiency	Promoting of Appliance Energy Efficiency and Transformation of the Refrigerating Appliances Market in Ghana	UNDP	01-Jan-11	31-Dec-13	World Bank	5,672,727	USD
	Renewable energy	Ghana Energy Development and Access Project GEDAP (formerly) Development of Renewable Energy and Energy Efficiency	ECG	26-Jul-07	30-Nov-13	GEF	5,500,000	USD
						IDA	90,000,000	USD
						Africa Catalytic Growth Fund	50,000,000	USD
						AFDB	18,250,000	USD
						Switzerland	11,000,000	USD

						Global Partnership on output based aid	6,250,000	USD
						Government of Ghana	29,500,000	USD
						Total Funding:	210,500,000	USD
	Renewable energy	Integration of renewable energy sources into the national energy grid mix (in preparation)	Unknown	2011		World Bank		
	Renewable energy	Solar PV Systems to Increase Access to Electricity Services in Ghana	Government of Ghana	10-Oct-08	31-Dec-11	Global Partnership on output based aid	4,350,000	USD
	Transport	Ghana Urban Transport	MRH	21-Jun-07	31-Dec-12	FDA	20,000,000	USD
						Global Environment Facility (GEF)	7,000,000	USD
						IDA	45,000,000	USD
						Government of Ghana (GoG)	18,000,000	USD
						Total funding:	90,000,000	USD
	Transport	Transport Sector Project	Government of Ghana	30-Jun-09	30-Jun-15	IDA	225,000,000	USD
	Climate strategy	Natural Resource and Environmental Governance Program (NREG)	Government of Ghana	01-Sep-08	30-Sep-12	FDA	4,100,000	USD
						EU	5,474,000	USD
						IDA	40,000,000	USD
						Dutch Embassy	28,739,000	USD
						DFID	6,440,000	USD
						Total Funding:	84,753,000	USD
	Forestry and land use	Ghana Natural Resource and Environmental Governance – DPO	Government of Ghana	03-Jun-10	30-Jun-11	Dutch Embassy	11,160,000	USD
						EU		
						Government of Ghana	2,000,000	USD
						FDA	1,590,000	USD
						IDA	10,000,000	USD

						Total Funding:	24,750,000	USD
	Forestry and land use	Chainsaw Milling Project	Forestry Commission	01-Jan-07	31-Dec-12	EU	2,200,000	EUR
	Forestry and land use	Growing Forest Partnership (GFP)	IUCN			World Bank		
	Forestry and land use	Chainsaw Milling Project	Forestry Commission	01-Jan-07	31-Dec-12	Tropenbos International	600,000	EUR
	Forestry and land use	Non-legally Binding Instruments on all types of forest in Ghana (UNFF/NLBI)	Forestry Commission	01-Dec-08	30-Nov-10	BMZ	400,000	USD
	Forestry and land use	Forest Investment Program (FIP)	Unknown	01-Jul-09		World Bank	70,000,000	USD
	Forestry and land use	Voluntary Partnership Agreement (VPA)	MLNR	2009		EU, DFID, Dutch Embassy		
	Forestry and land use	REDD+ R-PP Implementation	Forestry Commission	01-Jan-10	31-Dec-13	FCPF	200,000	USD
	Forestry and land use	Forest Conservation with emphasis on Mitigation and Adaptation to Climate Change	Forestry Commission			JICA	7,800,000	USD
	Forestry and land use	National Forestation Plantation Development Program (NFPDP)	Forestry Commission	10-Jan-10		Government of Ghana	40,000,000	GHC
	Forestry and land use	Ghana Cocoa Carbon Initiative	NCRC/KG			Cadbury		
	Forestry and land use	Towards Pro-Poor REDD	IUCN	01-Jan-09	31-Dec-13	DANIDA		
	Forestry and land use	Ghana Cocoa Carbon Initiative	NCRC/KG			Rockefeller Foundation		
	Climate strategy	Technology Needs Assessment (TNA) update	UNDP	01-Nov-09	30-Apr-12			
	Climate strategy	Second National Communication to UNFCCC (to be finalized)	EPA			UNDP	420,000	USD
	Carbon finance	Carbon Finance Project (in preparation)	MoFEP			World Bank	30,000,000	USD

7. Other Information

This chapter provides information on other Climate Change enabling initiatives that have not been directly addressed under any of the preceding sections. Effort is made to highlight the various on-going programmes and initiatives, including gaps, needs and challenges and the way forward.

