Country Case Study on Sources and Sinks of Greenhouse Gases in The Gambia

Final Report

Global Environment Facility

UNEP

PREFACE

In accordance with Article 4 of the United Nations Framework Convention on Climate Change (UNFCCC), all Parties are required to develop, periodically update, publish and make available to the Conference of the Parties, national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol using comparable methodologies to be agreed upon by the Conference of the Parties.

A methodology for conducting such inventories was developed by the OECD Environment Directorate, the International Energy Agency (IEA), and the IPCC Working Group I Technical Support Unit and was proposed as the standard methodology as required under the Convention.

In order to test and further refine the method, the UNEP Atmosphere Unit, working in collaboration with the UNEP Global Environment Facility (GEF), implemented a series of nine complementary national studies using these "IPCC Guidelines for National Greenhouse Gas Inventories".

This report is one of the nine technical reports resulting from this effort. Based partly on this study and on a series of regional workshops sponsored by UNEP under the GEF funded programme and with the assistance of experts from a number of countries, an improved version of the IPCC Guidelines was prepared and approved at the Tenth Plenary Session of the IPCC in Nairobi (November 1994).

The First Conference of the Parties to the UNFCCC (Berlin, April 1995) also adopted the IPCC methodology as the recommended standard to be employed by all Parties in making their inventories in accordance with Article 4.

It is hoped that this report will assist other country study teams in the development and updating of future inventories of greenhouse gases.

E. Dowdeswell

Elizabeth Dowdeswell
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Project GF / 4102-92-35 (PP/3011)

Government of The Gambia(GOTG)
United Nations Environment Programme (UNEP)
Organization for Economic Cooperation and Development (OECD) - Environment Directorate
Intergovernmental Panel on Climate Change (IPCC)
Global Environment Facility (GEF)

GOTG/UNEP/GEF CLIMATE CHANGE STUDY IN THE GAMBIA

1994

Department of Water Resources
National Environment Agency
National Climate Committee

November 1994

This Study Report is the final report of the GOTG/UNEP/GEF Climate Change Country Study Project titled 'Country Case Study on Sources and Sinks of Greenhouse Gases in The Gambia', Project Number - GF/4102-92-35 (PP/3011).

The Report is in two Volumes. Volume I is the National Inventory which consists of the Inventory proper and all the Surveys conducted to enhance the data availability for the development of the Inventory.

Volume II consists of the National Workshop Report, the Terminal Progress Report, and Terminal Financial Report.

Both Volumes together meet the objectives of the Project and form the expected Output of the Study.

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Global Environment Facility (GEF)

VOLUME I

NATIONAL GREENHOUSE GAS INVENTORY OF THE GAMBIA

1993

Department of Water Resources
National Environment Agency
National Climate Committee

November 1994

CONTENTS

CHAPTER 3 AGRICULTURE

CHAPTER 4 LAND USE CHANGE AND FORESTRY

TABLES

MAPS

FIGURES

ACKNOWLEDGEMENTS

This National Inventory of Greenhouse Gas Emissions is a product of unique multinational, multisectoral and interdiciplinary effort. While the major task of the development of the inventory has fallen on Mr Bubu Jallow , the Coordinator of the Project, the study would not have been successful without the valuable contribution of all the members of the National Climate Committe (NCC), particularly the Co-coordinator from the National Environment Agency and Coordinators of the various surveys.

We in the NCC deeply appreciate the effective consultancy, coordination and advice offered by Dr Martin Price of the Environment Change Unit, University Of Oxford in England. The Technical Assitance provided by the Ecological Monitoring Centre of Dakar, Senegal in the conduct of the Bushfires Survey and that provided by ENDA-TM Energy Programme of Dakar, Senegal covering the verification of the data collected, training in the applications of the spreadsheets, development of the worksheets and graphics contained in the document and , training and installation of Modem and E-mail System, go a long way in capacity building and technology transfer. The NCC would like to thank Youba Sokona, Dominique Revet, Libasse Ba and Moussa Fall from ENDA-TM in Dakar, Senegal, and Alioune Faye and Racine Kane from the Ecological Monitoring Center in Dakar, Senegal.

Financial support for the Project has been provided by the United Nations Environment Programme (UNEP) and the Global Environment Facility (GEF). Support in the form of training on the IPCC/OECD Methodology has also been received from UNEP, OECD Secretariat in Paris and IPCC Working Group I Secretariat in UK.

I have strong belief that this process of working together for the common future has been important in building a basis for continuing national, regional and international cooperation and on behalf of The Gambia National Climate Committee and the Government of The Gambia (GOTG), I wish to offer my sincere thanks to all who have participated in this endeavour.

Momodou M. SAHO
Director, Department of Water Resources,
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FOREWORD

Signature of the United Nations Framework Convention on Climate Change (UNFCCC) by The Republic Of The Gambia, in Rio de Janeiro in June 1992 and the subsequent ratification in March 1994 is a strong indication of The Gambia's recognition of the potential threat of the predicted Climate Change to the world's environment and economic development. The Convention calls for all parties to commit themselves to the following three objectives.

1 ***To develop, update periodically, publish, and make available to the Conference Of Parties (COP) their national inventories of anthropogenic emissions of greenhouse gases not controlled by the Montrea Protocol.***

2 ***To use comparable methodologies for inventories of greenhouse gas emissions and removals, to be agreed upon by the Conference Of Parties.***

3 ***To formulate, implement, publish and update regularly national programmes containing measures to mitigate Climate Change by addressing anthropogenic emissions.***

This national Inventory is an important step in the direction of meeting these commitments. In the preparation of the Inventory many technicians and scientists within the country and region have been involved. Thus, whatever the limitations in the Document, the inventory remains an authoritative statement of the views of these experts and is sanctioned by Government of The Republic of The Gambia.

It is with great pleasure that I acknowledge the contributions of all the members of the National Climate Committee, in particular the Director and Staff of the Department Of Water Resources as the Primary Executing Agency and the Executive Director and staff of the National Environment Agency as Co-coordinators of the Project.

I am confident that this national Inventory and its synthesis will provide a sound basis for future discussions and negotiations on the appropriate strategy and policy options regarding the issue of global warming and climate change, not only for the Gambia, but at the regional and international level.

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GLOSSARY

BOD_5	Biochemical Oxygen Demand
CH_4	Methane
CHIPS	Copenhagen Image Processing System
COP	Conference of Parties
C0	Carbon monoxide
CO_2	Carbon dioxide
CSD	Central Statistics Department
DCD	Department of Community Development
DLS	Department of Livestock
dm	dry matter
DOC	Degradable Organic Compound
DOF	Department of Forestry
DOP	Department Of Planning
DWR	Department of Water Resources
EC	European Community
ECU	Environment Change Unit (University of Oxford)
EMC	Ecological Monitoring Centre
ENDA-TM	Environment and Development in the Thirld World
EPA	Environmental Protection Agency
ESMAP	Energy Sector Management Assistance Programme
EU	Environment Unit
GAC	Global Area Coverage
GAMTAN	Gambia Tanneries
GDP	Gross Domestic Product
GEAP	Gambia Environment Action Plan
GEF	Global Environment Facility
Gg	Gigagrams (1000 tonnes)
GHG	Greenhouse Gases
GIS	Geographic Information System
Gj	Gigajoules
GOTG	Government of The Gambia
GPS	Global Positionning System
GWP	Global Warming Potential
ha	hectare
IEA	International Energy Agency
INC	Intergovernmental Negotiating Committee
IPCC	Intergovernmental Panel on Climate Change

ITC	International Trypanotolerance Centre
KMC	Kanifing Municipal Council
KSMD	Kombo St Mary District
Landsat-TM	Landsat Thematic Mapper (satellite)
LGA	Local Government Area
LHV	Lower Heating Value
LPG	Liquified Petroleum Gas (butane)
LRD	Lower River Division
m^3	cubic meter
MID(N)	MacCarthy Island Division (North)
MID(S)	MacCarthy Island Division (South)
MNRE	Ministry of Natural Resources and the Environment
MSG	Management Services Gambia Ltd.
MSW	Municipal Solid Waste
Mt	Million tonnes
$MTCO_2E$	Million Tonnes CO_2 Equivalent
MTIE	Ministry of Trade, Industry and Employment
NBD	North Bank Division
NEA	National Environment Agency
N_2O	Nitrous oxide
NOAA-AVHRR	National Oceanic and Atmospheric Administration - Advanced Very High Radiometric Resolution (satellite)
NOx	Nitrogen oxide
OECD	Organization for Economic Cooperation and Development
Pj	Petajoules
SPOT	Systeme Probatoire d'Observation de la Terre
t	tonne
toe	tonne of oil equivalent
UHC	Utility Holding Corporation
UNCED	United Nations Conference for Environment and Development
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
UK	United Kingdom
URD	Upper River Division
USA	United States of America
USAID	United States Agency for International Development
WD	Western Division
WMO	World Meteorological Organization

Chapter 1

INTRODUCTION

1.0 Country Overview

The Gambia, a British colony until 1965, is the smallest country (11,000 square kilometres) in Africa. This relatively flat and narrow stretch of land(13°N-14°N), not more than 50 km wide, follows the course of the Gambia River into the heart of Senegal.

The climate is "sudano-sahelian" with a short rainy season from June to October and a long dry season from November to May. Average annual temperature is about 28°C and average annual rainfall is about 850 mm. A slight warming and about 25- 30% decrease in rainfall has been realized in the time series of climate data during the past 40 years.

The population of The Gambia crossed the million mark according to the April 1993 census. The total number of persons enumerated was 1,025,867 consisting of 514,530 males and 511,337 females (CSD, 1993). The population change during the inter-censal period of 1983-1993 shows a steep and startling increase of about 49% and an annual growth rate of 4.1 percent per annum. The population density is among the highest in Africa and has risen from 47 persons per square kilometer in 1973 and 64 persons per square kilometer in 1983 to 96 persons per square kilometre in 1993. It is assumed that large scale influx across the international borders is a key factor responsible for the stupendous increase in population.

For the period 1986-1992 the economy of The Gambia was dominated by Trade, accounting for approximately 33% of the GDP, followed by crop production (16%), and Livestock (7%). Recently Tourism and Fisheries have become important economic sectors. Imports and consumption of fossil fuel products dominate the Energy sector with most of the commodity being consumed by the transport component of the sector. However, until the ban on the production of charcoal in the early 1980s biomass fuel production and consumption featured high in the energy sector. The present fuelwood extraction and consumption rate cannot be sustained by the remaining forest resources. Biomass fuels account for about 85% (EU/MNRE, 1992) of the energy needs of the country.

1.1 The Project Background

The 1980s witnessed the growth of public concern about the possibility of global warming and climate change. By 1990, a series of international conferences had issued urgent calls for a global treaty to address the problem. UNEP and WMO responded by establishing an intergovernmental Working Group to prepare for treaty negotiations. In response to the Working Group's proposal, the United Nations General Assembly at its 1990 session set up the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change (INC/FCCC) with the mandate to draft a framework convention and any related legal instruments it considered necsssary. The convention was negotiated between February 1991 and May 1992 and adopted on 9 May 1992 at the United Nations Headquarters in New York . At the "Earth Summit" in Rio the convention was signed by 155 signatories and came into force on 21st June 1994 having been ratified by more than 50 states.

Article 4 of the convention enjoins that all parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, shall:

" develop , periodically update, publish and make available to the Conference Of Parties, in accordance with Article 12, national inventories of the anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol using comparable methodologies to be agreed upon by the Conference Of the Parties; "

Since The Republic of The Gambia was one of the 155 signatories of the Convention in Rio and now that the Convention has been ratified by the Government, Article 4 of the convention has become binding and The Gambia is one of those countries that should submit a National Inventory to COP by 1997. However, this Inventory is an indication of The Gambia's committment to implement the convention.

It is worth noting that The Gambia has long been committed to joining the internationl comminity in addressing climate and climate change matters. The country was one of the first third world countries to develop a preliminary Inventory in 1991 for the 1988 base year long before it became mandatory under the Framework Convention.

The development of the Preliminary and present inventories is strongly based on the IPCC/OECD Methodology which was first introduced to experts outside the OECD community as the OECD Methodology in February 1991 at an experts Workshop in Paris. This was later adopted at Session 5 of the IPCC as the IPCC/OECD Methodology. It has since evolved to the present three-volume document from the single 1991 copy, thanks to the cooperation of the international scientific community, financial support from UNEP, GEF, OECD, IEA, the EC and the governments of the US, UK, Switzerland, Italy, Norway, Sweden, the Netherlands, Germany, France, Canada, and Australia, and significant (non-financial) contributions and resources in kind from UNEP, the US, Netherlands, UK, Japan, OECD and IEA .

1.2: Organisation of the Project

At the international level coordination of the UNEP/GEF Country Studies Programme, was contracted to the Environment Change Unit (ECU) of the University of Oxford in UK and the consultancy assigned to Dr Martin Price, Research Scientist with ECU. Dr Price visited The Gambia in November 1992 to catalize the initiation of the Project.

Based on the active participation of the Department of Water Resources (DWR) in climate change matters and previous experience in the development of an Inventory in 1991, the Department was selected as the Lead Agency and Contact Point of the Study and assigned the responsibility for the coordination of the Project. The National Environment Agency (NEA) (then the Environment Unit under the Ministry Of Natural Resources and the Environment) was selected as co-coordinator of the Project.

The National Climate Committee (NCC) presently composed of 12 active government and quasi-government institutions is charged with the overall implementation of the Project. The NCC was formed in 1992 as a requirement of the World Meterological Organization (WMO) World Climate Programme in taking a multisectoral and multidesiplinary approach to address Climate and Climate Change issues at the national level.

1.3 Organization of the Iventory Report:

This Inventory Report is organized in six chapters, different from the Chapter (module) organization of the IPCC/OECD Methodology Documents. This is due to the fact that Chapters (modules) 2 and 3 of the Methodology are not reported on. Chapter 2 is not reported on because there is no production of cement in The Gambia and no instructions for the calculation of greenhouse gas emissions is given for the other sources in this category. Chapter 3 of the Methodology deals with emissions from Solvents but no methods for the calculations of greenhouse gases are included in the Methodology and hence there is also no report on this Module

Chapter 1 is this Introduction, chapters 2 to 5 describe the process of development of the Inventory according to the source categories. These are as follows:

Chapter 2: Energy
Chapter 3: Agriculture
Chapter 4: Land Use Change and Forestry
Chapter 5: Wastes

Chapter 6 presents the Conclusions and Synthesis of the Inventory and recommendations for follow-up activities at the national and international level. Reports of the Surveys conducted during the Study are presented as Annexes to the Report.

1.4 References:

Central Statistics Department (CSD), 1993; Population and Housing Census, 1993: Provisional Report (1).

Enviroment Unit, MNRE, 1992; The Gambia Environment Action Plan, 1991.

Chapter 2

ENERGY

2.0 Overview of The Energy Sector.

In every national economy Energy forms a complex, pervasive but very essential sector. In The Gambia the energy supply system is dominated by biomass fuels and imported petroleum products.

The major biomass fuels commonly consumed in The Gambia in the 1970s and 1980s were firewood, charcoal, and groundnut shells. In July 1980 production of charcoal was banned but the product can be obtained from neighbouring Senegal and hence it is still consumed in the country. The amount of groundnut shells available depends on the annual groundnut production and due to the sahelian drought production has decreased markedly and use of the shells as source of energy is negligible. It is estimated that firewood accounts for about 84% of the total primary energy consumption of the country (MTIE,1992) and it is exclusively produced from the Gambia forest. Forest production excluding mangroves, represent about 40,000 m3/year.

The second most important energy source in The Gambia is petroleum products representing 26% of total energy consumption of the country. Fossil fuels are not produced but imports have been on the increase. Major fossil fuel products imported are gasoline, diesel/gasoil, and kerosene/jet fuel. Heavy fuel is mainly used by the Water Supply and Electricity Generating Utility and is becoming very important in terms of quantity imported. Electricity and Water Supply Utility and Transport sub-sector are the two main consumers of fossil fuel products in the country.

In the estimation of emissions of greenhouse gases from the Energy sector two categories are considered: combustion and fugitive activities. In the fugitive category coal production and activities in the oil and gas systems are considered. Since these systems and activities are non existent in the Gambia this category is not reported on. Hence only emissions from combustion of fossil and biomass fuels are considered.

2.1 Carbon Dioxide Emissions From Energy Sources:

Carbon Dioxide (CO_2) is the most common greenhouse gas produced by anthropogenic activities, accounting for about 60 % of increase in radiative forcing since pre-industrial times. By far the largest source of CO_2 emissions is from oxidation of carbon in fossil fuels, accounting for 70-90% of total anthropogenic CO_2 emissions. These emissions occur primarily from combustion of fossil fuels where most carbon in the fuels is emitted as CO_2 immediately during the combustion process. Some carbon is released as Carbon monoxide (CO), Methane(CH_4), or as non-methane hydrocarbons which are oxidized to CO_2 within anywhere from a few days to 8 to 10 years.

2.1.1: Data Used to Estimate Emissions from Fossil Fuels.

2.1.1.1: Fuel Consumption Figures From Institutions:

Data used to estimate $C0_2$ emissions from energy (fossil fuel combustion) were acquired from the Department of Central Statistics and Utility Holding Corporation (UHC)/Management Services Gambia (Ltd) (MSG), the Water Supply and Electricity Generating Services. The data supplied is fuel quantities in liters that has been supplied by the main fuel companies, Shell Marketing and Elf. Hence, it represents that which has been comsumed by the end users and approximates the total imports of the fuel types in the country.

