Country Case Study on Sources and Sinks of Greenhouse Gases in Senegal

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.

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Project GF / 4102-92-33

PNUE

United Nations Environment Programme (UNEP)
Organization for Economic Cooperation and Development (OECD) - Environment Directorate
Intergovernmental Panel on Climate Change (IPCC)
Global Environment Fund (GEF)

NATIONAL GREENHOUSE GAS INVENTORY : SENEGAL

Environment Directorate
Energy Directorate
Ecological Monitoring Centre
ENDA - Energy Programme

June 1994

CONTENTS

FOREWORD

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GLOSSARY

AGETIP	Agence d'Exécution des Travaux d'Intérêt Public
CFCs	Chlorofluorocarbons
CH_4	Methane
CHIPS	Copenhagen Image Processing System
CO	Carbon monoxyde
CO_2	Carbon dioxyde
COTOA	Compagnie des Textiles de l'Ouest Africain
CSS	Compagnie Sucrière Sénégalaise
BOD5	Biochemical Oxygen Demand
dm	dry matter
DO	Diesel Oil
ECU	Environmental Change Unit (University of Oxford)
EMC	Ecological Monitoring Centre
ENDA TM	Environment and Development in the Thirld World
ESMAP	Energy Sector Management Assistance Programme
GAC	Global Area Coverage
GDP	Gross Domestic Product
GEF	Global Environment Fund
Gg	Giga grams (1000 tonnes)
GHG	Greenhouse Gases
Gj	Giga joules
GO	Gasoil
GPS	Global Positionning System
GWP	Global Warming Potential
ha	hectare
HV	High Voltage (electricity)
ICS	Industries Chimiques du Sénégal
IPCC	Intergovernmental Panel on Climate Change
ITF	Inter Tropical Front
koe	kilogram oil equivalent
Landsat TM	Landsat Thematic Mapper (satellite)
LHV	Lower Heating Value
LPG	Liquified Petroleum Gas (butane)
LV	Low Voltage (electricity)
m^3	cubic meter

MASENS	Méthode d'Analyse du Système Energétique du Sénégal
MECI	Major Energy Consuming Industries
Mt	Million tonnes
$MTCO_2E$	Million Tonnes CO_2 Equivalent
MV	Medium Voltage (electricity)
MWh	MegaWatthour
N_2O	Nitrous oxyde
NAPE	National Action Plan for Environment
NOAA-AVHRR	National Oceanic and Atmospheric Administration - Advanced Very High Radiometric Resolution (satellite)
NOx	Nitrogen oxydes
NPK	Nitrogen, Phosphorus, Potassium
OECD	Organization for Economic Cooperation and Development
om	organic matter
PES	Plastiques Elastomères du Sénégal
PETROSEN	Société Nationale des Pétroles du Sénégal
Pj	Peta joules
RENES	Redéploiement Energétique du Sénégal
SAEC	Société Africaine d'Expansion Chimique
SAR	Société Africaine de Raffinage
sar	systematic aerial reconnaissance
SEGOA	Sénégalaise de Gaz, d'Oxygène et d'Acétylène
SENCHIM	Sénégal Chimie
SENELEC	Société Nationale d'Electricité
SIAS	Société Industrielle d'Aménagement urbain du Sénégal
SOCOCIM	Société Commerciale de Ciment
SONACOS	Société Nationale de Commercialisation des Oléagineux du Sénégal
SONEES	Société Nationale d'Exploitation des Eaux du Sénégal
t	tonne
toe	tonne of oil equivalent (in French : tep)
UNCED	United Nations Conference for Environment and Development
UNDP	United Nations Development Program
UNEP	United Nations Environment Program

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INTRODUCTION

Country Overview

Located between 12° and 17° 30' latitude north and 11° 30' and 17° 30' longitude west, Senegal is a West African country with an area of 196,192 sq km, and a dry tropical climate characterized by two seasons : a hot rainy season, from June to October and a dry season, with dominant north/north-east winds. The rainfall, which has been very erratic in the recent years, is influenced by the movement of the intertropical front and monsoon incursions. The climatic zonation (sudanian, sudano-sahelian, and sahelian zones) is reflected by the vegetation.

The population is estimated at 8 million inhabitants, with an annual 3 % growth rate. This trend is not followed by the economic growth rate which follows a negative trend, highly affected by the successive structural adjustment policies and a dependence on external aid. The devaluation of the CFA franc has added to these unfavourable conditions.

The Senegalese economy is dominated by the agricultural sector, accounting for 23 % of the GDP (1988). Over 70 % of the population - essentially rural - are engaged in this sector. The industrial sector contributes for 18 % to the GDP.

The energy sector is strongly dominated by the imports of oil products. The recent natural gas strikes are far short of being able to cover the country's energy requirements. Biomass fuel features high in the country's energy consumption, with a large domestic use of fuelwood and charcoal.

The use of this biomass for energy production has an important impact on the country's forest resources.

The Project Background

Senegal signed the ***United Nations Framework Convention on Climatic Change (UNFCCC)*** at the UNCED in Rio de Janeiro, in June 1992. The convention was ratified at the national level in May 1994.

The objective of the Convention is, according to its Article 2, *"the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent* *dangerous anthropogenic interference with the climate system. Such a level is to be achieved within a timeframe sufficient to allow ecosystems to adapt naturally to climate change..., and to prevent any threat to food production, while ensuring a sustainable economic growth".*

The Convention came into force in March 1994, and the first meeting of the Parties to the Conference will take place in March 1995 in Berlin. As from March 1997, Senegal - like all developing countries signatories to the Convention - is expected under article 12 *"to make available national inventories of anthropogenic emissions of all greenhouse gases not controlled by the Montreal Protocole, using comparable methodologies to be agreed upon by the Conference of the Parties".*

The methodology developed by IPCC/OECD (Intergovernmental Panel on Climate Change) in Cooperation with the OECD (Organization for Economic Cooperation and Development), and agreed upon by the Conference of the Parties permits all countries to have a common basis for preparing such inventories.

Thus, from July 1993 to June 1994, Senegal has conducted a GEF/UNEP funded national inventory, within the framework of a project coordinated by the Oxford University Environmental Change Unit (ECU).

The project was coordinated by the Ministry of Environment and Nature Protection, with the cooperation of the following bodies:

- ⇨ **Environment Directorate** : Wastes, Industrial Processes and CFCs;
- ⇨ **Energy Directorate** : Energy;
- ⇨ **Centre for Ecological Monitoring** : Agriculture and Land Use Change and forestry;
- ⇨ **ENDA - Energy Programme** : Technical assistance for all aspects of the study.

The team thus composed had the following tasks :

1. to collect available data, and where possible, complement them with field surveys;
2. to use these data to calculate greenhouse gas emissions according to the IPCC/OECD methodology;
3. to present a report of the results thus obtained.

In the process, we noted that such a methodology has some limitations. The most important one is that it ignores regional specificities, especially regarding the African countries. Some factors specific to Senegal have been used instead of the coefficients provided by the IPCC/OECD. All the comments and changes relating to the coefficients proposed for developing countries, are presented as notes accompanying the tables used for the calculation of greenhouse gas emissions.

The structure of the first six chapters of this report follows the order established in the IPCC/OECD methodological document entitled : "Greenhouse Gas Inventory Workbook - IPCC Draft Guidelines for National Greenhouse Gas Inventories . Volume 2."

Chapter 1: Energy
Chapter 2: Industrial Processes
Chapter 3: Agriculture
Chapter 4: Land Use Change and Forestry
Chapter 5: Wastes

Each chapter starts with a presentation of the sector, followed by methodological tables completed according to directions provided by the IPCC, and ends with comments relative to the application of such methodology to the sector being studied.

The conclusion of the report provides a synthesis of greenhouse gas emissions in Senegal in 1991, as well as a presentation of the sources of emission, the types of gas emitted, and an indication of their conversion in CO_2 equivalent, for an easy sectoral analysis.

Chapter I

ENERGY

The situation of the energy sector is based on the 1991 energy balance. Previous estimates (1988) had been made under the Project SEN/87/010 involving the United Nations Development Programme (UNDP), the Senegalese Ministry of Planning and Cooperation and the ENDA Energy Programme. It should be emphasized that some difficulties were encountered in the collection of all the statistical data necessary for the energy balance, which distort some comparisons and make them impossible.

However, data collected for the 1991 balance, compared to those for 1988, suggest **an increase of about 3% in the energy supply for a total final consumption which increased over the same period by more than 12 % , despite a decline of about 15% in oil product imports.**

It should be noted that the period under review coincided with the implementation of the RENES (Redéploiement Energétique au Sénégal) Programme, one objective of which is a drastic reduction in the imports of oil products.

I. ENERGY SUPPPLY

Like most Sahelian countries,the energy supply in Senegal is essentially based on biomass fuel, and on imports of crude oil and oil products.

(i) the domestic supply of fuels, mainly biomass fuel, accounts for over 489 000 toe, of which 174 476 is from bagasse and groundnut shells, over 4000 toe from natural gas, 579 toe from crude oil and 11 toe from methane.

Primary Energy Production (toe)

	1988	1991
Crude oil	2560	579
Natural Gas	7510	4 056
Methane (1)	-	11
Wood and Charcoal (2)	-	310 758
Bagasse	149 330	123 620
Groundnut shells	-	50 856
Total	159 400	489 880

Source : Energy Directorate / ENDA - Energy Programme.

(1): obtained from the decomposition of organic waste removed during the treatment of used water by SONEES for generating electricity energy.

(2): Fuelwood and charcoal production for consumption purposes

Concerning the bagasse, the quantities considered here are those used by the Senegalese Sugar Company (CSS) for generating electricity. Such quantities are below the national production level of agricultural waste.

(ii) Energy imports and exports (including international maritime bunkers) relate only to oil products and crude oil.

Overall balance of oil products

	1988	1991
Crude oil production (1000 t)	2.56	0.579
Crude oil imports (1000 t)	757.17	505.829
Petroleum products production (1000 toe)	705.35	529.978
Petroleum products imports (1000 toe)	236.82	339.079
Petroleum products exports (1000 toe)	87.75	66.397
Primary consumption of crude oil / petroleum products (1000 toe)	801.00	829.387
Final consumption of petroleum products (1000 toe)	499.73	563.780

Source : Energy Directorate / ENDA - Energy Programme.

Oil product imports increased over the period 1988/1991, against the period 1986/1988, while those of crude oil decreased, leading to a slowdown in oil refining.

La Société Africaine de Raffinage (SAR), has not broken its habit of arbitration between its own activity and the direct imports of refined oil products, based on price conditions, in order to cover the market needs, under the most profitable conditions for itself.

(iii) Electricity supply in Senegal is mainly ensured by SENELEC, the National Electricity Board, through a large network connecting: Dakar, Kaolack, Saint-Louis, the regional centers (Tambacounda, Ziguinchor) and other remote secondary centers.

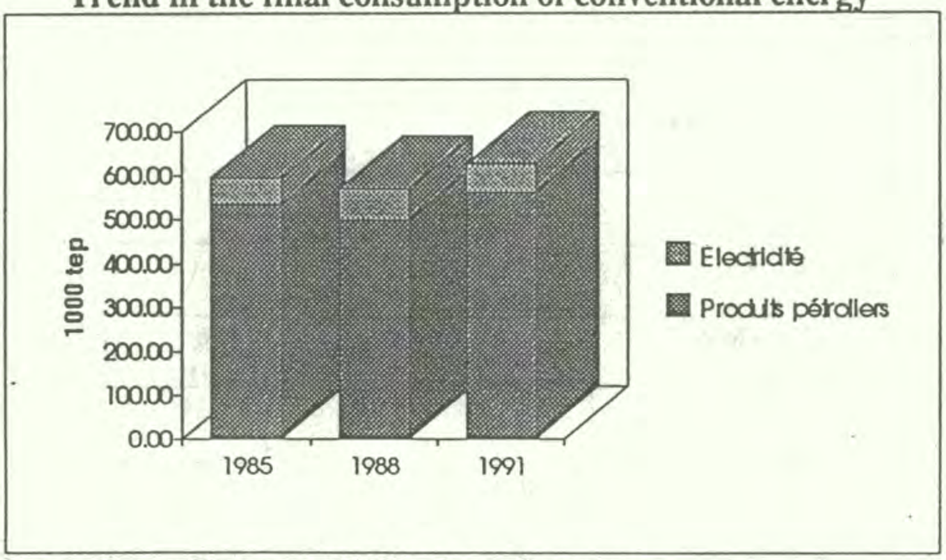
However, several self-producing industrial entreprises cover their own energy requirements and sell the surplus to SENELEC.

The production of electric energy still remains entirely of thermal origin: it went up from 838 GWh in 1985 to 924 GWh in 1991.

II. FINAL CONSUMPTION

The final consumption of conventional energy (oil products and electricity) increased by 16% between 1988 and 1991. Similarly, the oil products which accounted for 87.5% of this consumption (a stable proportion from 1988 to 1991), also recorded a steady increase, unlike electricity consumption which experienced a decline before slightly picking up again, without reaching, however, the 1988 level. (see diagram below).

Trend in the final consumption of conventional energy



Source : Energy Directorate / ENDA - Energy Programme.

The per capita consumption of conventional energy was estimated to be 86 koe (slightly higher compared to 1988); while that of electricity averaged 98 KWh, a drop of about 20% against 1988.

