FIRST NATIONAL COMMUNICATION OF THE REPUBLIC OF THE GAMBIA TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

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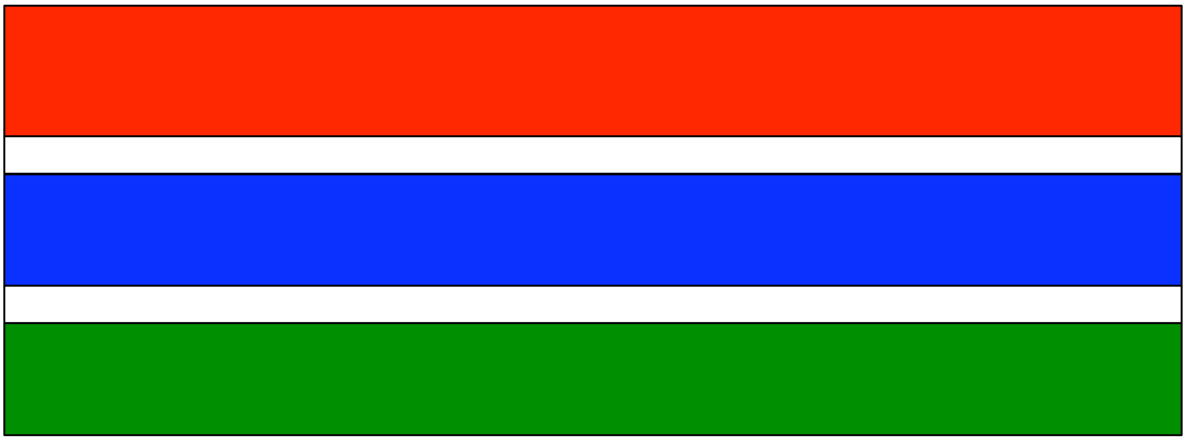

**Department of State for Fisheries,
Natural Resources and the Environment**

Department of Water Resources

National Climate Committee

Banjul, 2003

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Foreword

On behalf of the Government and people of the Republic of The Gambia, it is a great honour and pleasure for me to present this First National Communication of The Gambia to the United Nations Framework Convention on Climate Change (UNFCCC).

The development of this First National Communications has enabled my Department of State to develop an institutional framework that has brought together and consolidated the networking and dialogue between different economic sectors, CBOs and NGOs, and grassroots level communities.

Technicians and scientists of different backgrounds and disciplines have pooled their expertise and worked together to develop this informative document.

In this National Communication we have outlined the emissions of greenhouse gases from the major economic sectors and activities of the country, developed plausible climate change scenarios and based on these scenarios we have assessed the potential impacts of the projected climate change. The National Communication also contains measures and strategies to mitigate the concentration of greenhouse gases in the global atmosphere and adapt to the negative impacts of climate change. No detailed cost-benefit analysis was conducted on the mitigation and adaptation measures due to inadequate capacity to cost the effects of climate change.

The potential impacts of climate change on crop production, biodiversity and wildlife, coastal resources, forestry, fisheries, rangelands and livestock, and water resources have been studied in great detail. Most of the impacts are negative and the populations are vulnerable. Although The Gambia is a small country, there are opportunities to invest on small-scale projects to mitigate greenhouse gas emissions and adapt to adverse impacts of climate change. These projects would be in policy development, fuel switching including the efficient use of both renewable and non-renewable energy, use of efficient modes of transportation and conservation and sustainable use of forests.

Cooperation between developed countries and The Gambia will enable all Parties to meet their commitments based on the principle of common but differentiated responsibility. The mitigation and adaptation measures presented in this first national communications will require funding to build national adaptive capacity and provide appropriate technologies to address climate change.

Honourable Susan Waffa-Ogoo
Secretary of State for Fisheries, Natural Resources
and the Environment
State House, Banjul
THE GAMBIA

CHAPTER 1

NATIONAL CIRCUMSTANCES

1.1: Geography, Climate and Demography

1.1.1: Location

The Gambia is the smallest country (~11,000 km^2) on the African continent, lying between latitude 13 and 14 degrees North, and 17 and 12 degrees West. It consists of a narrow strip of land some 400 km long and 30 km wide on both sides of The Gambia River. It is bordered on the north, east and south, by the Republic of Senegal and on the west, by the Atlantic Ocean.

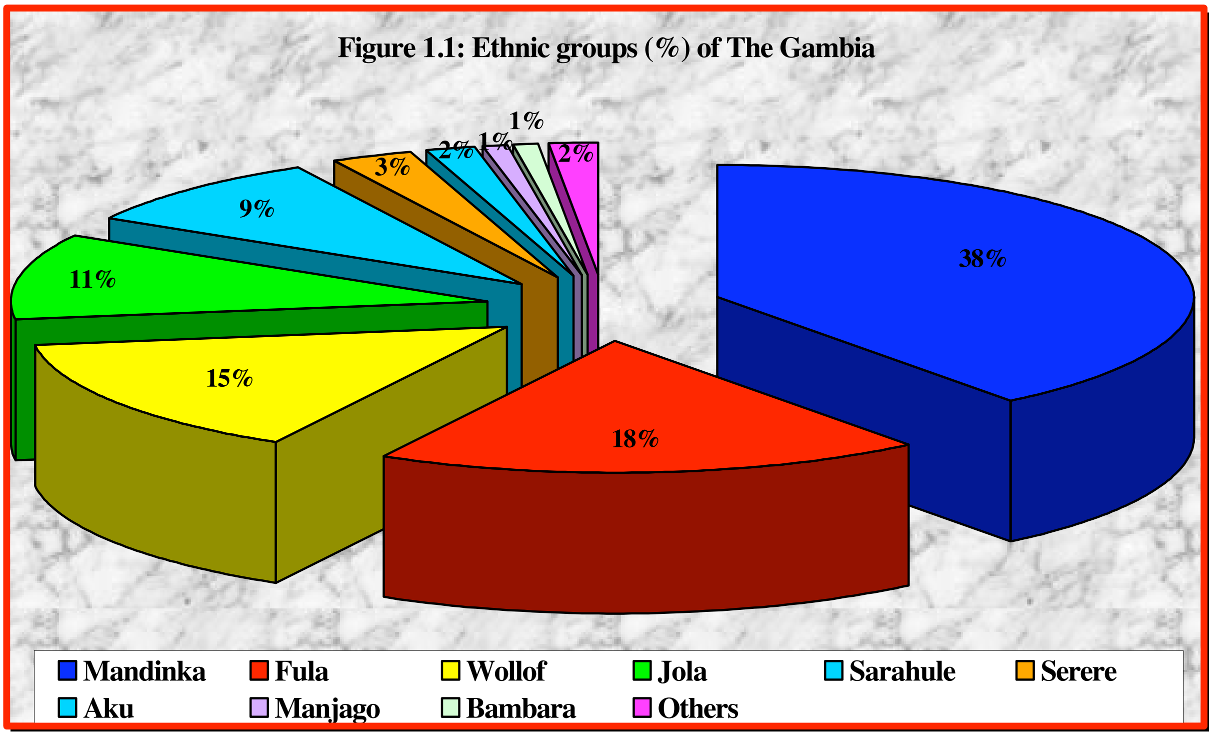
1.1.2: Climate

The country has a Sahelian climate, characterised by a long dry season (November to May), and a short wet season (June to October). Rainfall ranges from 850 - 1,200 mm. Average temperatures range from 18 - 30°C during the dry season and 23 - 33°C during the wet season. The relative humidity is about 68% along the coast and 41% inland during the dry season and generally about 77% throughout the country during the wet season. The prevailing climatic pattern favours only a short agrarian production regime (on average three months) which is the main source of employment and food supply for 80% of the population. Low rainfall and its poor distribution in the past two decades resulted in drought conditions that have affected the vegetation cover and food production potential.

1.1.3: Population

The population is now estimated at 1.33 million with a density of 130 persons/km^2, placing it among the five most densely populated countries in Africa (UNDP, 2000). Population growth rate is estimated at 4.2%, of which, 2.8% is the natural increase while 1.4% is net immigration resulting from the influx of refugees from the war-torn countries in the sub-region. Almost 38% of the population is concentrated in the urban areas around Banjul, the capital city and environs, and the rest (62%) in the rural areas. About 60% of the population is less than 25 years old (about half of this number is under age 10). The implication of this for education, health, and other social sector public expenditures is daunting. More importantly is the implication for growth in the labour force for which the prospects of employment opportunities, and training, are bleak at the moment. The relatively high population growth rate has been recognized as one of the constraints on development. The challenge lies in the fact that the population of the country will double every 16 years with the possibility of neutralizing the benefits of economic growth and undermining the country's oft avowed goals of poverty reduction.

The Gambia's social diversity is reflected in the different ethnic groups as shown in Figure 1.1 below. The ethnic groups and local languages are Mandinka, Fula, Wollof, Jola, Sarahule, Serere, Manjago and Aku (Creole). The majority of the population is Muslim (95%) and the rest are Christians. Despite the ethnic pluralism, there is harmony among the groups and intermarriage is common. There is no religious extremism and Muslims and Christians peacefully co-exist in the country.



1.2: Economic Policies and Trends

The main features of The Gambia's economy are its small size, narrow economic base and heavy reliance on agriculture, with limited number of cash crops, mainly groundnuts. This makes the economy vulnerable to the vagaries of the climate and to price changes in the international markets for these products. In the late seventies and early eighties, the country experienced significant decline in economic growth. To address this situation, The Gambia embarked on a series of structural adjustment programmes aimed at restoring maco-economic balance and economic growth.

Despite the gains recorded under these programmes, the structure of the economy remains weak and highly vulnerable to external shocks due mainly to the volatile nature of the major sources of revenue, namely re-export trade, ground nut export and tourism.

1.2.1: Analysis of general country situation

The Gambia is classified as one of the Least Developed Countries (LDC) in the world. The UNDP Human Development Report 2001 (UNDP, 2002) ranks The Gambia at 149 out of 161 countries, with a Human Development Index (HDI) of 0.396. The country has a GNP per capita of US$ 340 and a GDP per capita of US $1,100. The GDP growth rate in the 1999-2000 period was an impressive 5.6%. About 64% of the total population live below the national poverty line, whereas 59.3% of the population live below US$ 1 per day, and 82.9% live below US$ 2 per day.

The agricultural sector employs about 75 % of the labour force and contributes 21% of GDP with a growth rate of 2.7%. The sector is characterized by low productivity stemming largely from poor rainfall and over reliance on outdated technology. Structural and cultural problems hamper the development of the sector thus frustrating efforts to achieve food security. Of those who are extremely poor, 91% work in agriculture. According to the Poverty Reduction Strategy Paper (PRSP), groundnut farmers in The Gambia are the poorest of the poor.

As a percentage of GDP, the tourism industry grew by 3.7% as against 7.5% in 1998. The sector's contribution increased from 5.4% in 1998 to 5.7% in 1999. The telecommunication industry once again registered a significant growth of 8% and has emerged as the second most important industry in 1999 contributing 27.3% to the GDP. The electricity and water industries combined, grew moderately and registered a 2% growth, while the trade industry, the third most important in the economy contributed 21.1% to GDP. The total road network in The Gambia is 2,700 km long, of which 956 km are paved. The Gambia has 400 km of waterways, which include the Gambia River, the most navigable river in West Africa.

Preliminary estimates indicate the balance of payments accounts recorded an overall surplus of 101.2 million Dalasis in 1999. This positive upturn is, however, largely attributed to an improvement in the capital account as a result of the increase in official loans and grants. The current account deficit including official transfers deteriorated, slightly, from 3% in 1998 to 3.8% in 1999 of GDP reflecting the influence of the merchandise trade deficit.

During 1999 the total value of international trade was about 2.8 Billion Dalasis, a 5.4% increase over the 2.7 Billion Dalasis recorded for 1998. In 1999, total imports were valued at 2.6 Billion Dalasis, a 7.6% increase over 1998 while total domestic exports were valued at about 239 Million Dalasis. This resulted in a trade deficit of about 2.4 Billion Dalasis.

The Gambia's total outstanding external public debt amounted to US$420.8 million in 1999. The World Bank and Debt Relief International have indicated that The Gambia is entitled to 18 to 20% of debt relief. Worthy of mention is the fact that no external arrears were accumulated. The IDA, IMF and ADB have indicated their commitment to giving debt relief to the Gambia. The Government of the Gambia is also engaging bilateral development partners in negotiations for more relief. It is envisaged that the Gambia will benefit about US$67 million in debt relief.

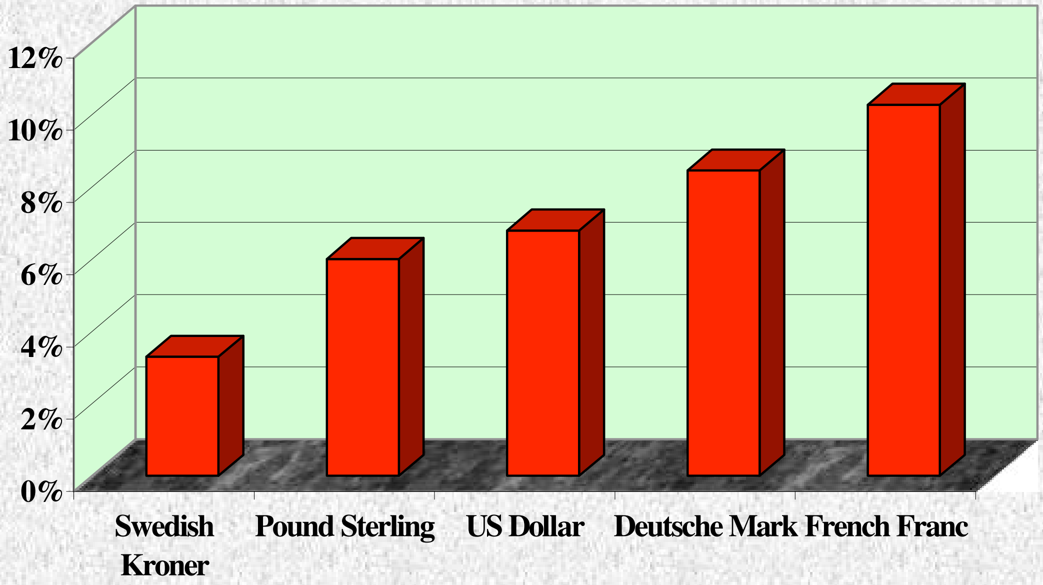
The Gambia has been operating a liberal exchange rate system since 1986, with the Dalasis floating within the context of an inter-bank market. There are no exchange controls or restrictions on current or capital accounts. In 1999, the Dalasis depreciated against all the currencies traded in the inter-bank market as illustrated in Figure 1.2 below.