Because it was not possible to obtain fuel consumption figures from all end-users especially for the Transport sector as explained in the following sub-section, an Energy Balance for the country could not be constructed. The Energy Balance serves the useful purpose of identifying where the energy of the country is coming from and where it is going to. Without the Energy Balance the data is incomplete.

2.1.1.2: Vehicle Numbers and Category Survey (Annex I):

For the purpose of trying to estimate emissions of greenhouse gases per category in the Energy Sector, an attempt was made to determine the amount of fuel consumed by the transport sub-sector through a Vehicle Numbers and Category Survey. The objectives of the survey were:

* to establish the population of vehicles (road and non-road) operating in The Gambia in 1993;
* to categorize the vehicles according to:
    - Light Duty Gasoline Passenger Vehicles **(LDGPV)**
    - Light Duty Gasoline Trucks **(LDGT)**
    - Heavy Duty Gasoline Vehicles **(HDGV)**
    - Light Duty Diesel Passenger Vehicles **(LDDPV)**
    - Light Duty Diesel Trucks **(LDDT)**
    - Heavy Duty Diesel Trucks **(HDDT)**
    - Ship/Boats
    - Motorized Canoes **(MC)**
    - Motorcycles
    - Aircrafts
    - Others (non-road vehicles);

* to estimate the amount of fuel consumed per category per year;
* to estimate the distance covered by each category per year;
* to estimate the age of the vehicle in each category.

The Survey was conducted in two parallel streams. One set of enumerators carried out physical counting of road and non-road vehicles that are seen to be operating. The second set of enumerators were stationed at the Police Department to record characteristics of all vehicles that have been registered at the Department. Results from the two streams were markedly different. Comparison with similar exercises carried out by the Department of Central Statistics placed doubt on the Vehicle Numbers obtained from the Police Department, but compared favourably with counts obtained in the Field Survey. A verification survey and reanalysis of the data carried out in July again placed more credibility on the Field Survey. It was found that the counts from the Police Department included vehicles that are non-existent and have been scraps for years back. For this reason it was concluded that the figures from the Field Survey should be maintained and counts from the Police Department discarded. The final figures from the Field Survey gave total number of vehicles as **5,232**, of which **2,532** are LDGPV, **730** are LDGT, **161** are HDGV, **226** are LDDPV, **1,038** are LDDT, **153** are HDDT, **107** are Ships/Boats and Motorize Canoes, **200** are Motorcycles, **3** are Aircrafts, and **30** are non-Road Vehicles (Farm vehicles, Forklifts, etc.).

Using the IPCC/OECD Methodology Workbook and default values in the Tables the data was entered in the Worksheets. The appropriate entries and results are given in Worksheet 1-1, sheets A, B and C.

ENERGY
Greenhouse Gas Inventory Workbook

CO2 FROM ENERGY

		Module	Energy				
		Sub module	CO2 from energy sources (Detailed Fuels Approach)				
		Worksheet	1.1				
		Sheet	A				
					STEP 1		
Fuel Types			A Production	B Imports	C Exports	D Stock Change	E Apparent Consumption
							E=(A+B-C-D)
Liquid Fossil	Secondary Fuels	Gasoline (tonnes)		18,322.004			**18,322.004**
		Gasoil (tonnes)		19,855.736			**19,855.736**
		Heavy Fuel (tonnes)		8,358.484			**8,358.484**
		Lamp Oil and Jet Fuel (tonnes)		18,902.328			**18,902.328**
		LPG (tonnes)		351.100			**351.100**
Liquid Fossil Totals							
Bunkers		Diesel/Gasoil (tonnes)					
		Heavy Fuel (tonnes)					
		Total Bunkers					
Biomass		Fuel Wood (tonnes)					**377,963.000**
		Total Biomass (tonnes)					**377,963.000**

		Module	Energy					
		Sub module	CO2 from energy sources (Detailed Fuels Approach)					
		Worksheet	1.1					
		Sheet	B					
				STEP 2		STEP 3		
Fuel Types			F Conversion Factor (Gj/t)	G Apparent Consumption (Gj)	H Emission Factor (kg C/Gj)	I Carbon Fraction (kg C)	J Carbon Fraction (Gg C)	
				G = (E*F)		I = (G*H)	J=(I*0.000001)	
Liquid Fossil	Secondary Fuels	Gasoline (tonnes)	44.800	820,825.790	18.9	15,513,607.439	**15.514**	
		Gasoil (tonnes)	43.330	860,349.043	20.2	17,379,050.661	**17.379**	
		Heavy Fuel (tonnes)	*39.775*	332,458.682	21.1	7,014,878.190	**7.015**	
		Lamp Oil and Jet Fuel (tonnes)	*44.670*	844,366.975	19.6	16,549,592.715	**16.550**	
		LPG (tonnes)	47.310	16,610.541	17.2	285,701.305	**0.286**	
Liquid Fossil Totals								
Bunkers		Diesel/Gasoil (tonnes)						
		Heavy Fuel (tonnes)						
		Total Bunkers						
Biomass		Fuel Wood (tonnes)	17.000	6,425,371.000	29.9	192,118,592.900	**192.119**	
		Total Biomass					**192.119**	

		Module	Energy				
		Sub module	CO2 from energy sources (Detailed Fuels Approach)				
		Worksheet	1.1				
		Sheet	C				
				STEP 4		**STEP 5**		**STEP 6**
Fuel types				K Carbon stored (Gg C)	L Net Carbon Emissions (Gg C)	M Fraction of Carbon Oxidized	N Actual Carbon Emissions (Gg C)	O Actual CO2 Emissions (Gg CO2)
					~~L = (J-K)~~		N = (L*M)	O=(N*[44/12])
Liquid Fossil	Secondary Fuels	Gasoline (tonnes)			15.514	0.99	15.358	**56.314**
		Gasoil (tonnes)			17.379	0.99	17.205	**63.086**
		Heavy Fuel (tonnes)			7.015	0.99	6.945	**25.464**
		Lamp Oil and Jet Fuel (tonnes)			16.550	0.99	16.384	**60.075**
		LPG (tonnes)			0.286	0.99	0.283	**1.037**
Liquid Fossil Totals					56.743		56.175	**205.976**
Bunkers		Diesel/Gasoil						
		Heavy Fuel (tonnes)						
		Total Bunkers						
Biomass		Fuel Wood (tonnes)			192.119	0.90	172.907	**633.991**
		Total Biomass			192.119	0.90	172.907	**633.991**

2.2 Methane and other trace gases from Traditional biomass Fuels Burnt for Energy.

Here emissions from the combustion of unprocessed (traditional) biomass fuels are considered. "Unprocessed biomass" is intended to include all traditional small scale use of biomass fuels, such as cookstoves and open fires. The consumption of biomass fuels (biofuels) such as wood, charcoal, crop residues, animal dung, etc, for energy production for domestic cooking and heating, industrial heat and power, and the production of industrial charcoal, produce carbon dioxide (CO_2) , methane (CH_4), carbon nonoxide (CO) , nitrogen oxide (NO_x), nitrous oxide (N_2O) and non-methane volatile organic compounds (NMVOCs). Emissions are estimated by using ratios of other trace gases to total carbon oxidized in the biomass.

2.2.1 Data Used to Estimate Emissions from Traditional Biomass Fuels:

2.2.1.1: Fuelwood Consumption Survey (Annex II):

The data used in this study was obtained through a sample survey with samples distributed country wide. The Survey was carried out by a Task Force comprising of the Departments of Community Development and Central Statistics, both being members of the National Climate Committee. The objective of the Survey was to estimate the quantity of biomass fuel consumed countrywide but due to time constraints this was limited to a sample of the population. Selection of samples followed the Central Statistics Department's sampling frame. The selection procedure recognized the existing Local Government Areas (LGAs) as the primary sampling units. Enumeration Areas (EAs) were assigned to each LGA based on the population and size of the LGA.. Hence the data gathered is more representative than any assembled before. Even though the survey was specifically meant to collect data on biofuels the design of the questionaire was such that it was able to pick out fuels such as kerosene. The values for charcoal are low because production has been banned by law and the quantities reported are consumption figures only. It is highly probable that the production of all the charcoal was carried out in the neighbouring country (Senegal) since there is no restriction in purchase and consumption.

The appropriate entries and results are given in Worksheets 1-2 and 1-3, sheets A, B and C.

			Module	Energy				
			Sub module	Traditional Biomass Burned For Energy				
			Worksheet	**1.2 - Optional Fuelwood Consumption Accounting**				
			Sheet	A				
	STEP 1				**STEP 2**		**STEP 3**		**STEP 4**
Local Government Area (LGA)	A Population by LGA (1000 persons)	B Per Capita Fuelwood Consumption (kt dm/1000 persons)	C Total Annual Wood Consumption (kt dm)	D Pre Capita Charcoal Consumption (kt Charcoal / 1000 persons)	E Total Annual Charcoal Consumption (kt charcoal)	F Charcoal Consumption Expansion Factor (kt Fuelwood / kt Charcoal)	G Wood Consumption For Charcoal (kt dm)	H Total Wood Consumption for fuel (kt dm)
			C = (A*B)		**E = (A*D)**		**G = (E*F)**	**H = (C+G)**
Banjul	42.407	0.237	10.032					10.032
Kanifing	228.945	0.296	67.758					67.758
Brikama	233.063	0.337	78.462					78.462
Kerewan	154.342	0.330	50.900					50.900
Mansakonko	64.687	0.400	25.883					25.883
George Town	86.618	0.698	60.430					60.430
Kuntaur	68.292	0.374	25.561					25.561
Basse	147.513	0.400	58.937					58.937
TOTAL	**1025.867**		**377.963**					**377.963**

METHANE AND OTHER GASES FROM TRADITIONAL BIOMASS FUELS BURNED FOR ENERGY

Module	Energy	
Sub module	Traditional Biomass Burned For Energy	
Worksheet	1.3	
Sheet	A	

	STEP 1			STEP 2		STEP 3		
	A Total Biomass Consumed (kt dm)	B Fraction of Biomass Which Oxidizes (Combustion Efficiency)	C Biomass Burned (kt dm)	D Carbon Fraction of Biomass	E Total Carbon Released by Biomass Fuels (kt C)	F CH4 -C Ratio	G Carbon Emitted as CH4 (kt C)	H CH4 Emissions from Biomass Burned (Gg CH4)
			C = (A*B)		**E = (C*D)**		**G = (E*F)**	**H = (G*[16/12])**
Wood (1)	377.963	0.87	328.827	0.475	156.193	0.0120	1.874	2.499
TOTAL					**156.193**		**1.874**	**2.499**

(1) : Consumption from column C of Worksheet 1-2

	Module	Energy						
	Sub module	Traditional Biomass Burned For Energy						
	Worksheet	1.3						
	Sheet	B						
	STEP 4			**STEP 5**				
	I CO-C Trace Gas Emissions Ratio	J C emitted as CO (kt C)	K CO emitted (Gg CO)	L Nitrogen-Carbon Fuel Ratio	M Total Nitrogen Released (kt N)	N N2O-N Trace Gas Emissions Ratio	O Nitrogen Emitted as N2O (kt N)	P N2O emitted (Gg N2O)
		J = (E*I)	**K=(J*[28/12])**		**M = (E*L)**		**O = (M*N)**	**P=(O*[44/28])**
Fuelwood	0.06	9.372	21.867	0.010	1.562	0.007	0.011	0.017
TOTAL		**9.372**	**21.867**		**1.562**		**0.011**	**0.017**

Module	Energy		
Sub module	Traditional Biomas		
Worksheet	1.3		
Sheet	C		
	STEP 6		
	Q NOx-N Trace Gas Emissions Ratio	R Nitrogen Emitted as NOx (kt N)	S NOx emitted (Gg NOx)
		R = (M*Q)	**S=(R*30/14)**
Fuelwood	0.121	0.189	0.405
TOTAL		**0.189**	**0.405**

2.3 Comments on the Applications of the IPCC/OECD Methodology in the Energy Module

Unless otherwise stated as below, default values given in the Workbook have been utilized.

Worksheet 1.1 Sheet B
Column F:
Conversion factor for Heavy Fuel adopted from the 1991 Greenhouse Gas Inventory Report of the Republic of Senegal (Senegal, 1994) which was calculated thus:

1 toe = 41.868 Gj
1 ton Heavy Fuel = 0.95 toe LHV
1 ton Heavy Fuel = (41.868Gj * 0.95) = 39.775 Gj

Conversion Factor (17 Gj/t) was adopted from the ESMAP/UNDP/World Bank Progress Report no 096/89 of the Republic of Senegal.

Conversion Factors for Kerosene and Jet Fuel have been averaged (1/2(44750 +44590) to arrive at the single figure of 44670. This is necessary as quantities of these fuels are not reported seperately.

Worksheet 1- 2 Sheet A
Column A
Population figures are those of 1993 Census results obtained from the Department of Central Statistics under the Ministry of Trade, Industry and Employment (MTIE).

Column B
Values in this column are based on results of the fuelwood survey (see annex II). Per Capita fuelwood consumption figures at LGA level are not available. However, since population and total annual fuelwood consumption figures are available from the 1993 National Population Census and from the Fuelwood Survey respectively, per capita fuelwood consumption was calculated.

Columns D, E, F and G are not applicable because charcoal production has been banned in The Gambia. Production and consumption figures are not available, not even from the Survey. However, the results of the Survey suggest that charcoal is being consumed and most of this figure is bought from Senegal and may already be accounted for in the Senegalese Inventory data. Accounting for it in The Gambia would be considered to be double-counting. This issue of production and

consumption of charcoal was discussed during the National Workshop and it is suggested that more investigations should be carried out on the issue.

2.4 References:

ESMAP/UNDP/WB, 1989; Joint UNDP/World Bank Energy Sector Management Assistance Program: Activity Completion Report no. 096/89 of the Republic of Senegal.

Ministry of Trade, Industry and Employment (MTIE),1992; Energy Programme: Sectoral Consultations on Natural Resources and the Environment.

Senegal, 1994: 1991 Greenhouse Gas Emissions Inventory Report of the Republic of Senegal.

Chapter 3

AGRICULTURE

3.0 Overview Of The Agriculture Sector:

Agriculture is a major resource base of the Gambian economy and two thirds of the population is engaged in the sector either doing subsistence farming, livestock raising, or cultivation of groundnuts for export or a combination of these activities. With the exception of a little over 2,000 hectares of irrigated rice production (less than 2 percent of cultivated land), agriculture in The Gambia is entirely rainfed. Over 75% of The Gambia's labour force is engaged in subsistence farming of rainfed crops. This dependence on largely rainfed agriculture for generating national income has made economic growth extremely dependent on climate. Constraints on productivity growth also stem from the increasing pressure of population on limited arable land of good quality and variation of international prices of agricultural produce. Agricultural technology is still rudimentary and extremely labour intensive. Due to the poor state of the soils fertilizer use in The Gambia, which averaged 25kgs per hectare in 1989, is higher than in other West African countries; but is still 75% below recommended usage (Jabara, 1990).

The sector provides over 90% of domestic export earnings and accounts for between 30 - 35 percent of the total Gross Domestic Product(GDP) and up to 85% of the Gross National Product(GNP). Most of these is contributed by a single crop - groundnut. However, recent fluctuations in groundnut prices and a climate characterized by drought have shifted agricultural sector policy towards diversification especially in the horticulture industry, livestock and fisheries sub-sector. Production in these sectors have recently been stimulated, culminating in price liberation and marketing reforms to encourage greater private sector participation in the economy. Also there is potential for diversifying Gambia's productive base into livestock production by increasing the present low off-take for cattle and stimulating breeding of small ruminants.

The Livestock production system which is predominantly traditional and has for decades concentrated on cattle development is characterised by transhumance (GEAP, 1992). This transhumance system has evolved over several years of adaptation in search of food and water and the evasion of diseases and vectors. However, one of the major objectives of the traditional system is to increase livestock numbers particularly cattle in lieu of productivity per animal. Within the livestock production system diversity in terms of species, breeds and numbers have evolved dependent upon environmental factors and socio-cultural attitudes. Consequently, in addition to cattle other species such as small ruminants, equine, swine, poultry and other short cycle species, e.g. rabbits, are exploited under the system.

Agricultural activities contribute directly to emissions of greenhouse gases through a variety of different processes. These include methane emissions from enteric fermentation in domestic animals, animal wastes, rice production, and non- CO_2 emissions from savannah burning and field burning of agricultural wastes. Each of these activities is considered here and results provided in the Worksheets.

3.1: Methane Emissions from Animals and Animal Manure:

Methane is emitted in herbivores as a by-product of enteric fermentation, a digestive process by which carbohydrates are broken down by micro-organisms into simple molecules for absorption into the bloodstream. Both ruminant and some non- ruminant (e.g pigs, horses) animals produce CH_4, although ruminants are the largest source since they are able to digest cellulose due to the presence of specific microorganisms in their digestive tracts. The amount of CH_4 released is dependent on the animal category, age , and weight, the quality and quantity of feed, and the energy expenditure of the animal.

3.1.1: Data used in the estimation of emissions from animals and animal manure; - Livestock Numbers and Composition Survey (Annex III):

Data used in the estimation of emissions from animals and animal manure are those obtained from the Livestock Numbers and Composition Survey conducted by the Department of Livestock Services (DLS) and the 1993 Statistical Year Book of The Gambia Agriculture published by the Department of Planning (DOP) of the Ministry of Agriculture and Natural Resources.