The 1988 sectoral distribution of the final consumption of oil products compared to 1991, is as follows :

Sectoral distribution of conventional energy final consumption

	1988	1991
MECI	23%	34%
Fisheries	9%	3%
Transports	53%	47%
Households	15%	15%

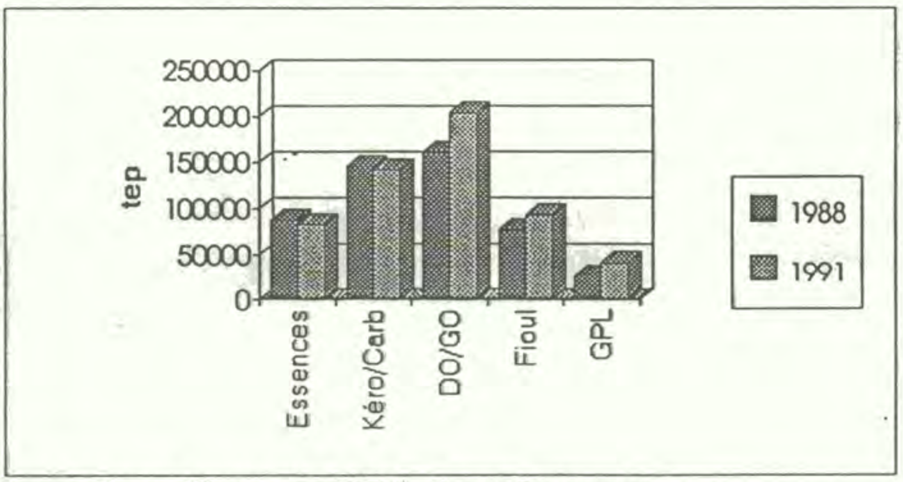
Source : Energy Directorate / ENDA - Energy Programme.

The transport sector (in particular road and air transport), though in relative decline, still remains a great energy consumer, largely outstripping the industrial sector whose relative share had, nonetheless,increased by 10 points from 1988 to 1991.

Only the relative share of the domestic sector in the final consumption remained constant (15%), while recording a significant absolute growth (from 77,000 toe in 1988, to nearly 100,000 toe in 1991).

2.1 Trend in the final consumption of oil products

According to the previously described trends and based on the various types of oil products (see graph below), the increases recorded relate to fuel oil, diesel oil/gas oil and LPG.

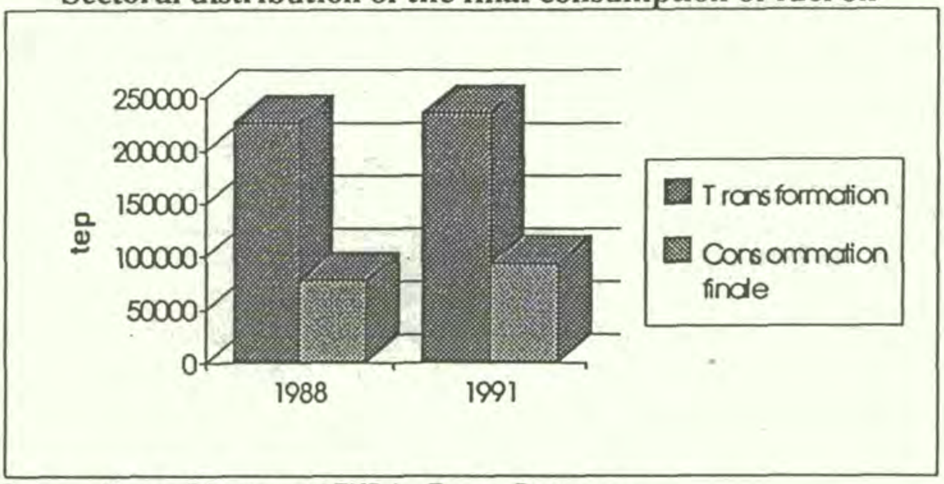


Source : Energy Directorate / ENDA - Energy Programme.

1- Fuel oil, which is mainly used by SENELEC for power generation and to a lesser extent by self-producers, is accounted for under: Energy Transformation in the balance;while the one used by industries is accounted for under the rubrique Fuel Oil

Final Consumption. One notes (see graph below) that, between 1988 and 1991, the consumption of fuel oil by industries increased more rapidly than for electricity production.

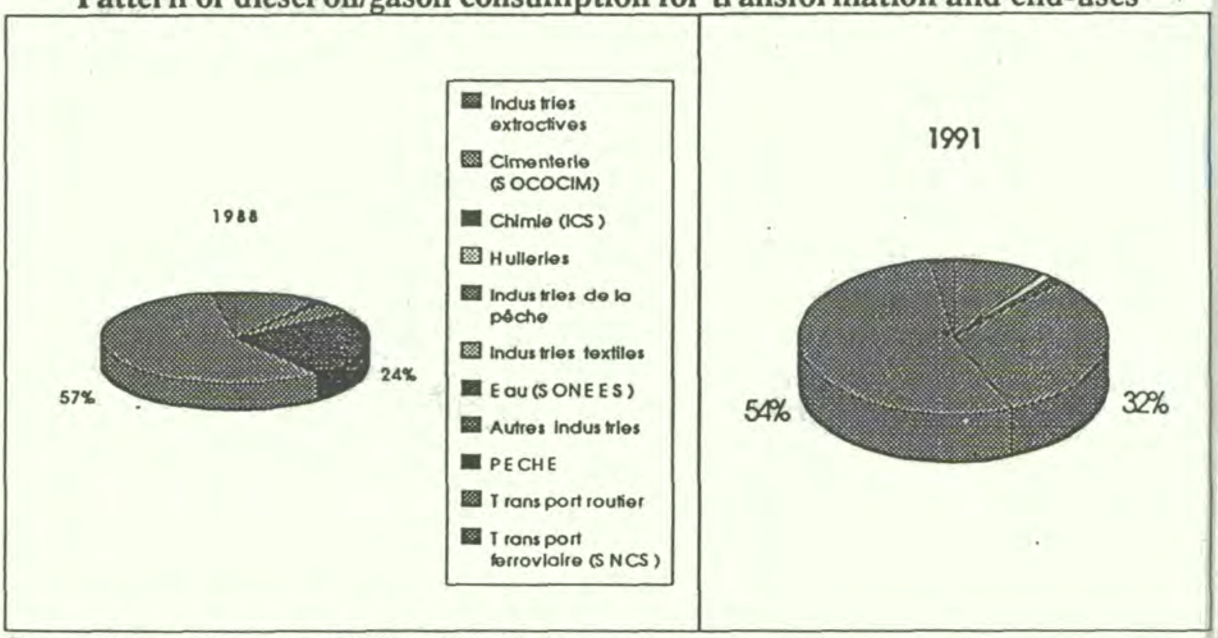
Sectoral distribution of the final consumption of fuel oil



Source : Energy Directorate / ENDA - Energy Programme.

2- The increase in diesel oil and gas oil consumption shows the growing share of industrial consumption and the continued dominance of the transport sector.

Pattern of diesel oil/gasoil consumption for transformation and end-uses



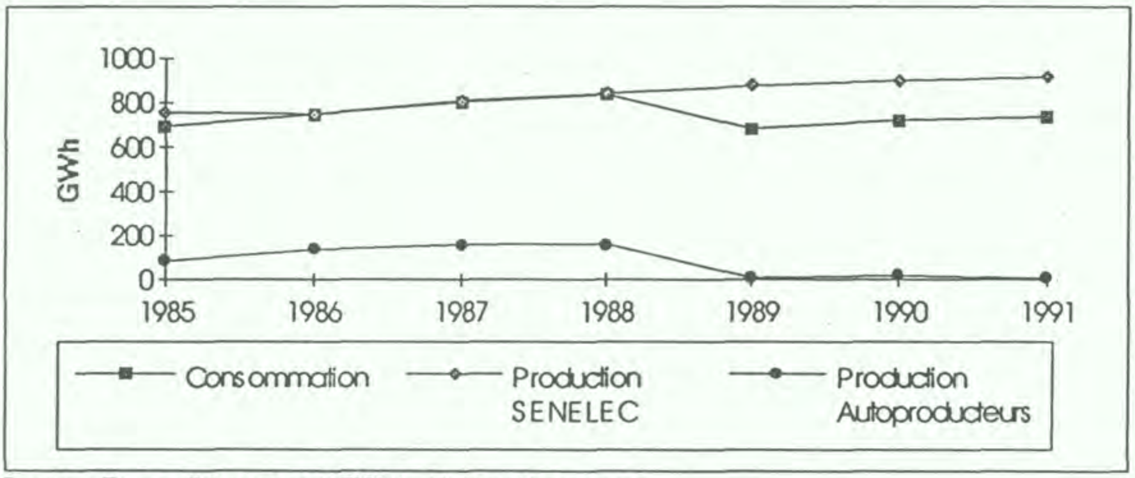
Source : Energy Directorate / ENDA - Energy Programme.

Overall, road transport continued to be the main consumer of diesel oil and gasoil. The extractive industries and railway transport, have maintained a stable.consumption level. Regarding fisheries, a sector in which data collection needs improvement,it is difficult to make any comparison.

3- The increase in the consumption of LPG (30% between 1988 and 1991) clearly indicates the on-going process of substitution for fuelwood and charcoal, typical of the energy transition taking place, particularly in urban areas. Such a process was initiated in 1987 (a 48.6% increase during the year) through a popular gas subsidization policy.

2.2 Trend in electricity production and consumption

Electricity consumption which kept pace with its production from 1986 to 1988, has had a less sustained growth since 1989.



Source : Energy Directorate / ENDA - Energy Programme.

The distribution by type of electricity consumed indicates a significant decline in low voltage which fell from 38% to 33% from 1988 to 1991. The shares of high voltage and mean voltage (industrial uses) went up from 40 to 42% and from 22 to 24% respectively. Electricity consumption in the industrial sector currently accounts for more than 65% of total electricity consumption.

2.3 Non-conventional energy consumption

The term "non-conventional energies" refers here to the bagasse used by CSS, the groundnut shells used by SONACOS, fuelwood and charcoal, which are mainly burned for domestic use, and methane transformed into electricity for self-consumption by SONEES.

The consumption of agricultural waste (groundnut shells and bagasse) for producing steam and electricity, increased by 16.8% betweeen 1988 and 1991, rising from

149,330 toe to 174,476 toe This growth was accompanied by a similar increase in the consumption of industrial oil products mentioned earlier on. This led to a significant increase in the energy consumption of the industrial sector during this period.

With respect to fuelwood and charcoal, only official data from Service des Eaux et Forêts are reported here, and only controlled production is taken into account. Fuelwood and charcoal consumption exceeds 200,000 toe, almost doubling the consumption accounted for in the estimates (104,351 toe).

Finally, SONEES reclaims organic waste when treating used water. From digesters, it produces methane which is transformed into electricity for its own use. Although the quantities produced are negligible, this proves the existence of untapped sources for the rehabilitation of waste, and more generally of renewable sources of energy (ENR).

III. APPLICATION OF THE IPCC/OECD METHODOLOGY

BILAN ENERGETIQUE DU SENEGAL - 1991

(tep)	Pétrole brut	Essence auto-avion	Kérosène et Carburéacteur	Diesel et Gazole	Fioul	Gaz de Pétrole Liquéfié	TOTAL Produits Pétroliers	Gaz Naturel	Electricité	TOTAL Energies Conventionnelle	Bagasse	Coque d'arachide	Bois de feu	Charbon de bois	Méthane	TOTAL Biomasse et déchets	TOTAL Energies
	1 tonne = 1 tep	1 tonne = 1.05 tep	1 tonne = 1.03 tep	1 tonne = 1.01 tep	1 tonne = 0.98 tep	1 tonne = 1.1 tep		1000 m3 = 0.8 tep	1 MWh = 0.086 tep		1 tonne = 0.4 tep	1 tonne = 0.4 tep	1 tonne = 0.4 tep	1 tonne = 0.7 tep	1000 m3 = 0.16 tep		
1 PRODUCTION D'ENERGIE PRIMAIRE	579						579	4056		4635	123620	50856	310758		11	485234	489870
2 IMPORTATIONS	505829		72887	85022	144610	36553	844901			844901						0	844901
3 EXPORTATIONS (-)		21486	8864	33149	2612	286	66397			66397						0	66397
4 SOUTAGES MARITIMES (-)				1077	9005		10082			10082						0	10082
5 VARIATIONS DE STOCKS (+ ou -)	-43271	-10830	1784	-6821	-964	-284	-60386			-60386						0	-60386
6 CONS. BRUTE PRIMAIRE et EQUIV.	549679	-10656	62239	57617	133957	36551	829387	4056		833443	123620	50856	310758		11	485234	1318678
7 TRANSFORMATIONS	549617	-92251	-85651	-139519	55590	-5222	282564	4056	82207	204414	+123620	+50856	+301324	-94917	11	380883	585297
7.1 Raffinerie SAR	549617	-92251	-85651	-166357	-180497	-5222	19639			19639						0	19639
7.2 Centrales SENELEC				25962	230699		256661	4056	-79513	181205						0	181205
7.3 Centrales Auto-Producteurs				876	5388		6264		-2695	3570	+123620	+50856			11	174476	178046
7.4 Charbonnières							0			0			+301324	-94917		206407	206407
8 AUTOCONS. INDUST. ENERG.					3115		3115			3115						0	3115
9 PERTES de TRANSP. et DISTRIB.							0		13466	13466						0	13466
10 UTILISATIONS NON ENERGETIQUES							0			0						0	0
11 CONSOMMATION FINALE		82780	141936	204269	93037	41759	563780		63352	627132			9434	94917		104351	731483
11.1 INDUSTRIES				89421	93037		182458		19189	201647						0	201647
11.1.1 Industries Grandes Consommatrices				25347	31008		56354		19189	75543						0	75543
11.1.1.1 Industries extractives				19964	27129		47093		9095	56188						0	56188
11.1.1.2 Cimenterie (SOCOCIM)				777			777		4341	5118						0	5118
11.1.1.3 Chimie (ICS)							0		302	302						0	302
11.1.1.4 Industrie du sucre (CSS)							0			0						0	0
11.1.1.5 Huileries				1249	777		2027		164	2191						0	2191
11.1.1.6 Industries de la pêche				78	1935		2012		1301	3313						0	3313
11.1.1.7 Industries textiles				390	1166		1556		646	2202						0	2202
11.1.1.8 Eau (SONEES)				2890			2890		3339	6228						0	6228
11.1.2 Autres industries				64074	62029		126104			126104						0	126104
11.2 PECHE		21159		25			21184			21184						0	21184
11.3 TRANSPORTS		61621	132084	113502			307207			307207						0	307207
11.3.1 Routier		61621		108610			170232			170232						0	170232
11.3.2 Ferroviaire (SNCS)				4892			4892			4892						0	4892
11.3.3 Aérien			132084				132084			132084						0	132084
11.4 MENAGES et AUTRES			9852	1320		41759	52931		44163	97094			9434	94917		104351	201445
11.4.1 Ménages						37661	37661		23648	61309						0	61309
11.4.2 Grande hotellerie				1320		4098	5418		2607	8025						0	8025
11.4.3 Autres			9852				9852		17908	27760						0	27760
12 ECARTS STATISTIQUES	62	-1185	5953	-7132	-11554	14	-13842	0	5389	-8453	0	0	0	0	0	0	-8453

Source : Energy Directorate / ENDA - Energy Programme.