1.2.2: Macro- economic policy and strategy

The Gambia continues to implement free market policies and strategies as enshrined in Economic Recovery programme (ERP) and its successor programme, the Programme for

Sustained Development (PSD). These two development programmes were subsumed into a long-term development strategy, known as Vision 2020.

Figure 1.2: Percentage depreciation of the Gambian Dalasi in 1999 against major international currencies



A number of reforms have been and continue to be undertaken on both the fiscal and structural fronts. On the fiscal front, public finances will be strengthened through a further reduction in the budget deficit and an improvement in the structure of government revenue and expenditure, including a reduction of import tariffs.

The structural measures will include encouraging private sector development, attracting foreign investment, facilitating economic diversification, deepening financial intermediation and upgrading the soundness of the banking system, resuming public enterprise reform, reforming the energy sector, strengthening the agricultural sector, strengthening the institutional capacity of the public administration, and implementing a comprehensive social agenda, especially in the education and health sectors.

The Gambia's medium term strategy is embedded in the Policy Framework Paper, which has been replaced by the PRSP. An interim PRSP (SPA II) has been prepared and was launched in November 2000 and the final document was prepared and adopted in 2001. The PRSP defines and outlines a people-centered approach to the eradication of poverty. It sets out the poverty reduction strategy and the implementation modalities for Vision 2020.

1.3: Social Development

1.3.1: Human development and poverty

According to the 2000 National Human Development Report (NHDR, 2000), HDI for The Gambia is 0.363 (Figure 1.4 below). The Life Expectancy Index (LEI) is 0.5, Educational Attainment Index (EAI) is 0.364 and the Real GDP Index (RGI) is 0.226. The figures reported in the global HDR are slightly different from those in the NHDR. The Global HDR (GHDR) reports an HDI of 0.396, an LEI of 0.37, an EAI of 0.37 and an RGI of 0.45. In terms of gender, the GHDR reports a gender-related development index of 0.388, while NHDR reports an index of 0.340. It must be noted that the GHDR figures have a two to three year time lag while those of the NHDR have a one-year lag.

Life expectancy at birth is still low at about 53 years overall, 52 years for men and 55 for women. Infant mortality was 73 per 1000 babies born in 2000, down from 159 per 1000 babies born in 1980. The under-five mortality rate is about 110 per 1000 children. Prevalence of malnutrition declined to 30% in 2000. About 62% of total population, (53% in the rural and 80% in the urban areas) have access to safe water supply. Sanitation services are available for 37% of the total population (35% of the rural population and 41% of the urban population (see table 1.1 below for additional health indicators for The Gambia)).

Table 1.1: Health indicators for The Gambia

Physicians per 1,000 people	0.04
Hospital beds per 1,000 people	0.6
Child immunisation rate (under 1 year) - Measles - Tuberculosis	 88% 97%
Prevalence of under –nourishment	25%
Child malnutrition (under 5 years)	30%
Births attended by skilled health staff	44%

In the area of education, the overall illiteracy level stands at 63% and that for females at 78%. Industry and manufacturing sectors account for 12% and 11% of GDP, respectively. The services sector, which is dominated by the hotel industry and a vibrant informal sub sector, contributes about 67% of GDP (Figure 1.3), and is the main foreign exchange earner. The growth rate of the services sector is 4.3%.

Rapid population growth and increasing urbanization have posed a threat to the environment and put pressure on limited natural resources, thus aggravating environmental problems such as soil degradation, loss of forest cover, loss of biodiversity and poor sanitation. Coastal erosion has become a serious problem. For example, in some areas along the Atlantic coastline, the beach has been retreating at a rate of 1-2 m per year for the past thirty years while severe coastal erosion has produced sandy cliffs two meters high in other areas. Soil salinity is another threat to the environment. Saltwater intrusion has destroyed many farmlands making many farming households poorer.

Figure 1.3: Contribution to GDP by main economic activity

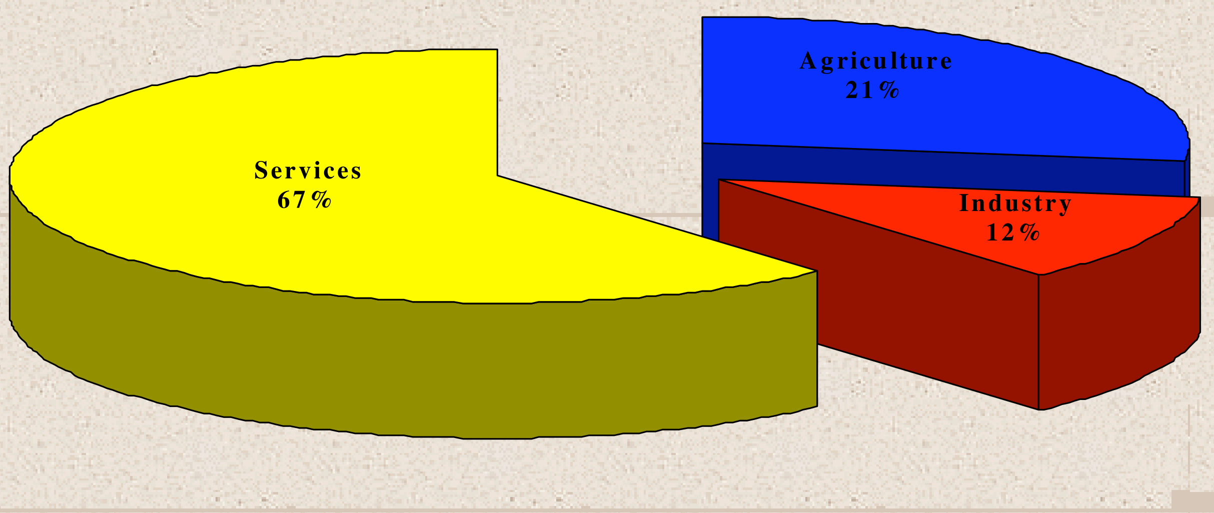
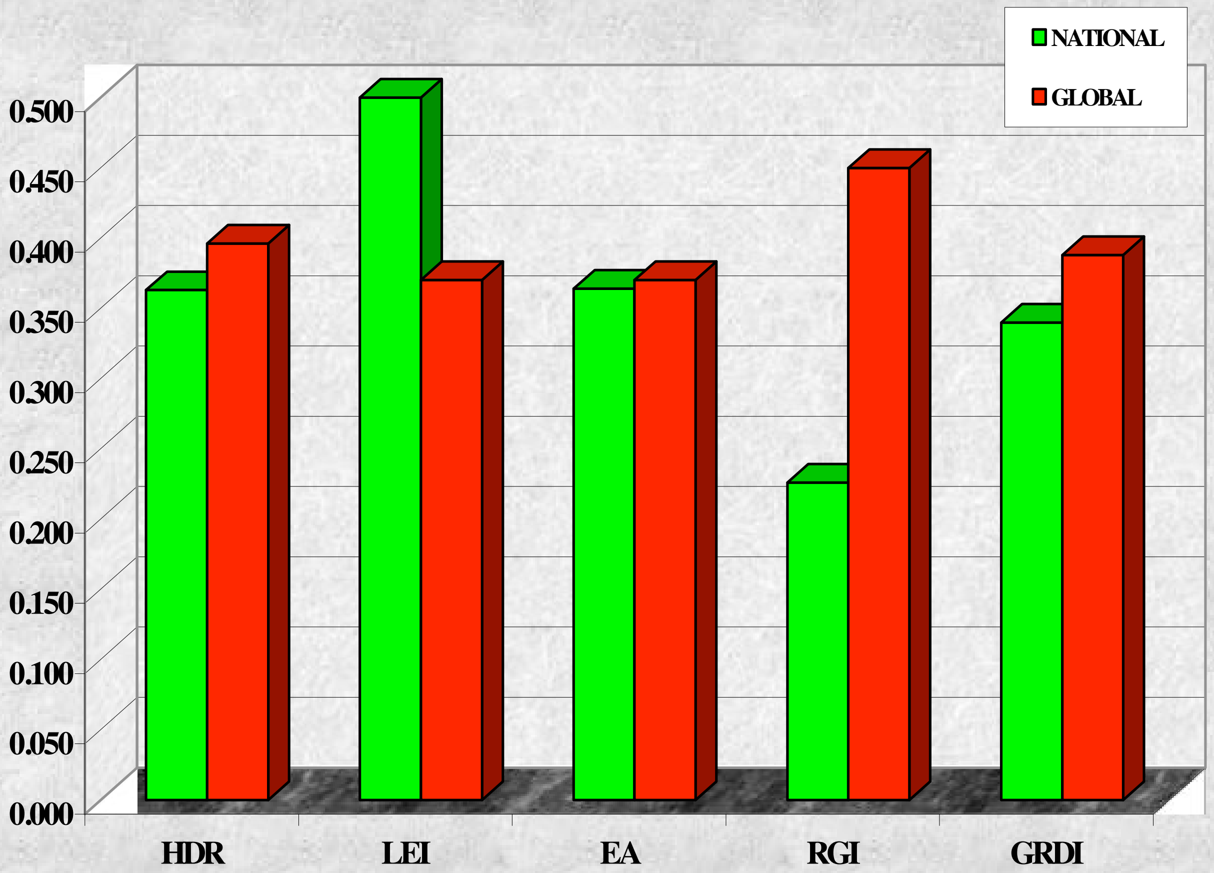


Figure 1.4: Statistics on human development in The Gambia (NHDR, 2000)



1.4: Sectoral Trends, Policies and Initiatives

1.4.1: Agriculture

The draft Agriculture policy objectives and strategies for agricultural development have been extended to the year 2020 and has been submitted to Cabinet for approval. Environmental degradation and depletion, increased pest and disease outbreaks, decreased use of vital inputs and low level of labour supply due to rapid rural to urban migration are major constraints besetting the agriculture sector. The focus of the new policy will be to increase farm productivity, diversify the farm household production and marketing mix and increase the share of household production to be marketed. The government is currently assisting farmers through the Federation of Agricultural Cooperatives. Government will continue to support the Agro-business Service Centre Association to introduce better seed varieties and to develop a commercially managed agricultural credit system. It has also taken cognizance of the fact that previous initiatives lacked the "ownership" element required to sustain them. As a result, Government is emphasizing grassroots-level empowerment of people and improvement of capacity at local levels.

1.4.2: Fisheries

The specific policy objectives of the fisheries sector as spelt out in the Strategic Plan for the Management and Development of the Fisheries sector include the following:

(a) to effect a rational long-term utilisation of marine and inland fisheries resources;
(b) to use fish as a means of improving nutritional standards of the population;
(c) to develop and expand artisanal fisheries and increase Gambian participation, especially women in the fishing industry;
(d) to increase employment opportunities and net foreign exchange earnings in the sector;
(e) to improve the economic environment of fisheries with a view to enhancing the sector's contribution to the national economy;
(f) to develop aquaculture, and
(g) to regulate industrial fishing activities with a view to achieving sustainable output.

Because fisheries resources are non-renewable, and subject to over exploitation, depletion and the influence of environmental factors, the under-pinning principle of the fisheries management system in The Gambia advocates for the enforcement of judicious and rational practices, consistent with the optimum exploitation and utilisation of fish resources.

1.4.3: Energy

The energy resource base of The Gambia comprises mainly of electricity, petroleum products, fuelwood, liquefied petroleum gas (LPG) and renewable energy. Electricity generation is almost exclusively produced using petroleum products. Because of the limited generation capacity, load shedding is frequent. The policy guidelines put in place to address the outage are increase efficiency of the utility sector, promotion of private sector participation in power generation and provision of affordable tariffs for the utility services by rehabilitating the transmission and distribution lines, installation of effective meters, together with vigorous billing system, use of heavy fuel oil (HFO) generating sets instead of diesel oil sets and introduce demand side management.

Other policy objectives in place include the encouragement of the use of renewable energy technologies and private sector participation in the supply and distribution of electricity.

1.4.4: Forests and forestry

Forests are estimated to cover about 48% of the land area of The Gambia and the forest cover is classified into four broad categories: *Closed forest (26,800 ha), Open forest (62,600 ha) Tree* and *Shrub Savannah (347,000 ha)* and *Mangroves (68,000 ha)* (Forster, 1983*)*. The Forestry sector share of GDP is estimated at less than 1%. This does not, however, take into consideration the significant informal trade in timber and non-timber forest products (fuelwood, fencing posts, wood carvings, honey palm oil and kernel, and wild fruits) that occur locally in the rural areas and across the border.

Forests provide more than 85% of the domestic energy need of the country in the form of woodfuel and about 17% of the domestic saw timber needs (EU/MNRE, 1992). The natural forest cover continues to be altered by forest fires, which remain the single most important cause of forest degradation. It is estimated that not less than 85% of the land area of The Gambia is burnt annually. Apart from wiping out regenerating trees and shrubs, forest fires also kill matured trees especially when the fires occur at the peak of the dry season when most of the vegetation is under severe water stress.