The Survey Methodology involved the development of questionnaires, sensitisation of farmers through the National Radio, and the recruitment and training of enumerators. Each enumerator was assigned an enumeration area (EA) which coincided mostly with an administration demarcation or a District. Large Districts were allocated 2 or 3 enumerators. A Supervisor was assigned to an Administrative Division which may consist of about seven Districts. Enumerators visit the farmers within the District and together with the farmer take a count of the animals, recording them according to category, sex, age, draught or non-draught, breed and species. In this way a total of 278,097 Cattle, 213,871 Goats , 155,132 Sheep, 33,448 Donkeys, 17,556 Horses, 241 Mules and 17,476 Draught Cattle were recorded. Details of the methodology and results of the Livestock Numbers and Composition Survey are given in Annex III.

Entries and results are indicated in Worksheet 4-1, Sheet A

3.2 Methane Emissions from Rice Production:

Anaerobic decomposition of organic material by methanogenic bacteria in flooded rice fields produces methane (CH_4) which escapes to the atmosphere primarily by diffusive transport through the rice plants during the growing season. Minor amounts of CH_4 escape via bubbles rising through the water column, and by diffusion across the water/air interface. Experiments have shown that CH_4 fluxes vary with soil type, temperature, redox potential, and PH; the type, timing, application mode, and amount of fertilizer applied; water depth; and with time of day as well as seasonally.

3.2.1: Data used to estimate emissions from rice production

Data on area harvested is obtained from the 1993 Statistical Year Book of The Gambia Agriculture. Harvested area is defined as the physical area under cultivation times the number of harvests. This method of counting hectare-days was used for the Jahally-Pacharr irrigation scheme.

Results of entries and calculations are given in Worksheet 4-2, Sheet A .

AGRICULTURE

Greenhouse Gas Inventory Workbook

IPCC Draft Guidelines for National Greenhouse Gas Inventories - Volume 2

LIVESTOCK

		Module	Agriculture			
		Sub module	Methane Emissions from Animals and Animals Manure			
		Worksheet	4.1			
		Sheet	A			
Livestock Type	A Number Of Animals (1000s)	B Emissions Factor for Enteric Fermentation (kg/head/yr)	C Emissions From Enteric Fermentation (Mg/year)	D Emissions Factor for Manure Management (kg/head/yr)	E Emissions from Manure Management (Mg/year)	F Total Emissions from Animals and Manure (Gg)
			C = (A*B)		**E = (A*D)**	**F = (C+E)/1000**
Non-Diary Multi-purpose	304.852	36.000	10,974.672	1.000	304.852	11.280
Donkey	33.448	10.000	334.480	1.200	40.138	0.375
Sheep	155.132	5.000	775.660	0.210	32.578	0.808
Horses and Mules	17.797	18.000	320.346	2.187	38.913	0.359
Swine	14.000	1.000	14.000	2.000	28.000	0.042
Goats	213.732	5.000	1,068.660	0.220	47.021	1.116
Poultry	550.271			0.023	12.656	0.013
TOTALS			**13,487.818**		**504.158**	**13.992**

RICE CULTIVATION

Module	Agriculture				
Sub module	Methane Emissions From Rice Production				
Worksheet	4.2				
Sheet	A				
	STEP 1			**STEP 2**	
Water Management Regime	A Harvested Area (Mha)	B Season Length (days)	C Megahectare-Days (Mha-days)	D Emission factor (kg/ha-day)	E CH4 Emissions by irrigation Regime (Gg)
			C = (A*B)		**E = (C*D)**
Continuously Flooded	0.0083	123	1.0156	6.25	6.348
Intermittently Flooded	0.0029	123	0.3506	3.75	1.315
TOTALS	**0.0111**		**1.3662**		**7.662**

3.3: Emissions of Non-CO_2 Trace Gases from Savannah Burning

Savannahs are tropical and sub-tropical vegetation formations with a predominantly continuous grass cover, occasionally interupted by trees and shrubs. Most of the growth of vegetation occurs during the wet season. During the dry season the grasses wither and die and fires are frequent. Most of the fires are man-made.

Savannah burning results in instantaneous gross emissions of CO_2 but because most of the grasses regenerate during the following wet season it is reasonable to assume that the net carbon dioxide released to the atmosphere is essentially zero. However, this assumption may not be valid when there is a lot of dead material on the ground.

In addition to $C0_2$, savannah burning releases other gases which are emitted due to incomplete burning and other varying factors such as temperature. These gases include methane, carbon monoxide, nitrous oxide and nitrogen oxide. Unlike CO_2 emissions from savannah burning, emissions of these other gases are net transfers from the biosphere to the atmosphere.

3.3.1: Data used in the estimation of emissions of non-CO_2 trace gases from Savannah Burning.

-Savannah Burning Survey by the Ecological Monitoring Centre in Dakar (Annex IV):

Heat sensitive channels on the Advanced Very High Resolution Radiometer AVHRR) of NOAA Satellite Series have application to Forestry and Agriculture through their ability to detect fires. Detection of fires is based on emittance of infrared radiation by the fire. Fires usually have a temperature around 500-600 ^oC and a peak emittance of 5 micrometres (Prince et al. 1990). Because the temperature of the fire relative to the surrounding area is high, it can be detected by low spatial resolution systems such as the AVHRR. The Ecological Monitoring Centre (Centre de Suivi Ecologique, CSE) in Dakar, Senegal carries out operational fire monitoring using NOAA AVHRR Satelite Images and the CopenHagen Image Processing Software (CHIPS).

The data used in the estimation of emissions of non-CO_2 trace gases from Savannah Burning were obtained from CSE under a contract agreement with the National Climate Committee. The process of determining the area and quantity of biomass burnt is reported in ANNEX IV and involves the acquisition, correction and classification (using Boxclass Module of Chips) of the satellite images. A False Colour Composite (FCC) of the images is performed by loading the first visible channel (AVHRR Channel 1) to the Blue Gun of the monitor, second visible channel (AVHRR Channel 2) to the Green Gun, and the Near Infrared Channel (AVHRR Channel 3) to the Red Gun. The burnt areas are then discernable on the image as distinct dark spots which can be picked up in all subsequent images by the same method of classification and false colour compositing. The total area burnt is determined by taking a count of the total number of pixels and multiplying by one square kilometre since the area of a pixel is one square kilometre. To obtain the total biomass burnt the resulting burnt surfaces Map was overlayed by a biomass map of The Gambia using EXTRACT Module of the IDRISI GIS Software. The results showed total area burnt as 35,500 hectares for the 1991/1992 dry season representing 60,386.72 tons of dry matter destruction by fire.

Results of calculation are shown in Worksheet 4 -3; Sheets A, B and C.

SAVANNAH BURNING

		Module	Agriculture				
		Sub module	Savannah Burning, Release of Non-CO2 Trace Gases				
		Worksheet	4.3				
		Sheet	A				
STEP 1					**STEP 2**		
A Area Burned by Category (k ha)	B Biomass Density of Savannah (t dm/ha)	C Total Biomass Exposed to Burning (kt dm)	D Fraction Actually Burned	E Quantity Actually Burned (kt dm)	F Fraction of Living Biomass Burned	G Quantity of Living Biomass Burned (kt dm)	H Quantity of Dead Biomass Burned (kt dm)
		C = (A*B)		**E = (C*D)**		**G = (E*F)**	**H = (E-G)**
Savannah 35.5	2.126	75.484	0.80	60.387	0.05	3.019	57.368
TOTAL		**75.484**		**60.387**		**3.019**	**57.368**

Module		Agriculture	
Sub module		Savannah Burning, Release of Non-CO2 Trace Gases	
Worksheet		4.3	
Sheet		B	
STEP 3			
I Fraction Oxidised (Combustion Efficiency) of Living on Dead Biomass	J Total Biomass Oxidised (kt dm)	K Carbon Fraction of Living and Dead Biomass	L Total Carbon Released (kt C)
	Living : J = (G*I) Dead : J = (H*I)		**L = (J*K)**
Savannah			
Living 0.8	2.415	0.45	1.087
Dead 1.0	57.368	0.40	22.947
TOTAL	**59.783**		**24.034**

Module	Agriculture					
Sub module	Savannah Burning, Release of Non-CO2 Trace Gases					
Worksheet	4.3					
Sheet	C					
STEP 4					STEP 5	
L Total Carbon released (kt C)	M Nitrogen-Carbon Ratio	N Total Nitrogen Content (kt N)	O Emission Ratio	P Trace Gas Emissions (kt C or kt N)	Q Conversion Factors	R Trace Gas Emissions from Savannah Burning (Gg)
		N = (L*M)		**P = (L*O)**		**R = (P*Q)**
24.034	0.006	0.144				
CH4			0.004	0.096	16/12	**0.128**
CO			0.060	1.442	28/12	**3.365**
		N = (L*M)		**P = (N*O)**		**R = (P*Q)**
N2O			0.007	0.168	44/28	**0.264**
NOx			0.120	2.884	30/14	**6.180**

3.4: EMISSIONS OF NON-CO_2 TRACE GASES FROM FIELD BURNING OF AGRICULTURAL RESIDUES

Large quantities of agricultural wastes are produced from farming systems and burning of the wastes is a common practice in the developing world. Residues are burned primarily to clear remaining straw and stubble after harvest and to prepare the field for the next cropping cycle. It is estimated that as much as 40% of the residues produced in developing countries may be burnt in fields which may be in the order of 425 Tg dry matter agricultural wastes or approximately 200 Tg carbon.

Like the burning of savannahs, burning of crop residues is not thought to be a net source of carbon dioxide ($C0_2$) because the carbon released to the atmosphere during burning is reabsorbed during the next growing season. However, crop residue burning is a significant sources of CH_4, C0, $N0_x$, and N_20.

3.4.1 Data used to estimate emissions from burning of Agricultural Residues: -Agricultural Waste Burning Survey (Annex V):

The data used in this study was generated from a survey conducted by the Department of Panning (DOP) of the Ministry of Agriculture and Natural Resources. The objective of the Survey was to estimate the quantity of crop residues burnt in the field. It was based on a sample survey and a sample consisting of 222 Villages was enumerated. Enumeration was carried out by 35 enumerators who were supervised by 5 Supervisors. Results of the Survey indicate that 4 percent of the Millet, 3 percent of Sorghum, 5 percent of the Rice, 6 percent of the Maize, 8 percent of the Cotton and 1 percent of the Groundnuts residues generated are burnt in the field. Detailed discussions of the survey methodology, and results are contained in Annex V.

Worksheet 4-4, Sheets A, B and C give the estimates of the quantity of gases emitted from this activity.

FIELD BURNING OF AGRICULTURAL RESIDUES

	Module	Agriculture
	Sub module	Field Burning of Agricultural Residues. Released of Non-CO2 Trace Gases
	Worksheet	4.4
	Sheet	A

	STEP 1			STEP 2		STEP 3		
Crops (specify locally important crops)	A Annual Production (kt crop)	B Residue to Crop Ratio	C Quantity of Residue (kt biomass)	D Dry matter Content	E Quantity of Residue (kt dm)	F Fraction Burned in Fields	G Fraction of Biomass which oxidizes (combustion efficiency)	H Total Biomass Burned (kt dm)
			C = (A*B)		**E = (C*D)**			**H = (E*F*G)**
Millet	52.177	7.5	391.328	0.40	156.531	0.041	0.9	5.739
Sorghum	8.972	7.5	67.290	0.40	26.916	0.027	0.9	0.643
Rice	12.056	1.4	16.878	0.70	11.815	0.700	0.9	7.443
Maize	23.772	1.5	35.658	0.40	14.263	0.065	0.9	0.830
Cotton	2.290	1.0	2.290	0.80	1.832	0.800	0.9	1.319
Groundnuts	76.724	0.6	46.034	0.76	34.986	0.012	0.9	0.366
TOTAL			**559.478**		**246.343**			**16.341**

		Module	Agriculture	
		Sub module	Burning of Agricultural residues, Release of Non CO2 Trace Gases	
		Worksheet	4.4	
		Sheet	B	
		STEP 4	STEP 5	
Crops (locally important crops)	I Carbon Fraction of Residue	J Total Carbon Released (kt C)	K Nitrogen-Carbon Ratio	L Total Nitrogen released (kt N)
		J = (H*I)		L = (J*K)
Millet	0.4709	2.703	0.0168	0.045
Sorghum	0.4709	0.303	0.0168	0.005
Rice	0.4144	3.085	0.0140	0.043
Maize	0.4709	0.391	0.0200	0.008
Cotton	0.4226	0.557	0.0500	0.028
Groundnuts	0.4500	0.165	0.0150	0.002
TOTAL		**7.203**		**0.132**

Module	Agriculture			
Sub module	Burning of Agricultural residues, Release of Non CO2 Trace Gases			
Worksheet	4.4			
Sheet	C			
	STEP 6			
	M Emissions Ratio	N Trace Gas Emissions (kt C or kt N)	O Conversion Factors	P Trace Gas Emissions from Field Burning of Agricultural Wastes (Gg)
		N = (J*M)		**P = (N*O)**
CH4	0.005	0.036	16/12	**0.048**
CO	0.060	0.432	28/12	**1.008**
		N = (L*M)		**P = (N*O)**
N2O	0.007	0.001	44/28	**0.001**
NOx	0.120	0.016	30/14	**0.034**

3.5: Comments on the applications of the IPCC/OECD Methodology in the Agriculture Sector:

Unless otherwise stated as below default values given in the Workbook have been used where applicable.

Worksheet 4.1; Sheet A:

Column A:
Except for Swine and Poultry, figures are results of the Livestock Numbers and Composition Survey. The Cattle Population of 296,014 comprise of 278,538 multi-purpose cattle and 17,476 draught cattle. The Horses and Mules population of 17,797 refers to 17,556 horses and 241 Mules. Swine and Poultry figures are obtained from the 1990 Statistical Year Book of the Gambian Agriculture (DOP, 1990) and are assumed for 1993. The figures are reported in blue to distinguish them from the most current data.

Column B:
Emission Factors used hereextracted from Tables 4.2 and 4.3A of the Workbook. Emission Factor of 18 kg/head/year is used for the Horses and mules category because the population of horses dominates.

Worksheet 4.2; Sheet A:

Column A:
The value of 0.0029 Mha harvested area refers to total area of 0.001425 Mha irrigated twice in the year (i.e., 2*0.001425 = 0.00285) and rounded.

Column D:
Gambia has an average temperature of 28^{o}C (1951-1990 calculated normal) and this value gives seasonal average Emission Factors corrected for average temperature (Ref. Table 4.7 of Workbook) as 6.25 for continuously flooded and 3.75 for intermittently flooded cultivation.

Worksheet 4.3; Sheet A:

Columns A to D
The results of the Savannah Burning Survey give 35.5 Kha and 60.387 Kt dry matter burnt which assumes a fraction of 80% of the total biomass actually burnt. Hence Columns B and C were calculated from these as

Column C = Column E/Column D
Column B = Column C/Column A

Column F:
Fraction of living biomass burnt (5%) was obtained from the 1991 Greenhouse Gas Inventory of the Republic of Senegal (Senegal, 1994).

Worksheet 4.3; Sheet B:

Columns I and K:
General default values given in Table 4.10 of the Workbook have been used in these columns of the Worksheet.

Worksheet 4.3; Sheet C:

Column L:
The figure 24.034kt C is from Column L of Worksheet 4.3, Sheet B.

Worksheet 4.4; Sheet A:

Column A:
Production figures of 52.177kt for Millet represents 43.664kt of Early Millet and 8.513kt of Late Millet obtained from the Statistical Year Book of Gambian Agriculture (DOP, 1993). Production figure of 2.290kt for Cotton is the 1992 production figure as no value was available for 1993. It is for this reason that the value is reported in blue.

Column B:
Except for Groundnuts values entered in this column were obtained from the 1991 Greenhouse Gas Inventory of the Republic of Senegal (Senegal; 1994). The residue-to-crop ratio of 0.6 for groundnuts is obtained from the National Greenhouse Gas Inventory of Uganda (Uganda,1994).

Column D:
Except for Groundnuts dry matter content values are obtained from the 1991 Greenhouse Gas Inventory of the Republic of Senegal (Senegal, 1994). The value of 0.76 for groundnuts is obtained from the National Greenhouse Gas Inventory of Uganda (Uganda,1994).

Column F:
Fraction burned in the field is calculated based on production figures obtained in the field.

Worksheet 4.4; Sheet B:

Column I:
Carbon fractions of residue is obtained from Table 4.12 of the Workbook and where values are not specified in the Table, those for the similar crop type are used as default values.

Column K:
Nitrogen-Carbon Ratios are obtained from Table 4.12 of Workbook and where values are not specified in the Table, those for similar crop type are used as default values.

Worksheet 4.4; Sheet C:

Column M:
Trace gas emission ratios are obtained from Table 4.13 of the Workbook.

3.6 References:

Cathy L. Jabara, 1990; Economic Reform and Poverty in The Gambia: A Survey of Pre- and Post-Economic Recovery Programme Experience.

Department of Livestock Services (DLS), 1992; Livestock Programme: Sectoral Consultation on Natural Resources and the Environment.

Department of Planning (DOP), 1993; 1993 Statistical Year Book of The Gambia Agriculture.

Prince, S. D., C. O. Justice, and S. O. Los, 1990; Remote Sensing of the Sahelian Environment: A Review of the current status and future prospects.

Senegal, 1994; 1991 Greenhouse Gas Emissions Inventory of the Republic of Senagal.

Uganda, 1994; 1990 Greenhouse Gas Emissions Inventory of the Republic of Uganda.