CO_2 EMIS PAR LES ACTIVITES RELATIVES A L'ENERGIE

		Module	Energie				
		Sous-module	CO_2 émis par les sources d'énergie (approche des combustibles détaillés)				
		Tableau	1.1				
		Feuille	A				
ETAPE 1							
Types de combustibles			A Production	B Importations	C Exportations	D Mouvements de stocks	E Consommation apparente
							E=(A+B-C-D)
Fossiles liquides	Combustibles primaires	Pétrole brut (tonnes)	579	505829		43271	463137
	Combustibles secondaires	Essences (tonnes)			20463	10315	-30778
		Diesel/Gazole (tonnes)		84180	32821	6754	44605
		Fioul (tonnes)		147561	2665	984	143912
		Kérosène (tonnes)			3055		-3055
		Carburéacteur (tonnes)		70764	5551	1732	63481
		GPL (tonnes)		33230	260	259	32711
Total de fossiles liquides							
Fossiles gazeux		Gaz naturel sec (1000 m3)	5071				5071
TOTAL							
Soutes		Diesel/Gazole (tonnes)					1066
		Fioul (tonnes)					9189
		Total en soutes					
Biomasse		Bagasse (tonnes)	309049				309049
		Bois de feu (tonnes)	23585				23585
		Charbon de bois (tonnes)	135596				135596
		Coque d'arachide (tonnes)	127141				127141
		Biomasse totale					

Module	Energie
Sous-module	CO2 émis par les sources d'énergie (approche des combustibles détaillés)
Tableau	1.1
Feuille	B

Types de combustibles			ETAPE 2 F Facteur de conversion (Gj par tonne ou 1000 m3)	G Consommation apparente (Gj)	ETAPE 3 H Facteur d'émission (kg de C/Gj)	I Fraction de carbone (kg de C)	J Fraction de carbone (Gg de C)
				G = (E*F)		I = (G*H)	J=(I*0.000001)
Fossiles liquides	Combustibles primaires	Pétrole brut (tonnes)	41.855	19384599	20.0	387691983	387.692
	Combustibles secondaires	Essences (tonnes)	44.800	-1378854	18.9	-26060348	-26.060
		Diesel/Gazole (tonnes)	43.330	1932735	20.2	39041240	39.041
		Fioul (tonnes)	*39.775*	5724042	21.1	120777291	120.777
		Kérosène (tonnes)	44.750	-136711	19.6	-2679541	-2.680
		Carburéacteur (tonnes)	44.590	2830618	19.5	55197047	55.197
		GPL (tonnes)	47.310	1547557	17.2	26617987	26.618
Total de fossiles liquides				29903986		600585659	600.586
Fossiles gazeux		Gaz naturel sec (1000 m3)	41.860	212272	15.3	3247763	3.248
TOTAL				37555998		825012462	825.012
Soutes		Diesel/Gazole (tonnes)	43.330	46190	20.2	933034	0.933
		Fioul (tonnes)	*39.775*	42400	21.1	894634	0.895
		Total en soutes		88590		1827668	1.828
Biomasse		Bagasse (tonnes)	*16.747*	5175705	*29.9*	154753592	154.754
		Bois de feu (tonnes)	*17.000*	400945	*29.9*	11988256	11.988
		Charbon de bois (tonnes)	*29.000*	3932284	*29.9*	117575292	117.575
		Coque d'arachide (tonnes)	*16.747*	2129256	*29.9*	63664747	63.665
		Biomasse totale		11638190		347981886	347.982

Module	Energie
Sous-module	CO2 émis par les sources d'énergie (approche des combustibles détaillés)
Tableau	1.1
Feuille	C

Types de combustibles			ETAPE 4 K Carbone stocké (Gg de C)	ETAPE 4 L Emission nette de carbone (Gg de C)	ETAPE 5 M Fraction de carbone oxydé	ETAPE 5 N Emission réelle de carbone (Gg de C)	ETAPE 6 O Emission réelle de CO2 (Gg de CO2)
				~~L = (J-K)~~		N = (L*M)	O=(N*[44/12])
Fossiles liquides	Combustibles primaires	Pétrole brut (tonnes)		387.692	0.99	383.815	1407.322
	Combustibles secondaires	Essences (tonnes)		-26.060	0.99	-25.800	-94.599
		Diesel/Gazole (tonnes)		39.041	0.99	38.651	141.720
		Fioul (tonnes)		120.777	0.99	119.570	438.422
		Kérosène		-2.680	0.99	-2.653	-9.727
		Carburéacteur (tonnes)		55.197	0.99	54.645	200.365
		GPL (tonnes)		26.618	0.99	26.352	96.623
Total de fossiles liquides				600.586		594.580	2180.126
Fossiles gazeux		Gaz naturel sec (1000 m3)		3.248	0.995	3.232	11.849
TOTAL				825.012		912.804	3346.950
Soutes		Diesel/Gazole (tonnes)		0.933	0.99	0.924	3.387
		Fioul (tonnes)		0.895	0.99	0.886	3.248
		Total en soutes		1.828		1.809	6.634
Biomasse		Bagasse (tonnes)		154.754	0.90	139.278	510.687
		Bois de feu (tonnes)		11.988	0.90	10.789	39.561
		Charbon de bois (tonnes)		117.575	0.90	105.818	387.998
		Coque d'arachide (tonnes)		63.665	0.90	57.298	210.094
		Biomasse totale		347.982		313.184	1148.340

Module	Energie
Sous-module	Combustion de la biomasse non traitée pour la production d'énergie
Tableau	1.2 - Comptabilisation optionnelle de la combustion du bois de chauffage
Feuille	A

	ETAPE 1			ETAPE 2		ETAPE 3		ETAPE 4
Catégorie de population (rurale, urbaine, etc...) (spécifier)	A Population (par catégorie) (1000 personnes)	B Consom-mation annuelle de bois combustible par habitant (kt de ms/1000 personnes)	C Consom-mation annuelle totale de bois (kt de ms)	D Consom-mation annuelle de charbon de bois par habitant (kt de ms/1000 personnes)	E Consom-mation annuelle totale de charbon de bois (kt de charbon de bois)	F Facteur d'expansion de consommation de charbon de bois (kt de bois de chauffage / kt de charbon de bois)	G Consom-mation de bois pour le charbon de bois (kt de ms)	H Consom-mation totale de bois pour les combustibles (kt de ms)
			C = (A*B)		E = (A*D)		G = (E*F)	H = (C+G)
Dakar Urbain	1626.944	0.009	14.252	0.103	166.868	5.5	917.772	932.024
Dakar Rural	59.364	0.037	2.167	0.089	5.262	5.5	28.942	31.109
Louga Urbain	53.997	0.046	2.503	0.053	2.877	5.5	15.826	18.329
Louga Rural	454.723	0.222	100.912	0.013	6.115	5.5	33.632	134.544
Thiès Urbain	347.205	0.033	11.532	0.042	14.574	5.5	80.157	91.689
Thiès Rural	670.281	0.475	318.048	0.019	12.997	5.5	71.484	389.533
Diourbel Urbain	580.374	0.044	25.420	0.047	27.327	5.5	150.298	175.719
Diourbel Rural	96.478	0.376	36.271	0.016	1.565	5.5	8.608	44.879
Tambacounda Urbain	110.650	0.031	3.433	0.104	11.510	5.5	63.307	66.740
Tambacounda Rural	301.688	0.306	92.167	0.020	6.118	5.5	33.647	125.814
Kaolack Urbain	194.816	0.041	8.035	0.081	15.715	5.5	86.431	94.467
Kaolack Rural	673.063	0.377	254.021	0.002	1.535	5.5	8.445	262.465
Fatick Urbain	55.403	0.065	3.600	0.056	3.094	5.5	17.017	20.616
Fatick Rural	479.460	0.191	91.702	0.007	3.281	5.5	18.047	109.749
Ziguinchor Urbain	162.538	0.024	3.975	0.058	9.433	5.5	51.881	55.856
Ziguinchor Rural	267.762	0.610	163.214	0.001	0.376	5.5	2.067	165.282
Kolda Urbain	66.436	0.213	14.137	0.085	5.626	5.5	30.942	45.079
Kolda Rural	573.124	0.800	458.545	0.001	0.299	5.5	1.644	460.189
Saint-Louis Urbain	182.017	0.004	0.797	0.051	9.368	5.5	51.521	52.319
Saint-Louis Rural	508.635	0.177	89.855	0.007	3.610	5.5	19.854	109.710
TOTAL	7464.959		1694.587		307.549		1691.522	3386.109

METHANE ET AUTRES GAZ EMIS PAR LA COMBUSTION TRADITIONNELLE DE COMBUSTIBLES DE BIOMASSE POUR LA PRODUCTION D'ENERGIE

	Module	Energie					
	Sous-module	Combustion de la biomasse traditionnelle pour la production d'énergie					
	Tableau	1.3					
	Feuille	A					

	ETAPE 1			ETAPE 2		ETAPE 3		
	A Consom-mation totale de biomasse (kt de ms)	B Fraction de la biomasse qui s'oxyde (efficacité de combustion)	C Combustion de la biomasse (kt de ms)	D Fraction de carbone de la biomasse	E Quantité totale de carbone émise par les combustibles de biomasse (kt de C)	F Rapport CH4-C	G Carbone émis sous forme de CH4 (kt de C)	H Emissions de CH4 générées par la combustion de biomasse (Gg de CH4)
			C = (A*B)		E = (C*D)		G = (E*F)	H = (G*[16/12])
Bois de feu (1)	1694.587	0.87	1474.291	0.475	700.288	0.0120	8.403	11.205
Consom-mation de charbon de bois (2)	307.549	0.88	270.644	0.870	235.460	0.0014	0.330	0.440
Production de charbon de bois (3)	1691.522	0.18	304.474	0.475	144.625	0.0630	9.111	12.149
Bagasse	309.049	0.88	271.963	0.440	119.664	0.0050	0.598	0.798
Coque d'arachide	127.141	0.88	111.884	0.440	49.229	0.0050	0.246	0.328
TOTAL					1249.266		18.689	24.919

(1) : Consommation indiquée à la colonne C de la feuille de calcul 2 si elle est utilisée.
(2) : Consommation indiquée à la colonne E de la feuille de calcul 2 si elle est utilisée.
(3) : Consommation indiquée à la colonne G de la feuille de calcul 2 si elle est utilisée.

Module	Energie							
Sous-module	Combustion de la biomasse traditionnelle pour la production d'énergie							
Tableau	1.3							
Feuille	B							
	ETAPE 4			ETAPE 5				
	I Rapport d'émission de gaz trace CO-C	J C émis sous forme de CO (kt de C)	K CO émis (Gg de CO)	L Rapport de combustibles azote-carbone	M Quantité totale d'azote émise (kt de N)	N Rapport d'émission de gaz trace N2O-N	O Azote émis sous forme de N2O (kt de N)	P N2O émis (Gg de N2O)
		J = (E*I)	K=(J*[28/12])		M = (E*L)		O = (M*N)	P=(O*[44/28])
Bois de feu	0.06	42.017	98.040	0.010	7.003	0.007	0.049	0.077
Consommation de charbon de bois	0.06	14.128	32.964	0.000	0.000	0.007	0.000	0.000
Production de charbon de bois	0.06	8.678	20.248	0.010	1.446	0.007	0.010	0.016
Bagasse	0.06	7.180	16.753	0.015	1.795	0.007	0.013	0.020
Coque d'arachide	0.06	2.954	6.892	0.015	0.738	0.007	0.005	0.008
TOTAL		74.956	174.897		10.983		0.077	0.121

Module	Energie		
Sous-module	Combustion de la biomasse traditionnelle pour la production d'énergie		
Tableau	1.3		
Feuille	C		
ETAPE 6			
	Q Rapport d'émission de gaz trace NOx-N	R Azote émis sous forme de NOx (kt de N)	S NOx émis (Gg de NOx)
		R = (M*Q)	S=(R*30/14)
Bois de feu	0.121	0.847	1.816
Consom-mation de charbon de bois	0.121	0.000	0.000
Production de charbon de bois	0.121	0.175	0.375
Bagasse	0.121	0.217	0.465
Coque d'arachide	0.121	0.089	0.191
TOTAL		1.329	2.848

EMISSIONS DE METHANE POUR LA PRODUCTION DE PETROLE ET DE GAZ

	Module	Energie		
	Sous-module	Emission de méthane pour la production de pétrole et de gaz (approche à un niveau)		
	Tableau	1.5		
	Feuille	A		
ETAPE 1				ETAPE 2
Catégorie	A Activité	B Facteur d'émission	C Emission de CH4 (kg de CH4)	D Emission de CH4 (Gg de CH4)
PETROLE			C = (A*B)	D=(C/1000000)
Exploration et forage (Optionnel si des données sont disponibles localement) 1	Nombre de puits forés 0	kg de CH4 / puits foré		
Production 2	Pj pétrole produit 0.024	kg de CH4 / Pj 2650	64.220	0.000064
Transport	Pj pétrole chargé dans les pétroliers	kg de CH4 / Pj		
Raffinage	Pj pétrole raffiné 23.004	kg de CH4 / Pj raffiné 745	17138.144	0.017138
Stockage	Pj pétrole raffiné	kg de CH4 / Pj raffiné		
			TOTAL DE CH4 POUR LE	0.017202
GAZ				
Production	Pj gaz produit 0.212	kg de CH4 /Pj 68000	14434.500	0.014435
Traitement, transport et distribution	Pj gaz consommé 0.212	kg de CH4 /Pj 228500	48504.166	0.048504
			TOTAL DE CH4 POUR LE GAZ	0.062939
EVACUATION ET BRULAGE DANS LA PRODUCTION DE PETROLE ET DE GAZ	Pj pétrole et gaz produits	kg de CH4 /Pj		
			EMISSIONS TOTALES DE CH4 POUR LE PETROLE	0.080141

(1) : Facteurs d'émission non fournis.