7.1 Technology Transfer

Ghana conducted technology needs and needs assessment through a consultative process in 2006. The TNA process sought to engage stakeholders to select and prioritize portfolios of technologies largely in the energy and waste sectors. Using the national criteria developed, the stakeholders prioritized the identified technologies.

For the energy sector, the following order of priority emerged:

- Biofuels
- Industrial energy efficiency improvement
- Energy efficiency lighting
- Solar PVs
- Natural gas combined cycle and Natural gas distribution system
- Management technologies and efficiency improvement in transport sub-sector
- Wind
- Solar water heating
- Small and mini-hydro

For the waste management technologies, the order of priority was as follows:

- Biomass for power generation (Co-generation from sawmill residue)
- Landfill methane gas capture for power generation
- Anaerobic and CH4 generations technologies for waste water handling (Biogas technologies)
- Incineration

Stakeholders further identified the following as barriers common to all technology transfer programmes in Ghana:

- High initial cost associated with the technologies
- Inadequate human and institutional capacities
- Access to technology information (e.g. cost, performance, vendors, etc.)
- Lack of comprehensive technology transfer policy
- Inadequate capacities in estimating and certifying potential greenhouse gas reductions associated with the technologies
- High interest rates

Review of legislative framework was done to assess the enabling environment, which could support implementation. Currently, Ghana has no specific legislation or policy on technology transfer in the very strict sense. However, there are laws, guidelines, standards and related policies, which should be taken into account if there is an intention to introduce a new technology into the country. Some of the institutions, policies, guidelines and related framework that may be relevant to technology transfer include:

Policy

- National Environmental Action Plan
- National Science And Technology Policy
- Ghana Poverty Reduction Strategy, 2002 – 2004
- Ghana Trade Policy, December, 2004

Legislative Instrument

- The Environmental Protection Agency Act, 1994 (Act 490)
- Energy Commission Act, 1997 (Act 541)
- Local Government Act, 1993 (Act 462)
- Ghana Investment Promotion Centre Act, 1994 (Act 478)
- Technology Transfer Regulations, 1992 (L.I. 1547)
- Council For Scientific And Industrial Research Act, 1996 (Act 521)
- Standards Decree, 1973 (NRCD 173)
- Ghana Standards Board (Food, Drugs And Other Goods) - General Labeling Rules, 1992 (L.I. 1541)
- Free Zone Act, 1995 (Act 504)
- Customs, Excise and Preventive Service (Management)(Duties, Rates and Other Taxes) Act, 1994
- Public Utilities Regulatory Commission Act, 1997 (Act 538)

Institutional Framework

- Ministry of Environment, Science and Technology (MEST)
- The Judiciary

- Ministry for Trade and Industry
- Science and Technology Policy Research Institute (STEPRI)
- Institute of Industrial Research (IIR)
- Institute for Scientific and Technological Information (INSTI)
- Ghana Regional Appropriate Technology Industrial Service (GRATIS)

Standards and Guidelines

- Ghana Landfill Guidelines – July, 2002
- Environmental Sanitation Policy – Technological Choice

The extent, to which Ghana can implement its prioritized technologies and help in addressing the global problem of Climate Change, will depend on the provision of adequate technical and financial resources by developed countries and the creation of an enabling environment. In respect of policy, there is sufficient evidence expressing government's commitment to take the necessary steps in the waste and energy sectors to achieve the objectives of sustainable development. Lack of the necessary financial resources, adequate capacities and a culture of technology development have, however, undermined the laudable policy directives. Fiscal and economic instruments have also not been given adequate attention. Therefore it is important for Ghana to pursue development of technology action plan to translate prioritized technology portfolios into actual implementation.