Chapter 4

LANDUSE CHANGE AND FORESTRY

4.0: Overview of the Landuse Change and Forestry Sector:

Forests are estimated to cover about 43% 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 (66,900 ha) (DOF, 1991). The Tree and Shrub Savannah woodland which constitutes about 70% of all forest types in the country has less than 10% tree cover or tree heights less than 11 metres. From the results of the 1982 Forest Inventory (Forster, 1983) it is concluded that the Open Forest and the Tree and Shrub Savannah types have increased. Similarly, the area of High Mangroves have been reported to decrease from 30,000 ha in 1959 to 15,000 ha in 1982. Mangroves are subjected to unsustainable illegal cutting for cross-border trade and occurence of death among high mangroves has been observed. The area of barren flats seem to be on a permanent increase too.

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 occurs 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.

Commercial fuelwood collection and intensive exploitation of the forest for other forest products is also responsible for the deterioration and degradation observed. Fuelwood consumers in the urban areas are very selective of the species they burn and such species are therefore subjected to very high pressure to the extent that where dead wood are short, the commercial dealers resort to felling and splitting live stems.

Land-use changes that result in alterations in the amount of biomass on the land produce a net exchange of greenhouse gases between the atmosphere and land surface. Biomass is a shorthand term for organic material, both aboveground and below ground and both living and dead, e.g; trees, crops, tree litter, roots, etc. The primary land-use changes that result in greenhouse gas 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 (eg., establishment of plantations).

When forests are cleared, most of the carbon in the cleared biomass is released to the atmosphere as carbon dioxide ($C0_2$). Clearing by burning (eg, biomass burning) releases other gases in addition to $C0_2$ which are by-products of incomplete combustion. These include methane, carbon monoxide, nitrous oxide, and oxide of nitrogen. $C0_2$ emissions from land clearing may or may not imply a net release of carbon dioxide to the atmosphere but emissions of these gases are net transfers from the biosphere to the atmosphere.

Land-use changes also result in greenhouse gas emissions through disturbance of forest soils. When forests are converted to crop lands, an average of about 25-50% of the soil carbon is released as $C0_2$, 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.

4.1: $C0_2$ Emissions from Burning of Aboveground Biomass On and Off Site due to Forest Clearing:

Clearing of forests for conversion to permanent cropland or pasture is usually accomplished by cutting undergrowth and felling trees followed by burning on-site or as fuelwood. By this process some of the biomass is burned while some remain on the ground where it decays slowly (usually over a period of ten years in the tropics). Of the burnt material, a small fraction (5-10%) is converted to charcoal which resists decay for 100 years or more, and the remainder is released

instantaneously into the atmosphere as $C0_2$. Carbon is also lost from the forest soils after clearing particularly when the land is cultivated. This can occur over 25 years period or more.

4.1.1: Data on Forest Clearing:

The data used in this element of the study is taken from results of the 1982 Forest Resources Inventory of The Gambia (Tables 4.1 and 4.2). The Inventory was based on sampling with prestratification carried out according to stand density, i.e., the forests have been classified according to the stock density (Forster, 1983). Gallery forests and mangroves were exceptions as they were delimitated irrespective of density classes. The prestratification was conducted with the help of aerial photography taken in October/November 1980.

The number of samples taken within a landuse class was dependent on the expected hectare-volume and on the total area of landuse class. Thus the number of samples was related to the total volume of the landuse class. In the Mangoves forest type a sample is a 10 metre wide and 50 metre long strip and in the Gallery forest type a 10 metre wide transect with various lengths was chosen as sample.

The 1982 Forest Inventory provides the last national-level data (Map 4.1 and Tables 4.1 and 4.2) and was based on the 1980 aerial photography. Due to the fact that population has increased markedly during the last ten years, the deforestation rates then must be different from what they may be in 1993. The GOTG/USAID Agricultural and Natural Resources Project conducted on aerial reconnaisances survey of the whole country in November 1993 and the photography is available as of July 1994. Intensive training and analysis of the data is now going on in The Gambia and it is hoped that a Forest Inventory will be produced from the analysis.

The time period of ten years between Forest Inventories may be adequate for most applications but to obtain data for use in a Greenhouse gas Inventory a more frequent inventory may be desirable. This may be possible through the use of high resolution satellite imegary such as that from LANDSAT-TM and SPOT.

Data entry and results of evaluation are indicated in Worksheet 5-1, Sheets A, B, C, D, E and F.

VEGETATION RESOURCES OF THE GAMBIA

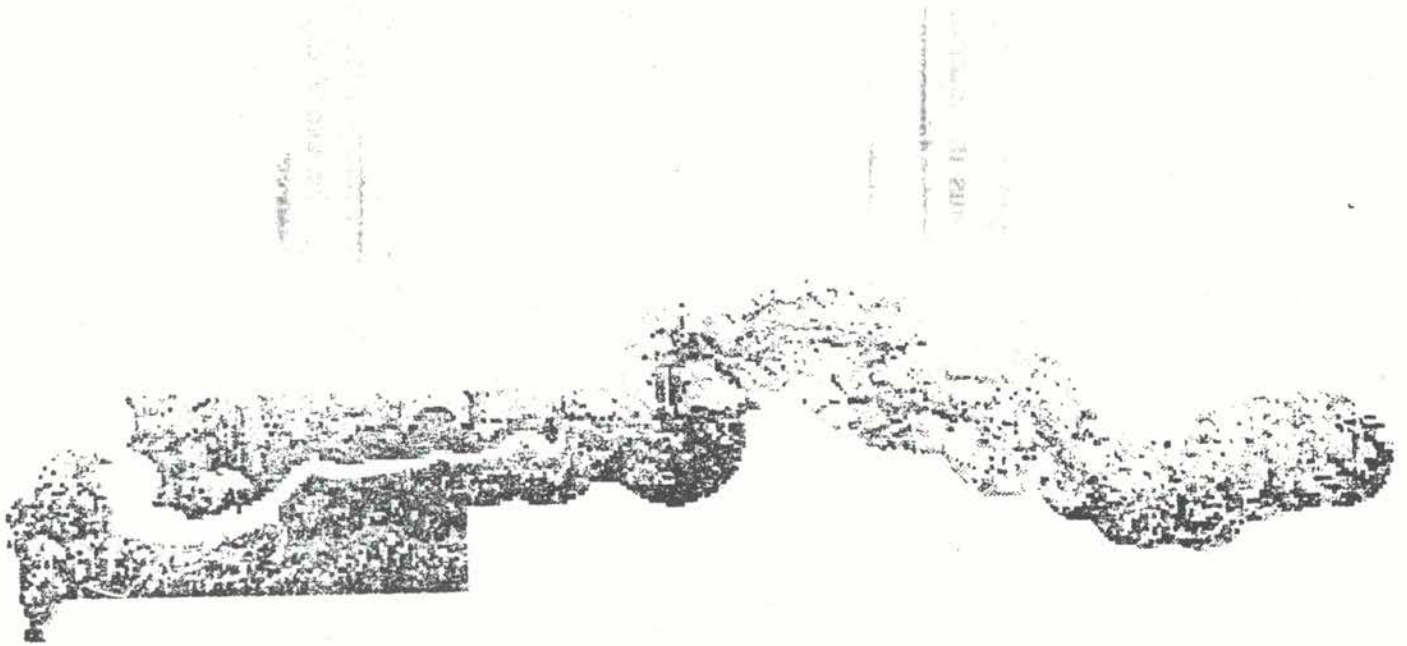


Table 4.1: **Areas of Landuse Classes per Division (1,000ha).**

Landuse Class	Landuse Type	Western Division	Lower River Division	North Bank Division	MacCarthy Island Division	Upper River Division	River Gambia	Total
I	High Mangroves	4.7	4.3	5.5	0.5			**15.0**
II	Low Mangrove	16.8	12.4	22.6	0.1			**51.9**
III	Gallery Forest	1.3	0.2	0.8	3.4	1.4		**7.1**
IV	Closed Woodland (incl. Gmelina Stands)	16.3	0.6	1.7	1.9	0.4		**20.9**
V	Open Woodland	29.1	16.0	4.9	11.3	1.4		**62.7**
VI	Tree and Shrub Savannah (incl. unstocked forest area)	15.0	52.3	38.8	136.6	105.0		**347.7**
VII	Fallow land	11.3	12.5	27.4	28.1	22.8		**102.1**
VIII	Wooded Upland crops	12.3	2.6	2.6	0.5			**18.0**
IX	Upland Crops	60.6	27.0	68.0	70.7	47.8		**274.1**
X	Swamps cultivated	1.8	7.9	9.4	12.2	2.2		**33.5**
XI	Swamps uncultivated	1.2	11.2	15.8	29.8	12.7		**70.7**
XII	Barren flats	6.0	5.8	6.4	1.8	1.8		**21.8**
XIII	Water Surface	4.9	1.8	5.1	8.2	1.8	52.7	**74.5**
XIV	Towns & Villages	7.2	1.2	2.4	2.3	1.6		**14.7**
	Total	**188.5**	**155.8**	**211.4**	**307.4**	**198.9**	**52.7**	**1,114.7**

Source: Foster (1983)

Table 4.2: **1982 Forests Inventory results per Division (after Foster, 1983).**

Division	Area (ha)	N/ha	G/ha m2	Dm cm	Hm m	Vt/ha m3	Vt thm3	Vs/ha m3	Vs thm3	Vf/ha m3	Vf thm3	dead %	dec %	I/ha m3	I thm3
Western Division	149,017.0	81.0	4.2	26.0	11.0	29.2	3,447.0	7.7	1,153.0	21.4	3,194.0	6.0	56.0	0.7	103.0
Lower River Division	115,370.0	90.0	4.5	25.0	11.0	28.9	3,339.0	8.1	934.0	20.8	2,405.0	17.0	64.0	0.7	75.0
North Bank Division	149,582.0	70.0	4.0	27.0	12.0	25.6	3,824.0	9.4	1,405.0	16.2	2,419.0	8.0	21.0	0.6	92.0
MacCarthy Island Division	253,002.0	75.0	2.6	21.0	9.0	9.8	1,753.0	1.4	253.0	8.4	1,500.0	8.0	34.0	0.2	43.0
Upper River Division	178,859.0	58.0	2.1	21.0	9.0	9.8	1,753.0	1.4	253.0	8.4	1,500.0	8.0	34.0	0.2	43.0
Natural Forest Tree-bearing Non-forest areas	**845,830.0**	**74.0**	**3.3**	**24.0**	**10.0**	**19.6**	**16,548.0**	**5.4**	**4,585.0**	**14.1**	**11,963.0**	**9.0**	**45.0**	**0.5**	**406.0**
Western Division Gmeline Stands	1,239.0	415.0	10.4	17.0	10.0	57.7	72.0	36.1	45.0	21.6	27.0	8.0	2.0	5.2	6.0
Western Division Unstocked Forest	650.0														
Area	**847,719.0**	**75.0**	**3.3**	**24.0**	**10.0**	**19.6**	**16,620.0**	**5.5**	**4,630.0**	**14.1**	**11,990.0**	**9.0**	**412.0**	**0.5**	**412.0**

Legend: N/ha=number of stems per hectare; G/ha=Basal Area per hactare; Dm=mean diametre in centimetres (cm); Hm=mean Height in metres; Vt=total volume of timber in thousand cubic metres (thm3); Vt/ha=Total volume of timber per hectare; Vs=Total volume of saw wood in thousand cubic metres (thm3); Vs/ha=Volume of saw wood per hectare; Vf=Volume of fuelwood in thousand cubic metres(thm3); Vf/ha=volume of fuelwood per hectare; dec=decay; I=total incremental volume (1000m3); and I/ha=total incremental volume per hectare.

LAND USE CHANGE & FORESTRY

Greenhouse Gas Inventory Workbook

IPCC Draft Guidelines for National Greenhouse Gas Inventories - Volume 2

FOREST CLEARING

			Module	Land Use Change & Forestry						
			Sub module	Forest Clearing - CO2 Release From Burning Above Ground Biomass On and Off Site						
			Worksheet	5.1						
			Sheet	A						
				STEP 1						STEP 2
Forest Types				A Area Cleared Annually (kha)	B Biomass Before Clearing (t dm /ha)	C Biomass After Clearing (t dm/ha)	D Net Change in Biomass (t dm/ha)	E Annual Loss of Biomass (kt dm)	F Fraction of Biomass Exposed to Burning On Site	
							D = (B-C)	E = (A*D)		
Tropical	Closed Forests (categories III and IV of Table 4.1)	Broableaf	Logged	0.560	240	10	230	128.800	0.5	
	Open Forests (categories V and VI of Table 4.1)			8.208	36	10	26	213.408	0.5	
TOTAL				8.768				342.208		

			Module	Land Use Change & Forestry					
			Sub module	Forest Clearing - CO2 Release From Burning Above Ground Biomass On and Off Site					
			Worksheet	5.1					
			Sheet	B					
				STEP 2 continued					
Forest Types				G Quantity of Biomass Exposed to Burning On Site (kt dm)	H Fraction of Biomass Oxidized On Site (Combustion Efficiency)	I Quantity of biomass Oxidized On site (kt dm)	J Carbon fraction of Abovegroun d Biomass (burned on site)	K Quantity of carbon Released (kt C)	
				G = (E*F)		I = (G*H)		K = (I*J)	
Tropical	Closed Forests (categories III	Broadleaf	Logged	64.400	0.9	57.960	0.45	26.082	
	Open Forests (categories V and VI of Table			106.704	0.9	96.034	0.45	43.215	
TOTAL				**171.104**		**153.994**		**69.297**	

			Module	Land Use Change & Forestry								
			Sub module	Forest Clearing - CO2 Release From Burning Above Ground Biomass On and Off Site								
			Worksheet	5.1								
			Sheet	C								
					STEP 3						STEP 4	
Forest Types				L Fraction of Biomass Exposed to Burning Off Site	M Quantity of Biomass Exposed to Burning Off Site (kt dm)	N Fraction of Biomass Oxidized off Site (Combustion Efficiency)	O Quantity of Biomass Oxidized Off Site (kt dm)	P Carbon Fraction of Above ground Biomass (burned off site)	Q Quantity of Carbon Released as CO2 (from biomass burned off site)	R Total Carbon Released as CO2 (from on & off site burning)	S Total CO2 released (kt CO2)
					M = (E*L)		**O = (M*N)**		**Q = (O*P)**	**R = (K+Q)**	**S = (R*[44/12])**
Tropical	Closed Forests (categories III	Broadleaf	Logged								
	Open Forests (categories V and VI of Table										
TOTAL				**0.369**	**126.252**	0.9	**113.626**	0.45	**51.132**	**120.429**	**441.573**

			Module	Land Use Change & Forestry								
			Sub module	Forest Clearing- CO2 Released From Decay of Above Ground Biomass								
			Worksheet	5.1								
			Sheet	D								
				STEP 5								
Forest Types				A Annual Area Cleared (10 Year average) (kha)	B Biomass Before Clearing (t dm/ha)	C Biomass After Clearing (t dm/ha)	D Net Change in Biomass (t dm/ha)	E Average Annual Loss of Biomass (kt dm)	F Fraction Left to Decay	G Quantity of Biomass to Decay (kt dm)	H Carbon Fraction in Aboveground Biomass	I Portion C Released as CO2 (kt C)
							D = (B-C)	E = (A*D)		G = (E*F)		I = (G*H)
Tropical	Closed Forests (categories III and IV of Table	Broadleaf	Logged	0.560	240	10	230	128.800	0.473	60.922	0.45	27.415
	Open Forests (categories V and VI of Table			8.208	36	10	26	213.408	0.362	77.254	0.45	34.764
TOTAL				**8.768**				**342.208**	**0.418**	**138.176**		**62.179**

	Module	Land Use Change & Forestry					
	Sub module	Forest Clearing- Soil Carbon Release					
	Worksheet	5.1					
	Sheet	E					
				STEP 6			
Forest types		A Average Annual Forest Cleared (10 year average)	B Soil Carbon Content of Cleared land (t/ha)	C Total Annual Potential Soil Carbon Loss (kt C)	D Fraction of Carbon Released	E Carbon Release from Soil Carbon (kt C)	
				C = (A*B)		**E = (C*D)**	
Tropical	Closed Forests (categories III	0.560	60	33.6	0.5	16.8	
	Open Forests (categories V and VI of Table	8.208	60	492.5	0.5	246.2	
TOTAL		**8.768**		**526.1**		**263.0**	

Module	Land Use Change & Forestry
Sub module	Forest Clearing- Total CO2 Emission
Worksheet	5.1
Sheet	F

STEP 7				
A Immediate Release From Burning (kt C)	B Delayed Emissions From Decay (kt C)	C Long Term Emissions From Soil (kt C)	D Total Annual Carbon Release From Forest Clearing (kt C)	E Total Annual CO2 Release From Forest Clearing (kt CO2)
			D = (A+B+C)	**E = (D*[44/12])**
120.429	62.179	263.040	445.648	**1634.044**

4.2: Non-$C0_2$ Trace Gas Emissions from On-Site Burning of Cleared Forest:

On-site burning of cleared forests is similar to all other activities related to biomass burning and which have been described in preceeding sectors. These include burning of traditional biomass fuels (Energy Sector), savannah burning, and field burning of crop residues (Agriculture Sector).

4.2.1: Data Used in the Estimation of Emissions from on-site Burning of Cleared Forests.

The data used is obtained from the 1982 Forest Inventory described in the preceeding sub-sector and some of the information in worksheet 5-1 is being input here as data.

Entries and results of estimation are provided in Worksheet 5-2, Sheet A.

4.3: $C0_2$ Emissions from Managed Forests:

Managed forests include all categories of forests that experience periodic or on-going human interventions that affect carbon stocks. The Category also includes some tree planting activities such as plantation establishment and other afforestation/reforestation programmes.