(2) : Si les facteurs d'émission par défaut sont utilisés, ces catégories comprendront les émissions de production, autres que celles provenant de l'évacuation et du brûlage.

(3) : Si les facteurs d'émission par défaut sont utilisés, les émissions provenant de l'évacuation et du brûlage doivent être comptabilisées à cet endroit.

IV. COMMENTS

TABLE 1.1-B :

- Column F : *(Converting tons and 1,000 m3 to Gj)*

* For fuel : no conversion factor is indicated in Table 1-2, page 1.8. Consequently, we had to refer to an alternative source: "Memento d'Economie de l'Energie", 2nd Edition, 1986, Total-CFP/Direction Economique. Thus, the following calculation made:

1 toe = 41.868 Gj.
1t of heavy fuel = 0.95 toe LHV
1t of heavy fuel = (41.868 Gj x O.95) = 39.775 Gj.

* For biomass : As no conversion factor was indicated in Table 1-2, p. 1.8.,we calculated one for bagasse and groundnut shells on the basis of data derived from the Energy Estimates for the year 1991. We entered the figures corresponding to the bagasse and groundnut shells expressed in toe, which were multiplied by 41.868 Gj :

0.4 toe/t x 41.868 Gj = 16.75 Gj.

* For fuelwood and charcoal : we used the ESMAP/UNDP/World Bank coefficients provided in the Progress Report no. 096/89 of the Assistance Programme for the Management of the Energy Sector:

- Fuelwood: 17 Gj/t
- Charcoal: 29 Gj/t

- Column H : *(Emission Factor in kg C/Gj)*

* For diesel oil and fuel oil : Since no conversion factor is indicated in Table 1-3, page 1.9, we assumed that the diesel oil factor was equivalent to the gasoil factor : 20.2 Kg C/Gj. For heavy fuel, we used the residual fuel oil ratio as the next closest coefficient: 21.1 kg C/Gj.

* For bagasse, fuelwood, charcoal and groundnut shells : As more accurate national data were unavailable, we used the coefficient in Table 1-3, p.1.9., for solid biomass, or 29.9 kg C/Gj.

TABLE 1.1-C :

- **Column L** : *(Net Carbon Emission)*

We did not substract the result in Column K from the result in Column J, as allowed by the methodology. We simply entered the result in Column J, Table 1.1-B.

- **Column M** : *(Oxidized Carbon Fraction)*

* for biomass : we entered the figures provided in Table 4-10, p.4.22, module 4 (Agriculture), which indicates the general default values for oxidized fraction (combustion efficiency).

TABLE 1.2-A :

- **Column A** : *(Population)*

Data derived from the document: "Population du Sénégal: structure par sexe et par age en 1988 et projections de 1988 à 2015", Direction de la Prévision et de la Statistique, Dakar, Septembre 1992, 30 pages.

- **Column B & D** : *(Annual fuelwood and charcoal consumption)*

Estimates based on the study: "Les consommations domestiques d'énergie de cuisson en Afrique : le cas du Sénégal", Libasse Ba, ENDA - Programme Energie, Dakar,1991, 8 pages and appendices.

- **Column F** : *(Charcoal Consumption Expansion Factor, kt fuelwood, kt charcoal)*

* Conversion factor taken into account in constructing the energy balance.

TABLE 1.3-A :

- **Column B** : *(Fraction of Biomass which oxidizes)*

The coefficients entered for: fuelwood, charcoal, bagasse, groundnut shells, are those in Table 1-5, page 1.16

For charcoal production, we entered the coefficient used in constructing the energy balance: 18%.

- **Column D** : *(Carbon Fraction of Biomass)*

For charcoal consumption, we entered the figure in Table 1-5, page 1.16.

For fuelwood and charcoal production, we calculated the average of those values in Table 1-5.

For bagasse and groundnut shells, we entered the average value for agricultural residues in Table 1-5.

- **Column F** : *(CH_4-C Ratio)*

The figures used are from Table 1-6, page 1.17.

TABLE 1.3-B :

- **Column I** : *(CO-C Trace Gas Emission Ratio)*

The figure used is the ratio for general biomass provided in Table 1-6, Page 1.17.

- **Column L** : *(Nitrogen-Carbon Fuel Ratio)*

The figures used are from Table 1-5, page 1.16.

For charcoal consumption, we entered 0, as no data were provided in the various methodological documents.

For bagasse and groundnut shells, we entered the average value for agricultural residues.

- **Column N** : *(N_20-N Trace Gas Emissions Ratios)*

We applied the ratio provided for general biomass throughout, as recommended below Table 1-6, page.1.17.

TABLE 1.3-C :

- Column Q : *(NOx-N Trace Gas Emissions Ratio)*

We applied the ratio provided for general biomass, as recommended below Table 1-6, page 1.17.

TABLE 1.5-A :

- Column A : *(Activity)*

* <u>Number of oil wells drilled</u> : from PETROSEN.
* <u>Pj oil produced</u> : we multiplied the crude oil produced (579t) by 41.868 Gj by toe/1000000.
* <u>Pj oil refined</u> : we multiplied the oil refined (549,617t) by 41.868 Gj by toe/1000000.
* <u>Pj gas produced</u> : we multiplied natural gas production (5071 thousand m3) by 41.868 Gj by 1000m3/1000000.
* <u>Pj gas consumed</u> : we multiplied natural gas consumption (5071 thousand m3) by 41.868 Gj by 1000m3/1000000.

- Column B : *(Emissions Factor)*

* <u>Oil production</u> : estimated by taking the average in the range of values corresponding to "The Rest of the World" provided in Table 1-8, page 1.26 : (500+300)/2=2650 kg CH_4/Pj.
* <u>Oil refining</u> : estimated by taking the average in the range of values corresponding to "The Rest of the World" provided in Table 1-8, page 1.26 : (1400+90)/2=745 kg CH_4/Pj.
* <u>Gas processing, transportation and distribution</u> : estimated by taking the average in the range of values corresponding to "The Rest of the World", as provided in Table 1-8, page 1.26 : (340,000+117000)/2= 228500 kg CH_4/Pj.
* <u>Production of natural gas</u> : estimated by taking the average in the range of values corresponding to "The rest of the World" in Table 1-8, page 1.26: (40000 + 96000)/2 = 68000 kg CH_4/Pj.

Chapter II

INDUSTRIAL PROCESSES

I. CEMENT PRODUCTION

Cement production from Clinker is the only industrial process generating greenhouse gases. Other uses of industrial by-products for energy production have been reported in Chapter I dealing with energy.

Limestone (marl) which is locally extracted is milled, then burned at 1500 °C to produce clinker. Gypsum is added to the clinker to obtain cement.

Four types of cement are produced in Senegal :

- Cap-Vert: the main production of SOCOCIM, used in construction;
- CHF: for blast furnace construction;
- SCV: mainly used for works requiring high resistance to pressures, e.g. dams.
- SENAC: used for the production of asbestos.

Cement production from : 1989 - 1993

Year	1989	1990	1991	1992	1993
Clinker	359 995	432 604	469 363	561 635	552 245
Total cement	391 448	472 814	503 278	603 146	589 987
Including : Cap-Vert	372 934	452 640	491 411	594 667	581 554

Source : SOCOCIM.

II. APPLICATION OF IPCC/OECD METHODOLOGY

CO_2 EMIS DANS LA PRODUCTION DE CIMENT

Module		Procédés industriels	
Sous-module		CO_2 émis dans la production de ciment	
Tableau		2.1	
Feuille		A	
ETAPE 1			ETAPE 2
A Quantité de clinker produite (t)	B Facteur d'émission t de CO_2 / t de clinker produite	C CO_2 émis (t)	D CO_2 émis (Gg)
		C = (A*B)	D = (C/1000)
469363	0.4985	233977.456	233.977

III. COMMENTS

Table 2.1-A :

- **Column A** : *(Quantities of clinker produced)*

Source: SOCOCIM.

- **Column B** : *(Emission Factor, t CO2/t clinker produced)*

Figures provided on page 2.4, re : paragraph where it is indicated that : "the IPCC/OECD method assumes that the average CaO content in cement is 63.5%, so the recommended emission factor for cement production is 0.498 tonnes of CO_2 per tonne of cement produced".

Chapter III

AGRICULTURE

I. LIVESTOCK

The total number of the livestock has been estimated from a Systematic Aerial Reconnaissance (SAR) was made. The principle of SAR is the following : the animals are counted from a light aircraft fly at low altitude and on predetermined lines; this is followed by the use and extrapolation of the results to a geographically or administratively defined area.

Sampling is carried out according to rules which guarantee its representativity with some degree of accuracy : the distance between the set flight lines, the utilization of a Global Positioning System (GPS) that helps localize the observations made, the utilization of photographies and the consideration of altitude and speed.

A complete air coverage of Senegal was achieved in 1989 and 1990, resulting in the following assessment of the total number of livestock as follows :

1.1 Cattle

A total number of 1,765,546 head was identified at the national level.

The highest numbers are found in the Provinces of Linguère (169,816), Tambacounda (163,077), Matam (152,415), Bakel (141,700), Kaffrine (126,750) and Podor (103,048). These six Provinces account for almost 50 % of the inventoried cattle. The Province of Linguère where cattle breeding is the dominant activity contains 10 % of the cattle.

When comparing regional data, the Region of Saint-Louis (in the North) is by far ahead, with more than 20 % of the total; followed by the Regions of Tambacounda (in the East) and Louga (in the North) with 18 % and 16 %, respectively. These three Regions account for 50 % of the cattle.

Field surveys on the composition of the herds took three months. These showed that dairy cows represent 37.5 % of the total.

1.2 Small Ruminants

There are more small ruminants than cattle, with a total of 2,161,059 head.

The leading Province is Linguère (in the sylvopastoral zone) with 321,860 head, 15 % of the national animal population. The number of small ruminants in this Province is higher than in the other Provinces, except for Louga and Saint-Louis. The highest concentrations are found in the sandy Ferlo. The importance of small ruminants in such an adverse environment "highlights the remarkable resistance of small ruminants, their capacity to quickly re-establish their numbers, their role as food and for market oriented production and, especially, their paramount importance for those who live in such a constraining and uncertain environment" (Landais, 1985).

The Provinces of Podor and Matam have 288 534 and 284 840 heads respectively, more than 13 % of the total, followed by Kaffrine, further South, with 218,418 small ruminants : 10 % of the total. number.

However, numbers of small ruminants have decreased in the North, since 1989, when Mauritanians stopped their transhumances in that part of the country.

The Central-Western rural Provinces have the highest densities with 33 head/km^2 in Bambey and Diourbel and 29 in Mbacké.

As for cattle, the regional analysis of data shows the dominance of the Region of Saint-Louis which has 678,287 : 32 % of the national population of small ruminants. It is followed by Louga with 540,701 head : 25 % of the national population. Of course, the smallest numbers are found in Lower Casamance and in the Province of Vélingara in Higher Casamance, which are more oriented to agriculture and forestry than animal husbandry.

1.3 Horses and Asses

The figures relating to these two species have not been considered in this study due to their poor representativity by comparison with the former, and also to the unreliability of the results of their counting via the nation-wide Systematic Aerial Reconnaissance (some of these animals are kept in enclosures inside compounds). The figures emanating from the Department of Animal Husbandry have been used for these two types of animals, for which field census is relatively easy (the Plan of Action for Livestock) : 365,285 horses and 302,455 asses. The same applies for poultry, for which estimates are very approximate.

1.4 Poultry

Poultry statistics (which are impossible to estimate from an aircraft) are rather complex because of the great inter-annual variation in their numbers (mortality caused by diseases for traditional poultry, rapid reconstitution of their populations). According to official estimates (the Plan of Action for Livestock), Senegal had 10,500,000 in 1991, the reference year for this study.

II. RICE CULTIVATION

Rice production is an important component of Senegalese agriculture. The production areas are located in the North in Senegal River basin, the South-East in the Anambé bassin (irrigated regimes), and in the South where there is enough rainfall to flood shallow areas for rainy season crops. The cropping systems are rather numerous :

- Submerged and upland rice cultivation
- Plain upland rice cultivation with short cycle varieties
- Upland rice cultivation supported by an easyly accessible water table
- Shallow submerged rice cultivation with long or medium term varieties
- Aquatic rice cultivation in saline areas
- Irrigated rice cultivation with two production cycles per year.

The latter system is the most productive and involves continuous flooding, unlike the other two which involves intermittent flooding (little or no supervised traditional rice cultivation for subsistence).

The surface area and production of each of the two main cropping systems (flooded and intermittently flooded) were determined from the official statistics collected by the supervisory services and the regional agricultural services. Field missions made it possible to verify data accuracy and cropping systems.

III. SAVANNAH BURNING

Remote sensing was used to estimate the surface areas affected by savannah burning in 1991. The approach is based on an interactive supervised classification, validated in the field with a Global Positioning System (GPS).

The spatial analysis of the results shows a close relationship between fire occurrences and the exploitation patterns of the natural resources of the areas concerned.