The main objectives of the national forest policy are to:

1. preserve, maintain and develop forest land resources covering at least 30% of total land area;
2. ensure that 75% of forest lands are managed and protected; and
3. ensure that sufficient supply of forest produce needed by both urban and rural population is available.

To achieve the above objectives, the forest policy will promote and encourage:

1. popular use of affordable alternatives for energy in urban areas to bridge the gap between the demand and what the forest can sustainably supply;
2. community ownership and management of forest lands;
3. multiple use of forest and forest lands;
4. efforts in the development of new strategies for the prevention and the control of bush fire;
5. active participation of private individuals and the private sector in the production of forest produce and its marketing;
6. nationwide tree planting;
7. national awareness concerning conservation and rational utilization of forest resources; and
8. urban forestry.

1.4.5: Water resources

The water policies of The Gambia are obsolete due to the increase demand and commensurate expanded mandate of the agencies responsible for the management of the water resources of the country. The Department of Water Resources (DWR), with the collaboration of donor partners (EC/EDF, UNDP, UNCDF and UNICEF), is working towards the updating of the policies, strategies and regulations of the water resources sector.

There is undoubtedly a continuing need for the provision of basic water supply facilities in the rural areas to assure 100% access to potable water by the rural population. As a matter of policy, the modern concrete-lined well and the Mark II (improved type) hand pump have been adopted, as the standard well and hand pump in the country. The introduction of renewable (solar and wind) energy-powered pumps and complementary borehole construction as well as the installation of reticulation systems in towns and villages with large population is being vigorously pursued.

The Private Hand-pump Maintenance Scheme and the training and use of Area Mechanics, initiated by the Gambia-German Hand-dug Wells (GITEC) Project is a policy that is presently being replicated across the country. Effective community participation includes community education with regard to water sanitation, well utilisation and maintenance, the appointment of a Village Well Committee and the financial contribution towards the cost of maintenance of the constructed well and hand pumps and water supply facilities in the villages. The introduction of economic incentives and user charges is being considered in the new policy and regulations.

It is logical that the water resources of the nation should be controlled by law. This law should invest the DWR with statutory powers and responsibilities to control the abstraction of water by means of the issue of water licenses and other regulatory measures. The Water Resources Act should define the type of water rights to be adopted as regards surface water and groundwater. Basic and applied research are the key to future progress, and increased attention should be given to the overall coordination of research and exploration programmes in the water resources sector. It should be government policy to allocate funds to areas that promise the greatest advances in water management and technology use.

1.4.6: Biodiversity and wildlife

In The Gambia, the development of a strategy and policy concept for biological diversity started with the Banjul Declaration and the Wildlife Conservation Act of 1977. These documents, particularly the Banjul Declaration, provide the basis for the conservation and sustainable use of biological resources in The Gambia.

Over the last two decades, the Government of The Gambia has taken various legal, policy and institutional measures to promote the conservation and sustainable use of the country's biodiversity. The most recent policy focuses on developing a comprehensive development policy framework, which includes institutional strengthening of public education to create greater awareness, conservation and research. The first ever comprehensive biodiversity/wildlife policy and a bio-safety and biotechnology framework for The Gambia have been developed and are currently under review for Cabinet approval, before enactment into a law by the National Assembly.

In the wildlife sector, the initial policy strategy was to set up a system of protected areas and a total of six national parks were established. The new policy objective is to increase national parks to 5% of total land area, and put an emphasis on community conservation and bio-diversity research to acquire baseline data. Various biodiversity-related sectoral laws support the above mentioned policy measures. These include the National Environmental Management Act (NEMA) of 1994, the Fisheries Act of 1995, the Fisheries Regulations of 1995, The Wildlife Conservation Act of 1977, the Wildlife Regulations of 1978, the Banjul Declaration of 1977, the Forest Act of 1997, the Forestry Regulations of 1998, the Plant Importation and Regulation Act of 1963 and the Prevention of Damage by Pests Act of 1962.

1.4.7: Waste management

The present policy direction on waste management is to relocate old solid waste dump sites to more appropriate sites and create land fills to better manage the ever increasing solid waste being generated in the country. Supporting policies and legislation include the NEMA, 1994; Public Health Act, 1990; Public Health Regulations, 1990; Banjul Market Slaughter House Regulations and Banjul and Kombo St. Mary's Slaughter House (Licensing and Management) Regulations Local Government Act (1963) CAP.33: 0130.

The Local Government Authorities (LGA) (Dissolution and Appointments Decree 1994) appointed management committees with functions of regulating the disposal of refuse, the prevention, abatement and removal of nuisances, and generally for the oversight of health and sanitation. There are no set guidelines as to disposal methods in the legislation.

The Waste Management policy objective is to preserve and improve the health and quality of life of all Gambians through sound environmental management. Problems addressed include poor sanitation, waste management and disposal. The policy targets the minimization of the waste management's impacts on human, fauna, flora and natural environment and minimization of landfill/dumpsite volume. The principle of the waste management policy is the prevention of waste production, waste utilization and recycling, and controlled disposal of waste, which cannot be utilized (after biological, thermal or chemical-physical treatment).

1.5: References

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Strategy for Poverty Alleviation (SPAII – PRSP), SPACO, April 2002

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CHAPTER 2

2: NATIONAL INVENTORY OF GREENHOUSE GAS EMISSIONS

2.1: Introduction

The United Nations Framework Convention on Climate Change (UNFCCC) seeks to stabilise concentrations of greenhouse gases (GHGs) in the atmosphere and commits Parties to take measures to mitigate GHG emissions, in accordance with the principle of common but differentiated responsibility and taking into account their national priorities and aspirations. Inventories of GHGs provide the means for monitoring reductions of GHGs by Parties and are therefore important components of national communications.

The Intergovernmental Panel on Climate Change (IPCC) has developed guidelines for computing of GHGs (by Parties) to enable their comparison. The inventory presented below was calculated using methodologies recommended in the GHG inventory reference manual produced by the IPCC. This inventory used 1993 as the base year because more data was available that year than any other. In fact specific surveys were conducted in 1993 to generate data needed for the inventory exercise.

Not all emission categories of the 1996 Revised Guidelines (IPCC.OECD.IEA, 1997) are reported on in this chapter of the National Communication. This shortcoming is due to the following:

1. Sub-category B: *Fugitive emissions from Fuels* of Category 1: *Energy* is also not reported. Estimation of fugitive emissions could not be conducted because there is no fuel produced in The Gambia. Primary fuels do not exist and oil and gas activities such as coal mining and oil refining are not conducted.

2. The bulk of the emissions from Category 2: *Industrial Processes* could not be estimated. Metal, cement, lime/limestone, soda ash, adipic and nitric acid, pulp and paper, ammonia, carbide and glass production do not exist. Asphalt roofing, road paving with asphalt, and concrete plumise stone production are conducted but data is lacking and documentation is inadequate for use in the development of a credible national inventory. Consumption of halocarbons and sulphur hexafluoride (SF_6) from refrigeration assembly, operation and disposal could not be quantified due to inadequate labeling, documentation and age of the equipment that enter the country. Similarly, data on foam products, fire extinguishers, solvents, aerosols and propellants, and equipment containing SF_6 are not readily available. Some study is necessary because the equipment are found in most public, commercial facilities and residential properties.

3. Category 3: *Solvent and Other Product Use* has not been reported on because the methodology for this category is still being developed.

The details of the methodology and data sources are under the respective emission categories below.

2.2: Emissions of Greenhouse Gases from the Energy Sector

In The Gambia, energy sector activities that contribute directly to the emission of GHGs have been identified as electricity production, transportation, domestic consumption of energy, and industrial and agricultural processes. The emissions consist of direct GHGs from energy consumption (Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Nitrogen Oxides (NOx), Carbon Monoxide (CO) and Non Methane Volatile Organic Compounds (NMVOC)) and Sulphur Dioxide (SO_2). Emissions from energy systems are calculated from fuel combustion, including fuelwood. It is assumed that all fossil fuel imported and all wood fuel gathered are consumed. Details of the methodologies can be found in the National Inventory (NCC, 2002).

2.2.1: Results of estimation of emissions from the energy sector due to fuel combustion

From Table 2.1 below, total emissions due to fuel combustion and based on the 1996 IPCC Guidelines, consist of 181,064 tonnes (t) CO_2, 2,911 t CH_4, 40 t N_2O, 54,536 t CO, and 6,987 t NMVOC. CO_2 constitutes 73% of the emissions while CO represents 22% (Figure 2.1).

The bulk of CO_2 emissions came from road transport, representing 60% and the energy industries emitted 30% of the CO_2. The residential sub-sector is the major emitter of CH_4. The sector emitted over 99% (3Gg) or 3,000 t CH_4. Energy Industries emitted about 94% of the total N_2O emitted, the manufacturing and construction industries emitted about 6% while the combined emissions of the remaining sectors is less than 1%. The residential and road transport sub-sectors are responsible for the bulk of NOx emissions from the energy sector. Together, they emit about 93% of the total, while energy industries emit about 7%. The residential sub-sector emitted 47,000 t (47 Gg) and the road transport sub-sector emitted 6,000 t (6 Gg) of the total CO emissions. Similar to the emissions of CO, 86% or 6,000 t(6 Gg) of the NMVOC emissions are from the residential sub-sector while 14% or 1,000 t (1 Gg) came from the road transport sub-sector.

2.2.2: Data gaps, expertise, sustainability and recommendations

The Gambia has a good activity data set for the development of the national inventory of emissions of GHGs in the energy sector. Between the development of the 1993 Inventory in 1994 and 1999, discrepancies have been found in the quantity of fuel imported. The values collected during this study have been confirmed as the most accurate and have been computerized.

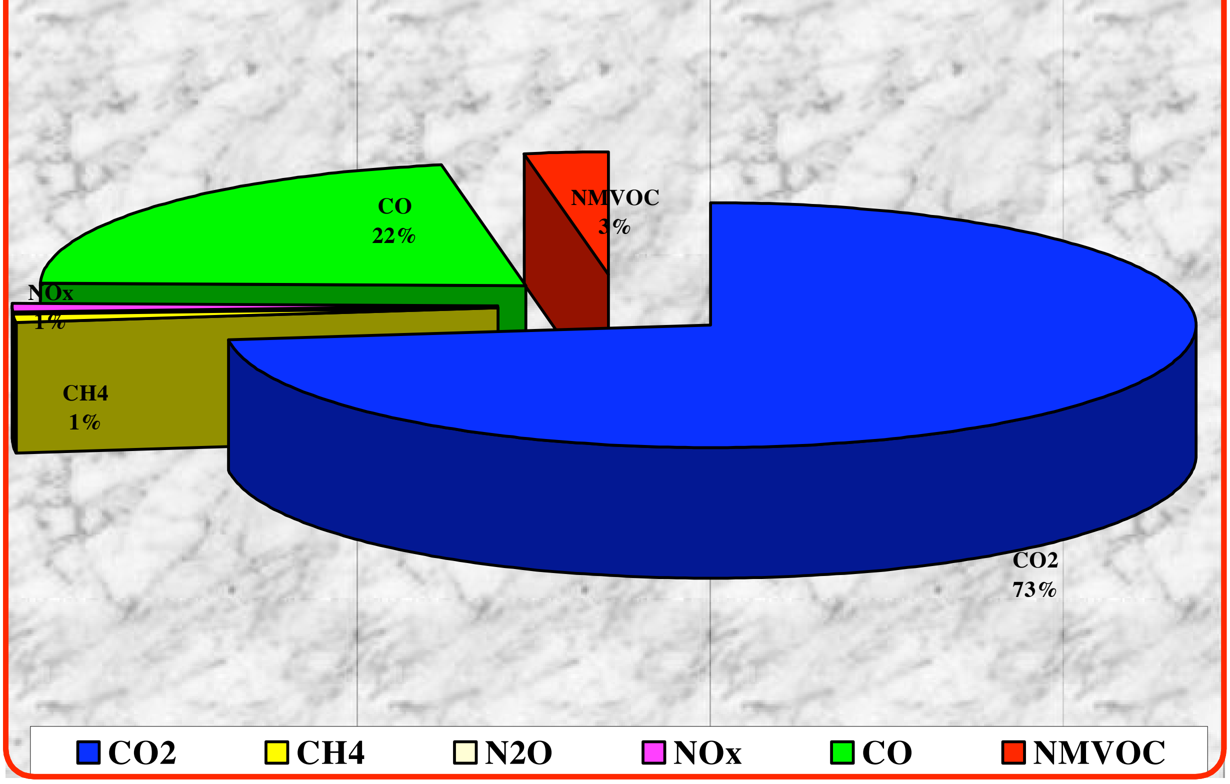
Data on fuelwood needs improvement. In 1993 the National Climate Committee (NCC) conducted the only nation-wide survey on fuelwood consumption. As this was conducted during the dry season it has become necessary to conduct another survey during the wet season so as to eliminate the effect of seasonal variation on fuelwood consumption.

More than 20 members of the NCC received training on the development of national inventory of GHG emissions using the Revised 1996 IPCC Guidelines and Software. The training was conducted during the national workshop on Inventories of GHGs and included activity data needs and collection, emission coefficients and factors, hands-on-exercises on the recording of the data in the worksheets, and reporting of the results. Out of the members trained during the workshop 2 have continued to enter the data in the modules and developed the energy sector inventory. Thus expertise has been developed in the development of the inventory.