Though the technology needs assessment considered issues, which related to policy, hardly did it suggest how these prioritized actions would be implemented. Apart from the fact that the assessment highlighted most on technology needs aspects without an action plan, the analytical work generally focused on Climate Change mitigation technologies in two main sectors. To make this complete, there is the need to conduct complementary assessment to focus on adaptation technologies. This is necessary to ensure that efforts to address Climate Change technology needs are wide enough to support resilience building and low carbon footprint interventions.

7.2 Research and Systematic Observation

7.2.1 Development of Climate Scenarios

As part of the Ghana Climate Change country studies, National Climate Change scenarios have been developed. Climate Change Scenarios for the climatic variables: mean monthly rainfall amount; maximum, minimum and mean daily temperatures have been constructed to cover the whole of Ghana for the years 2020, 2050, and 2080. This was done in accordance with the requirements of the Country Working Groups for Climate Change Vulnerability and Adaptation Assessment on Fisheries, Tuber Production, Health, Cocoa Production, Gender and Women Livelihoods, Land Use Management. Monthly means for the period 1961-2005 of the above climatic variables were computed. These stations were later grouped to define climatic means for ten specific areas of the country and used as baseline climates of these areas. With the establishment of these baseline climates, climate scenarios were constructed.

There are, in general, three basic groups of methods available for the construction of Climate Change scenario. These are the process-based methods, empirically based methods and synthetic or statistical methods. For this study, a process-based method was selected. Process-based methods rely primarily upon the use of General Circulation Models (GCMs) in conjunction with Simple Climate Models (SCMs).

In spite of their limitations, GCMs provide a powerful tool to generate physically realistic scenarios of future climate. In order to assess the impacts of future Climate Change on natural and socio-economic systems, some manipulation of GCM data is often necessary. In developing Climate Change scenarios for Ghana, the 'Linked Model' approach was adapted. In this approach, the results of GCM experiments are combined with those of simple time-dependent climate models through appropriate scaling techniques to obtain internally consistent global and regional changes of various climatic variables. These changes can then be added to the observed baseline climatology for a particular region of the earth to obtain a range of geographically explicit future Climate Change scenarios.

Three GCMs, whose experimental results validated best against global observed rainfall patterns, were selected. These are the Hardly Centre Model 2 (HADCM2), the UK Meteorological Office Transient Model (UKTR.) and the UK Meteorological Office High Resolution Model (UKHI). The average of the three (3) GCM experimental results was used in the calculations. This was to eliminate any internal inconsistencies that might be within individual models. The simple climate model used is known as MAGICC (Model for the Assessment of Greenhouse Gas Induced Climate Change) developed by the Climatic Research Unit (CRU) of the University of East Anglia (UEA). MAGICC consists of a set of coupled gas cycle. Results of the climate scenario development have been presented in section 4.1.

7.2.2 Institutional Framework and Capacities

There are a number of existing national institutions and private organizations in Ghana whose mandates/activities border on climate and Climate Change issues. These institutions have been identified as important players in Climate Change issues, hence requiring the need to be strengthened (both technically and financially), to continuously support research and systematic observation, aimed at contributing actively to national, regional and global climate research programs. Some of the important institutions that have been involved in the Climate Change activities in Ghana are outlined below. It must be noted, however, that the list is by no means exhaustive.

7.2.2.1 Ghana Meteorological Services Agency (GMeT)

The GMeT was set up in December 2004 by the Ghana Meteorological Agency Act (Act 682) to replace the former Ghana Meteorological Services Department. The primary function of Ghana Meteorological Services Agency (GMet) is to provide efficient weather services through the collection, processing, storage and dissemination of meteorological data to end-users. Recipients of information from the GMet include the Ministry of Agriculture, Lands and Survey Department, NADMO, Universities, Research institutions, Airlines, Maritime Operations, Banks, Cocoa Farmers and producers of other crops. Since these clients of GMet provide indispensable services to the public, the data from which the GMet provides analytical meteorological information should be robust, accurate and reliable to ensure prompt delivery of services to the clientele. 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:

- Inadequate professional staff
- Inadequate level of funding for the Agency
- Poor or outdated infrastructure for climate information gathering and forecasting.
- Lack of efficient telecommunication system
- High computational interconnectivity is needed at synoptic stations to send data to aid forecasting.
- More automated weather and computation stations are needed.