3.1. Method of Estimation of Burned Areas Through Remote Sensing

The savannah burning map developed during this study is the result of the processing of NOAA-AVHRR images.

The distortions of the raw images are corrected using the conventional methods of geometric correction (Bocoum et al., 1991). This results in a corrected image, recorded in the five channels of the AVHRR sensor. The best prints are then selected, taking into account the cloud coverage criterion which is the main impediment to monitoring savannah fires with daytime images. In Senegal the sky is cloudy for much of the year, due to the circulation of the tropical trade wind which builds up between December and April, corresponding to a large part of the fire season; this is concludes with the first rains in June.

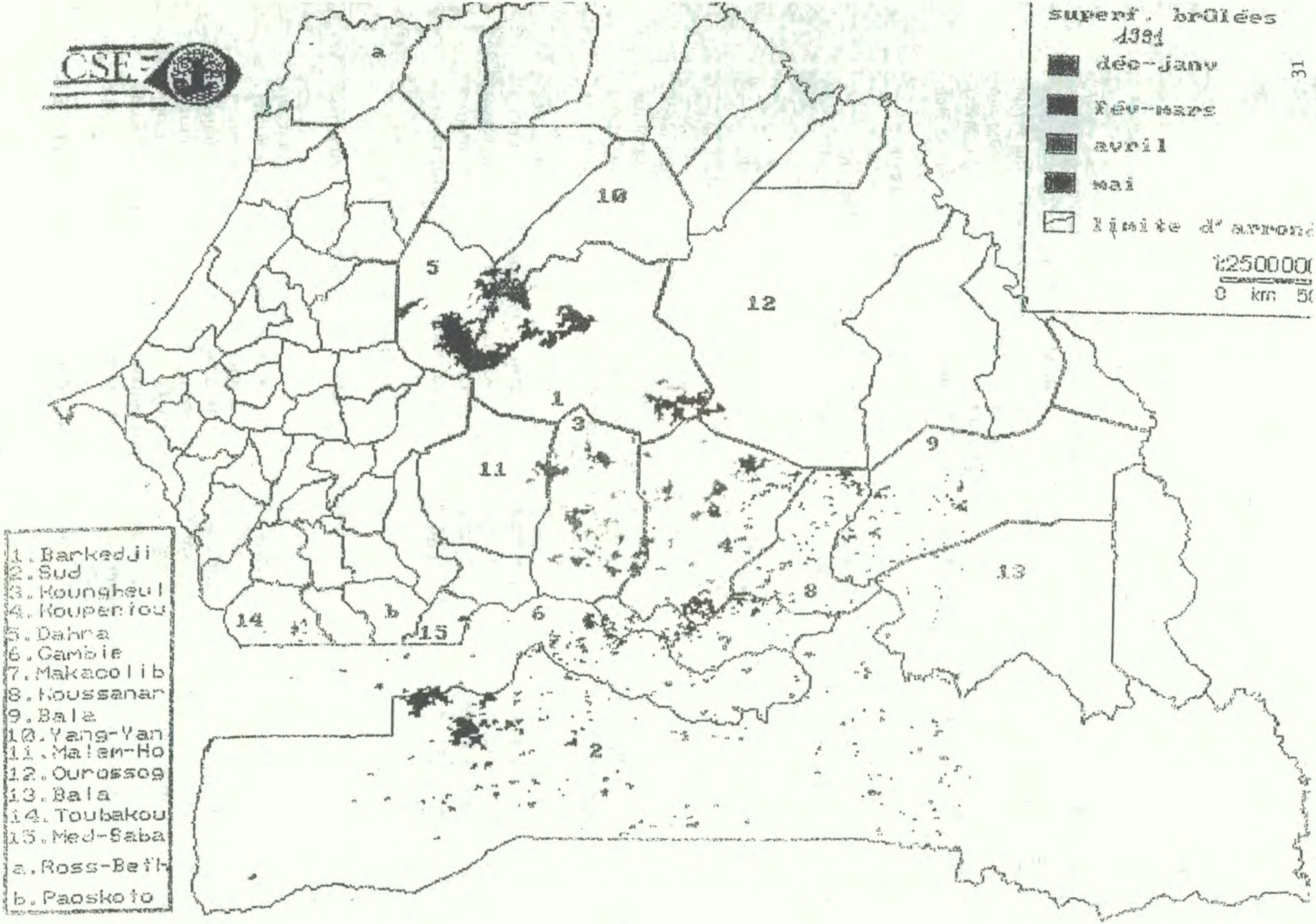
3.2. Classification of Burned Areas

The approach consists in a semi-automatic identification of burned areas. The starting point is a coloured image obtained after placing the channels of thermal (3), visible (1), and near infrared (2) in the red, blue and green, respectively. The resulting image permits the identification of distinct and dark spots representing burned areas, different from the permanent elements of the physical environment in that they suddenly appear and vanish progressively under the action of wind, trampling and several other factors (Langaas, 1991). This method of identification of burned savannah has been applied to wider areas in the sub-region, by resorting to NOAA-GAC images whose spatial resolution is far more reliable than AVHRR (Malingreau, et al., 1989).

Classification takes place interactively on the screen, using the CHIPS parallelepiped classification which uses thresholds taken from the specific frequency histogrammes. Such an approach is practical for two reasons :

- visual identification is made at a very early stage thanks to the channel combination, which allows for the adjusment of the thresholds used in the classification;

- the identified areas are those which have burned recently, giving remarkably low reflections, and which have not had enough time to evolve to a point that one can be dubious about their nature or area.



superf. brûlées
déc-janv
fév-mars
avril
mai
limite d'arrond
1:2500000
0 km 50
1. Barkedji
2. Sud
3. Koungheul
4. Koupentou
5. Dahra
6. Gambie
7. Makacolib
8. Koussanar
9. Bala
10. Yang-Yan
11. Malem-Ho
12. Ourossog
13. Bala
14. Toubakou
15. Med-Saba
a. Ross-Beth
b. Paoskoto

3.3. Identification and Mapping of Burned Areas

The result of image classification is superimposed on the map delimiting the sub-provinces. This operation is possible with the cross-tabulation module available in the Idrisi geographic information system software (Eastman, 1990). The final map permits the localization of the areas burned as a result of the passage of fires in the different sub-provinces of Senegal. In total the burned areas amount to 483,800 hectares, about 2.4 % of the national territory. It can be assessed either globally or by taking into account specific criteria such as the dates of occurrences (seasonality), local influences (variations...).

3.4. Analysis of Savannah Burning Distribution

a) Chronological analysis

The distribution map of savannah burning in 1991 (figure 1) shows a chronological evolution. The first big fires occured in the North in December, creating significant losses in grass cover. In February-March, the fires progressively shifted Southward in a more scattered way. Minor fires were observed a little further North in the second fortnight of May.

This evolution in time reflects the dryness of the grass cover, in keeping with a North-South gradient, due to the progessive arrival of the dry season following the withdrawal of the ITF (Inter Tropical Front). The influence of local conditions in the geography of burned areas is clear in two cases :

- in the North, in the Province of Linguère, the area and continuity of burned areas can be explained by the dominance of a continuous grass cover.

- in the South, the scattered structure of burned areas is due to the greater presence of trees which bring more discontinuity to a grass cover in which late drying perenials predominate, as well as a more dense human settlement.

b) Spatial Analysis

The study of the map shows that the burned areas are concentrated in the Central-Eastern part of the country, east of a line linking the Sub-provinces of Ross-Béthio in the North and Paoskoto in the South. This imaginary line isolates the major towns and a large part of the groundnut basin to the West; burned areas are located in the East (see figure 1), in the poorly populated regions (shrub savannah, forest/tree savannah zones), which sheds more light on the rural specificity of the savannah burning phenomenon (Fredericksen et al., 1990). However, there are no burned aeras in the far North which is essentially rural.

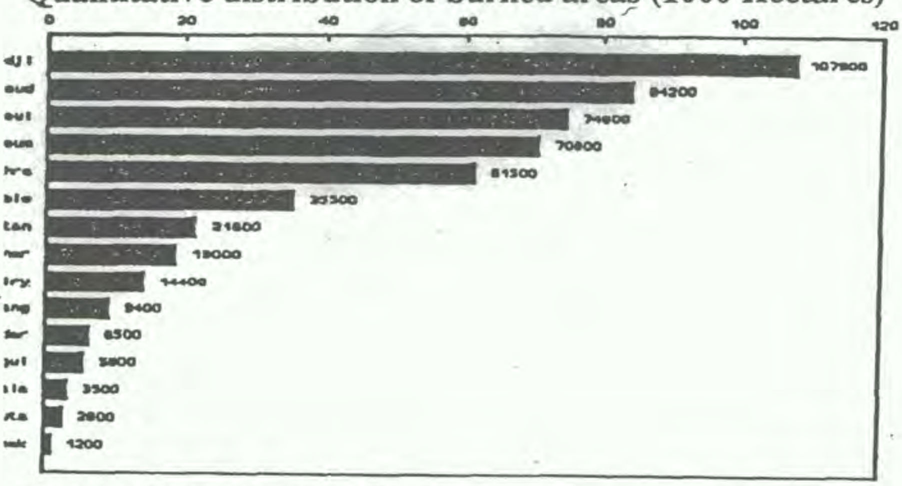
Burned areas are located in two major zones : the Southern part of the Province of Linguère; and the large corridor starting East of the Region of Tambacounda through The Gambia to the Provinces of Kolda and Vélingara. The demarcation line between these two entities goes along the northern part of the Provinces of Koumpentoum, Koungheul and Koussanar.

- Central-Western fires

These represent 35.5 % of the total area burned in 1991 and are distributed between the shrub savannah (196,800 hectares) the transition zone (141,500 hectares) and the low density agricultural zone (9,500 hectares). The pastoral zone in the North has a small share (300 hectares), which can be explained by the low level of plant production following a poor rainy season in 1991 in the Northern part of the country (very late rainfalls, inadequate distribution in time and space).

Fires are widely tributed in this Centre-West eco-geographic zone (previous table) which is a vast traditional cattle breeding area. The frequent population movements for grazing purposes constantly endanger plant resources, otherwise highly needed. They occur relatively early, since at the end of November the vegetation is so dry that fires can cover massive areas, if nothing is done to stop their progression as is often the case, due to the lack of maintenance of firebreaks.

Quantitative distribution of burned areas (1000 Hectares)



Source : Ecological Monitoring Centre.

- **Forest zone fires**

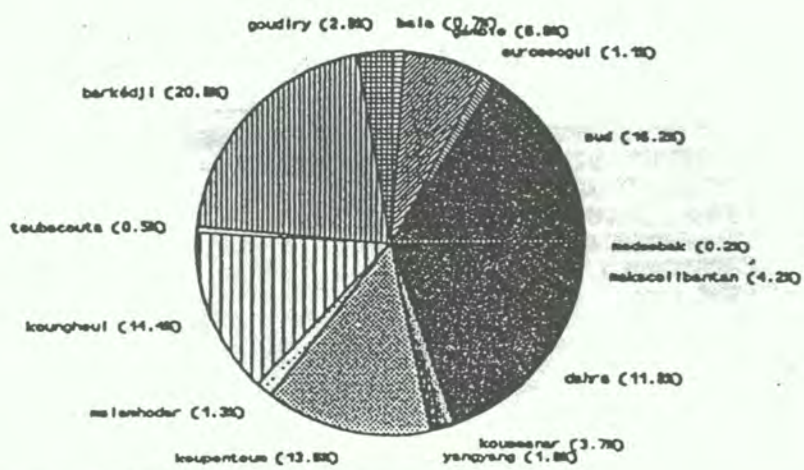
This second zone presents different characteristics to the previous one. In 1991 burned areas accounted for 64.5 % in this zone. The Provinces of Koumpentoum (70,800 ha) Makacoulibantang (21,800 ha), Koussanar (19,000 ha) and Goudiry (14,000 ha) are among the most affected. South of The Gambia (the Regions of Kolda and Ziguinchor) where 30 % of the land is devoted to agriculture, 84,200 ha burned. The use of fire for clearing purposes and the abundant combustible materials have largely contributed to the periodicity of fires in this part of the country.

In the classification, the Province of Kédougou is not taken into account, for reasons related to the high density of the plant cover which saturates the signal received by the AVHRR sensor. This should not significantly affect the results of this study, since fires have been relatively rare and strictly confined to a few areas in this zone where natural conditions (topography and moisture mainly) are little conducive to their spreading.

Finally, the statistics relating to fires in The Gambia have been taken into account in the graph (figure 3) so as to highlight the importance of the spatial continuity in fire dynamics.

Province-specific share of total burned areas

% du total des s.b. par arrondissement



Source : Ecological Monitoring Centre.

Overall, the time-space analysis of the fire map provides valuable data on the distribution of burned areas and the local variability of the phenomenon, which seems to be highly related to ecological and geographical conditions. It also suggests the existence of a close relationship between the way natural resources are managed by populations and repeated fires.

3.5. Quantity of Biomass Effectively Burned by Fires

The biomass effectively burned essentially relates to the grass vegetation; the contribution of the ligneous biomass (above ground) accessible to fires (dead leaves on the ground, shrubs, dry low leaves) is not easy to determine in the Sahelian context.

Superimposition of the 1991 biomass map on that of savannah burning made it possible to determine the total biomass burned. Cropping areas are not taken into account, since the biomass exposed (crops) is, to a large extent, spared by the fire, fields being cleared before the dry season and residues burned taken into account under "Land Use". The spatial distribution of the biomass effectively burned according to the type of savannah is indicated in the table below. Total biomass burned in savannah areas is 557 766 tonnes of dry matter, that is 1.4 % of the overall production of savannah areas, and 2.7 % of the grass biomass (in the calculation of gas emissions, about 80 % of this biomass is considered to be burned). In contrast to the North, where the grass cover has not grown very much, the shrub savannah has been more seriously affected.