Table 2.1: Emissions of GHGs from the energy sector in 1993

	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
	(t)						
TOTAL	**181,064**	**2,911**	**40**	**2,224**	**54,536**	**6,987**	
Energy Industries	54,369	2		145	11	4	
Manufacturing Industries and Construction	3,376			9			
Road Transport	108,000			1,000	6,000	1,000	
Commercial/Institution	8,000				1,000		
Residential	4,000	3,000		1,000	47,000	6,000	
Agriculture/Forestry/ Fisheries	3000						

Figure 2.1: Emissions of greenhouse gases by gas (%) from the energy sector in 1993



Sustainability in the development of the inventory is assured by the signing of a Memorandum-Of-Understanding (MOU) between DWR (Focal Point of the UNFCCC) and the DoSTIE, Central Statistics Department (CSD), Gambia Public Transport Corporation (GPTC) and Gambia Civil Aviation Authority (GCAA). By signing the MOU, concerned institutions have agreed to make data available to the Inventory Team through the DWR as and when required.

It is recommended that the Department of Energy under the Office of the President, be provided with the required logistics such as a computer and the inventory software to be fully responsible for the development of the energy sector inventory as and when required.

Due to the lack of country-specific emission factors and coefficients, default values provided in the IPCC Guidelines are used in this inventory. Its is recommended that the Inventory Team should, as a matter of priority, develop country specific emission factors and coefficients where found necessary. This aspect is a national priority and the National Communications Support Programme (NCSP) in New York and UNDP have understood it that way and have included The Gambia in the Regional Project on the Improvement of Inventories through the development of regional and national emission factors.

2.3: Emissions of Greenhouse Gases from Industrial Processes

2.3.1: Introduction

The industrial sector in The Gambia is underdeveloped. Banjul Breweries produces beer, malt and mineral water. Various cottage industries exist and these process and produce food on a relatively small scale. Therefore, only emissions from beverage and food production are assessed for the Industrial Processes category. These activities are not related to energy but chemically or physically transform materials. During these processes Non-Methane Volatile Organic Compounds (NMVOC) are released. The methodology employed is described fully in NCC, 2002.

2.3.2: Results of estimation of emissions from industrial processes

2.3.2.1: Emissions of NMVOC from alcohol beverage production

In 1993 Banjul Breweries produced about 120.5 million litres of Julbrew Lager, about 48 million litres of Guinness and about 50 million litres of malt drink (Table 2.2). Production of these quantities of beverages resulted to emissions of about 422 kg of NMVOC for Julbrew lager, 168 kg of NMVOC for Guinness and 174 kg of NMVOC for the malt drink. Thus, in 1993, a total of 764 kg of NMVOC were produced due to production of beverages at Banjul Breweries.

2.3.2.2: Emissions of NMVOC from bread and other food production

Table 2.3 shows emissions from the production of bread and other food items. Bread production is responsible for 92.5% of the emissions while production of animal feed and fish processing produce 4.9% and 2.1% respectively, of the emissions. Meat, poultry and production of cakes has a combined emission of about 0.5%.

Table 2.2: Emissions of non-methane volatile organic compounds from industrial processes in The Gambia in 1993					
Alcoholic beverage Type	**Quantity of Alcoholic Beverage Produced (hl)**	**Emission Factor (kg NMVOC/hl)**	**NMVOC Emitted (kg)**	**NMVOC Emitted (Gg)**	**Share of Emissions by beverage type (%)**
Julbrew Lager	12048	0.035	421.68	0.00042168	**92**
Guinness	4795	0.035	167.83	0.00016783	**4**
Malt	4969	0.035	173.92	0.00017392	**4**
			Total (Gg)	**0.00076343**	**100**

Table 2.3: Emissions of NMVOC from bread and other food production					
Food Production Type	**Quantity of Food Produced (t)**	**Emission Factor (kg NMVOC/t food processed)**	**NMVOC Emitted (kg)**	**NMVOC Emitted (Gg)**	**Percentage Share of Emissions by type of food (%)**
Meat	49	0.3	14.78	0.00001478	**<0.5**
Poultry	1.11	0.3	0.33	0.00000033	**<0.5**
Fish	7736	0.3	2,320.80	0.00232080	**2.1**
Bread	12975	8.0	103,796.87	0.10379687	**92.5**
Cakes	509	1.0	508.52	0.00050852	**<0.5**
Animal Feed	5538	1.0	5,538.02	0.00553802	**4.9**
			Total (Gg):	**0.11217933**	**100**

2.3.3: Conclusions and recommendations

Presently, only the Alcohol Beverage and Food Production sub-modules of the industrial sector of The Gambia can be assessed. Data on all other sub-modules are not readily available. An attempt was made to collect data on other sub-modules but this ended up being a useless exercise for this Inventory development process.

The data have not been properly recorded or not recorded at all. Some of the equipment are so old that labels have faded or non-existent. The Industrial Processes category is likely to be a big emitter because most of the equipment used is obsolete. These include used refrigerators, freezers, air conditioners, and compressor units that are leaking even at the time of importation.

It is recommended that a complete data gathering and collection study should be conducted for the Industrial Processes category in The Gambia. Since this is the first time this category is being assessed in The Gambia historical, data needs to be assembled in the data bank. Based on the collected data, it will be possible to extrapolate emissions for past years.

All emissions factors used are those from the 1996 Revised IPCC Guidelines on the development of National GHG emissions (IPCC.OECD.IEA.UNEP, 1997).

2.4: Emissions of Greenhouse Gases from the Agriculture Sector

2.4.1: Introduction

Agricultural activities contribute directly to emissions of GHGs through a variety of different processes. These include CH_4 emissions from enteric fermentation in domestic animals, animal waste management, rice production, and non-CO_2 emissions from savannah burning and field burning of agricultural wastes. Each of these activities is considered in this report and the results of analysis from the worksheets are also presented.

The data collection and analysis methods used are reported in the National Inventory (NCC, 2002). All the data collected were input in the IPCC/OECD/IEA Modules. The methodology consists of step by step instructions and worksheets contained in the revised IPCC 1996 Revised Guidelines (IPCC.OECD.IEA, 1997).

2.4.2: Results of estimations of emissions from the agriculture sector

2.4.2.1: Emissions from enteric fermentation

From Table 2.4 and Figure 2.2, a total of about 12,105 t CH_4 are produced through enteric fermentation in livestock and about 522 t CH_4 are produced from manure management. This converts to a total of 12.63 Gg CH_4 from livestock production in The Gambia.

2.4.2.2: Emissions from manure management

As shown at the bottom of Table 2.5, manure deposited by livestock that are grazing extensively in pastures produces about 16,722 kg of nitrogen per year. This value is used to estimate emissions from agricultural soils under section 4.2.5.

Table 2.4: Emissions of greenhouse gases from livestock production

Livestock Type	Number of Animals	Emission Factors for Enteric Fermentation	Emissions from Enteric Fermentation	Emission Factors for Manure Management	Emissions from Manure Management	Total Annual Emissions from Domestic Livestock
	('000s)	(kg/head/yr.)	(t/yr.)	(kg/head/yr.)	(t/yr.)	(Gg)
Cattle	304.852	32	9,755.26	1.000	304.85	10.06
Sheep	115.589	5	577.95	0.210	24.27	0.60
Goats	213.732	5	1,068.66	0.220	47.02	1.12
Donkeys	33.448	10	334.48	1.190	39.80	0.37
Horses	17.556	18	316.01	2.180	38.27	0.35
Mules/Asses	0.241	10	2.41	1.190	0.29	0.00
Swine	50.000	1	50.00	1.000	50.00	0.10
Poultry	740.000	0	0.00	0.023	17.02	0.02
Totals			**12,104.77**		**521.53**	**12.63**

Figure 2.2: Emissions of methane from enteric fermentation in various animals

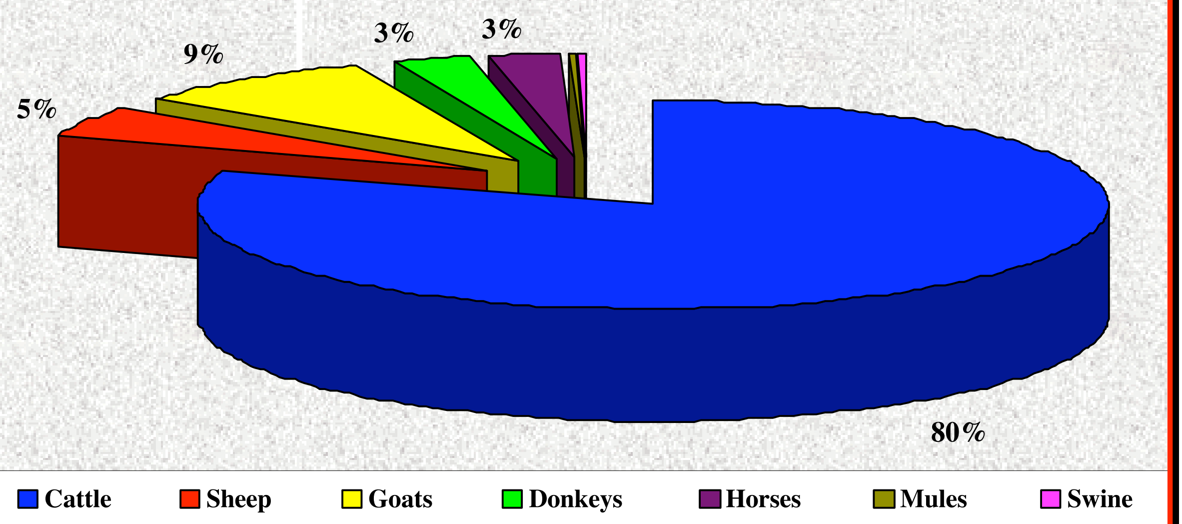


Table 2.5: Emissions of greenhouse gases from manure deposited in pastures

Livestock Type	Number of Animals ('000s)	Nitrogen Excretion (kg//head/(yr.)	Fraction of Manure Nitrogen per AWMS (%/100, a fraction)	Nitrogen Excretion per AWMS, Nex (kg/N/yr.)
Non-dairy Cattle	304.852	40	0.96	11,706.32
Poultry	740.000	0.6	0.81	359.64
Sheep	115.582	12	0.99	1,373.11
Swine	50.000	16	0.93	744.00
Goats	213.732	12	0.99	2,539.14
			TOTAL	16,722.21

Note: ***A Nex value of 12 and Fraction of Manure Nitrogen value of 0.99 are assumed for Goats, as Goats and Sheep have similar characteristics. It is assumed that all livestock manure in Africa is managed as a solid on pastures and ranges (IPCC 1996 Revised Guidelines for National Greenhouse Gas Inventories: Workbook).***

2.4.2.3: Emissions from rice production

Table 2.6 shows that about 81% (22.1 Gg) of the CH_4 emissions from rice production activities come from the deep water fields, 11% (2.1 Gg) come from activities in irrigated rice fields, and 8% (2.1 Gg) come from the shallow-water, drought prone "banta-faros" of the country. "Banta-faros" is the local name for upland fields, which sometimes remain under water for about 2 months of the rice-growing season. The irrigated fields have a longer period under water than the "banta faros" and the irrigation scheme is mostly tidal.

Table 2.6: Methane emissions from rice cultivation in The Gambia in 1993							
Water Management Regime			**Harvested Area (m^2 /1 000 000 000)**	**Scaling Factor for Methane Emissions**	**Correction Factor for Organic Amendment**	**Seasonally Integrated Emission Factor for Continuously Flooded Rice without Organic Amendment (g/m^2)**	**CH_4 Emissions (Gg)**
Irrigated	**Intermittently Flooded**	**Single Aeration**	0.148	0.5	2	20	2.960
Rainfed	**Drought Prone**		0.134	0.4	2	20	2.144
Deep Water	**Water Depth > 100 cm**		0.692	0.8	2	20	22.144
Totals			**0.97**				**27.248**

Note: *Default values provided in Tables 4.10 and 4.11 of the Workbook (IPCC, 1996) are used for Scaling Factor Correction Factor for Organic Amendment and Seasonally Integrated Methane Emission Factor.*

2.4.2.4: Emissions from Savannah burning (bushfires)

Net CO_2 released from the burning of savannah is considered to be zero because most of the grasses that regenerate during the following wet season absorb the CO_2. Other gases such as CH_4, CO, N_2O and NOx are emitted due to incomplete burning and other factors such as temperature.

From Table 2.7, 94% (2.77 Gg) of the emissions from Prescribed Burning of Savannah are CO, 4% represent emissions of CH_4 (0.11 Gg) and emissions of NOx represent about 2%. Emissions of N_2O are insignificant. It should be noted that only three years of data were available for savannah burning.

Table 2.7: Emissions of GHG from prescribed burning of Savannah in The Gambia			
Year/Trace Gas	**1990**	**1991**	**1993**
CH_4	0.20	0.11	0.11
CO	5.21	2.98	2.77
N_2O	0.0025	0.0014	0.0003
NOx	0.09	0.011	0.11

2.4.2.5: Emissions from crop residue burning

Similar to the burning of savannas, crop residue burning is not thought to be a net source of CO_2 but is a significant source of CH_4, CO, NOx and N_2O. Table 2.8 shows the quantity of carbon and nitrogen released from burning crop residues in the field. For both carbon and nitrogen release, burning of cotton residues contributes about half of the pollution. Burning of rice straw contributes 28% of carbon and 26% of nitrogen released while burning of groundnut residues contributes 9% of the carbon and nitrogen released.

Emissions of trace gases due to burning of agricultural residues are mainly in the form of CO (Table 2.9) representing about 92% of the total emissions, while emissions of CH_4 and NOx contributed about 8%. Emissions of N_2O were comparatively insignificant.