7.2.2.2 Centre for Remote Sensing and Geographical Information Services (CERSGIS)

The CERSGIS was established in 1993 by the University of Ghana and equipped with funds from the Government of Ghana, the Danish International Development Assistance (DANIDA) through the Institute of Geography of the University of Copenhagen and the United Nations Development Program. Under the Ghana Environmental Resource Management Project (GERMP) the capabilities of the Unit have been enhanced to enable it undertake the production of land use information under the Environmental Information System Development (EISD) component of the GERMP. The Government of Ghana, DANIDA, and the International Development Association (IDA) of the World Bank provided funding. In addition to producing land use information, the GERMP also had the objective of building capacity at CERGIS to make it a self-funding but non-profit making organization by providing services in respect of the following:

- Spatial data management and analysis for both Government agencies and interested private sector institutions in Ghana.
- Environmental remote sensing and geographic information systems development and applications.
- Training and research support for natural resource appraisal and monitoring including rural and urban land use patterns and trends.

CERSGIS can therefore support the Climate Change /Sea level rise program by providing all stakeholders access to spatial data sets and assisting other national experts and institutions to develop a multiple-risk based vulnerability assessment using Geographic Information and image processing System. CERSGIS has a training laboratory, for up to 20 trainees, equipped with modern equipment, resource library and also has the capacity to provide effective training in its areas of competence.

7.2.2.3 Council for Scientific and Industrial Research (CSIR)

Council for Scientific and Industrial Research (CSIR) was re-established by Act 521, 1996 and was mandated to carry out functions including but not limited to:

- Pursuing the implementation of government policies on scientific research and development.
- Encourage, in the national interest, scientific and industrial research for development of agriculture, health, medicine, environment, technology and other services sectors and to harness close linkages with the productive sectors of the economy.
- Undertaking or collaborating in the collation, publication, and dissemination of the results of research and other useful technical information; and
- Co-operating and liaising with international and local bodies and organizations, in particular the universities and the private sector on matters of research.

There are a number of research institutions under CSIR whose activities have relevance to Climate Change activities. These include Crops Research Institute, Oil Palm Research Institute, Animal Research Institute, Forestry Research Institute, Institute of Industrial Research, Water Research Institute, Soil Research Institute, Savanna Agricultural Research Institute, Institute for Scientific and Technological Information and Science and Technology Policy Research Institute.

7.2.2.4 Water Research Institute (WRI)

Vulnerability assessment of water resources (water resources was reported in the first national communication) in Ghana was mainly carried out by a research team (put together as a Country Working Group) from this institute. There is, however, the need to strengthen capacity in the water vulnerability assessment in two main areas of data collection and research. In the area of data collection, there is the need for equipment replacement and installation of modern ones. Training of personnel to man the new equipment will also be relevant. Other collaborating institutions to be strengthened for data collection include Hydrological Services Department and the Meteorological Services Department.

In research, WRI will need to be strengthened to undertake continuous research in Climate Change and impacts on water resources even at the basin level. Capacity in hydrological and water resources management modeling will need to be enhanced in the Institute. In this direction, there will be the need to establish some collaboration with other research centers with keen interest in this area of study. GMet will also need to be strengthened in the area of climate research to support the hydrological modeling.