4.3.1: Data used in the evaluation of $C0_2$ emissions from managed forests:

In addition to data obtained from the 1982 Forest Inventory expert judgement from the Forestry Department has been used.

Results of all entires are in Worksheet 5-5, Sheets A, B and C.

ON-SITE BURNING OF CLEARED FORESTS

			Module	Land Use Change & Forestry			
			Sub module	On-Site Burning Of Cleared Forests			
			Worksheet	5.2			
			Sheet	A			
STEP 1				STEP 2			
A Carbon Released (kt C)	B Nitrogen-Carbon Ratio	C Total Nitrogen Released (kt N)		D Trace Gas Emissions Ratios	E Trace Gas Emissions (kt C)	F Conversion Factors	G Trace Gas Emissions from burning of Cleared Forests (kt CH4, CO)
(From Column K Worksheet 5.1, Sheet B)		C = (A*B)			**E = (A*D)**		**G = (E*F)**
69.297	0.01	0.693	**CH4**	0.012	0.832	16/12	**1.109**
			CO	0.060	4.158	28/12	**9.702**
					(kt N)		(kt N2O, NOx)
		C = (A*B)			**E = (C*D)**		**G = (E*F)**
			N2O	0.007	0.005	44/28	**0.008**
			NOx	0.121	0.084	30/14	**0.180**

MANAGED FORESTS

			Module	Land Use Change & Forestry			
			Sub module	Managed Forests			
			Worksheet	5.5			
			Sheet	A			
				STEP 1			
Forest Type			A Area of Managed Forest (kha)	B Annual Growth Rate (t dm/ha)	C Annual Biomass Increment (kt dm)	D Carbon Content Of Dry Matter	E Total Carbon Increment (kt C)
					C = (A*B)		**E = (C*D)**
Tropical	Plantations	All species	30	*3.000*	90	0.45	40.5
			A Number of Trees (1000s of trees)	B Annual Growth (t dm/1000 trees)			
Afforestation Programs			37.50	*2.875*	107.81	0.45	48.5
			37.50				**89.0**

Module	Land Use Change & Forestry							
Sub module	Managed Forests							
Worksheet	5.5							
Sheet	B							
			STEP 2					
Forest Type	F Commercial Harvest (km3 roundwood)	G Biomass Expansion factor (t dm/m3)	H Total Biomass Removed in Commercial Harvest (kt dm)	I Total Traditional Fuelwood Consumed (kt dm)	J Other Wood Use (kt dm)	K Total Biomass Consumption (kt dm)	L Wood Removed From Forest Clearing (kt dm)	M Total Biomass Consumption From managed Forests (kt dm)
			H = (F*G)	***(from column H, Worksheet 1-2, Sheet A)***		**K = (H+I+J)**	**(from column M, Worksheet 5.1, Sheet C)**	**M = (K-L)**
Gmelina	4.8	0.5	2.400					
			2.400	**377.963**		**380.363**	**126.252**	**254.111**

Module	Land Use Change & Forestry		
Sub module	Managed Forests		
Worksheet	5.5		
Sheet	C		
STEP 3		STEP 4	
N Carbon Fraction	O Annual Carbon Release (kt C)	P Annual carbon Uptake (+) and Release (-) (kt C)	Q Convert to CO2 Annual Emission or Removal (Gg CO2)
	O = (M*N)	**P = (E-O)**	**Q = (P*[44/12])**
0.45	114.350	25.334	**92.893**

4.4 Comments on the applications of the IPCC/OECD Methodology in the Landuse Change and Forestry Sector:

Unless otherwise specified in this sub-section default values in Tables presented in the Workbook have been used in the Worksheets.

The final results obtained for CO_2 in the Landuse Change and Forestry Sector and reported in the Overview (Table 6.1) seems to be a large overestimation compared to emissions from the sector in Senegal. This may be due to the lack of most recent data on this sector in The Gambia. Thus, this will affect overall results of the Inventory.

Worksheet 5.1, Sheet A

Column A:
Classification of forest types based on 1982 Forest Inventory. Based on expert judgement from the Department of Forestry, 2% of the forest area is cleared annually. On a very small scale, logging takes place in the Gallery Forest and Closed Woodland (including Gmelina Stands) categories. Thus 0.560 kha (=0.02*(20.9+7.1) kha) represents area of Gallery Forest and Closed Woodland cleared annually. Similarly 8.208 kha (=0.02*(347.7+62.7) kha) represents area of Tree and Shrub Savannah (including unstocked forest area) and Open Woodland cleared annually.

Column F:
Fraction of Biomass Exposed to Burning on site adopted from the 1991 Greenhouse Gas Inventory Report of the Republic of Senegal (Senegal, 1994)

Worksheet 5-1, Sheet C

Column L:
This value has been calculated as the ratio of the apparent biomass consumed (Column D, Worksheet 1.2) to the sum of the apparent consumption and total biomass consumed on-site (Column G, Worksheet 5.1, sheet B) and this has been used as a general value since separate values for Closed and Open Forest could not be calculated.

Worksheet 5-1, Sheet D

Column F:
Figures from the 1991 Greenhouse Gas Emissions Inventory of the Republic of Senegal (Senegal, 1994) have been used here as no specific information is available for The Gambia.

Worksheet 5-1, Sheet E

Column A:
The average reported here is an estimate of the 10 year average between the 1972 and 1981 Aerial Surveys from which Forest Inventories were made. This is not a result from the Forest Inventory and it is for this reason that it is reported in blue.

Worksheet 5-5, Sheet A

Column B:
Average of 3.0 calculated from the 1991 Greenhouse Gas Inventory Report of the Republic of Senegal (Senegal, 1994).

4.5 References:

Department of Forestry (DOF), 1991; Forestry Programme: Sectoral Contribution to the Gambia Environmental Action Plan (GEAP).

Environment Unit, MNRE, 1992; The Gambia Environmental Action Plan.

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

Chapter 5

WASTE

5.0: Overview of the major waste discharging Systems and Sectors:

5.0.1: Wastewater

The Sewerage System.

The Sewerage System was commissioned in 1989 and serves only the capital city, Banjul, which has a population of about 42,407 as at April 1993 (CSD,1993). The System is designed such that sewerage gravitates from compounds along sewerage pipes into two stations for grit removal prior to entering the Gambia River Estuary via a sea outfall pipe of 950 metres. Removal of grit is the only form of treatment of the System.

The Hotels and Tourism Industry:

Tourism in The Gambia started in 1965/66 when the first batch of air charter tourists, numbering 300 visited the country. It has since been evolving with an increase in number of Hotels and hotel beds. Out of the sixteen hotels in The Gambia, nine are located in the Kombo St Mary area on the coastline. The domestic sewerage from most of these hotels is discharged into the ocean or estuary. Some hotels discharge their sewerage into treatment ponds at Kotu.

The Commercial and Industrial Sector:

This Sector is still underdeveloped and on a small scale. The major institutions that discharge waste water of reasonable quantity into the estuary are Banjul Breweries and GAMTAN (tannery). Banjul Breweries discharges 1.5 million litres of waste water every month, while the Tannery discharges 450,000 litres every month (Sissoho, 1992).

5.0.2: Solid Waste:

Solid Waste is collected from residential, commercial, markets and recreational areas, offices and institutions such as schools, hospitals, fish processing industries, and hotels. Constituents include food leftovers, paper, construction wastes, grass and other industrial waste. Thirty-nine tons of refuse is collected daily from Banjul and Kombo St. Mary. Twenty-seven tonnes of this collection is by composers and the rest by tipper-trucks. Banjul has a waste generation rate of 0.68 kg/cap/day, 7% of which is from Hotels, 25% from Government institutions and the rest from residential and recreational areas. The waste generation rate for Kombo St Mary is 0.55 kg/cap/day.

Most of domestic waste generated in Banjul and Kombo St Mary is disposed in two main dump sites (landfills); one at Mile Two and a large disused laterite quarry at Bakoteh. Other smaller dump sites exist even in the capital city and major settlements (Serrekunda and Bakau) on Kombo St Mary.

Disposal and treatment of industrial and municipal wastes can produce emissions of most of the important greenhouse gases. In this chapter we discuss emissions resulting from landfilling of solid waste and treatment of liquid wastes.

Methane is the most important gas produced in the waste category of sources. Significant amounts of the annual global methane produced and released into the atmosphere are a by-product of the anaerobic decomposition of man-made waste.

5.1 Methane Emissions From Landfills:

Methane (CH_4) is produced from anaerobic decomposition of organic matter in landfills by methanogenic bacteria. Organic waste first decomposes aerobically (oxygen present) and is then attacked by anaerobic non-methanogenic bacteria, which convert material to simpler forms like cellulose, amino acids, sugar, and fats. These simple substance are further broken down to gases and short-chain organic compounds, which form the substrates for methanogenic bacteria. The resulting biogas consists of approximately 50% $C0_2$ and 50% CH_4 by volume.

The two most common type of waste management that lead to biogas production are open dumping, generally practiced in developing countries, and sanitary landfilling, generally practiced in developed countries and urban areas of developing countries.

5.1.1: Data used in the estimation of methane emissions from Landfills:

The data used to estimate methane emissions from Landfills is derived from the use of Worksheet 6-1 (supplemental) after inputting the population figures of the 1993 population census.

Following the step by step instructions in the Methodology and Workbook the results in Worksheet 6-1 and 6-1 (Supplemental) were arrived at.

WASTE

Greenhouse Gas Inventory Workbook

IPCC Draft Guidelines for National Greenhouse Gas Inventories - Volume 2

LANDFILLS

	Module	Waste								
	Sub module	Methane Emissions from Landfills								
	Worksheet	6.1								
	Sheet	A								
A Annual MSW Landfilled (Specify sub-categories if any) (Gg)	B Fraction DOC (Gg DOC / Gg MSW)	C Annual DOC Landfilled (Gg)	D Fraction which Actually Degrades	E Annual Carbon Released as Biogas (Gg)	F Fraction CH4 (Gg C-CH4 / Gg C-Biogas)	G CH4-C Emissions (Gg C)	H Conversion Factor (16/12)	I CH4 Emissions (Gg CH4)	J CH4 Recovered (Gg de CH4)	K Net CH4 Emissions (Gg CH4)
		C = (A*B)		**E = (C*D)**		**G = (E*F)**		**I = (G*H)**		**K = (I-J)**
Domestic Waste 44.059	0.150	6.609	*0.582*	3.846	0.500	1.923	1.333	2.564	0.000	2.564
Industrial Waste 326.447	0.060	19.587	*0.330*	6.464	0.500	3.232	1.333	4.309	0.000	4.309
TOTAL **370.506**		**26.196**		**10.310**		**5.155**		**6.873**	**0.000**	**6.873**

MSW : Municipal Solid Waste

DOC : Degradable Organic Carbon

Module	Waste			
Sub module	Methane Emissions from Landfills			
Worksheet	**6.1 (supplemental)**			
Sheet	**B**			
A Population (Banjul and Kanifing Municipal Council) (1000 persons)	B Waste Generation Rate (Gg MSW / 1000 persons / year)	C Waste Generation (Gg MSW)	D Fraction Landfilled	E MSW Landfilled (Gg MSW)
		C = (A*B)		**E = (C*D)**
Urban Population				
271.352	0.232	62.941	0.7	**44.059**

MSW : Municipal Solid Waste

5.2: Methane Emissions from Wastewater

Wastewater streams are estimated to emit 300-400 Gg CH4/year, which represents 8-11 percent of the total global methane emissions of 360,000 Gg CH4/year. The amount of organic material in the wastewater stream, indicated by the Biochemical Oxygen Demand (BOD), determines its methane generation potential. The two basic types of wastewater are Municipal and Industrial wastewater.

5.2.1: Data used in the estimation of methane emissions from wastewater

The data used in the evaluation of methane emissions from wastewater was extracted from a study report entitled "Rapid Assessment of Liquid and Solid Waste Pollution Sources in Banjul, The Gambia" by Ms Isatou I. M. Sissiho, a member of staff of the Water Quality Control Division of the Department of Water Resources and response to questionnaires sent to some of the industries. The data was gathered in 1992.

5.2.1a: Municipal Wastewater:

In the estimation of emissions from municipal wastewater only the city of Banjul was considered since this is where households have been connected to the sewerage system. There is an over estimation of population because not all households are connected to the sewerage system at the time of the Study. No information is available on treatment of sewerage except that two control points exist for grit removal. Hence a value of 0 Gg BOD_5 has been.

Results of the computations are given in Worksheet 6-2, Sheet A.

5.2.1b: Industrial Wastewater:

Data on Industrial Wastewater was extracted from Sissoho, (1992). The data is on wastewater generated by Banjul Breweries, the Abbatoir at Abuko, and the Tannery at Abuko. The requests for data sent to these and other Industries were not replied to except a reply from YAMS for data on number of slaughters at the Abbatoir in Abuko. The data was combined with default values in Table 6.5 of the Workbook to determine annual wastewater flow.

Results of calculations are given in Worksheet 6-3, Sheets A and B.

METHANE EMISSIONS FROM WASTEWATER

Module	Waste							
Sub module	Methane Emissions from Municipal Wastewater							
Worksheet	6.2							
Sheet	A							
A Population (Banjul) (1000 persons)	B Wastewater BOD Generation Rate (Gg BOD5 / 1000 persons / year)	C BOD Generated (Gg BOD5)	D Fraction Anaerobically Treated (Gg BOD5)	E Quantity of BOD5 Treated Anaerobically (Gg BOD5)	F Methane Emission Factor (Gg CH4/kg BOD5)	G CH4 Emissions (Gg CH4)	H Methane Recovery (Gg CH4)	I Net CH4 Emissions (Gg CH4)
		C = (A*B)		**E = (C*D)**		**G = (E*F)**		**I = (G*H)**
Banjul								
42.407	0.014	0.573	0	0.0	0.22	0.0	0	0
TOTAL		**0.573**		**0.000**		**0.000**	**0.000**	**0.000**

BOD : Biochemical Oxygen Demand

BOD : The amount of oxygen consumed by the organic material in the wastewater during decomposition. A standardized measure of BOD is the 5 day test (BOD5), expressed in milligrams per litre (mg/l).

	Module	Waste						
	Sub module	Methane Emissions from Industrial Wastewater						
	Worksheet	6.3						
	Sheet	A						
			STEP 1			STEP 2		
			A Annual Wastewater Outflow (M litres)	B BOD Concentration Rates (kg / litre)	C Total BOD Generated Gg BOD (Gg BOD)	D Fraction of Wastewater Treated Anaerobically	E Quantity of BOD Treated Anaerobically (Gg BOD)	F Methane Emission Factor (0.22 Gg CH4 / Gg BOD5)
					C = (A*B)		**E = (C*D)**	
Food and Beverages	Beer		18.000	0.0850	1.530	0.1	0.153	0.22
	Fish processing		13.202	0.0040	0.053	0.1	0.005	0.22
	Slaughter house		4.039	0.0200	0.081	0.1	0.008	0.22
	Soft drinks		3.745	0.0008	0.003	0.1	0.000	0.22
	Tannery		5.400	0.0200	0.108	0.1	0.011	0.22

Module		Waste		
Sub module		Methane Emissions From Industrial Wastewater		
Worksheet		6.3		
Sheet		B		
		STEP 3		
		G Total Methane Released (Gg CH4)	H Methane Recovered (Gg CH4)	I Net Methane Emissions (Gg CH4)
		G = (E*F)		I = (G-H)
Food and	Beer	0.034	0	0.034
	Fish processing	0.001	0	0.001
	Slaughter house	0.002	0	0.002
	Soft drinks	0.000	0	0.000
	Tannery	0.002	0	0.002
TOTAL				**0.039**

5.3: Comments on the applications of the IPCC/OECD Methodology to estimate emissions from Wastes

Unless otherwise stated as below default values in the Workbook have been used where appropriate.

Worksheet 6.1, Sheet A

Column A:
The value of 44.059 Gg MSW landfilled is calculated using Worksheet 6.1 (Supplement), Sheet B, based on Urban (Banjul and Kanifing Local Government Area) population figures for 1993. The value of 370.506 Gg MSW is the total MSW landfilled from different industries

Column B:
Fraction DOC is adopted from the 1991 Greenhouse Gas Inventory of the Republic of Senegal (Senegal, 1994)

Column D:
Fraction which actually degrades is adopted from the 1991 Greenhouse Gas Inventory of the Republic of Senegal (Senegal, 1994)

Worksheet 6.1, Sheet B (supplement)

Column B:
Waste generation rate is caculated from results of the study: "Rapid Assessment of Liquid and Solid waste Pollution in Banjul", (Sissoho, 1992).

Column D:
Fraction landfilled is adopted from the 1991 Greenhouse Gas Inventory of the Republic of Senegal (Senegal, 1994).

Worksheet 6.2, Sheet A

Column A:
Population of the capital city, Banjul, only

Coulmn B:
Wastewater BOD Generation Rate adopted from the 1991 Greenhouse Gas Inventory of the Republic of Senegal (Senegal, 1994).

Column D:
There is no specific information on wastewater treatment and hence the default value of 0.1 is adopted from the Workbook.

Worksheet 6.3 Sheet A

Column B:
BOD values adopted from the Workbook and value for Meat Packing assumed for Slaughter house.

Column D:
No specific information available on treatment and hence default value of 0.0 adopted from the Workbook.

5.4 References:

Central Statistics Department (CSD), 1993; Population and Housing Census, 1993: Provisional Report (1).

Senegal, 1994; 1991 Greenhouse Gas Emissions Inventory of the Republic of Senegal.