Zonal Distribution of Burned Biomass

Affectation des sols	Biomasse totale	Biomasse exposée	Biomasse touchée par les feux
Zone pastorale	2 867 523 t/ms	1 714 200 t/ms	266 t/ms
Savane arbustive	3 454 600 t/ms	1 843 500 t/ms	188 000 t/ms
Savane arborée/forêt	21 440 500 t/ms	11 016 800 t/ms	105 100 t/ms
Zone de transition (savane arbustive associée à une agriculture très localisée)	2 502 600 t/ms	1 316 000 t/ms	136 300 t/ms
Zone agro-forestière	9 175 900 t/ms	4 731 500 t/ms	128 100 t/ms
Total	39 441 123 t/ms	20 622 000 t/ms	557 766 t/ms

Source : Ecological Monitoring Centre.

3.6. Origin of Savannah Fires

Field surveys made it possible to identify some causes of fires; they can be classified into two categories :

a). Anthropogenic Causes

About 99 % of the fires identified are anthropogenic, either through carelessness or lack of concern.

In Northern Senegal (highly pastoral) fires very often result from campfires that are not completely put out by herdsmen constantly on the move. Field investigations unveiled also the existence of fires deliberatly started in order to :

- speed up gum exudation from *Sterculia setigera* or *Acacia Senegal*;
- clear crop fields (quite generalized utilization of fire for clearing and preparing the fields for next crop year);
- enrich and renew grazing lands;
- clear roads and tracks;
- destroy agricultural and animal (e.g.,ticks) pests.

Cigarette ends thrown away by careless smokers are also said to have triggered several fires along main roads.

In the Southern part of the country (a forest zone mainly, with a dense cover) natural resource husbandry is the prime cause of savannah fires. Indeed with the depletion of wood resources in the North, following drought and massive felling, the exploitation zone has progressively been focussed in the South which is endowed with a more dense wood cover and a greater variety of species. On top of the considerable utilization of fire in many resource uses - including charcoal production, poaching in the game reserve of Niokolo Koba and hunting nearby, and honey harvesting - there are several socio-economic considerations that suggest a popular will to adopt a passive attitude as regards the regulations limiting their access to these very resources.

There are also other considerations : adjacency of The Gambia which creates a cross border dynamic (smuggling); the recurrence of fires along main roads, and especially the railroad; as well as the starting up of roadworks within the framework of the opening-up policy of the Region of Tambacounda (the opening of the road Dialakoto-Kédougou which goes through the game reserve of Niokolo-Koba).

b). Natural Causes

They are related to several factors, particularly lightening and rockslides. These factors contribute little to the area of savannah fires.

IV. BURNING OF AGRICULTURAL RESIDUES IN THE FIELDS

Agricultural residues include groundnut leaves, rice straw, millet and maize leaves and stalks, cotton leaves and stalks. In general, rural populations in the Sahel have several uses for these residues (cattle feed in the dry season, household and enclosure fences). In addition, the clearing work which gives rise to field burnings happens at the end of the dry season. The residues remain on the field for nine months, which explains why the fraction which has not been used in the ways mentionned loses its nutritive values partly through trampling from cattle, or rot on the spot. Thus, the burned fraction is very small for the country's main crops (groundnuts, millet-sorghum and maize).

- *Groundnut leaves* : they provide an important source of animal feed and at least 90 % (taking into account transport losses) are collected for this purpose by farmers and stored for the animals. The fraction burned on the field is negligible, or non-existent.

- *Millet leaves and stalks* : stalks are partly used to make fences, the rest is left on the spot. With consumption by livestock, deterioration through trampling (they remain on the field for the whole dry season) and the fraction that decomposes, the quantity burned when clearing the fields is estimated at 10 - 20 % . The leaves are used to feed the animals.

- *Maize leaves and stalks* : either the leaves are used as cattle feed or they progressively lose their nutritive values. But the stalks are not used for making fences as is the case with millet. Apart from the proportions consumed by livestock (about 30 to 40 %), they are mainly burned on the spot.

- *Rice straw* : In the rice growing schemes of the Senegal River Valley, where 70 % of local production come from, due to the supervision provided to the local population, 80 % of the straw is burned. The reason is to avoid a prolonged presence of wandering cattle in rice fields, as the latter are seen as the main vectors for the dissemination of wild rice (seeds contained in dung). The remainder is either gathered in the form of enriched (with molasse) husks, is used to feed the animals in the fold, or buried in the ploughed fields as organic fertilizer. In Lower and Middle Casamance, some rice residues are left in the fields for grazing, the remainder being also buried for soil improvement. The fraction burned is negligible.

- *Cotton seeds* : nearly one third are used to feed livestock, the remainder for vegetal oil production.

- *Cotton stalks* : they are not consumed by livestock and do not quickly lose their nutritive value because of their solidity. Apart from the small fraction used by local people for energy purposes (availability of several other combustibles in the production areas), more than 80 % of cotton stalks are burned on the field.

Residue/production ratios used in the calculation of gas emissions have been computed from field research by agricultural researchers.

V. FERTILIZERS

In order to obtain locally produced, as well as imported quantities, the previous approach was used with the producer and customs.

5.1. Production

Fertilizers are produced by ICS (Chemical Industries of Senegal).

NPK Fertilizers

Year	Total production (tonnes)
1989	116 780
1990	138 658
1991	171 045
1992	159 606
1993	130 643

Source : ICS.

5.2. Consumption

Fertilizers are marketed in Senegal by SENCHIM/ICS

Fertilizer Sales in Senegal

Type	% des éléments constitutifs			Total (tonnes)
	Azote (N)	Phosphore	Potassium	
Diamonium de phosphore (DAP)	18	46	0	2 482
Diamonium de phosphore (DAP)	10	10	20	1 662
Diamonium de phosphore (DAP)	6	20	10	6 137
Diamonium de phosphore (DAP)	8	18	27	1 439
DAP soufré et boré	8	18	27	8 700
Trisuperphos-phate (TSP)	0	40	0	1 897
Double superphosphate (DSP)	0	30	0	2 093
Double superphosphate (DSP)	14	22	12	5
Urée	46	0	0	7 548

Source : SENCHIM / ICS.

5.3. Imports

Type d'engrais	Importations (tonnes)
Nitrate de sodium	8
Nitrate d'ammonium	23 207
Urée	22 298
Autres engrais chimiques ou minéraux azotés	151

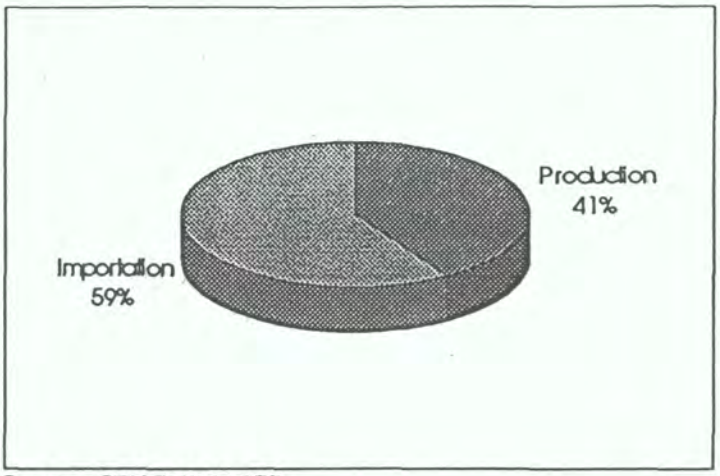
Source : SENCHIM / ICS.

5.4. Total Consumption of Fertilizers in Senegal

Importations	45 664
Production	31 963
Total (tonnes)	77 627

Source : SENCHIM / ICS.

As can be seen on the pie chart below, more than half of the fertilizers consumed in Senegal are imported.



Source : SENCHIM / ICS.

VI. APPLICATION OF IPCC/OECD METHODOLOGY

BETAIL

		Module	Agriculture			
		Sous-module	Emissions de méthane des animaux et du fumier animal			
		Tableau	4.1			
		Feuille	A			
Type de bétail	A Nombre d'animaux (1000)	B Facteur d'émission de fermentation entérique (kg/tête/an)	C Emissions de la fermentation entérique (Mg/an)	D Facteur d'émission pour la gestion du fumier (kg/tête/an)	E Emissions de la gestion du fumier (Mg/an)	F Total des émissions générées par les animaux et le fumier (Gg)
			C = (A*B)		E = (A*D)	F = (C+E)/1000
Vaches laitières	666.317	36	23987.4	1.000	666.3	24.654
Autres vaches	1099.229	32	35175.3	1.000	1099.2	36.275
Anes	302.455	10	3024.6	1.200	362.9	3.387
Moutons et chèvres	2161.000	5	10805.0	0.215	464.6	11.270
Chevaux	365.285	18	6575.1	2.200	803.6	7.379
Porcs	102.767	1	102.8	2.000	205.5	0.308
Volailles	10500.000	*0*	*0.0*	0.023	241.5	0.242
TOTAUX			79670.2		3843.8	83.514

CULTURE DU RIZ

Module	Agriculture				
Sous-module	Emissions de méthane générées par la production de riz				
Tableau	4.2				
Feuille	A				
ETAPE 1				ETAPE 2	
Régime de gestion des eaux	A Zone de récolte (Mha)	B Durée de la saison (jours)	C Mégahectares-jours (Mha-jours)	D Facteur d'émission (kg/ha-jour)	E Emission de CH4 par régime d'irrigation (Gg)
			C = (A*B)		E = (C*D)
Innondation constante	0.051	120	6.1	5.90	35.813
Innondation intermittente	0.048	120	5.7	3.98	22.848
TOTAUX	0.098		11.8		58.661

INCINERATION DE LA SAVANE

		Module	Agriculture				
		Sous-module	Incinération de la savane, émission de gaz trace sans CO2				
		Tableau	4.3				
		Feuille	A				
ETAPE 1					ETAPE 2		
A Zone incinérée par catégorie (k ha) (spécifier)	B Densité de la biomasse de savane (t de ms/ha)	C Biomasse totale exposée à l'incinération (kt de ms)	D Fraction réellement incinérée	E Quantité réellement incinérée (kt de ms)	F Fraction de biomasse vivante incinérée	G Quantité de biomasse vivante incinérée (kt de ms)	H Quantité de biomasse morte incinérée (kt de ms)
		~~C = (A*B)~~		E = (C*D)		G = (E*F)	H = (E-G)
Savane herbeuse 0.3	0.724	0.266	0.95	0.253	0.03	0.008	0.245
Savane arbustive 196.8	1.661	188.000	0.90	169.200	0.03	5.076	164.124
Zone de transition 141.5	1.660	136.300	0.85	115.855	0.03	3.476	112.379
Savane arborée / forêt 54.8	4.660	105.100	0.80	84.080	0.05	4.204	79.876
Zone agro-forestière 67.4	3.739	128.100	0.80	102.480	0.05	5.124	97.356
TOTAL		557.766		471.868		17.887	453.980

Module		Agriculture	
Sous-module		Incinération de la savane, émission de gaz trace sans CO2	
Tableau		4.3	
Feuille		B	
ETAPE 3			
I Fraction oxydée (efficacité de combustion) de la biomasse vivante et morte	J Biomasse totale oxydée (kt de ms)	K Fraction de carbone de la biomasse vivante et morte	L Total de carbone émis (kt C)
	Vivante : **J = (G*I)** **Morte :** **J = (H*I)**		**L = (J*K)**
Savane herbeuse			
Biomasse vivante 0.8	0.006	0.45	0.003
Biomasse morte 1	0.245	0.40	0.098
Savane arbustive			
Biomasse vivante 0.8	4.061	0.45	1.827
Biomasse morte 1	164.124	0.40	65.650
Zone de transition			
Biomasse vivante 0.8	2.781	0.45	1.251
Biomasse morte 1	112.379	0.40	44.952
Savane arborée / forêt			
Biomasse vivante 0.8	3.363	0.45	1.513
Biomasse morte 1	79.876	0.40	31.950
Zone agro-forestière			
Biomasse vivante 0.8	4.099	0.45	1.845
Biomasse morte 1	97.356	0.40	38.942
TOTAL	468.290		188.032

	Module	Agriculture	
	Sous-module	Incinération de la savane, émission de gaz trace sans CO2	
	Tableau	4.3	
	Feuille	C	

ETAPE 4					ETAPE 5	
L Total de carbone émis (kt C)	M Rapport azote-carbone	N Teneur totale en azote (kt N)	O Rapport d'émission	P Emissions de gaz trace (kt C ou kt N)	Q Facteur de conversion	R Gaz trace émis par l'incendie de la savane (Gg)
		N = (L*M)		P = (L*O)		R = (P*Q)
188.032	0.006	1.128				
CH4			0.000	0.000	16/12	0.000
CO			0.060	11.282	28/12	26.324
		N = (L*M)		P = (N*O)		R = (P*Q)
N2O			0.007	1.316	44/28	2.068
NOx			0.120	22.564	30/14	48.351

INCINERATION SUR LE TERRAIN DES RESIDUS AGRICOLES

			Module	Agriculture				
			Sous-module	Incinération ouverte des résidus agricoles, émissions de gaz trace sans CO2				
			Tableau	4.4				
			Feuille	A				
ETAPE 1				ETAPE 2		ETAPE 3		
Cultures (Spécifier les cultures importantes localement)	A Production annuelle (kt de récolte)	B Rapport résidus-production	C Quantité de résidus (kt de biomasse)	D Teneur en matière sèche	E Quantité de résidus secs (kt de ms)	F Fraction incinérée dans les champs	G Fraction de la biomasse oxydée (efficacité de combustion)	H Biomasse totale incinérée (kt de ms)
			C = (A*B)		E = (C*D)			H = (E*F*G)
Mil et sorgho	670.606	7.5	5029.545	0.4	2011.818	0.05	0.9	90.532
Riz	193.869	1.4	271.417	0.7	189.992	0.70	0.9	119.695
Maïs	102.632	1.5	153.948	0.4	61.579	0.05	0.9	2.771
Coton	52.000	1.0	52.000	0.8	41.600	0.80	0.8	26.624
Arachide	727.816	0.0	0.000	0.0	0.000	0.00	0.0	0.000
TOTAL			5506.910		2304.989			239.622

		Module	Agriculture	
		Sous-module	Incinération ouverte des résidus agricoles, émissions de gaz trace sans CO2	
		Tableau	4.4	
		Feuille	B	
ETAPE 4			ETAPE 5	
Cultures (Spécifier les cultures importantes localement)	I Fraction de carbone des résidus	J Total de carbone émis (kt C)	K Rapport azote-carbone	L Total d'azote émis (kt N)
		J = (H*I)		L = (J*K)
Mil et sorgho	0.4709	42.631	0.0168	0.716
Riz	0.4144	49.601	0.0140	0.694
Maïs	0.4709	1.305	0.0200	0.026
Coton	0.4226	11.251	0.0500	0.563
TOTAL		104.789		1.999

Module	Agriculture			
Sous-module	Incinération ouverte des résidus agricoles, émissions de gaz trace sans CO2			
Tableau	4.4			
Feuille	C			
ETAPE 6				
	M Rapport d'émission	N Emission de gaz à l'état de trace (kt C ou kt N)	O Facteurs de conversion	P Emission de gaz à l'état de trace par incinération sur le terrain des déchets agricoles (Gg)
		N = (J*M)		P = (N*O)
CH4	0.005	0.524	16/12	0.699
CO	0.060	6.287	28/12	14.670
		N = (L*M)		P = (N*O)
N2O	0.007	0.014	44/28	0.022
NOx	0.120	0.240	30/14	0.514

VII. COMMENTS

TABLE 4.1-A :

The number of dairy cows was determined from a survey by the Department of Animal Husbandry on the cattle structure of herds of cattle. They account for 37.5 % of the cattle.