7.2.2.5 Environmental Protection Agency (EPA)

Environmental management became topical in Ghana after the 1972 Stockholm Convention. This led to the establishment of the Environmental Protection Council (EPC) in 1974. The EPC was later transformed to the Environmental Protection Agency by an Act of parliament (Act 490) in 1994. The Environmental Protection Agency is the leading public body for protecting and improving the environment in Ghana. It is the mandate of EPA to make sure that air; land and water are looked after by everyone in today's society by implementing Government policies, inspecting and regulating businesses and reacting when there is an emergency such as a pollution incident. EPA seeks to accomplish its mandate by undertaking the following activities:

- Create awareness to mainstream environment into the development process at the national, regional, district and community levels;
- Ensure that the implementation of environmental policy and planning are integrated and consistent with the country's desire for effective, long-term maintenance of environmental quality;
- Ensure environmentally sound and efficient use of both renewable and non-renewable resources in the process of national development;
- Guide development to prevent, reduce, and as far as possible, eliminate pollution and actions that lower the quality of life;
- To apply the legal processes in a fair, equitable manner to ensure responsible environmental behaviour in the country;
- Continuously improve EPA's performance to meet changing environmental trends and community aspirations;
- Encourage and reward a commitment by all EPA staff to a culture based on continuous improvement and on working in partnership with all members of the Ghanaian community.

EPA has an Energy Resources and Climate Change unit, which is well positioned to offer strategic technical support to the development and implementation of climate smart projects, which have direct bearing on Climate Change issues in the country. In addition, the Unit is supported by climate change focal points in the various departments in the Agency.

7.3 Education, Training and Public Awareness

7.3.1 Ghana's Policy on Environmental Education

Education, training and public awareness have been identified as one of the important components of capacity building on Climate Change under the convention and Ghana recognises this important thrust. Therefore Ghana believes that the successful implementation of its environmental policy including aspects of Climate Change must be premised on the fact that the citizenry understands the functioning of the environment and the related issues in order to contribute meaningfully to its protection, improvement and enhancement.

To achieve this, continuous and detailed environmental education programs are being implemented at all levels so that every Ghanaian becomes aware of the problems and fully assumes his/her responsibilities in the protection of the environment. Environmental Education therefore forms an integral part of the educational system. Sustained effort is being made to promote awareness among policy makers, provide training for resource managers at appropriate levels, and promote greater public awareness and motivation for environmental action. The government believes that economic prosperity of the nation depends on a high quality environment; losses being experienced reduce the living standards of the present generation; and that the prosperity of future generations will be prejudiced by today's excesses. However, current Climate Change programmes on education and awareness creation have the following shortfalls:

- Inadequate education and public awareness programmes on Climate Change and its effects such as disasters.
- Limited public access to information on Climate Change and its effects. Weak participatory processes for addressing Climate change and its effects.
- Inadequate educational materials and funding.

7.3.1.1 Making the Education Sector Responsive to Climate Change

Policy recommendations for the education sector on Climate Change have to target both the formal and informal education.

A. Formal Education

- Most of the effects of Climate Change that act as threats to the education sector have to be addressed through actions in other sectors such as health, water, agriculture, public infrastructure, etc. Processes to integrate Climate Change issues in education involve providing inputs for other sectors such as adaptation strategies.
- Nevertheless, some adaptation measures can also be taken up within the education sector. A few examples are:
  - Awareness creation on Climate Change in schools: Awareness-raising on Climate Change and its expected effects can be integrated into school curricula at the different levels of education. For instance, school programmes could address the theme of Climate Change, as well as the concepts of adaptation and mitigation, in relation to environmental education and sustainable management of natural re- sources. Aspects of prevention, preparedness and disaster risk reduction could be taught both in primary and in secondary schools and further on in higher education.
  - The establishment or strengthening of environmental/sustainability clubs in primary and secondary schools in the country is recommended. These clubs can be used as focal groups for Climate Change education and awareness creation among school children in the country.

Apart from the domestic efforts, the New Delhi Work Programme provides important facilitating drive to achieve the full aspiration of Article 6 of the UNFCCC, by contributing to the development strategy for implementation. In that light Ghana conducted a national survey on the implementation of Article 6.