Sissoho, I. M., 1992; Rapid Assessment of Liquid and Solid Waste Pollution Sources in Banjul, The Gambia.

Chapter 6

CONCLUSION AND RECOMMENDATIONS

The development of a National Inventory of Sources and Sinks of Greenhouse Gas Emissions should make it possible for any particular country to identify the human activities and sectors that are most important in increasing concentrations of greenhouse gases and also what gases are most significantly increasing and at what rates. Having identified the most important sectors and gases that contribute to the Enhanced Greenhouse Effect it is possible to take measures to mitigate emissions through appropriate policy options.

6.1 Achievements of the National Inventory

The process of the development of The Gambia National Inventory has made it possible to:

(1) identify data gaps, data needs, and future actions to ameliorate data collection and standardization, not only for the purpose of Inventory development, but also for other needs of the institutions;

(2) bring together experts and technicians from different institutions of government and private sector to work together and improve networking and intersectoral communication. and awareness;

(3) develop capacity and awareness to a certain degree in the understanding of interations between local, regional and global environments.

6.2: Problems in Data Collection and Applications of the IPCC/OECD Methodology in The Gambia.

6.2.1: Data Collection:

This is the most critical stage in the development of a National Inventory for without the data the Inventory is incomplete. During the planning stages of the Project Consultants visited The Gambia so as to identify the availability of the required data. It was possible, during these visits, to meet various institutions and organizations from which the data could be made available. It was also possible to identify from these institutions and organizations what data was easily available

and what data was not available. Those instistutions at which the data already exist, there was strong promise that the data will be made available as and when requested by the National Climate Committee. For those areas where data was not readily available it was decided to conduct Surveys to gather the required data.

Two main problems were encountered from those institutions that indicated that data was available. Firstly, the data available was not in the format required for the development of a National Inventory of emissions of Greenhouse Gases. The data gathered, which was in most cases inadequate in terms of its temporal coverage, has to be compiled to suit the requirements of the development of the Inventory. It was difficult to gather all the data for a particular year. It is for this reason that the Inventory is developed for 1993. More data was collected for 1993 than any other year. Secondly, despite the fact that the required data was in these institutions it was difficult for it to be made available to the National Climate Committee. This is particularly true of the Commercial and Industrial Institutions that felt very reluctant to supply the requested data and information. These institutions were visited on so many occasions and on each visit excuses were given as to the unavailability of the data at that particular time. Only two commercial institutions (YAMS Enterprise and Banjul Breweries) supplied data on number of animals slaughtered and production figures. The data supplied by YAMS covered only three months and thus had to be extrapolated to be of use for the development of the Inventory. The data from Banjul Breweries just gives one bulk production figure instead of breaking the figure according to the category of produce. So the figure is virtually unusable since, for example, the methane emissions factors and BOD estimates for various industrial wastewater treatment at food processing facilities (beer, wine, soft drinks, meat packing, fish processing) are different.

A system of cooperation between the NCC and Private Sector Institutions should be instituted especially that these same institutions have been written to and visited more than three times during the Project implementation period. They have also been supplied with the draft Inventory document so that they can verify how the data they supply is being used and for what purpose. One-to-one discussions of the use of the data was also carried out with the staff of the Institutions but this has not improved the situation.

The data collection through the conduct of Surveys also had its problems. Firstly, expertise was a limitation as such Surveys were never conducted at national scale solely by nationals. Secondly, due to the limitation in expertise the Project Coordinator and members of the NCC responsible for conducting the Surveys were not sure of what to expect and so underestimated the time required to conduct the Surveys and the budget needed. The time alloted for the Surveys (one

month) was inadequate and because of budgetry constraints, extension was not possible.

The Fuelwood Survey needs to be at different times of the year because rate of consumption and weight of wood varies with time of the year. The Survey was conducted during the rainy season when the wood is wet, heavier and difficult to gather. During the dry season the weight will be lighter and easier to gather because there is less undergrowth in the forest and conditions are drier. This is likely to make some difference in the results of the Survey.

More time was needed to analyse the the data collected through the Surveys. The period of nine months to finalize the Inventory turned out to be short and Survey Coordinators were forced to work under pressure to finish and submit the data for the development of the Inventory.

6.2.2: Problems Encountered in the Applications of the IPCC/OECD Methodology in The Gambia:

The IPCC/OECD Methodology demands a lot of time and effort to be understood, things that a technician in The Gambia or the developing world finds difficult to come by under the prevailing socio-economic climate. The material in all the documents is new to all the members of the National Climate Committee and more time (in excess of the one year used to develop the National Inventory) is needed for each and everyone to be reasonably comfortable in the understanding and applications of the Methodology.

The Methodology was developed outside the developing world. Most of the Emission Factors and Coefficients were developed and tested in environments that are different from The Gambia. The present Inventory is developed assuming these emission factors and coefficients. This is likely to introduce some uncertainties in the results. Country or regional specific factors and coefficients would be better and should be developed.

6.3: Synthesis of The Gambia National Inventory

6.3.1: Major Greenhouse Gases:

As shown in Table 6.1 (Overview) and Figure 6.1, Carbon Dioxide ($C0_2$) is emitted most with a total of 1,747,127 tons (1,747.127 Gg) followed by Carbon

Monoxide (35,942 tons), Methane (35,351 tons), Nitrogen Oxide (6,799 tons) and Nitrous Oxide (291 tons).

6.3.2: Major Emissions Sectors

Results of the Inventory (Table 6.1 and Figure 6.2) have shown that Landuse Change and Forestry sector is the highest emitter of greenhouse gases in The Gambia. Forestry, Range and Grasslands, and Agriculture share about all of the country's vegetative land area. The distribution of land between these sectors and among users within a sector is determined by land-use demand and supply factors, as moderated by land-use policy and law. The most common factors that affect landuse include:

(1) demographic variables such as human population and its growth rate, rural/urban distribution and dependence on land resource;

(2) economic factors like income level, technological development, dependence on export of land-based products, and rates of economic growth;

(3) type and intensity of land-use such as shifting versus permanent agriculture, clear cutting versus selective harvesting; and

(4) biophysical factors like soil productivity, topography and climate.

Considering the size of The Gambia net emissions of over 1,500,000 tons of Carbon Dioxide, about 9,702 tons of Carbon Monoxide, and 1,109 tons of Methane (Table 6.1) per year from Landuse Change and Forestry should be seen as a sizeable contribution to the enhanced greenhouse effect. The figure 1,541,151 tons (1,541.151 Gg) of CO_2 is a result of emissions of 1,634,044 tons of $C0_2$ due to forest clearing and an uptake of 92,892 tons of Carbon Dioxide by managed forests (plantations). This is a clear indication that there is need to identify changes in the land-use policy, law and tenure that discourages forest clearing at the same time significantly influencing the sustainable distribution of land among forestry, rangeland and livestock, and agriculture.

Non-greenhouse gas reduction objectives such as preservation and enhancement of biodiversity of flora and fauna, soil conservation, watershed management could also be looked into. Human population and its growth rate, rural/urban distribution and dependence on land resources should also be studied.

Energy use accounts for the bulk of the carbon dioxide emissions in most developing countries but results of the Inventory (Table 6.1 and Figure 6.2) suggest that this is not the case in The Gambia. An annual emission of about 206,000 tons of $C0_2$ from Energy is far less than emissions of CO_2 from the Landuse and Forestry sector.

The Energy sector consists of the major end-use sub-sectors: industry, residential and commercial, transport, and agriculture, and the energy supply sub-sector, which consists of resource extraction, conversion, and delivery of energy products. Greenhouse gas emissions occur at various points in the sector, from resource extraction to end use, and accordingly, it is extremely necessay to evaluate the quantity of energy used at each point of the sector.

During the development of the Inventory it was not possible to obtain data and information on every point of the sector. The best data type obtained was quantity of fuel that is assumed to be supplied to the sector. The major fuels were gasoline, diesel/gas oil, kerosene and heavy fuel. It was not possible to quantify what fraction of this fuel was supplied to the various points of the Sector. This entailed the construction of an Energy Balance for the country which is the first step in the development of an Inventory for the energy sector. Since this is non existence it is highly recommended that the study should be undertaken by the mandated Institution, i.e., the Energy Unit of the Ministry of Trade, Industry and Employment.

6.3.3: Global Warming Potential (GWP)

Comparing the effectiveness of these gases in their contribution to the greenhouse effect and global warming, Nitrous Oxide is 270 times more effective in warming the earth and lower atmosphere than carbon dioxide. So that emissions of 291 tons of Nitrous Oxide is equivalent to emissions of 78,470 tons of Carbon Dioxide. Similarly Methane is 22 times more effective in warming the earth and lower atmosphere than carbon dioxide implying that 35,351 tons of methane emission is equivalent to 711,711 tons of Carbon Dioxide emission (Table 6.1 and figure 6.3). Expressing these in percentage terms (Figure 6.4) Carbon Dioxide will contribute 69%, Methane about 28% and Nitrous Oxide 3% of the warming expected in the 100-year period from 1993 resulting from emissions of these gases in The Gambia in 1993.

This method of comparing emissions of trace gases is referred to as Global Warming Potential(GWP). It is the time-integrated warming effect due to the instantaneous release of a unit mass (1kg) of a given greenhouse gas in today's

atmosphere, relative to that of carbon dioxide. The index thus describes the relative effectiveness of various greenhouse gases in contributing to potential global warming. The GWP of 22 for Methane used in this report represents the direct (11) and indirect effects of Methane. The indirect effects of Methane are considered comparable to the direct effects (EPA, 1994). The use of the direct and indirect effects also follow the suggestions of INC 9th Session that requests that the indirect effects be included. The magnitude of the indirect effects of other gases are either zero or uncertain (EPA, 1994).

The major advantage of Global Warming Potential (GWP) is that it can be used to compare emissions from one activity with another such as emissions from biomass fuel combustion with those from rice production. It can also be used to compare emissions from sectors or even countries.

Considering the GWP of each GHG reported above we obtain a total of 2,537,308 TCO_2E and, with a population of 1,025,867, the per capita emission is 2.473 TCO2/capita/year. This is twice the per capita emission of Senegal and hence at a first glance the emissions in The Gambia would appear to be excergerated. However, one has to bear in mind that The Gambia has poppulation density of 96 persons per square kilometer while Senegal has a population density of about 41 persons per square kilometer. Thus the two-to-one comparison in both the per capita emission and population density tend to lend credibility in the emissions in both countries.

6.4 Recommendations

A lot of data is available that is useful for inventory development but a lot of difficulties have been encountered in collecting the data. The data is, however, not in the format useful for Greenhouse Gas Inventory development. The National Climate Committee should devise a mechanism that will allow the data available and needed for Inventory development to be transformed in the required format. The Committe should also work with all the Institutions required to contribute to the data gathering process, to adopt the required format. Central Statistics Department, as the main Government Institution mandated to collect and analyze various types of data, and the National Enviroment Agency, as the lead agency in the development of the Environment Information System, should be actively involved in this activity.

The results of the Fuelwood Survey indicate high and alarming usage of charcoal in the Greater Banjul area. It is recommended that the Forestry Department, in

the farming community on these alternate practical uses of crop residues, such as for fuel, livestock feed and most importantly for soil improvement should be carried out. The Department of Communnity Development should take an active lead in this effort.

It is very expensive to carry out nationwide Livestock Census on annual basis. For the development of a GHG Inventory it is recommended that results of the annual NASS surveys conducted by the Department of Planning should be used to interpolated between the decadal Livestock Census.

The Ecological Monitoring Centre in Dakar, Senegal has proved to be very experienced in monotoring of Bush Fires. Bush Fires have been a menance to The Gambia for a long time and will continue so unless and until there are positive efforts made towards reducing their extent and frequency of occurence. This can only be achieved through cooperation with the Ecological Monitoring Centre in Dakar, Senegal as it is clear that The Gambia cannot establish such a centre on her territory because of the expenditure involved. Thus the National Climate Committee, with the Departments of Forestry, Livestock and Water Resources taking the lead, should initiate and put in place mechanisms required for cooperation with the Ecological Monitoring Centre in Dakar. This cooperation will go beyond the collection of data for GHG Inventory development.

Experience during the development of the present Inventory has shown that a wealth of experience exists at the ENDA-TM of Senegal. Co-operation with this NGO will go a long way to enhancing capacity building and technology transfer especially in energy matters and global change studies. The Energy Unit and the Central Statistics Department of the Ministry of Trade, Industry and Employment, and the Department of Community Development, responsible of coordinating NGO matters, should take the lead in the establishment of such cooperation.

The results of the Fuelwood Survey have stressed the observation that wood is not only important as a source of fuel but also provides significant income for the dealers. However, this significance of fuelwood as a source of income is at the expence of some unfriendly environmental effects, such as deforestation and emission of greenhouse gases which introduce other socioeconomic problems. The Forestry Department and the Energy Unit of the Ministry of Trade, Industry and Employment should come up with programmes that will reduce the dependancy on wood as a source of energy and promote the mitigation of the greenhouse gas emissions. Such programmes could build on the experience of, and supplement the Butane Gas Programme which has been introduced as alternative fuel especially for cooking and related operations.

The use of the results of one-time Survey data, such as the Fuelwood, Savannah Burning and the Agricultural Waste Burning Surveys, is likely to introduce uncertainty in the results of the Inventory. Since seasonal factors obviously come into play in these Surveys, they should be repeated annually for at least five years so as to establish some trend in the data and to avoid bias through the use of only one years data. This will improve the precision of the estimates derived from the data and overall results of the Inventory.

Contrary to the recommendation contained in the Livestock Numbers and Consumption Survey, efforts should be made in mitigating greenhouse gas emissions through the reduction of animal population by increasing off-take productivity and promoting other mitigating options.

Considering the importance of the Private Sector and NGOs in the development of the National Inventory, and the fact that these organizations have not responded positively to the invitation by the NCC, a system of cooperation between the NCC and these Institutions should be instituted.

Eventhough most the Members of the National Climate Committee have been exposed to the step by step instructions in the IPCC/OECD Methodology, non is confortable in the development of a national Inventory. It is recommended that a national training workshop be organized for key members of the NCC so as to train them to a leve that they will be able to develop emissions inventory for the Sector they represent. It is only through this training that more members of the Committee could be effectively used in the development of the Inventory.

The IPCC/OECD Methodology was developed outside the developing world. Most of the Emission Factors and Coefficients were developed and tested in environments that are different from The Gambia. The present Inventory is developed assuming these emission factors and coefficients. This is likely to introduce some uncertainties in the results. Country or regional specific factors and coefficients would be better and should be developed.

Greenhouse gas emissions occur at various points in the Energy Sector; from resource extraction to end use, and accordingly, it is extremely necessay to evaluate the quantity of energy used at each point of the sector. During the development of the Inventory it was not possible to obtain data and information on every point of the sector. This entailed the construction of an Energy Balance for the country which is the first step in the development of an Inventory for the energy sector. Since this is non existence it is highly recommended that the study should be undertaken by the Energy Unit of the Ministry of Trade, Industry and

Greenhouse gas emissions occur at various points in the Energy Sector; from resource extraction to end use, and accordingly, it is extremely necessay to evaluate the quantity of energy used at each point of the sector. During the development of the Inventory it was not possible to obtain data and information on every point of the sector. This entailed the construction of an Energy Balance for the country which is the first step in the development of an Inventory for the energy sector. Since this is non existence it is highly recommended that the study should be undertaken by the Energy Unit of the Ministry of Trade, Industry and Employment and use can be made of the expertise of ENDA-TM of Dakar in Senegal.

Now that we are aware of the contribution of The Gambia to the greenhouse effect and its resultant global warming, it is recommended that the NCC should come up with programs for the Mitigation of greenhouse gas emissions. These could be conducted nationally or in colalboration with other governments and institutions at regional or global level. This cooperation could be in the form of joint ventures such as through the Joint Implementation Programme.

It is highly recommended that any Programmes that arise from the development of and are a follow-up to this Inventory should be continued within the UNEP/GEF Country Study Programme.

Finally, the results of the Inventory should be used to develop policies required to mitigate emissions. Non-greenhouse gas reduction objectives such as preservation and enhancement of biodiversity of flora and fauna, soil conservation, watershed management should be promoted. Human population and its growth rate, rural/urban distribution and dependence on land resources should also be studied within the context of mitigation of greenhouse gas emissions and adaptation to climate change.

Access to data and information within the region has been greatly facilitated by the introduction and use of the E-mail System. The GHG Conferencing System has been very instumental in keeping abreast with activities within the region and helpful in keeping us on track. We sincerely recommend that the UNEP/GEF Programme should continue supporting Africa Network whom we always call upon to assist when there are minor problems in the hardware and software.