Table 2.8: Total carbon and total nitrogen released from burning of crop residues		
Crop type	**Total carbon released**	**Total nitrogen released**
Groundnuts	0.16	0.0023
Millet (Early & Late)	0.13	0.0020
Maize	0.09	0.0017
Rice	0.49	0.0069
Sorghum	0.01	0.0003
Cotton	0.89	0.0134
Sesame	NA	NA
Total	**1.7781**	**0.0267**

Table 2.9: Emissions of trace gases from burning of crop residues in the field					
	Emission Ratio	**Emissions (Gg C/N)**	**Conversion Ratio**	**Actual Emissions** *(Gg Trace Gas)*	**Percentage distribution of emissions by gas (%)**
Methane (CH_4)	0.005	0.0089	16/12	0.0118	4.4
Carbon Monoxide (CO)	0.060	0.1063	28/12	0.2480	91.6
Nitrous Oxide (N_2O)	0.007	0.0002	44/28	0.0003	0.1
Nitrogen Oxide (NOx)	0.121	0.0032	46/14	0.0106	3.9

2.4.2.6: Emissions of non-CO_2 trace gases from agricultural soils

To estimate emissions of GHGs from agricultural soils, it is necessary to use, as input, the quantity of synthetic fertilizers applied to the soil, manure input from animal waste, production of nitrogen-fixing crops, and amount of crop residues that is left on the soil as manure. These inputs are shown in Table 2.9. Emissions of N_2O from application of fertilizers occur through volatilization of nitrogenous fertilizer into the atmosphere.

Tables 2.10 and 2.11, and Figure 2.3 show emissions of N_2O from agricultural soils. About 98% of the emissions come from agricultural fields and about 2% come from leaching due to applications of synthetic fertilizers and animal waste. The nitrogen from these sources volatilizes into the atmosphere.

2.4.3: Constraints in the development of the inventory for the agriculture sector

1. Data on flood duration and water depth in rice production ecology should be determined. Local emission factors and coefficients to be used in the calculation of emissions from rice production should be developed locally or in collaboration with other regional institutions.

2. Only one survey has been carried out on crop residue burning, and to establish a trend that will be usable with limited bias, more surveys should be conducted as crop production varies with climate.

Table 2.10: Direct and indirect emissions of nitrous oxide from agricultural soils				
Emission Source	**Nitrogen Input**	**Fraction of Nitrogen in Input**	**Emission Factors and Value Used**	**Nitrous Oxide Emissions ($Gg\ N_2O$)**
Direct Soil Emissions from Agricultural Fields	Synthetic Fertilizers, Animal Waste, Nitrogen-Fixing Crops, and Crop Residue	-	$EF_1 = 0.0125$	0.16630
Direct Soil Emissions from Cultivation of Histosols	Area of Cultivated Organic Soils	-	$EF_2 = 10.0000$	Not Estimated because area of cultivated organic soils could not be established
Pasture range and Paddock (Grazing Animals)	16.722 tonnes Nitrogen	-	$EF_3 = 0.0200$	0.00053
Atmospheric Deposition of NH_3 and NOx	56.5 t volatized nitrogen	$Frac_{GASF}$ 0.1	$EF_4 = 0.0100$	0.00060
	3.3 t volatized nitrogen	$Frac_{GASM}$ 0.2		
Leaching	565 t synthetic fertilizers	$Frac_{LEACH}$ 0.03	$EF_5 = 0.0250$	0.00400
	16.7 t nitrogen as part of excretion from livestock			
Total				**0.17143**

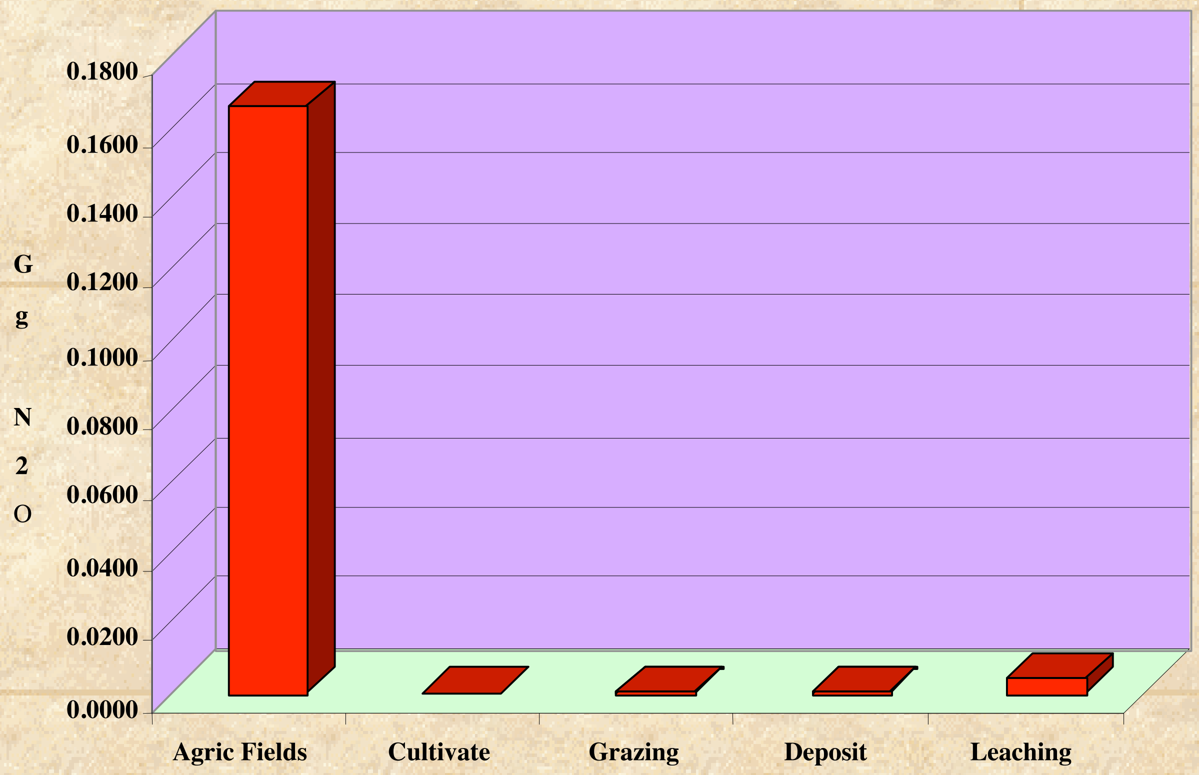
Table 2.11: Direct soil emissions of nitrous oxide from agricultural fields (see first row of Table 2.10 above)				
Type of Nitrogen Input into the Soil	**Amount of Nitrogen Input (Kg N/yr.)**	**Emission Factor for Direct Emission (kg N_2O-N/kg N)**	**Direct Soil Emissions (Gg N_2O-N/yr)**	**Remarks**
Synthetic Fertilizers	508,500.00	0.0125	0.0064	Total nitrogen excreted and fraction of nitrogen excreted were used to calculate emissions
Animal Waste	13,043.32	0.0125	0.0002	
Nitrogen-Fixing Crops	4,603,200.00	0.0125	0.0575	Production figures for groundnuts were used in the calculation
Crop Residue	3,343,655.70	0.0125	0.0418	

3. There is no country specific data on savannah burning. Figures used were adopted from the Centre de Suivi Ecologique (CSE) satellite image covering the period 1990, 1991 and 1993. Default conversion factors from IPCC guidelines were used.

4. Annual fertilizer importation figures were used in the calculations because it could not be determined how much of such quantities were actually applied on the soil. There are no

organic (Histosols) soils in The Gambia. All other values used in the calculations were obtained from the 1996 Revised IPCC Guidelines as default values.

Figure 2.3: Emissions of nitrous oxide from agricultural soils in The Gambia



2.5: Emissions of Greenhouse Gases from Land-Use Change and Forestry

2.5.1: Introduction

According to IPCC.OECD.IEA, (1997) land-use changes that result in alterations in the amount of biomass on the land produce a net exchange of GHGs between the atmosphere and the land surface. Biomass is a shorthand for organic material, both aboveground and below ground and both living and dead, e.g. tree crops, tree litter, roots, etc. The primary land-use changes that result in GHG emissions and uptake are conversion of forests to non-forests (e.g., conversion of forests to pasture or cropland) and conversion of non-forests to forests (e.g., establishment of plantations).

When forests are cleared, most of the carbon in the cleared biomass is released to the atmosphere as CO_2. Clearing by burning (e.g., biomass burning) releases other gases in addition to CO_2, which are by-products of incomplete combustion. These include CH_4, CO, N_2O, and NOx. CO_2

emissions from land clearing may not imply a net release of CO_2 to the atmosphere but emissions of these gases are net transfers from the biosphere to the atmosphere.

Land-use changes also result in GHG emissions through the disturbance of forest soils. When forests are converted to croplands, an average of about 25-50% of the soil carbon is released as CO_2, primarily through oxidation of organic matter. Loss of forests may also result in increased net CH_4 emissions to the atmosphere since forest soils are a natural sink of CH_4, i.e.; forest soils absorb atmospheric CH_4.

2.5.2: Estimates of emissions from the land-use change and forestry

2.5.2.1: Estimates of CO_2 emissions from changes in forest and other woody biomass stocks

The category *Changes in Forest and Other Woody Biomass Stocks* as used in this inventory is very broad, potentially including a wide variety of land-use practices. It includes plantations, forests that are logged or otherwise harvested, the planting of trees in villages, farms and urban areas and any other significant stocks of woody biomass. The method for calculating the net changes in biomass stocks is given in NCC (2002a).

Estimates show that 0.05 kilotonnes carbon (kt. C.), 71.30 kt. C., 11.63 kt C. and 3.22 kt. C. were realised by management of the *Tectonic grandis* plantations, open dry forest, gmelina plantations, and our village and urban tress, respectively. On the other hand, 103.42 kt. C. are pumped into the atmosphere from forest clearing and logging exercises conducted in The Gambia. The net effect is the emissions of 63.15 Gg CO_2 into the atmosphere from changes in the forest and other woody biomass in The Gambia (see Table 2.12 below).

Table 2.12: Emissions due to changes in forest and other woody biomass stocks

Total Biomass Consumption From Stocks *(Commercial Harvest+Traditional fuelwood+other wood-Quantity of biomass burned off site)* (kt dm)	Carbon Fraction	Annual Carbon Release (kt C)	Net Annual Carbon Uptake (+) or Release (-) (kt C)	Annual CO_2 Emission (-) or Removal (+) (Gg CO_2)
206.84	0.5	103.42	-17.22	-63.15

2.5.2.2: Emissions from forest and grassland conversions

It is estimated that in 1993, 492 kilotonnes dry matter (kt dm) of the vegetation cover of The Gambia were lost from conversion of savannah to other forms of land-use. This led to a release into the atmosphere of 110.7 kt C due to the on-site burning of 246 kt dm. Another 193.5 kt C was released due to off-site burning of about 184 kt dm. It is estimated that 292 kt dm has decayed due to the conversion of 89,000 hectares (ha) of savannah during the 10-years, leading to emissions of about 146.11 kt C into the atmosphere. From Table 2.13 below, a total of 692.05 Gg CO_2, 1.77 Gg CH_4, 15.50 Gg CO, 0.01 Gg N_20 and 0.44 Gg NOx were released into the atmosphere. About 99% of the emissions from this category are CO_2.

Table 2.13: Emissions of carbon and trace gases from forest and grassland conversion					
	Carbon dioxide (CO_2)		Non-CO_2 trace gase		
	Carbon Released (kt. C)	Carbon Dioxide Released (Gg CO_2)		Carbon and/or Nitrogen Released (kt C/kt N)	Quantity of Trace Gases Emitted (Gg)
On-Site Burning of Biomass	110.70 *(not included in the Total below)*	*The carbon released on-site translates to release of trace gases shown in the next columns.*	**CH_4**	1.33	1.77
			CO	6.64	15.50
			N_2O	0.01	0.01
			NOx	0.13	0.44
Off-Site Burning of Biomass	193.50	281.38			
Decay of Aboveground Biomass	146.11	410.67			
TOTAL	**339.61**	**692.05**			

2.5.2.3: Emissions from abandonment of managed lands

Based on assessments by Teusan (1994), about 361,000 ha of land were abandoned and continued to regenerate during the 20 years preceding 1993 (i.e., from 1973). A total of about 43.3 million t dry matter has been accumulated due to this regeneration. As 50% of biomass is assumed to be carbon, this accumulation of biomass translates to carbon uptake in aboveground biomass of 21.6 million t carbon. Total land area abandoned more that 20 years ago (i.e., before 1973) was 450,000 ha. This abandonment resulted in a biomass accumulation of 720,000 t dry matter and 360,000 t carbon removal from the atmosphere. Thus, total carbon uptake by the regeneration process is about 22 million t carbon and a removal of over 80,600 Gg of CO_2 from the atmosphere.

2.5.2.4: Emissions and/or removals from mineral and organic soils

Based on the reclassification of the land-use system of The Gambia, Table 2.14 below was arrived at. Some of the data collected for this analysis are extracted from the Land Resources Survey (LRS, 1991) under the Department of Livestock Services (DLS).

Between 1973 and 1993 the soil carbon from mineral soils has decreased by about –534 kg. This gives an annual carbon loss of 26.7 kg per year and CO_2 emissions of 97.9 kg per year from disturbance of mineral soils. These emissions occur mainly from disturbance of the wetland soils particularly due to the deterioration of our mangrove systems.

Based on a total land area of 274,100 ha for upland crops and 505,300 ha for pasture/forest, the net carbon loss per annum from organic soils is 8,008,500 Mg per year. This is equivalent to an annual carbon loss of 8,008.5 Gg per year and total CO_2 emissions of 29,364.50 Gg CO_2 per year (Table 2.14 below).