7.4 Assessment of Implementation of Article 6 of the UNFCCC in Ghana

Improving awareness and understanding of climate change, and creating solutions to facilitate access to information on a changing climate are key to winning public support for climate related policies. The UNFCCC, through its Article 6, and the Kyoto Protocol, through its Article 10 (e), call on governments to educate, empower and engage all stakeholders and major groups on policies relating to climate change. In particular, Article 6 of the Convention, which addresses the issue of climate change related education, training and public awareness, is the main vehicle by means of which the Convention fosters action to develop and implement educational and training programmes on climate change. Therefore, in the light of fulfilling the provisions of article 6 of the convention, a national survey was conducted. The objectives of the national survey were to identify and inventory;

- Current national activities and programmes that are relevant to Article 6
- Assess human resources and other assets for implementation and
- Provide need for greater capacity and funds

The following were the major findings from the exercise:

- *Public awareness on Climate Change* -The general perception of the Ghanaian general public on changes in climatic elements was clear in all the ecological zones of Ghana with most of their observations occurring within the last half decade. Ninety percent of the respondent recognised that the changes in global climate are mainly due to effects of human-induced activities.
- *Public access to information on Climate Change issues* - access and availability of information on Climate Change was very limited in Ghana. The main sources of information were found to be newspapers, followed by television and radio. Most Ghanaians considered Environmental Protection Agency (EPA) and Ghana Meteorological Agency (GMet) as the most possible sources of information on Climate Change issues. English language in addition to all major languages in Ghana including Akan, Ga, Ewe, Dagbani, Hausa and Nzema were chosen for dissemination of information on Climate Change.
- *Education* - incorporation of Climate Change into school curriculum at all levels is the surest means to ensure sustained and continued awareness on Climate Change in Ghana.
- *Public Participation* - Participation could be enhanced by promoting the following practical actions:
    - Provide funds, logistics, expert knowledge and information
    - Motivate stakeholders
    - Institute training of trainers programme
    - Make available brochures, hand-outs, etc. for awareness creation
    - Support community-based programme that are relevant to Climate Change
    - Ensure frequent interaction with other stakeholders
    - Support and incorporate Climate Change activities in public education on open days for awareness creation (farmers day, students forum and festivals)
    - Formation of environmental clubs
    - Provision of equipment (forecasting and expansion of forecasting stations, satellite images)
    - Join and support good local initiatives

- *Training* - training of stakeholders remains the backbone to sustain action on Climate Change. Training should be organized from local, sub-regional, regional and international levels. Training of trainers is therefore considered to be very effective to achieve wider participation in Climate Change training. Targeted workshops and outreach programmes were considered very important forms of training for all stakeholders.

8. Constraints and Gaps, and related financial, technical and capacity needs

Overview of constraints and gaps and related financial, technical and capacity needs identified through the preparation of the SNC are discussed here. The national needs are summarized under; human and institutional capacity-building needs required to enhancing local knowledge; financial resources to conduct studies and implement adaptation and mitigation projects, and strengthen the legislative and institutional framework.

8.1 Barriers to Implementing the UNFCCC in Ghana (constraints, Gaps and Needs)

8.1.1 Problems and Constraints in the GHG Inventory Process

The major constraints encountered during the inventory preparation are summarized as follows:

- Data gaps, incompatible data formats and poor data quality across inventory sectors.
- Lack of clear and formal institutional arrangements for data collection, data sharing and archiving.
- Available data are fit for sector planning, but fail to meet all the information requirements of the IPCC methodology for the inventory.
- Poor documentation of the inventory from data compilation to estimates.
- Application of lower tier IPCC methodologies.

8.1.2 Planned Improvement Activities to Address the Identified Problems and Constraints

- Develop national capacities among relevant institutions to use new guidelines, methodologies, tools and softwares to meet the new reporting requirements.
- Conduct national surveys, studies and scientific research, aiming at developing disaggregated activity data and emission factors needed for the GHG inventory estimation, with special focus on key categories and those with high uncertainty.
- Improve existing national GHG monitoring system aimed at sustainably collecting and archiving data in the required format and quality. This must address as much as possible, institutional arrangements to facilitate data collection and sharing among the various national institutions, within a recognised legal framework.