6.5 References

EPA, 1994; Inventory of U. S. Greenhouse Gas Emissions and Sinks: 1990-1993

TABLE 6.1: OVERVIEW OF GREENHOUSE GAS EMISSIONS IN THE GAMBIA (1993)

	Gigagrams (Gg)				
	Carbon Monoxide	Carbon Dioxide	Methane	Nitrogen Oxide	Nitrous Oxide
	CO	**CO2**	**CH4**	**NOx**	**N2O**
MODULE 1 : ENERGY					
CO2 from Energy		205.976			
Methane and other gases from Traditional Biomass Fuels Burned for Energy	21.867		2.499	0.405	0.017
Sub-total module 1	***21.867***	***205.976***	***2.499***	***0.405***	***0.017***
MODULE 4 : AGRICULTURE					
Methane Emissions from Animals and Animal Manure			13.992		
Methane Emissions from Rice Production			7.662		
Savanna Burning, Release of Non-CO2 Trace Gases	3.365		0.128	6.180	0.264
Field Burning of Agricultural Residues, Release of Non-CO2 Trace Gases	1.008		0.048	0.034	0.001
Sub-total module 4	***4.373***		***21.830***	***6.214***	***0.266***
MODULE 5 : LAND USE CHANGE & FORESTRY					
Forest Clearing		1634.044			
On-site Burning of Cleared Forests	9.702		1.109	0.180	0.008
Managed Forests		-92.893			
Sub-total module 5	***9.702***	***1541.151***	***1.109***	***0.180***	***0.008***
MODULE 6 : WASTE					
Methane Emissions from Landfills			6.873		
Methane Emissions from Wastewater			0.000		
Methane Emissions from Industrial Wastewater			0.039		
Sub-total module 6			***6.912***		
TOTAL	**35.942**	**1747.127**	**32.351**	**6.799**	**0.291**
Global Warming Potential (GWP), 100 years integration		**1**	**22**		**270**
1000 TCO2E		**1747.127**	**711.711**		**78.470**
%		**68.9**	**28.0**		**3.1**

Figure 6.1: GHG Emissions(Gg) by type of Gas in The Gambia (1993)

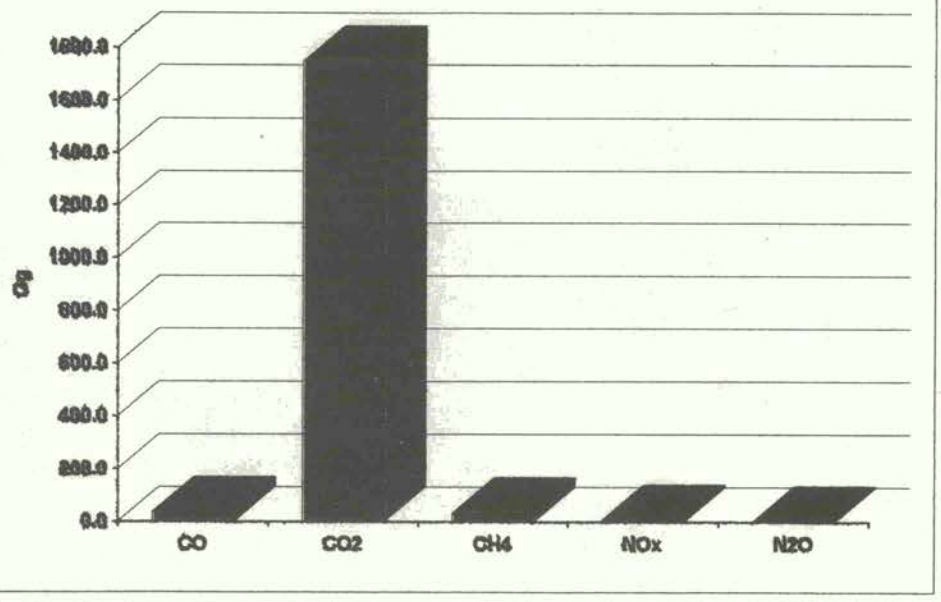


Figure 6.2: GHG Emissions by Sector in The Gambia in 1993

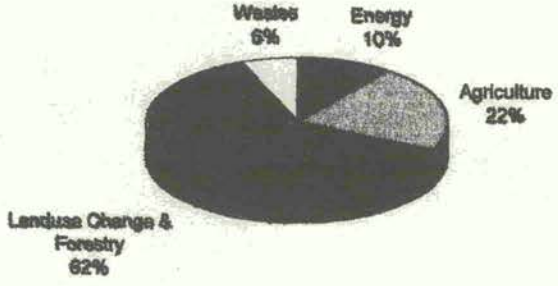


Figure 6.3: GHG Emissions by Gas in The Gambia (1993) in TCO2E

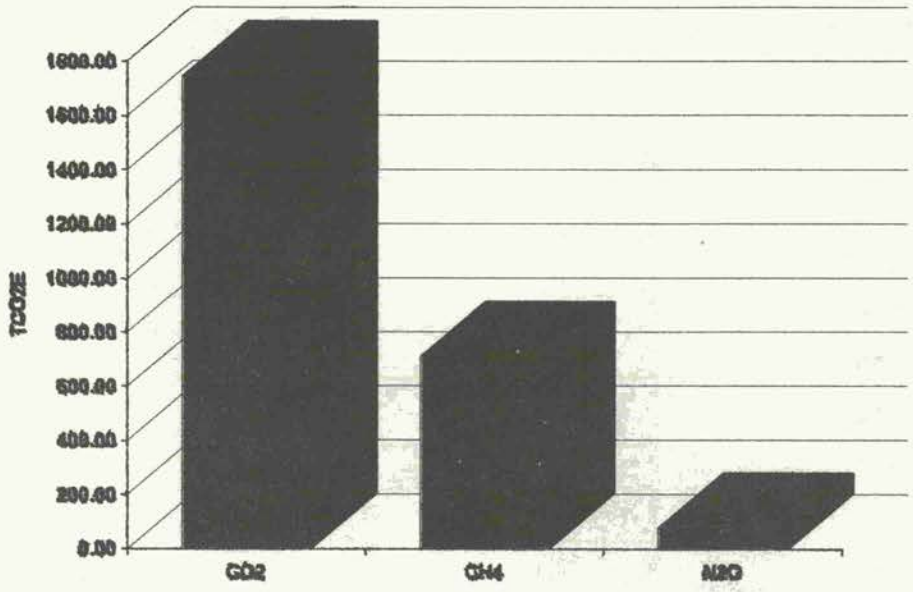
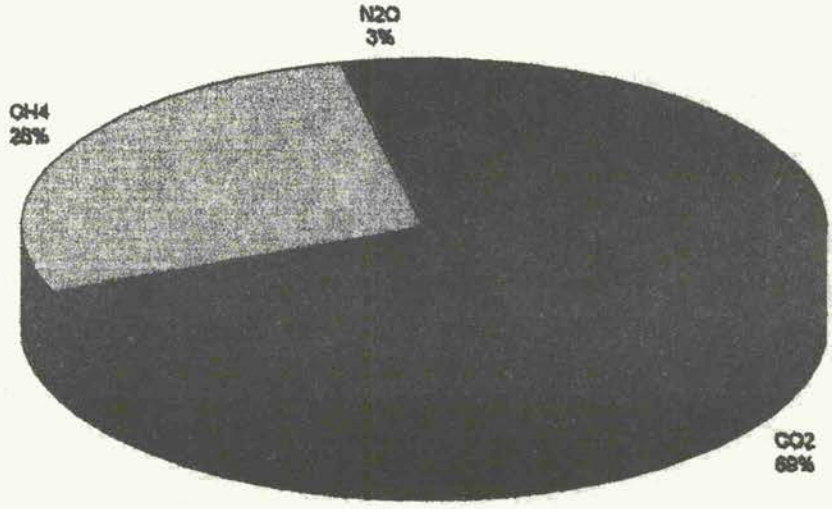


Figure 6.4: Percentage contribution by Type of Gas in The Gambia (1993) using GWP (TCO2E) comparison



ANNEX I

THE TRANSPORT SURVEY

BY

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&

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REPORT ON THE TRANSPORT SURVEY

INTRODUCTION

The transport survey arose from the need to inventorize Gambia's sources and sinks of Greenhouse gas emissions. A survey of this nature had never been launched in the past. Previous transport surveys had focused mainly on traffic configurations in relation to travel patterns so as to facilitate the transport planning process. Hence careful planning was required if the survey was to be successful. Above all, a multi-sectoral approach was required so that the relevant data source could be identified and the logistics worked out accordingly. It was in view of this consideration that the planning Unit of the Ministry of Works & Communications and the Corporate Management Office of the Gambia Public Transport Corporation were invited to conduct the survey.

As a logical first step, contacts were made with various institutions, both government and private, concerned with issues relating to transport management and operation . Insurance companies, trade unions, the Department of Customs and Excise and the Police Department were visited frequently in an attempt to asses the degree of accuracy of their data collection systems and in particular, to ascertain whether these conform with the requirements of the development of an Inventory of Greenhouse Gas emissions. Following extensive discussions, it was decided that the records of the licensing Authority of the Police Department could be used as a reliable data source since they provided all the information spelt out in the UNEP format. It was also possible, in using these records, to effect spot checks to ensure if a particular vehicle is operational at the time of the survey. Once the original license application of a vehicle is retrieved, this could be cross-referenced to the renewal date in 1993 thus establishing that the vehicle in question is operational.

METHODOLOGY

The survey has the following objectives:

(1) to establish the total vehicle population in the country as at 1993.
(2) to establish the number of vehicles per category
(3) to establish the amount of fuel consumed in a period of 1 year in each category of vehicles
(4) to establish the distances covered by a vehicle in each category of vehicles.
(5) the age of a vehicle in each category

The survey was divided into two components namely Field Survey and Desk Survey. The Field Suevey sought to ascertain distances traveled by each vehicle and the amount of fuel consumed in the process over a one month period. The age of the vehicle was also taken into account. The latter involved an inventory taking of vehicles that were operational in 1993, in accordance with the characteristics hilighted above.

Following the selection of enumerators, training sessions were held and field exercises conducted at Kanifing. Given the volume of work involved a total of 11 enumerators were selected of whom two were deployed in the licensing Authority Office for the Desk Survey and the rest were engaged in the Field Survey.

RESULTS

Both components commenced on 17 September 1993. While the Field Survey ran for 1 month, the Desk Survey continued for two months and ended on the 21 November 1993. Thus both components complimented each other in providing the required data.

The Desk Survey identified the following vehicle categories.

(1) Light Duty Gasoline Vehicles (LDGPV)
(2) Light Duty Gasoline Trucks (LDGT)
(3) Heavy duty Gasoline Vehicles (HDGV)
(4) Light Duty Diesel Vehicles (LDDV)
(5) Light Duty Diesel Trucks (LDDT)
(6) Heavy Duty Diesel Trucks (HDDT)
(7) Motor Cycles (MC)
(8) Other Tractors, harvesters, bulldozers, boats aircraft, etc.)

It was revealed that there are about 25,700 vehicles registered in the Gambia. The result was however refutted by members of the National Climate Committee and at both the Regional Workshop in Nairobi, Kenya and the National Workshop in The Gambia. A verification of the Survey was requested and results showed that the records obtained from the Police Department contained a lot of dead cars. The number of dead cars could not be assessed because of the short period of the Survey. It was therefore decided that figures from the Desk Survey should be dropped and be used later for an other purpose after thorough analysis. The results can be used in the Greenhouse Gas Mitigation analysis to identify scrapage rate, for example.

The Field Survey was conducted in all parts of the country. Given the presence of greater numbers of vehicles in the Greater Banjul Area, it was decided to commence the survey in this area and gradually spread to other parts of the country. Enumerators armed with simple questionnaires would stop a vehicle when it was convenient to do so and, after the usual courtesies, engage the driver in a short but revealing interview. A total of 5,232 vehicles was covered and this figure is close to the records at the Central Statistics Department where the number of vehicles registered and re-registered in The Gambia is about 9,000. It is for this reason that the results of the Field Survey are kept and those of the Desk Survey are discarded for further use. The coverage is sufficient to give responsible accurate indicators of the facts being investigated.

Of the 5,232 vehicles covered, 2,532 are LDGPV, 730 are LDGT, 161 are HDGV, 226 are LDDPV, 1038 are LDDT, 153 are HDDT, 107 are Ships/boats and motorized canoes, 200 are Motorcycles, 3 are Aircrafts, and 30 are Non-road Vehicles.

It has been reliably learnt that average of thirteen aircraft landings are made daily at Banjul International Airport. The fuel consumed by these aircraft could not be realistically assessed as the air space of the Gambia is so small that only a negligible quantity is consumed over Gambia territory. The quantity of fuel supplied to international flights for 1993 was

A total of 155 fishing trawlers have been licensed to operate in the Gambian waters for 1993. Seventy-six of these are registered in the Gambia. The total fuel supply to these vessels was 912,323 litres. The average distance traveled in Gambian waters in any period of time could not be assessed as the records are not available.

There are about 15 recreational boats in the country; these consume about 150 litres of fuel daily. The distance covered per day could not be assessed due to lack of reliable recording system.

REPORT ON THE FUELWOOD SURVEY:

INTRODUCTION

It is a known fact that wood is the most predominantly utilized fuel in the Gambia. However, there has not been much effort by way of surveys or other fact finding studies, to ascertain its consumption rate, its contribution to desertification or to the greenhouse gas effect, and the sustainability of the activity based on the available forests. Thus this Survey was a timely effort not only for thr development of the Inventory but also for other useful purposes in the future.

This survey was carried out by the task force on fuelwood consumption, comprising of the Central Statistics Department (CSD) and the Department of Community Development (DCD). The task force is part of the Gambia National Climate Committee formed in November 1992, comprising of a number of government departments and other relevant organizations under the leadership of the Department of Water Resources. The Survey aimed at evaluating the fuelwood consumption throughout the whole country. These figures shall be input in the Methodology calculations, along with other types of data, to determine the quantity of greenhouse gases emitted into the atmosphere in The Gambia, and thus quantify our national contribution to the greenhouse effect and global warming.

METHODOLOGY

Given the existing latitude of variation in the consumption of fuelwood across the country, for any survey to be comprehensive, thorough and yield the required results it needs to be conducted countrywide.

To ensure that the above is fulfilled, the selection procedure recognized the existing local government areas (LGA) as primary sampling units. The number of enumeration areas (EAs) assigned to a LGA depended on the size of its populations. This is to say that proportionate sampling unit should be the household.

As for Banjul and Kanifing Municipal Council (KMC), the populations do not present so mush heterogeneity so a simple random method of selection was used to select the EAs for inclusion.

The remaining six LGAs (Brikama, Mansakonko, Kerewan, Georgetown and Basse) were treated differently. This stems from the fact that each of the administrative headquarters of these LGAs is characterized by life styles distinct from the rest of the settlements in the same LGA. Thus the LGA was split into two substrata, the administrative headquarters, and the rest of the LGA. The rest of the LGA outside the administrative heardquarters is typically characterized as more rural. The number of EAs selected from each substratum depended on its size in relation to the whole. All the EAs selected were fully enumerated.

TRAINING AND DATA COLLECTION

In order to accomplish the task, a total of fifty enumerators and five supervisors were recruited and given two days training at the Rural Development Institute in Mansakonko about 200kms from Banjul. Two of the Supervisors were also charged with overall coordination of the Survey in addition to other supervisory duties. The data collection commenced two days after training, i.e., 3 September 1993 and lasted for twenty-two days. The consumption figures presented are those reported by the respondents for any seven days period between 3 September and 26 September 1993.

The enumeration was done by well experienced dedicated and perseverant enumerators. Supervision was very thorough both from the Survey coordinators and the Project management, which ensured proper data collection and avoidance of shortages of materials like questionnaires, especially.

The personal interview method of data collection was used. The enumerators asked the respondents about their fuelwood consumption in the last six days. On the day of his/her arrival for interview (the seventh day) he/she went with a scale and weighed the fuelwood to be consumed for that day. The data are recorded in the questionnaires.

Despite the above facts, the figures are not the perfect consumption of fuelwood owing to the following facts:

1. Data collection was done during the rainy season and no adjustments were made for the increase in weight of fuelwood due to absorption of moisture. This may not be totally alarming since only flammable wood was weighed.

2. The amount of wood consumed is highly seasonal especially in the rural areas, where its use for heating is crucial during the cold period (October to January). If annual consumption rates are required the survey should be

conducted during the dry season and be repeated for one or more years to establish trends.

3. Despite all efforts to alley fears and false anxieties, the price figures reported, especially for areas outside the Greater Banjul might have been inflated. This is however not unique to this survey; almost all inquiries into expenditure figures are inflated to some extent. This was because the Survey coincided with the campaign through/over radio of the possibility of introducing butane gas as a substitute to fuelwood.

CONCLUSION/RECOMMENDATIONS

The results of the survey show that over 107,500 (Figure 2a & 3a) households in the entire nation depend on firewood for the preparation of their meals. This figure represents about 97.6% (figure 2b) percent of the national population. Dependence on firewood as the main source of fuel for cooking is countrywide. Only a minority few, who are likely to be the affluent, use alternative fuels. In some LGAs such as Georgetown and Kuntaur, the survey suggests an entire dependence on firewood for cooking (figure 2a). It is only in the Greater Banjul (Banjul and Kanifing) that nearly five percent of the households afford alternative fuel types. It is encouraging to note that in this area nearly five percent of the population is using butane gas for cooking purposes.

Already it has been pointed out that about 97.6% of the households in the Gambia depend on firewood as their main source of fuel for cooking. The breakdown of the above figure into the various species of wood revealed that 42% of the households depend on pterocarpus erinaceus locally called (keno) for fuel (Table 3b). This figure represents about 45,144 households (figure 3a). In Banjul, for example hardly any other type of wood is used other than pterocartu erinaceus. In Kanifing 71.7 percent of all the household depend on this species. The second most important type of fuel consumed is the combretum glutinosum, locally called jambakatang, and it is utilized by about 20.0 percent of the population. Other widely utilized varieties include prosopis Africana (Kembo, 7.7 percent) and terminalia macroptera (wolo, 7.4 percent).

Table 4 gives the corresponding quantities of wood utilized per day in kilos and by type. It has been shown that the most vulnerable spices is the pterocarpus erinaceus which accounts for 37.1% and Combretum Glutinosum accounts for 25.6% of the quantity of fueled used in the Gambia.