Table 2.14: Emissions from mineral and organic soils

Change in Soil Carbon for Mineral Soils

Soil type	Land area		Soil carbon		Net change in Soil Carbon in Mineral Soils (Tg per 20 yr.)
	1973 (Mha)	1993 (Mha)	1973 (Tg)	1993 (Tg)	
High Activity Soils	0.00	0.00	0.0000000000	0.0000000000	0.0000000000
Low Activity Soils	0.86	0.88	0.0000288210	0.0000290820	0.0000002610
Sandy	0.20	0.20	0.0000008020	0.0000007820	-0.0000000200
Volcanic	0.00	0.00	0.0000000000	0.0000000000	0.0000000000
Wetland (Aquic)	0.07	0.06	0.0000043510	0.0000035760	-0.0000007750
Totals	1.13	1.13			-0.0000005340

Carbon loss from managed organic soils

	Land Area (ha)	Annual Rate of Loss of Carbon (Mg C/ha/yr.)	Net Carbon Loss from Organic Soils (Mg/yr.)
Upland Crops	74,100	20	5,482,000
Pasture/Forest	505,300	5	2,526,500
Total			**8,008,500**

Emissions from mineral and managed organic soils

Source	Unit Conversion	Total Annual Carbon Emissions (Gg C)	Total CO_2 Emissions (Gg CO_2/year
Total Net Change in Soil Carbon (-0.000000534 (Tg/20years)	-50	0.0000267	0.0000979
Total Net Carbon Loss from Organic Soils (8,008,500 Mg/year)	0.001	8,008.5	29,364.50
TOTAL EMISSIONS FROM SOILS			**29,364.50**

2.5.2.5: Net greenhouse gas emissions from land-use change and forestry

In 1993, the Land-Use Change and Forestry Sector can be regarded as a CO_2 sink. As shown in Table 2.14 and Figure 2.4 the sector removed more than 50,000 Gg of CO_2 from the atmosphere, but emitted 2 Gg CH_4, 0.01 Gg N_2O, 0.44 Gg NOx and 15 Gg CO.

The net removal of CO_2 in the Land-use Change and Forestry sector (see Table 2.14 and Figure 2.4 below) consists of the following:

Emissions of 63 Gg CO_2 from changes in biomass stocks;
Emissions of 1,245 Gg CO_2 from conversion of forest and grasslands;
Removal of 80,696 Gg CO_2 due to abandonment of managed lands; and
Emissions of 29,365 Gg CO_2 due to soil disturbance.

2.5.3: Conclusions and recommendations

The 1993 National Inventory of GHGs developed for the Land-use Change and Forestry in 1994 (NCC, 1994) was based on data from the 1982 Forest Inventory (Forster, 1983). The results obtained showed that the Forestry Sector of The Gambia was a major source of GHGs. In 1988 a survey was conducted and the land-use and forestry data were updated. In 1993 a full Forest Inventory was conducted and again data on forests were updated. It is these data that came out of the 1988 reanalysis and the 1993 Forest Inventory that has been used to update the 1993 National Inventory of GHGs for the Land-use Change and Forest sector.

Table 2.15: Emissions of greenhouse gases in the land-use change and forestry sector of The Gambia in 1993

	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)	NOx (Gg)	CO (Gg)
Total Land-Use Change and Forestry	**-50,023**	**2**	**0.01**	**0.44**	**15**
A Changes in Biomass Stocks	**63**				
Tropical Forests					
Grasslands/Tundra					
B Forest and Grassland Conversion	**1,245**	**2**	**0.01**	**0.44**	**15**
Tropical Forests	0				
Grasslands/Tundra	1,245				
C Abandonment of Managed Lands	**-80,696**				
Grasslands/Tundra	-80,696				
D CO2 Emissions from Soil disturbance	**29,365**				

Note: ***For the purposes of reporting, the signs for removals from the atmosphere are always (-) and for emissions into the atmosphere the sign is (+).***

The updated inventory shows that the Land-use Change and Forestry Sector of The Gambia has changed from being a carbon source in the 1980s to a carbon sink in 1993. This change is mainly due to the intervention of the Gambia-German Forestry Project during the past 15 years and also the efforts of the Government of The Gambia in promoting tree planting and community forestry. These activities should be taken into full consideration in identifying and developing mitigation measures and policies.

2.6: Emissions of Greenhouse Gases from Waste Management

2.6.1: Introduction

Domestic, agricultural and industrial waste is generated in the form of solid and liquid. There is no form of waste management or separation in The Gambia. Solid waste is collected from residential properties and commercial services, markets, recreational areas, government offices and institutions (schools and hospitals), fish and poultry processing plants, industries, hotels, etc. The waste constitutes the following: leftover food, paper, grasses, construction waste and other cuttings.

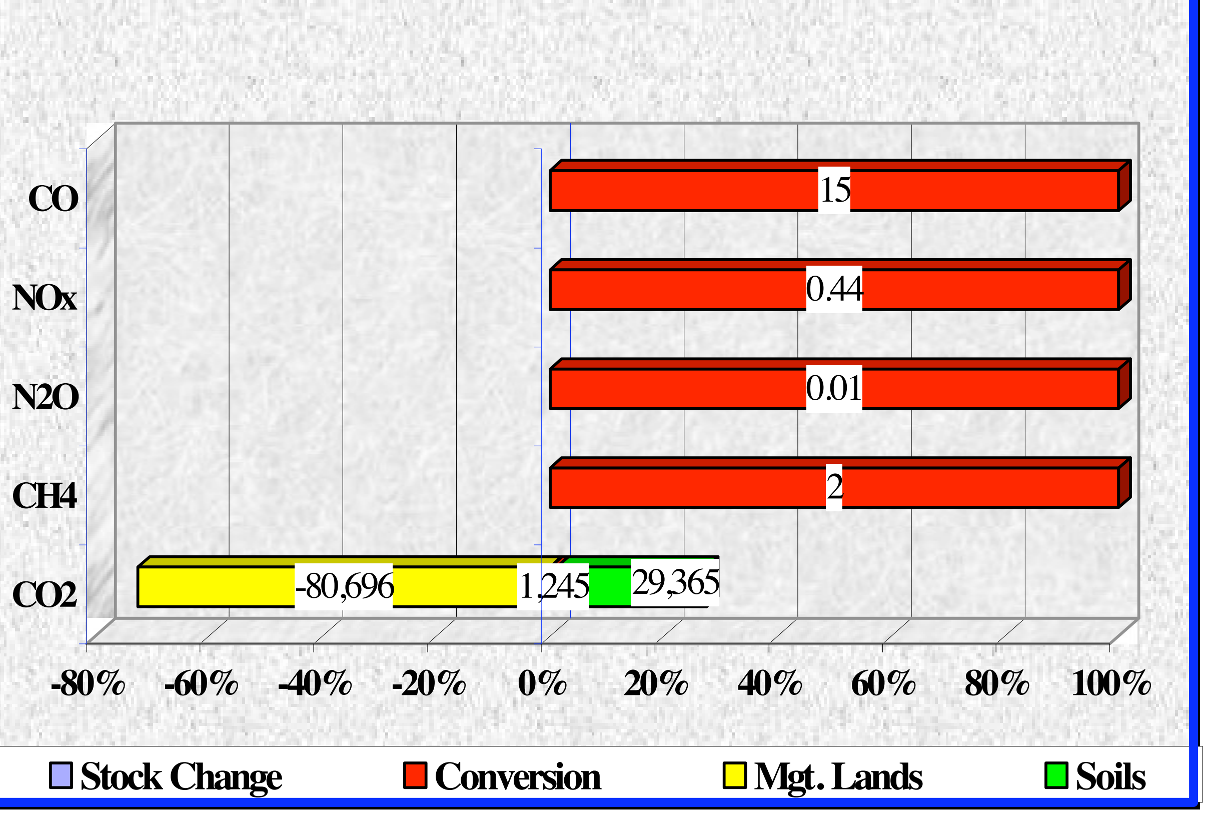
2.6.2: Estimates of emissions from waste Management

2.6.2.1: Methane emissions from solid waste disposal sites

Data in Table 2.16 shows results of the analysis of emissions due to total annual solid waste disposed at the disposal sites in The Gambia in 1993. A total of 119.51 Gg of Municipal Solid

Waste (MSW) was disposed of at solid waste disposal sites (SWDS). This amount could be much higher if the Area Councils were collecting all the waste in the Divisions. Waste is only collected infrequently in market areas, in Brikama, Basse and Mansakonko and other growth centres. The result is a gross annual methane generation of 9.39 Gg of CH_4. None of the CH_4 generated is being recovered.

Figure 2.4: Greenhouse flows in the land-use change and forestry category



2.6.2.2: Methane emissions from wastewater produced in the domestic and commercial sectors

As shown in Table 2.17, the urban population of over 270,000 in Banjul and the Kanifing Municipality in 1993 produced a total of 3.65 million kg of wastewater. With a recommended degradable organic component (DOC) of 13.5 kg per person per year, a total of 0.73 Gg of CH_4 was emitted in 1993.

2.6.2.3: Methane emissions from wastewater produced in the industrial sector

The industrial sector of The Gambia is under-developed. Most of the industries (metal, fertilizer, paper and pulp, petroleum refining and petrochemicals, and rubber) included in the IPCC Guidelines for the development of National Inventory for Industries do not exist. Only the Food and Beverage industry is considered in this study. Table 2.18 shows that a total of 6.9 Tg of wastewater from industrial source was produced. This quantity resulted to the emissions of 137.96 Gg of CH_4.

Table 2.16: Quantity of methane emissions from solid waste disposal sites in 1993								
Total Annual MSW Disposed to SWDSs (Gg MSW)	**Methane Correction Factor**	**Fraction of DOC in MSW**	**Fraction of DOC which Actually Degrades**	**Fraction of Carbon Released as Methane**	**Conversion Ratio**	**Potential Methane Generation Rate per Unit of Waste (Gg CH_4/Gg MSW)**	**Realized (Country specific) Methane Generation Rate per Unit of Waste (Gg CH_4/ Gg MSW)**	**Net Annual Methane Emissions (Gg CH_4)**
119.51	**0.6**	**0.255**	**0.77**	**0.5**	**1.33**	**0.131**	**0.08**	**9.39**

Note: ***The value 0.6 is default value from Table 6.2 of Workbook. The value 0.255 in the third Column is average of default values given in Table 6.3 of Workbook, as there are no country specific values. Values in Columns 4 and 5 are recommended default values.***

Table 2.17: Emissions of methane from production and management of waste water in the domestic and commercial sectors

Region or City	Population (1,000 persons)	Degradable Organic Component (kg BOD/1000 persons/yr.)	Total Domestic/Commercial Organic Wastewater (kg BOD/yr.)	Emission Factor (kg CH_4/kg BOD)	Methane Emissions Without Recovery/Flaring	Net Methane Emissions (Gg CH_4)
Banjul	42.326	13,505.00	571,612.63			
Kanifing Municipality	228.214	13,505.00	3,082,030.07			
			3,653,642.70	**0.20**	**730,728.54**	**0.73**

Note: ***Population figures in the second column are from CSD, (1996). Value of 13,505 in the third column is default value given in the Workbook (IPCC.OECD.IEA, 1997). BOD is Biochemical Oxygen Demand***

2.6.2.4: Indirect nitrous oxide emissions from human sewage

Sewerage system exists only in Banjul. With a per capita protein consumption of 9.125 kg per person per year and a population of 42,326 served by the sewerage system, emissions of N_2O are estimated as 1,000 kg N_2O (0.001 Gg) per annum (Table 2.19 below).

From Tables 2.15 to 2.19 above, the gross annual CH_4 emitted in The Gambia in 1993 was about 148 Gg. As shown in Figure 2.5, 94% of the CH_4 emitted came from wastewater handling, particularly from the industrial sector and 6% of the emissions came from solid waste disposal.

2.6.3: Conclusions and recommendations

From the data collected on the total annual waste produced in The Gambia the following observations can be made:

1. waste produced is not sorted;
2. lack of adequate resources to collect all the waste in major towns and municipalities makes the results a gross underestimation;
3. all the waste dumped at the disposal sites are not managed;
4. the location of existing disposal sites are inappropriate in terms of environmental sanitation;

Table 2.18: Emissions of methane from industrial wastewater handling

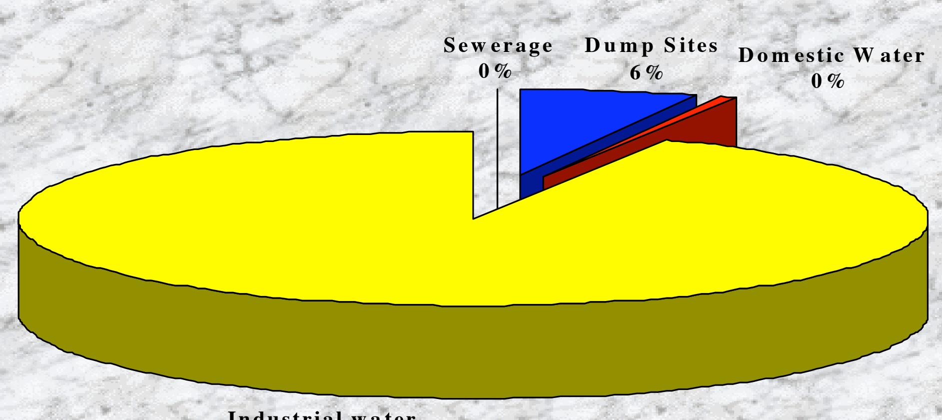
Industries	Total Industrial Output (t/yr.)	Degradable Organic Component (kg COD/m^3 wastewater)	Total Organic Wastewater from Industrial Source (kg COD/yr.)	Emission Factor (kg CH_4/kg COD)	Methane Emissions without Recovery/Flaring	Net Methane Emissions (Gg CH_4)
Food & Beverage						
Beer	2635	17	1,157,447,837.29			
Wine			0.00			
Slaughter House	39961	2.5	407,105,645.16			
Fish processing	130622	2.5	4,349,710,451.61			
Soft drinks	1240	17	256,320,628.33			
Tannery	53426	2.5	727,655,969.03			
		Total	**6,898,240,531.42**	**0.02**	**137,964,810.63**	**137.96**

COD is Chemical Oxygen Demand

Table 2.19: Emissions of nitrous oxide from human sewage

Per Capita Protein Consumption (Protein in kg/person/yr.)	Population (number)	Fraction of Nitrogen in Protein $Frac_{NPR}$ (kg N/kg protein)	Emission factor EF_6 (kg N_2O-N/kg sewage-N produced)	Total Annual N_2O Emissions (Gg N_2O/yr)
9.125	**42,326**	**0.16**	**0.01**	**0.0010**

Figure 2.5: Emissions of methane from waste management



5. There is no information on the proportion of the various constitutes that make up household waste, and from waste from institutions;
6. fire out break is common at the disposal sites;
7. scavengers collect any material that may be useful to them;
8. animals graze around the disposal site;
9. there is inadequate data and information on waste management;
10. there is lack of strong legislation to enforce proper waste management; and
11. administrative and legal frameworks together with institutional and financial commitments are needed to develop an effective management system.