8.1.3 Problems, Constraints and Needs in Mitigation Assessment

- Mitigation assessment is the first important step towards developing sustainable actions to address future climate disruption, and at the same time contributing to poverty reduction goals. During the SNC the following inherent constraints were identified:
  - General of lack of requisite datasets and models in most of the sectors. However, data in energy and forestry sectors are largely useable. There is urgent need to collect sector-wide development and economic data, to improve on mitigation assessment. Access to robust models is also needed for Ghana.
  - Lack of capacities and skills to deploy energy and non-energy models. Develop local capacities in using GHG mitigation methodologies, tools and softwares.
  - Weak awareness among decision-makers on climate change needs, to Address the Identified Problems and Constraints.

8.1.4 Problems, Constraints and Needs in Vulnerability, Impact and Adaptation Assessment

- Unavailability of consistent datasets. Improved meteorological and vulnerable sector monitoring, through modernization of equipment and extension of monitoring networks. Capacity building in the area of methodologies, tools and guidelines to conduct V&A studies is critical.
- Coarse spatial and temporal resolutions of climate scenarios do not match the requirements of policy horizons of Ghana. Build technical capacity for monitoring and data collection, data management and updating of basic data sets, and preparation of basic maps and databases.
- Lack of national and regional climatic prediction models and downscaling models, thus, Global Circulation Models (GCMs) were used with low spatial resolution. Precipitation modeling using these GCMs models gave poor results.
- Lack of financial resources to address human, institutional, technological and research needs and also implement adaptation measures.

8.2 Financial needs of Ghana for efficient implementation of the Convention

Ghana has good track record to attract multi-lateral and bilateral resources directly or indirectly to support the implementation of the Convention. Particularly, the Global Environment Facility (GEF) through UNDP has been supporting Ghana to execute a number of climate change enabling activities including:

- Preparation of the Initial National Communication (INC).
- Technology Needs Assessment (TNA) and Technology Transfer (TT)

- National Capacity Self-Assessment for Global Environmental Management (NCSA). This project was implemented to assess the capacity constraints and potentials for implementing the three international environmental conventions on biodiversity, Climate Change and desertification,
- Enabling Activities for the Preparation of Ghana's Second National Communication to the UNFCCC.
- Energy Efficiency for Refrigerating Appliances Project
- Sustainable Land Management in Ghana Project
- Pilot Bus Rapid Transit System Project

The above-mentioned projects have been executed with UNDP support, and technical support from other United Nations agencies including UNEP and UNFCCC. In addition, National Communication Support Programme (NCSP), which is a UNEP/UNDP programme, has provided technical support during the preparation of the SNC through training workshops, provision of guidelines and guidance materials, review of studies and reports and provision of online support. Ghana's contribution in these projects is in the form of kind cost, including human resources, office space and furniture, communications, and the associated costs. Financing activities of climate change in general has been receiving a great deal of attention in Ghana. The efforts are generally related to:

- Coordination and governance- at the Ministry of Finance and Economic Planning (MoFEP), frantic efforts are underway to coordinate all forms of supports (domestic and international) to Climate Change in Ghana. This is to address potential overlaps and duplication of efforts and above all distributing resources to where they are needed most. MoFEP is also engaged in the process of developing national Climate Change budgeting guidelines to facilitate mainstreaming of Climate Change into national planning.
- Capacity building - capacity building for public and private sector institutions is critical to positioning Ghana to access emerging international financing opportunities. Ghana therefore requires considerable support in capacity building. The support could be reflected in three thematic forms: legal, institutional and human.

- Financial needs – financial needs may be required in the following areas:
    1. *Research Funding* - The need to focus on climate research activities is important to Climate Change planning in Ghana at all levels. A common need across these includes improvements in baseline information upon which decisions can be made. Funding could be deployed in the following areas among many others:
        - Develop robust Climate Scenarios for Ghana at the right scale.
        - Comprehensive investigation into the proposed mitigation options
        - Development of technology action plan and integration into national development process.
        - Continuous climate observations throughout the country
        - Upgrading of computational facilities
        - Establishment of technology development and innovation centre.
    2. *National Reporting Systems under UNFCCC*– Ghana needs additional financial resources to support its national reporting systems under the UNFCCC, especially, in the wake of the Cancun agreements. This would require that more resources are made available to develop and mainstream a robust MRV system that is able to address both international and domestic reporting mechanisms and at the same time support decision-making processes on accountability. Financial resources would also be needed to support development of technology action plan for Ghana.