The survey shows that approximately D477,062 worth of fuel is consumed daily in the Gambia. However, not all of this enters the market, especially in areas outside Greater Banjul. In view of the high dependence of Gambians on wood as source of fuel and the many socioeconomic implications this has both on fauna and flora, serious attention should be paid by the government to optimize the use of wood.

It is worth noting that wood is not only important as a source of fuel but also provides significant income for the dealers. But this significance of fuelwood as a source of income is at the expence of some unfriendly environmental effects, such as deforestation and emission of greenhouse gases which introduce other socioeconomic problems. The wood dealers' lust for short term benefits also provide no room for caution in conserving important flora species.

This study could not look into people's preferences for the various fuels that could be utilized domestically. However, the idea of introducing alternative fuels, especially for cooking and related operations, such as butane gas, is expected to be given applause welcome, other things being equal (including affordability). For our study, we therefore stipulate this as a recommendation.

Another factor that is likely to introduce uncertainty in the results of the Survey is the timeliness of the study. Since seasonal factors obviously come into play, the study should be conducted two or more times in the year to thrash out this effect. The Survey should also be conducted annually for at least five years to establish trends and to avoid bias trough the use of only one years data. This will improve the precision of the estimates derived from the data.

ACKNOWLEDGMENT

This Survey could not have been undertaken without the financial support of UNEP/GEF Country Studies Programme, the only agency that supplemented government's input (manpower and infrastructure). Special thanks must be extended to the Heads and staff of Departments of Central Statistics and Community Development for the support provided to us during the implementation of the Survey. Special tribute to the Department of Water Resources for their efficient management of the National Climate Committee and the Survey in particular. Our sincere regards are extended to the Department of Forestry, for providing a supervisor, and the respondents without whose cooperation the data could not have been solicited.

TABLE II.1 AGE DISTRIBUTION AND NUMBER OF HOUSEHOLDS PER LOCAL GOVERNMENT AREA

LOCAL GOVERNMENT AREA	AGE DISTRIBUTION		NUMBER OF HOUSEHOLDS	AVERAGE HOUSEHOLD SIZE
	0-15	16 AND OVER		
BANJUL	444.00	509.00	143.00	6.70
KANIFING	2,946.00	3,410.00	747.00	8.50
BRIKAMA	4,401.00	4,596.00	1,010.00	8.90
MANSAKONKO	7,131.00	1,874.00	402.00	10.00
KEREWAN	3,019.00	2,898.00	680.00	8.70
GEORGETOWN	1,722.00	1,786.00	433.00	8.10
KUNTAUR	960.00	1,049.00	174.00	11.50
BASSE	4,438.00	4,661.00	562.00	16.20
THE GAMBIA	**19,661.00**	**20,873.00**	**4,151.00**	**9.80**

TABLE II.2a NUMBER OF HOUSEHOLDS BY MAIN TYPE OF FUEL USED FOR COOKING

LOCAL GOVERNMENT AREA	MAIN TYPE OF FUEL USED				
	FIREWOOD	CHARCOAL	KEROSENE	BUTANE GAS	OTHERS
BANJUL	6,014.00	0.00	89.00	267.00	0.00
KANIFING	25,430.00	144.00	36.00	1,261.00	36.00
BRIKAMA	25,956.00	155.00	0.00	52.00	0.00
MANSAKONKO	7,177.00	18.00	0.00	18.00	0.00
KEREWAN	17,346.00	261.00	0.00	261.00	0.00
GEORGETOWN	10,691.00	0.00	0.00	0.00	0.00
KUNTAUR	5,915.00	0.00	0.00	0.00	0.00
BASSE	9,046.00	16.00	16.00	32.00	0.00
THE GAMBIA	**107,575.00**	**594.00**	**141.00**	**1,891.00**	**36.00**

TABLE II.2b DISTRIBUTION OF HOUSEHOLDS BY MAIN TYPE OF FUEL USED FOR COOKI

LOCAL GOVERNMENT. AREA	MAIN TYPE OF FUEL USED				
	FIREWOOD	CHARCOAL	KEROSENE	BUTANE GAS	OTHERS
BANJUL	94.4	0.0	1.4	4.2	0.0
KANIFING	94.5	0.5	0.1	4.8	0.1
BRIKAMA	99.2	0.6	0.0	0.2	0.0
MANSAKONKO	99.5	0.2	0.0	0.3	0.0
KEREWAN	97.2	1.4	0.0	1.4	0.0
GEORGETOWN	100.0	0.0	0.0	0.0	0.0
KUNTAUR	100.0	0.0	0.0	0.0	0.0
BASSE	99.3	0.2	0.2	0.3	0.0
THE GAMBIA	**97.6**	**0.6**	**0.1**	**1.7**	**0.0**

TABLE II.3A NUMBER OF HOUSEHOLDS BY WOOD TYPE USED

	WOOD TYPE USED					
LOCAL GOVERNMENT AREA	PTEROCARPUS ERINACEUS (keno)	PROSOPIS AFRICANA (kembo)	COMBRETUM GLUTINO (Jambakatang)	TERMINALIA MACROTERA (wolo)	OTHERS	TOTAL
BANJUL	6,014.00	0.00	0.00	0.00	0.00	**6,014.00**
KANIFING	18,226.00	3,062.00	360.00	648.00	3,134.00	**25,430.00**
BRIKAMA	8,101.00	2,901.00	1,710.00	3,730.00	9,507.00	**25,956.00**
MANSAKONKO	2,315.00	807.00	1,471.00	413.00	2,171.00	**7,177.00**
KEREWAN	3,156.00	626.00	4,852.00	1,356.00	7,356.00	**17,346.00**
GEORGETOWN	3,062.00	321.00	6,296.00	370.00	642.00	**10,691.00**
KUNTAUR	2,447.00	306.00	1,598.00	442.00	1,122.00	**5,915.00**
BASSE	1,816.00	276.00	5,220.00	1,054.00	680.00	**9,046.00**
THE GAMBIA	**45,144.00**	**8,299.00**	**21,507.00**	**8,013.00**	**24,612.00**	**107,575.00**

TABLE II.3b PERCENTAGE DISTRIBUTION OF HOUSEHOLDS BY WOOD TYPE USED (%).

	WOOD TYPE USED					
LOCAL GOVERNMENT AREA	PTEROCARPUS ERINACEUS (keno)	PROSOPIS AFRICANA (kembo)	COMBRETUM GLUTINO (Jambakatang)	TERMINALIA MACROTERA (wolo)	OTHERS	TOTAL
BANJUL	100.0	0.0	0.0	0.0	0.0	100.0
KANIFING	71.7	12.0	1.4	2.6	12.3	100.0
BRIKAMA	31.2	11.2	6.6	14.4	36.6	100.0
MANSAKONKO	32.3	11.2	20.5	5.8	30.2	100.0
KEREWAN	18.2	3.6	28.8	7.8	42.4	100.0
GEORGETOWN	28.6	3.0	58.9	3.5	6.0	100.0
KUNTAUR	41.3	5.2	27.0	7.5	19.0	100.0
BASSE	20.1	3.1	57.7	11.6	7.5	100.0
THE GAMBIA	**42.0**	**7.7**	**20.0**	**7.4**	**22.9**	**100.0**

TABLE II.4 **QUANTITY OF FUELWOOD CONSUMED PER DAY IN KILOGRAMS**

LOCAL GOVERNMENT AREA	TEROCARPUS ERINACEUS (keno)	PROSOPIS AFRICANA (kembo)	COMBRETUM GLUTINO (Jambakatang)	TERMINALIA MACROTERA (wolo)	OTHERS	TOTAL (KILOGAMS)	TOTAL (KILOTONNES)
BANJUL	27,484.000	0.000	0.000	0.000	0.000	27,484.000	**10,031.660**
KANIFING	133,050.000	22,350.000	2,629.000	4,733.000	22,877.000	185,639.000	**67,758.235**
BRIKAMA	76,319.000	11,316.000	15,085.000	23,613.000	88,631.000	214,964.000	**78,461.860**
MANSAKONKO	28,158.000	1,736.000	15,430.000	4,089.000	21,500.000	70,913.000	**25,883.245**
KEREWAN	20,681.000	4,798.000	38,357.000	15,363.000	60,253.000	139,452.000	**50,899.980**
GEORGETOWN	35,339.000	5,272.000	103,862.000	7,908.000	13,181.000	165,562.000	**60,430.130**
KUNTAUR	38,810.000	523.000	18,985.000	6,920.000	4,791.000	70,029.000	**25,560.585**
BASSE	32,720.000	2,964.000	96,461.000	19,121.000	10,205.000	161,471.000	**58,936.915**
THE GAMBIA	**392,561.000**	**48,959.000**	**290,809.000**	**81,747.000**	**221,438.000**	**1,035,514.000**	**377,962.610**

ANNEX III:

NATIONAL LIVESTOCK CENSUS
1993/1994

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LI VESTOCK NUMBERS AND COMPOSITION SURVEY:

INTRODUCTION AND BACKGROUND:

The National Livestock Census was conducted as part of the endeavour to inventorize sources and sinks of greenhouse gas emissions at the national level.

Due to the physiological nature of the stomach of ruminants (cattle, sheep, and goats) methanogenesis is a normal characteristic of ruminant digestion. However, non-ruminants (horses and donkeys) do emit methane also, although to a lesser extent. To get a global picture of the overall contribution of livestock to emissions of greenhouse gases it was thought prudent to include both ruminant and non-ruminant species in the Census.

Given that since 1977/78 no comprehensive livestock census has been conducted in the Gambia, Department of Livestock Services (DLS) has always recognized it as an important priority need which could not be fulfilled due to scarce resources.

In the absence of reliable data on livestock populations, the National Herd structure and population dymanics, policy makers, planners and researchers are forced to resort to data generated from sample surveys and estimates, (e.g., National Agricultural Sample Survey (NASS) and Livestock Sector Review) when the need arises.

It cannot be overemphasized that accurate/ realistic data on livestock populations (that only a census can generate) must be made available for the assessment of livestock/environment interface and its implications for sound environmental protection. It is in the above context that the need to conduct the 1993/94 national Livestock Census must be regarded.

Survey Methodology:

Prior to the onset of the census, livestock Owners countrywide were sensitized about the planned activity through panel discussions ("Radio Bantaba") and Radio announcements through the National Media.

A series of consultations/meetings attended by staff of the DLS and the International Trypanotolerance Centre (ITC) were held to design/develop the census questionnaires. Three separate questionnaires were developed for cattle, small ruminants and draught animals respectively. Guidelines for the interpretation of the terms/categories used in the questionnaires were also elaborated to help reduce error in data entry resulting in misapprehension of terms by the enumerators.

A total of 40 enumerators (drawn up mainly from DLS extension staff and some additional staff of ITC and Action Aid - The Gambia) and 5 supervisors (all Divisional Veterinary Officers of DLS) were recruited to execute the programme. A Training Workshop for supervisors was conducted in Abuko, the Headquarters of DLS on the 11th October 1993 and the objectives were to introduce participants to the questionnaires, have practical exercises and field test the questionnaires in Gunjur to allow for revision of the content in case they were found to be deficient in certain areas. Both the Workshop and the field testing of the forms were successfully accomplished and the necessary revisions an the documents were effected. The supervisors conducted Divisional Training Workshops for the enumerators duting the period of 14th-16th of October 18th, 1993 and the actual census was to start on October 18th, 1993 but an unexpected delay in the acquisition of funds resulted in the dates being shifted.

Each enumerator was assigned an enumeration area (EA) which coincided mostly with the administrative demarcation of a district although some of the larger districts (e.g , Upper Badibou, Fulladu West and East) had 2-3 enumerators working within the district. The supervisors were each responsible for an administrative Division except the supervisor for North Bank Division who was also supervising work in MacCarthy Island Division North (MID/N) to minimize need for frequent ferry crossings. All enumerators were given a listing of all villages in their respective EA (obtained from The Central Statistics Department).

The collected raw data were entered and analysed at the Computer Unit of the ITC and further analysed at the Orwin Microlab, Wye College, Unuversity of London. The data received from ITC in ASCII format were exhaustively analysed using Microsoft Excel 5.0.

Questionnaire Administration.

For the administration of these questionnaires, the enumerators had to visit each compound in the village/settlement and in consultation with compound heads and Livestock Owners, count the animals.

1. Cattle-enumerators visited cattle herds at their tying places ("Correo") early in the mornings and in consultation with herd owners and herdsmen counted the different sexes and age categories. Drought animals and non-Ndama cattle found in the herd were also counted.

2. Small ruminants and draught animals.

Data on small ruminants is segregated by species (sheep and goats) sex and breed. This information was collected from compound heads in the afternoons till early evenings (i.e after the herd visits to collect cattle data). Data on draught animals is also segregated by species (horses and donkeys), sex and then categorized.

CENSUS RESULTS AND DISCUSSIONS:

1. CATTLE DATA.

NO. OF VILLAGES	1,319
NO. OF OWNERS	5,026

FEMALE CATTLE

younger<1 year	26,730
not calved	52,831
calved	112,765
working female	1,080
FEM0ALE TOTAL	**193,406**

MALE CATTLE

younger <1 year	24,638
younger < 3 years	43,990
3 years and older	7,584
working male	7,758
MALE TOTAL	**93,970**
DRAUGHT CATTLE TOTAL:	**17,476**
GRAND TOTAL CATTLE:	**304,852**

2. SMALL RUMINANT DATA

NO. OF VILLAGES	1,713
NO. OF OWNERS	32,385

2.1 GOATS:

suckling females	67,979
non suckling	122,021
male goats	23,732
GOATS TOTAL (GOATS)	**213,732**

2.1 SHEEP:

Suckling	40,426
Non Suckling Females	90,561
Non Suckling Male	24,145
SHEEP TOTAL (GRAND)	**155,132**

3.0: DATA ON DRAUGHT ANIMALS:

NO. VILLAGES	1,658
NO. OF OWNERS	23,648
Young female donkey	4,222
Working female donkey	13,024
Young male donkey	3,374
Working male donkey	12,828
TOTAL DONKEYS:	**33,448**
Young female horse	1,893
Working female horse	7,616
Young male horse	1,514

Working male horse	6,533
TOTAL HORSES:	**17,556**
Mules	241
TOTAL HORSES AND MULES:	**17,797**
TOTAL DRAUGHT CATTLE:	**17,476**
GRAND TOTAL OF DRAUGHT ANIMALS:	**68,721**

A more detailed breakdown of the census results is given in Tables III.1 to III.3

CONCLUSIONS AND RECOMMENDATIONS

From 1990 to 1992 various estimates (NASS,) has put the cattle population at between 316,000 and 340,000 heads, however the actual population as recorded through the census was only 278,538 heads, plus and additional 17,476 draught cattle population making a grand total of 296,014 heads. This points out clearly the inadequacy of over dependence on estimates/projections.

Given that data from the Ministry of local Government and Lands indicates that there are about 15000 villages and approximately 5,000 heads in the country and enumerators have recorded data from 1,319 villages and 5,026 herd owners, all the indications are that the census was conducted in a diligent manner.

In connection to the cattle data the small ruminant population has recorded an overall increase from the estimates (i.e ., an increase of about 11,000) of 1991.

With regards to the National Cattle herd, the recommendation will be to effect a policy of increasing numbers to reach target population of 300,000. This target could be attained through curbing calf mortality concomitant with an increase in off-take productivity .
It is also clear that the country can sustain a numerical increase in the small Ruminant population given the popularity of semi-intensive production systems like fattening scheme being promoted by the DLS.

Acknowledgments

The core funds for conducting this census was provided by the United Nation Environment Project (UNEP) through financial resources made available to The National Committee on Climate Change. The Department of Livestock Services is grateful for this assistance.

It will not be possible to list here all the agencies/departments/individuals who have in one way or the other contributed towards the successful conducting of this census.

On behalf of The Directorate of DLS, I am hereby expressing sincere gratitude to everyone who was in anyway involved in the census.

Special acknowledgment goes to The National Climate Committee, the supervisors, the enumerators, staff of the computer Unit at The International Trypanotolerance Centre, Radio Gambia and The Statistics and Information Unit of the Department of Livestock Services.

NATIONAL LIVESTOCK CENSUS 1993/94:

Table III.1 CATTLE DATA:

DATA PER DIVISION	KSMD	LRD	MID(N)	MID(S)	NBD	URD	WD	GRAND TOTAL
Total Female less than 1 year	48	2,750	3,736	5,309	4,005	6,644	4,238	26,730
Total Female not calved	53	5,395	7,125	9,382	10,266	12,153	8,457	52,831
Total Female calved	104	10,353	15,205	22,582	18,037	29,733	16,751	112,765
Total Male less than 1 year	41	2,672	3,285	4,990	3,743	6,307	3,600	24,638
Total Male less than 3 years	84	3,405	4,082	6,370	5,555	19,452	5,042	43,990
Total Male over 3 years	33	1,413	2,572	2,810	2,253	6,503	2,000	17,584
Total Working Female	0	41	208	164	614	26	27	1,080
Total Working Male	0	773	881	1,396	915	3,396	397	7,758
Total Working Oxen	3	3,660	543	5,465	2,672	1,026	342	13,711
Total Working Cows	0	249	67	3,024	211	205	9	3,765
DIVISIONAL TOTAL	366	30,711	37,704	61,492	48,271	85,445	40,863	304,852
Total non-Ndama	1	154	135	70	122	287	235	1,004

NB: TheTotal for non-Ndama species is included in the various categories and hence it is reported here only for information. Working cattle are of two types. Purely working cattle (working oxen and cows in the Table) are those kept at home and purposedly used as draught animals. Cattle clasified as working male and female in the Table are those kept in the bush with other cattle and sometimes used as draught animals

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