In view of the facts mentioned, the following are recommended:

1. a solid waste strategy needs to be developed for The Gambia;
2. proper landfill sites should be selected;
3. there is need to design and operate municipal landfills;
4. authorities responsible for the collection of solid waste should develop their own solid waste disposal plan and submit it to the NEA for approval;
5. a monitoring strategy for the emissions (CH_4 and SO_2) and the leachate from the dumpsites should be developed;
6. tree planting around the dumping sites should be encouraged so that they can serve as wind breaks, to prevent the spread of waste into non-dumping sites, as well as to serve as CO_2 sink;
7. public awareness about waste management should be increased; and
8. the capacity of the personnel on waste management in the municipalities and Area Councils should be increased.

2.7: References

DLS/LRS, 1991. National Land Resources Survey of The Gambia

Forster, H., 1983. Evaluation of the National Forest Inventory of The Gambia, Technical Report no. 10. Gambia-German Forestry Project, Banjul.

NCC, 1994. 1993 National Inventory of Greenhouse Gas Emissions of The Gambia

NCC, 2002a. Updated 1993 Inventory of Greenhouse Gas Emissions of The Gambia

IPCC.OECD.IEA, 1997. 1996 Revised IPCC Guidelines for National Greenhouse Gas Inventories.

Teusan, S. M., 1994. Monitoring of the Land-use Change in The Gambia between 1990 and 1993.

Table 2.20: Summary report for national greenhouse gas inventories (Gg)

Greenhouse gas source and sink categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO	NMVOC	SO_2	HFCs		PFCs		SF_6	
									P	A	P	A	P	A
Total National Emissions and Removals	**181**	**-50,023**	**193**	**0.23**	**3**	**73**	**7**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
1 Energy	**181.0645**	**0.0000**	**2.9114**	**0.0400**	**2.2238**	**54.5359**	**6.9867**	**0.0000**						
A Fuel Combustion (Sectoral Approach)	181.0645		2.9114	0.0400	2.2238	54.5359	6.9867							
1 Energy Industries	54.3691		0.0022	0.0004	0.1446	0.0108	0.0036							
2 Manufacturing Industries and Construction	3.3758		0.0001	0.0000	0.0091	0.0005	0.0002							
3 Transport	108.4297		0.0179	0.0009	1.0807	6.3442	1.2000							
4 Other Sectors	14.8900		2.8912	0.0386	0.9893	48.1804	5.7828							
5 Other (please specify)	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000							
B Fugitive Emissions from Fuels	0.0000		0.0000		0.0000	0.0000	0.0000	0.0000						
1 Solid Fuels			0.0000											
2 Oil and Natural Gas			0.0000		0.0000	0.0000	0.0000	0.0000						
2 Industrial Processes	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.11**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
A Mineral Products	0.00					0.00	0.00	0.00						
B Chemical Industry	0.00		0.00	0.00	0.00	0.00	0.00	0.00						
C Metal Production	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0
D Other Production	0.00				0.00	0.00	0.11	0.00						
E Production of Halocarbons and Sulphur Hexafluoride									0.00	0.00	0	0	0	0
F Consumption of Halocarbons And Sulphur Hexafluoride									0.00	0.00	0	0	0	0
G Other (please specify)	0.00		0.00	0.00	0.00	0.00	0.00	0.00				0		0

P = Potential emissions based on Tier 1 Approach. A = Actual emissions based on Tier 2 Approach.

Table 2.20: Summary report for national greenhouse gas inventories (Gg) (continued)

Greenhouse gas source and sink categories	CO_2 Emissions		CO_2 Removals		CH_4	N_2O	NO_x	CO	NMVOC	SO_2	HFCs		PFCs		SF_6	
											P	A	P	A	P	A
3 Solvent and Other Product Use		**0**				**0**			**0**							
4 Agriculture					**40**	**0**	**0**	**3**								
A Enteric Fermentation					12											
B Manure Management					1	0										
C Rice Cultivation					27											
D Agricultural Soils						0										
E Prescribed Burning of Savannas					0	0	0	3								
F Field Burning of Agricultural Residues					0	0	0	0								
G Other (please specify)					0	0										
5 Land-Use Change & Forestry	**(1)**	**0**	**(1)**	**-50,023**	**2**	**0**	**0**	**15**								
A Changes in Forest and Other Woody Biomass Stocks	(1)	63	(1)	0												
B Forest and Grassland Conversion		1,245			2	0	0	15								
C Abandonment of Managed Lands				-80,696												
D CO_2 Emissions and Removals from Soil	(1)	29,365	(1)	0												
E Other (please specify)		0		0	0	0	0	0								
6 Waste					**148**	**0**	**0**	**0**	**0**	**0**						
A Solid Waste Disposal on Land					9											
B Wastewater Handling					139	0										
C Waste Incineration																
D Other (please specify)					0	0										
7 Other (please specify)																

(1) The formula does not provide a total estimate of both CO_2 emissions and CO_2 removals. It estimates "net" emissions of CO_2 and places a single number in either the CO_2 emissions or CO_2 removals column, as appropriate. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).

Table 2.20: Summary report for national greenhouse gas inventories (Gg) (continued)

Greenhouse gas source and sink categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO	NMVOC	SO_2	HFCs		PFCs		SF_6	
									P	A	P	A	P	A
Memo Items														
International Bunkers	42		0.00	0.00	0.00	0.00	0.00	0.00						
Aviation	42		0.00	0.00	0.00	0.00	0.00	0.00						
Marine	0		0.00	0.00	0.00	0.00	0.00	0.00						
CO_2 Emissions from Biomass	1,046													

Table 2.21: Short summary report for national greenhouse gas inventories

Greenhouse gas source and sink categories	CO_2 Emissions		CO_2 Removals		CH_4	N_2O	NO_x	CO	NMVOC	SO_2	HFCs		PFCs		SF_6	
											P	A	P	A	P	A
Total National Emissions and Removals		**181**		**-50,023**	**193**	**0**	**3**	**73**	**7**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
1 Energy — Reference Approach[1]		**186**														
Sectoral Approach[1]		**181**			**3**	**0**	**2**	**55**	**7**	**0**						
A Fuel Combustion		181			3	0	2	55	7							
B Fugitive Emissions from Fuels		0			0		0	0	0	0						
2 Industrial Processes		**0**			**0**	**0**	**0**	**0**	**0.11**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
3 Solvent and Other Product Use		**0**				**0**			**0**							
4 Agriculture					**40**	**0**	**0**	**3**								
5 Land-Use Change & Forestry	**(2)**	**0**	**(2)**	**-50,023**	**2**	**0**	**0**	**15**								
6 Waste					**148**	**0**										
7 Other (please specify)		**0**		**0**	**0**	**0**	**0**	**0**	**0**	**0**						
Memo Items:																
International Bunkers		**42**			**0**	**0**	**0**	**0**	**0**	**0**						
Aviation		42			0	0	0	0	0	0						
Marine		0			0	0	0	0	0	0						
CO_2 Emissions from Biomass		**1,046**														

P = Potential emissions based on Tier 1 Approach. A = Actual emissions based on Tier 2 Approach.

(1) ***For verification purposes, countries are asked to report the results of their calculations using the Reference Approach and explain any differences with the Sectoral Approach. Do not include the results of both the Reference Approach and the Sectoral Approach in national totals.***

(2) ***The formula does not provide a total estimate of both CO_2 emissions and CO_2 removals. It estimates "net" emissions of CO_2 and places a single number in either the CO_2 emissions or CO_2 removals column, as appropriate. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).***

CHAPTER 3

3: ASSESSMENT OF OPTIONS TO MITIGATE CONCENTRATION OF GREENHOUSE GASES

3.1: Introduction

On the basis of the assessment in Chapter 2, a total of 181 Gg of CO_2 were emitted into the atmosphere while about 50,000 Gg of CO_2 were removed from the atmosphere by various socio-economic activities conducted in The Gambia in 1993 (NCC, 2002). This indicates that The Gambia is a net source but the forestry sector is a net sink of CO_2.

Considering the size of The Gambia, the net absorption of over 50,000 Gg of CO_2, per year from the land-use change and forestry category should be seen as a sizeable contribution to the removal of GHGs from the atmosphere. The Gambia is also contributing to the stabilization of their concentration in the atmosphere. This is a clear indication that there is need to identify changes in the land-use policy, law and tenure that significantly influence and encourage forest conservation and sustainable management. Non-GHG reduction objectives such as preservation and enhancement of biodiversity, soil conservation, watershed management could also be looked into.

A mitigation assessment typically focuses on long-term opportunities for reducing GHG emissions or enhancing carbon sinks. In an effort to meet the requirements of the Convention but taking particular consideration of the national needs for sustainable development the NCC designed the mitigation assessment to satisfy the needs of the various possible users or stakeholders. The primary users of the assessment will be policy- and decision-makers.

3.2: Approach in the Mitigation Assessment

3.2.1: Stakeholder consultation and desk review of literature

The first step in the assessment of mitigation was to gather data and information through stakeholder consultation and desk review of literature on mitigation of greenhouse gases. The consultations were conducted at both the community and technical levels and was largely based on the 1993 Inventory of Greenhouse Gases (NCC, 2002). This culminated in the identification of a long list of potential mitigation options that could be stand-alone projects or could be collapsed into a single project.

Based on desk review and scoping meeting involving various stakeholders, the following list of categories of mitigation options were developed and screened for further analysis.

1: Residential Sector

(a) Switching to Energy Sources/Equipment with Lower GHG Emissions.

2: Energy

(b) Switching and promotion of renewable (Solar Home Systems and LPG).

3: Transport Sector

(c) Revitalisation of River Transport for movement of passengers and bulk cargo.

4: Agriculture Sector

(d) Water management in rice cultivation and maintenance of soils.

5: Rangelands and Livestock Sub-sector

(e) Rehabilitation of degraded rangelands including afforestation, reforestation, grass and shrub establishment, control of grazing lands, halophyte establishment on salinized lands, etc.
(f) Improving the quality of the diet through mechanical and chemical feed processing and strategic supplementation.
(g) Improve production using enhancing agents and improved genetic characteristics.
(h) Improved production efficiency through improved reproduction.

6: Forestry Sector

(i) Forest protection and conservation and increase efficiency in forest management.
(j) Reforestation, afforestation and agroforestry.
(k) Urban and community forestry.

7: Waste Management Sector

(l) Landfill management.
(m) Waste recycling.
(n) Waste composting.

In screening this long list of mitigation measures, national and project screening criteria and indicators were used to reduce the long list of potential mitigation measures to a manageable list of potential projects. The criteria included the availability and ease of collecting the data needed for project development and implementation, the benefits and costs of the projects, the economic and social importance of the project in the country, and, most importantly whether the project meets the dual objectives of sustainable development and reduction of the concentrations of GHGs in the atmosphere. The additional national indicators used include:

- national development benefits and policy priority;
- how well the projects span the range of GHG mitigation opportunities in the country;
- how representative these projects are of GHG mitigation opportunities in the country or sub-region as a whole; and
- the availability of information to assess these projects.

The outcome of the screening was the reduction of the 11 options to the following 8 options that were then subjected to in-depth analysis using benefit-cost and cost effectiveness.

(i) Rural electrification using Solar Home Systems to displace a planned diesel plant.
(ii) Greenhouse gas reduction through the use of Improved Cooking Stoves.
(iii) Carbon sequestration through reforestation and protection of existing forests.
(iv) Large scale introduction of Liquefied Petroleum Gas to displace fuel wood.
(v) Utilizing waste for two city authorities to generate landfill gas for bottling.
(vi) Integrated crop and livestock farming- utilizing rice straw (treated with urea) as cattle feed.
(vii) Managing a multi-product forest for cashew nuts, honey-bee-keeping, etc.
(viii) Waste management using composting.

3.2.2: In-depth analysis of options and project ideas

The in-depth analysis of the eight options consisted of assembling data for the base year on the activities and technologies/practices that are associated with GHG emissions or carbon storage. The assembly of base-year data was also heavily dependent on the 1993 Inventory of Greenhouse Gases (NCC, 2002) and other sectoral data and information. After the base year data and information were documented in some detail, then, attempt was made to project and evaluate the future. The development of scenarios of the future requires data on the activities that result in GHG emissions or shape opportunities for carbon storage.

Various criteria were applied to screen the list of options during the in-depth analysis. At the screening stage, a rough assessment of the potential attractiveness of options was made using the matrix shown in Table 3.1 below. The matrix provides a qualitative indication of the attractiveness of each option by ranking it very low (1), low (2), medium (3), high (4) and very high (5) as judged according to each criterion.

A quantity assessment used scoring method that varies from 1 (lowest) to 10 (highest). The score is multiplied by the weight to give a total score for particular criteria. According to the example in Table 3.1 the highest possible score was 30 and the project scored a total of 21.5 thus attaining 72% of the maximum score. This implies that the project is viable and could have wide scale application.