Using census by aircraft, it is difficult to discriminate between sheep and goats. As a result the two have been counted together and refered to as "small ruminants". However, the difference between the emission factors is very small and has no fundamental bearing on the calculations.

TABLE 4.3-A :

The biomass density of each type of savannah and the biomass exposed to burning, have been directly determined from NOAA-AVHRR satellite images validated by field measurement. This means that biomass exposed is not a result of the multiplication of average biomass per hectare by burned area (in ha) as proposed by the IPCC/OECD. It has been directly extracted from the biomass map, created by the Centre for Ecological Monitoring, using a module of the Idrisi GIS software. The method consists of superimposing the fire map on that of plant production, permitting the extraction of the fraction effectively burned. The figure obtained was multiplied by 0.8 as indicated in the methodology.

The share of woody biomass out of the reach of fires has not been taken into account.

TABLE 4.4-A:

Groundnut leaves have not been taken into account in the computations since they are burned. They are almost entirely consumed by livestock.

The quantities of burned crop residues are very small in the Sahelian context due to the multiple uses for these products (making fences, feeding cattle) and to the great losses in nutritive value during the eight to nine months of the dry season (cattle trampling, rotting, wind action..). Burning the small quantities remaining takes place when ploughing the fields for the next crop, that is nearly eight months after harvest.

TABLE 4.4-B:

In the Senegalese statistics there is no difference between millet and sorghum which have always been accounted together since 1960. However, we have estimated that millet represents about 80 % of the total, leading to the calculation of the Nitrogen-Carbon Ratio on the basis of a combination : (80 % of 0.016 + 20 % of 0.02).

The carbon fraction contained in cotton is not available, not even the default value; consequently, the potato coefficient was used. The same applies for the Nitrogen-Carbon Ratio, where that of soy-bean was used because the characteristics of these two products are quite similar.

As far as cotton is concerned, no study has been carried out in Senegal on the Residue/Production Ratio, or on the Dry Matter Content of stalks. The figures used resulted from discussions with professionals in the cotton sector.

Chapter IV

LAND USE CHANGE AND FORESTS

I. IDENTIFICATION OF HOMOGENEOUS ECOLOGICAL ZONES

The study of land use changes and forestry is based on a preliminary stratification of the national territory according to land uses (agricultural area, fallow land, grazing land, tree savannah, forest); this made it possible to determine homogeneous zones, taking into account the variability of phenomena in different environments.

The baseline data used for this purpose are mainly Landsat TM satellite images of November 1988 and 1990, as well as topographic maps at 1/200,000 (for geographic corrections on digital and paper images).

The satellite images are the best medium to delimit the strata, offering an overall view which integrates data on soil cover and vegetation.

The choice of Landsat TM images can be explained by the fact that their size (180 km x 180 km) allows for a homogeneous coverage of the study area. Therefore this size of Landsat TM images is more adapted to stratification, and the 30 m x 30 m resolution is sufficient to identify the type of land use.

For digital interpretation on the screen we have used channel 4 in the red, 3 in the green and 2 in the blue. The same composition has been used for paper and digital images.

1.1. Method of Stratification

- Definition of Strata Nomenclature

This depends on the characteristics of the study area, as well as the number and area of the strata identified. The satellite image is photo-interpreted first, to define the agricultural and the non-agricultural zones. Second, according to the land use and the difference in colour between soil and vegetation the agricultural zone is subdivided on the basis of the intensity of agriculture, and the non-agricultural zone is equally subdivided.

Two approaches were used for this stratification :

- stratification on paper images, without geometrical correction;
- direct stratification on non-corrected image on the screen.

- **Stratification on paper image, without geometrical correction**

This was used for the western half of the country which is covered by 6 Landsat TM scenes with 22 useful quarter scenes. The interpreted digital data are geometrically corrected.

- **Stratification on the screen**

The boundaries of the strata are identified and drawn on the screen. This made it possible to make a more precise stratification; as the scale is larger the work is done directly on the image.

In total, 13 strata have been defined at the national level. Each boundary delineation is based on the texture and colour of the image.

1.2.Identification of Eco-geographical Areas According to Land Use

- Walo Zone

This zone, which covers an area of 7,615 km², corresponds with the flood lands of the Senegal River valley (in the far north of the country), characterized by heavy soils with potentially very high yield. The tree cover is clearly dominated by *Acacia nylotica* (Goniakié) which was a wide riparian forest of which only some traces in depressions and closed forests remain. The grass cover has almost disappeared, due to persisting droughts, leaving the soil at the mercy of eroding winds.

Walo is also the area of the hydro-agricultural schemes which are to be extended when the Manantali and Diama dams come into service. The land potential and the economic prospects are already attracting more and more people, posing land distribution problems.

- Pastoral Zone

The pastoral zone is south of the Senegal River Valley; it is subdivided into two subparts : the North-West which is sandy, with brown-red and ferruginous soils, and the South-East (lateritic) characterized by gravelly soils with occasional lateritic outcrops. The pastoral zone has a pseudo shrub steppe vegetation where thorny shrubs (*Accacia radiana*, *Balanites aegyptiaca*) predominate; it is highly influenced by man in the sandy part. It also has a relatively dense woody stratum in which *Pterocarpus lucens* is dominant in the lateritic part. In total the pastoral zone covers 39,611 km^2 : 20 % of the national territory.

Land use has not changed greatly in recent years, as the climatic conditions, the nature of the pastoral system (extensive cattle breeding) and the prevailing legislation are not very conducive to the development of agriculture, except for subsistence crops.

- Dense Agricultural Zone

This is the former groundnut bassin (Central Western), characterized by a high concentration of agriculture. About 53% of cultivated lands are for groundnut, while 43 % are for millet-sorghum. In this sandy zone, where the environment has become highly artificial because of population pressure (<100 people/km^2 on average), the cultivated areas have remained relatively stable for mor than ten years. All available lands are cultivated except the unsuitable saline lands of the estuaries of the Sine and the Saloum Rivers. The light brown, brown-red and ferruginous soils are consequently being impoverished by mechanization, abandonment of fallow lands, insufficient fertilizers for overexploited soils, and droughts. This zone covers 20 718 km^2.

- Less Dense Agricultural Zone

This zone, which is the continuation of the fairly dense agricultural zone, corresponds with the northern limits of rainfed crops. Possibilities of extension are thereby reduced. It is characterized by a trend towards the dominance of pastoral activities. It covers 8 527 km^2.

- Fairly Dense Agricultural Zone

Agriculture, associated with cattle breeding, is less important here, occupying 50 % of the area. It used to be a groundnut area, especially in its northern part (Ndiambour), but rainfed cultivation retreated significantly (except for the short cycle speculation such as cowpea), following the worsening climatic conditions. A sizeable fraction of the population has turned to trading, or migrated. In its Southern part, this zone covers the Saloum swamps ("tannes") increasingly unfit for agriculture because of their salinity, whence the progressive shrinking of cultivated areas.

This zone, which covers 5 250 km^2, might stretch North-East, where settlement by farmers from the groundnut basin has been noted.

The three agricultural strata have a total area of 34,495 km², (17 % of the total surface area of the country with more than 60 % of the population)

- Mangrove

This stratum, covering 6,342 km², stretches along the Saloum and Casamance Rivers. These are lands which are highly affected by salinization. They used to be colonized by a specific kind of vegetation (mangrove) now endangered by the salinity of the soils resulting from droughts (insufficient fresh water). This highly productive vegetation (15 to 20 tonnes/hectare/year) is represented by two species : *Rhizophora racemosa* and *Avicennia africana*. In the last 20 years it has greatly shrunk; presently the cover is only 25 %. The loss of the nutritive values of the mangrove is related to the salinity and acidity of soils exacerbated by shortage of rainfall, which is reflected by the appearance of "tannes" (barren land stretches degraded by excess salt). It is worth noting that in addition to these natural processes, mangroves are subjected to an intense illicit expploitation (oysters, timber and fuel wood, extension of rice fields) that has noticeably contributed to its degradation.

- Forest/Tree Savannah

At present this stratum, and the agro-forestry zone in the South, are the only places where native forests can still be found in Senegal. This is due to the best climatic conditions and the low population density. It covers 46,085 km² and is one of the main wood exploitation zones, with the last elements of the big game (antelopes, elephants).

- Agricultural Transition Zone

This is the transitional zone between the agricultural domain and the shrub savannah, on the one hand, and the pastoral zone on the other. Since the persistent occurrence of drought and following the saturation of soils in the Centre-West, the groundnut basin is shifting toward this zone characterized by great agricultural potentialities; the only problem being that it is landlocked.

The agricultural colonization of this area in order to relieve congestion in the Centre-West reflects a political will, through which the "Terres Neuves" Project was initiated in this zone with several hundred farming families settling there between 1975 and 1984. Changing the land use engenders adverse effects, insofar as the same cropping practices which degraded the soils of original settlement area have been transfered.

The agricultural transition zone has an area of 15,079 km².

- **Shrub Savannah**

This is ditinguished from the tree savannah by the fact that the woody stratum is lower because of less favourable climatic conditions. It covers 20,795 km².

Forests (tree savannah and shrub savannah) cover 66,880 km², meaning that 34 % of Senegal is not yet used for agriculture; to this should be added over 70 % of the agro-forestry zone where agriculture occupies less than 30 % of the area.

- **Urban Area**

This consists of Dakar and its suburbs : 164 km². The other urban areas are not indicated on the map, so that it can be more easily read.

- **Agro-forestry Zone**

Sited in the far South of Senegal, this is partly in the Guinean sector in its Western part, and Sudano-guinean to Guinean in the East. It contains semi-arid and dense forests and dry and open forests, associated with agriculture (using one third of the zone) in low-lying areas (a relatively high population density due to the great natural potential. Its area is 24,539 km².

Further East, the zone is being used for the expansion of agriculture and cultivation of new crops such as cotton, groundnut and maize. This entails a lot of clearings, which explains the progressive shift from tree formations to shrub formations noticeable in the vicinity of settlements. In addition, salinization in low-lying areas suitable for rice cultivation is a real constraint which people try to circumvent by colonizing new land, especially on the plateau.

- **Lake Guiers**

Lake Guiers is the major permanent source of fresh open water of Senegal. Hydro-agricultural infrastructures are being developed all around it. The area of the lake zone, around which irrigation and market gardening schemes are being developed is 452 km².
The chemical substances contained in the drainage waters are a source of pollution.