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Annex: Summaries of selected Project proposals

Annex 1:

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 in is 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 evapotranspiration at higher temperatures. 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 is 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 to 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 Plan 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, 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 transboundary 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 Program on Energy Efficiency Labelling

Duration:

5 years implementation-horizon. This is a highly conservative estimate

Financial resources

Conservative cost estimates of the project (investment, implementation and transaction costs) is range between USD 4million and USD 5million.

Annex 2:

Enhance National Capacity to Adapt to Climate Change through Improved Land Use Management

Project Context

Effective land management in Ghana is an essential component in developing climate change adaptation strategy. The threat of desertification is more serious in the savannah zone, which forms about 68% of the total land area of Ghana. The biodiversity of Savannahs are high, the perennially dry climate causes extensive annual biomass burning. Therefore, small changes in climate or land-use can have a large impact on biomass and soil properties and consequently the land productivity. In addition to this, there are natural hazards i.e. floods, line squalls, drought, soil erosion and bushfires. The hazards threaten food security by the damage to agricultural food production. Due to the population pressure in the Savanna areas of Ghana with activities like overgrazing, firewood collection and unorthodox agricultural activities on land, the productivity gradually declines over time. There is the need for proper management of land resources to ensure conservation and its sustainable use for future generations.

Rationale and Justification

The threat of desertification in the savannah as a result of deforestation, overgrazing, seasonal bush burning, and soil erosion is enormous. About 30-40% of Ghana's land area has been observed to be threatened by desertification and the Savanna zone is the worst affected by this threat. Farming and other land-based livelihood activities are vulnerable due to the decline in fertility status of the soil within the savanna areas. Thus food security for the country and livelihoods of farmers in the savanna has become critical and some interventions are necessary to reverse current trends. Low rainfall and high temperatures has greatly impacted on agricultural activities by disrupting the seasonal cycle of major food crops grown in the area. In recent times, there have been farmlands inundated by floods lasting several weeks resulting in heavy harvest losses. The depletion of biodiversity and the generally arid climate with occasional drought have resulted in desertification and climate variability which leads to a lack of water resources to support fauna and flora lives. Growing aridity may cause reduction in groundwater recharge of between 5 and 22% by the year 2020 and then 30 to 40% projection by 2050.

Project Description

This is an intervention to forestall land degradation is necessary halt the degradation trend and get on the path of rehabilitation and restoration. The overall goal therefore has been dubbed 'Sustainable land-use practices for climate change adaptation and national development.

Overall goal and objectives

The overall objective of this project is to ensure sustainable land-use management for climate change adaptation and national development. The specific objectives include:

- To identify gaps in existing land-use regulations and review policies to deal with land management issues
- To implement and enforce land use regulations for sustainable development
- To enhance the capacity of vulnerable groups to sustainably utilize land resources
- To promote farming technologies that enhances productivity of agricultural lands.

Development context

The objectives of this project are in line with the national sustainable development objectives, viz. MDG's, GSGDA and GPRS, etc. as it seeks to reduce extreme poverty and hunger, enhance livelihoods and generally strengthen the economy to adapt to potential adverse impacts of climate change. The project also addresses the same concerns and actions, which implement those international protocols as UNFCCC, CBD and CCD, which Ghana has rectified.

Short-term output

- *Gaps in existing land-use regulations and policies identified to deal with land management issues*
- Land use policies for sustainable development implemented and enforced
- Capacity of vulnerable groups for sustainable utilization of land resources enhanced.
- Degraded lands within the Savanna areas rehabilitated and ecologically restored.
- Promotion of farming technologies that enhances productivity of agricultural lands

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

Financial resources
Conservative cost estimates of the project (investment, implementation and transaction costs) is range between USD 2.5million and USD 3million.