Cost-effectiveness analysis was also conducted to identify the least-cost option for reaching a goal. A typical tool used to assess cost-effectiveness is a decision matrix (Table 3.2) that analyzes the cost-effectiveness of mitigation options by comparing costs with benefits of the options measured in a common metric. The measurements are added up across the different policy objectives (and weighted based on relative importance) and compared to costs to determine cost-effectiveness and the options are ranked.

To utilize the matrix one determines the options to be examined, the objectives for which the options will be scored and the relative weights associated with each objective, the scenarios which may be part of the analysis and the costs of each mitigation option. Once these have been determined and entered into the table, one can begin scoring the measures on a scale of 1(very low) to 5 (very high) indicating how well each measure meets each objective under different scenarios. The decision matrix then automatically calculates weighted scenario scores for each option. A total score is also calculated. Cost-effectiveness is also automatically calculated by dividing the cost of the option by the incremental (mitigation scenario – current policy scenario) total score.

Throughout the analysis **c**osts and benefits were typically expressed to occur over a period of time in terms of their net present value (NPV), which was calculated using a discount rate (DR). The DR reflects the return on foregone present consumption that is scarified to secure future consumption. In this study, an appropriate DR of 10% was used to evaluate the present value of monetary costs and benefits of the mitigation options. In order to assess an option's cost-effectiveness, the discounted costs and benefits are related to its GHG savings or carbon storage.

These costs and benefits are quantified where possible or at least described qualitatively where quantification is not possible. Where the benefits of the mitigation options with regards to climate change could not be monetised the benefits were stated simply in terms of either t carbon abated or stored.

Table 3.1: Project identification by screening mitigation options				
Criteria Groups			**Qualitative Score (VL-VH)**	**Quantitative Score (1-10)**
1. Criteria 1	**Weight =**			
1.1 Sub-criteria				
1.2 Sub-criteria				
1.3 Sub-criteria				
Weighted Sub Total				**=**
2. Criteria 2	**Weight =**			
2.1 Sub-criteria				
2.2 Sub-criteria				
2.3 Sub-criteria				
Weighted Sub Total				**=**
3. Criteria 3	**Weight =**			
3.1 Sub-criteria				
3.2 Sub-criteria				
Weighted Sub Total				**=**
4. Criteria 4	**Weight =**			
4.1 Sub-criteria				
4.2 Sub-criteria				
4.3 Sub-criteria				
Weighted Sub Total				**=**
5. Criteria 5	**Weight =**			
5.1 Sub-criteria				
Weighted Sub Total				**=**
6. Criteria 6	**Weight =**			
6.1 Sub-criteria				
6.2 Sub-criteria				
6.3 Sub-criteria				
Weighted Sub Total				**=**
	Sum of Weights =		**Total Score =**	**=**
			Max. Score =	

The relationship between total amount of "avoided" CO_2 and the cost per unit CO_2 avoided was expressed using cost curves. A GHG-reduction cost curve relates the quantity of GHG that can be reduced by mitigation options to the cost per unit GHG reduction. Correspondingly, a cost curve for stored carbon relates the quantity of stored, or sequestered, carbon to the cost per unit carbon stored. Cost curves for GHG reduction and for carbon storage can be combined to express the relationship between total amount of ''avoided'' GHG and the cost per unit GHG avoided.

The development of an implementation strategy for the mitigation options involves an assessment of policy and programme options to encourage their adoption. This assessment may combine quantitative analysis with workshops that facilitate interaction between the analysts and relevant policy-makers, and other interested parties in a particular country. Due to resource and time constraints this exercise was not attempted. However, the strategy for implementation is qualitatively expressed in Chapter 9.

3.3: Summary of the analysed projects

3.3.1: Displacement of diesel generator by solar home systems

The Energy Division of DoSTIE proposed this project. This project fits well within the proposed National Energy Policy, Strategy and Action Plan developed in November 2001 and the Electric Power Sector Master Plan. It also links with the Regional Solar Programme (RSP) funded by the European Union through CILSS Programme. The rationale of the project is to:

1. provide solar home systems to the rural poor;
2. improve the affordability of solar photovoltaic (PV) energy services for rural and peri-urban households in Gambia;
3. significantly reduce GHG emissions associated with fossil fuel consumption;
4. create a sustainable solar PV market within The Gambia; and
5. increase local employment opportunities.

At the end of the project it is expected that the use of fossil fuel for electricity generation will be reduced and access to electricity by rural communities will increase. Improved standard of living of the people will be realized and access to and awareness in solar PV technologies based services will increase. The global benefit of reduction in emissions of and concentrations of GHGs in the atmosphere will be realized. The community would be sensitized and should be willing and capable of participating in the implementation of the project, especially in the development and maintenance of the financial capacity required for the sustenance of the installed infrastructure and facilities.

Economic Analysis of the Project

The Government's intervention to install 1 Megawatt (MW) diesel power plant in a rural community with 5,000 households (HH) weighed against the option of replacing the diesel generators with solar PV generators using concentrators of 4,000 watts each to provide the equivalent 1 MW of electrical energy. For this project the following assumptions and scenarios apply.

Greenhouse gas flows:

1. Baseline CO_2 emissions (6,479 t per year) without the mitigation project. Using a 1 MW diesel generating set for twenty years is estimated as (20 yr. * 6,479 t CO_2/year) = 129,575 t CO_2;
2. CO_2 emissions under the mitigation project for 20 years is assumed to be zero t CO_2; and
3. CO_2 emissions reduction in 20 years is 129,575 t CO_2.

Financial Assessment: It is assumed here that the greenhouse reduction can be marketed.

<u>Profits from the GHG offset</u>

1. Estimated cost of the project (infrastructure and management) is **US $2,449,680**
2. NPV of revenue from the sale of GHG offset = **US $ 1,125,087.**
3. Based on monetary and carbon benefits alone, this project may prove to be none viable. However, considering non-monetary benefits such as social, health and environment it is a cost-effective project.

Table 3.2: Decision matrix for evaluating mitigation/adaptation measures

Measures		Objectives					Score	Total Score	Cost of Measure ($M)	Cost Effectiveness (cost/incremental unit of benefit)
		Objective #1:	Objective #2:	Objective #3:	Objective #4:	Objective #5:				
	Weights:									
	Scenario:									
Measure # 1 (Current Policy)							0			
							0	0	N/A	N/A
							0			
Measure #2:							0			
							0	0		#DIV/0!
							0			
Measure #3:							0			
							0	0		#DIV/0!
							0			
Measure #4:							0			
							0	0		#DIV/0!
							0			
Measure #5:							0			
							0	0		#DIV/0!
							0			
Measure #6:							0			
							0	0		#DIV/0!
							0			
Measure #7:							0			
							0	0		#DIV/0!
							0			

3.3.2: Greenhouse gas abatement using improved cooking stoves to reduce fuelwood consumption

The project is proposed by the Department of Community Development (DCD) and The Gambia Rural Development Agency (GARDA), an indigenous NGO that is active in rural development through the implementation of environment projects. The project will be implemented nationwide for a period of 15 years and will involve 25,000 HH which are currently using the traditional three-stone cooking technology that consumes a lot more fuelwood. Average number of people per HH is 8 and thus the number of persons to be served by the project is 200,000 people.

The objective of the project is to reduce GHG emissions by introducing Improved Cooking Stoves (ICS) technology to displace fuelwood. The project will lead to reduction in CO_2 emissions through fuel switching to more efficient cooking technologies. The project will also lead to a reduction in the rate of deforestation.

These objectives and outputs of the project will be achieved through sensitizing the local communities on the need for introducing and adopting ICSs not only based on the advantages for individual household but also on the broader issues such as environmental degradation and deforestation. Training will be organized for the community members and tradesmen in the construction and maintenance of ICSs to make the project sustainable.

The following represents results of simple analysis of the effectiveness and efficiency of the project.

Quantity of fuelwood used:
Based on per capita fuelwood consumption of 0.82 kg/day, 200,000 people will consume 897,900,000 kg (0.82*200,000*365*15). This is equivalent to 897,900 t fuelwood.
With the project total consumption will be 0.4*897,900 is 359,160 t wood.

CO_2 Flow
Assuming that 1kg wood emits (0.5*44/12) 1.8333 kg CO_2

Total CO_2 emitted in 20 years under the base case is 1,646,120 t CO_2

Total CO_2 emitted in 20 years under the mitigation project is 658,448 t CO_2

Total CO_2 saved in 20 years is 987,672 t CO_2.

Financial assessment
Assuming that the value of Certified Emission Reduction (CER) = **US $ 5 per tonne CO_2 and** DR (10%) = **0.1**

Cost of CO_2 saved will be US $ 4,938,360.00

Cost of mitigation project is US $ 2,952,000.00

Financial benefit to communities is US $ 1,986,357.00

3.3.3: Reducing greenhouse gas emissions from burning of waste through composting

The NEA and the municipalities developed this project.

Analysis of Project:

CO_2 Emissions in Base case: Compost
75 t organic waste/day would be produced over a period of 15 years.

75t/day *365 = 27,375 t/yr. = 27,375*1.8333 t CO_2 = 50,187 t CO_2
15-year lifetime assuming growth rate of 4**%** **= 822,219 t CO_2**

CO_2 Emissions in the mitigation project
30 t of organic waste/day would be composted for the first year of project implementation
30 t /day leaving a balance of 45 t. Therefore the total emission during project will be about **268,856 t CO_2**

Amount CO_2 in Base case – Amount CO_2 by Project Case:
822,218.57 - **268,855.57 = 553,363 t CO_2**

Financial Assessment

(a) Total Discounted Net cost of Project is US $ 1,780,396
(b) Assuming that the world CER is US$ 5/tCO_2 = US $ 5* 553,363 tCO_2 **= US $ 2,766,815**
(c) About 432 thousand 50-kg bags of compost are produced with a total revenue of 432,000 * US $ 1 = US $ 432,000 for the project period.
(d)
rofit based on sale of CERs and compost is US $ (3,198,815- 1,780,396) = **US $ 1,418,419**

3.3.4: Carbon sequestration through forest management

The Project entitled "Carbon Sequestration Through Reforestation and Protection of Existing Forests" is proposed by the DOF and is projected to run for 7 years. It will be implemented in two pilot districts in each of the five divisions of the country (10 pilot districts). The objective of the mitigation project is to ensure quantifiable sequestration of carbon through:

1. farm boundary planting;
2. forest enrichment planting; and
3. community natural forest management.

It will also support the present policy of the forestry sector involving community forest management and promoting community-led conservation of the remaining forest. Full public participation will be ensured and promoted. Networking, especially between Central Government institutions and NGOs, which has been initiated, will be promoted.

Global benefits of the project will be ensured by sequestering carbon through reforestation and protection of existing forests and through biodiversity conservation. Local environmental benefits include combating desertification, controlling erosion and improving soil quality, improving biodiversity and stocking of forests, and enhanced watershed management. The local community will also benefit from increased practical knowledge of sustainable forest resource management and there will be increased and diversified economic opportunities for rural villagers through increased understanding of sustainable forest management and fruit-tree cash crop opportunities.

Project Analysis:
It is assumed that for the project life (7 years), 140,000 trees (20,000 trees/year) will be planted. It is further assumed that 1 t biomass is equivalent to 1.8333 t CO_2. Thus from table 3.3, with the establishment of 140,000 trees, about 970,000 t CO_2 will be absorbed from the atmosphere.

Management of Private Forests on degraded lands

For the management of private forests on degraded land 52,500 trees will be planted over a period of 7 years (Table 3.4). A total of 56,145 t CO_2 will be absorbed from the atmosphere.

Table 3.3: Farm boundary fruit tree planting

Year	Number of trees	Cumulative Number of trees	Area (ha)	Annual growth increment	Biomass (t)	Equivalent t CO_2 absorbed
1	20,000	20,000	800	14.5	1,600	2,933
2	20,000	40,000	1,600	29.0	46,400	85,065
3	20,000	60,000	2,400	43.5	104,400	191,397
4	20,000	80,000	3,200	58.0	185,600	340,260
5	20,000	100,000	4,000	72.5	290,000	531,657
6	20,000	120,000	4,800	87.0	417,600	765,586
7	20,000	140,000	5,200	101.5	527,800	967,616

Table 3.4: Private (forest) farm lands on degraded sites

Year	No. of trees	Cumulative number of trees	Area (ha)	Annual growth increment	Biomass (t)	Equivalent t CO_2 absorbed
1	7,500	7,500	50	12.5	625	1,146
2	7,500	15,000	100	25.0	2,500	4,583
3	7,500	22,500	150	37.5	5,625	10,312
4	7,500	30,000	200	50.0	10,000	18,333
5	7,500	37,500	250	62.5	15,625	28,645
6	7,500	45,000	300	75.0	22,500	41,249
7	7,500	52,500	350	87.5	30,625	56,145

Community Forestry (Management of Natural Forests by Communities)

A total of 1,875 ha of community forestry will be established with each hectare holding 56 trees. Thus, the total number of trees under the baseline case is 105,000 trees. Under the mitigation project the number of tress per hectare will be increased to 100, giving 187,500 trees in the 7-year life of the project. Thus, the number of trees planted for the 7-year period is about 82,500 (187,500 - 105,00) trees (Table 3.5).

Project viability:

(a) Assuming a cost of CERs from mitigation project of US \$ 5.00 per tonne of CO_2 and DR of 10%, revenue from sale of CERs will be US \$ 7,428,509 (table 3.6) for the three components of the carbon sequestration project.
(b) Total project cost (infrastructure development and management of project) is estimated at US \$ 4,828,530
(c) Thus project viability is indicated by a profit of US \$ 2,599,978

3.3.5: Reducing CO_2 emissions from fuelwood consumption through large-scale introduction of liquefied petroleum gas

Moukhtara Holding Company (MHC), a major Gambian company with a brick factory and a sawmill, plans to switch 144,000 Gambian consumers to use LPG rather than fuelwood. MHC will import, distribute, and market the LPG to consumers in The Gambia who would otherwise have consumed fuelwood.