- **Others (Thies Cliffs, the Coast)**

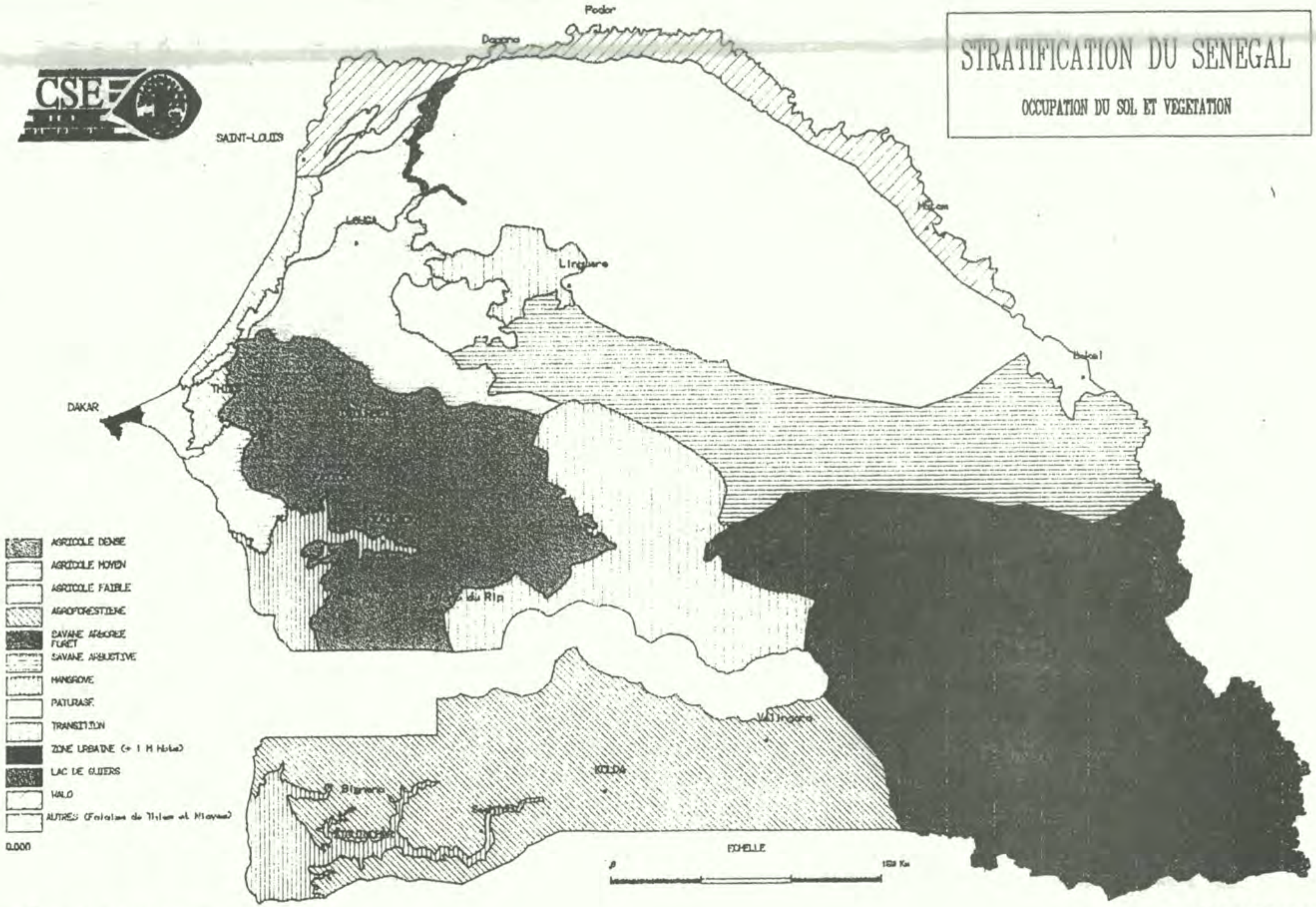
The cliffs of Thies are a zone of relatively high relief, with lateric outcrops limiting the agricultural potential of the lands to the benefit of open space.

The coastal zone or "Niayes" is a stretch of land of about 5 km of width running along the Atlantic Ocean, from Dakar to the mouth of Senegal River in Saint-Louis. It is mainly characterized by a succession of dunes and depressions whose rich soils are an ideal environment for market gardening and fruit crops that are very dominant in the system of production. This zone produces more than 80 % of the fruits and vegetables in Senegal. The vegetation is being degraded because of intensive exploitation, drought and urban and industrial expansion (around of Dakar).

In total, these two ecosystems, characterized by their relief, type of land use and climate, cover 2,067 km^2.

STRATIFICATION DU SENEGAL

OCCUPATION DU SOL ET VEGETATION



CARTE REALISEE DANS LE CADRE DE L'ETUDE DES SOURCES D'EMISSION DE GAZ A EFFET DE SERRE (Projet III-GF/4102-92-35)

CENTRE DE SUIVI ECOLOGIQUE - MARS 1994

Identification of Eco-geographical Areas According to Land Use

Zones	Superficie (km²)	Caractéristiques	Affectation
1. Walo	7 615	Plaine inondable	Périmètres irrigués
2. Zone pastorale	39 611	Substrat sableux à l'ouest, gravillionnaire à l'est. Dégradation autour des points d'eau (300 mm / an)	Elevage extensif
3. Zone agricole dense	20 718	Sols en dégradation continuelle, salinisation par endroits, absence de jachère	Activité agricole intense
4. Zone agricole faible	8 527	Pluviométrie en baisse, faible productivité	Agriculture et élevage
5. Zone agricole moyenne	5 250	Salinisation au sud, dégradation des terres au nord	Agriculture
6. Mangrove	6 342	Salinisation, mortalité des palétuviers, surexploitation du bois	Usages multiples (exploitation du bois, culture des huîtres...)
7. Savane arborée / forêt	46 085	Sols peu profonds, dégradation de la végétation (800 - 1000 mm / an)	Agriculture (15 - 20%), élevage, exploitation forestière
8. Zone agricole de transition	15 079	Recul de la savane au profit de l'agriculture (700 - 800 mm / an)	Agriculture, élevage, exploitation forestière
9. Savane arbustive	20 795	Faible densité humaine, intensité des feux, sols peu profonds	Elevage et exploitation forestière
10. Zone agroforestière	24 539	Bonne pluviométrie (> 1000 mm / an), zone forestière	Agriculture (à 30%), exploitation forestière
11. Falaises / littoral	2 067	Relief accidenté, cordon dunaire, avancée des dunes	Elevage et maraîchage
12. Lac de Guiers	452	Eau douce permanente	Irrigation et consommation humaine
13. Zone urbaine (>1 000 000 Hab)	164	Forte densité humaine	Activités économiques diverses

Source : Ecological Monitoring Centre.

II. DETERMINATION OF THE TREE COVER PER STRATUM

The tree cover has been determined from aerial photographs (20 300) of the whole country, taken between 1989 and 1992. The analysis of vertical photographs involves the identification of the various components of the terrain. This is done by projecting the photographs on a 32cm x 20cm screen containing 320 dots which are randomly scattered. Following the identification of the various components, the dots appearing over each tree are counted. The results are expressed as a percentage and presented in the form of maps.

The national average in terms of tree cover is 10.2%. The results, superimposed over the major strata identified in the land use survey, show that this percentage is highly variable especially as a result of anthropogenic action as well as differences in the eco-climatic conditions.

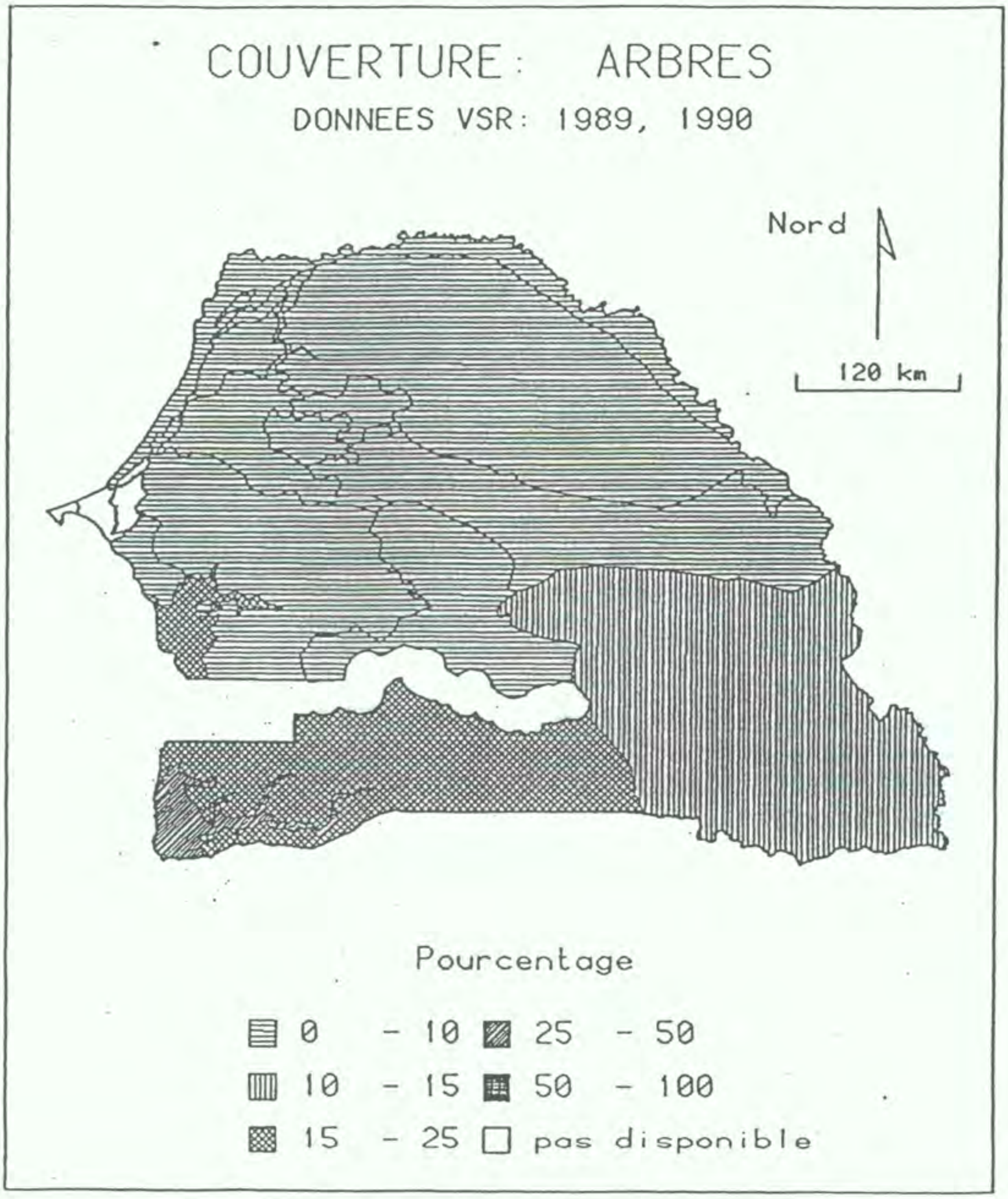
The tree cover is at lowest in the midwest, in agricultural areas (see following table). This is due to several factors including the use of wood; the mechanization of cropping techniques which is bringing about changes in production systems which used to be compatible with the preservation of trees in the agrarian landscape (e.g. the system of land management in the Serer environment); and the pruning of fodder trees to feed the cattle in the middle of the dry season.

The tree cover is also relatively poor in the Walo region and the pastoral area. The reasons are, on the one hand, the many clearing activities to create irrigated perimeters in the Walo area (characterized by the most intensive clearing activities in order to grow rice and sugar cane), and on the other hand, the drought and the pruning of trees by herders in the pastoral area.

On the contrary, in the eastern region, the tree cover is rather high - 14% on average, sometimes as high as 30 or 40%, especially in the Niokolo Koba park -. This also holds for the southmost area of the country characterized by agro-forestry. This characteristic derives from a high concentration of state-controlled forests and a high annual rainfall (700 - 1200 mm).

However the highest level of tree cover is to be found in the estuaries in Casamance, where the climatic conditions promote the growth of mangroves (Avicennia africana and Rhizophora racemosa especially), palm plantations in the swamps (Elaeis guineensis) and plantations of palmira (Borassus aethiopium). However, it should be pointed out that the mangroves are among the ecosystems that are most affected by the present lack of rain and human use. Thus, because of the poor protection provided to mangroves, a very high level of degradation of the species takes place in the Saloum and consequently, only a few protected islands are still in existence. The percentage of the mangrove coverage in this part of the country has fallen down to 3-5% in areas that are heavily affected by human activities and by salt water incursions.

Map of the Tree Cover



Source : Ecological Monitoring Centre.

Tree Cover per Zone depending on the type of soil occupation

Strates	Essences dominantes	Recouvrement moyen
1. Walo (vallée inondable)	Acacia (nilotica, sieberiana, senegal), Zizyphus mauritiana	4 %
2. Zone pastorale	Balanites aegyptiaca, Boscia senegalensis, Guiera, Acacia raddiana, Calotropis procera, Pterocarpus lucens	5.2 %
3. Zone agricole dense	Acacia albida, Cordyla pinnata, Adansonia digitata, Anogeissus leiocarpus, Combretum glutinosum	3.7 %
4. Zone agricole faiblement dense	Adansonia, Acacia seyal, Acacia raddiana, Guiera, Combretum glutinosum	2.3 %
5. Zone agricole moyennement dense	Acacia raddiana, Guiera, Combretum glutinosum, Acacia albida	3.2 %
6. Mangrove	Rhizophora racemosa, Avicennia africana	20 % (faible dans la mangrove du Saloum)
7. Savane arborée / forêt	Combretum glutinosum. Terminalia macroptera, Bombax costatum, Borassus aethiopium, Sterculia setigera, Pterocarpus erinaceus	14.4 %
8. Zone agricole de transition	Combretum, Cordyla pinnata, Sterculia, Guiera, Prosopis africana	7.2 %
9. Savane arbustive	Pterocarpus lucens, Combretum, Guiera, Grewia bicolor	7.4 %
10. Zone urbaine	---	---
11. Lac de Guiers	---	2.6 %
12. Falaises de Thiès / littoral	Acacia seyal, Elaeis guineensis	5.3 % (sur littoral)
13. Zone agro-forestière	Khaya senegalensis, Parkia biglobosa, Pterocarpus erinaceus, Daniella oliveri, Borassus aethiopium, Elaeis guineensis, Detarium, Oxytenanthera abyssinica	21.6 %

Source : Ecological Monitoring Centre.

III. CLEARING OF FORESTS

Land use change is reflected in an increase in cultivated areas and a decline in the forest cover. In other words, land use is characterized by the gradual cultivation of wooded areas on the one hand and the clearing of forests on the other hand. It should be pointed out that there are few forests, strictu sensu, in Senegal. What exist are mostly tree- or shrub-covered savannas.

- Assessment of Clearings for Agricultural Purposes

For the 1980 - 1990 period, fieldwork as well as the available documentation were used for a national assessment of areas of land cleared annually for agricultural purposes. No data were available to enable such an evaluation for earlier periods.

An analysis of estimates based on the comparison of satellite images of different periods, complemented by various additional data provided by the national Forestry Commission, indicates a 0.6% annual decline in the forest cover.

Between 1980 and 1990, about 51 900 ha of forest were cleared for agricultural purposes.

- Impact of Logging on the Land Use Change

Every year, Senegal loses 28 100 ha of forest as a result of logging for lumber and timber as well as charcoal and firewood. The Forestry Commission is unable to control a large part of this activity. The major harvesting areas are the southern and eastern regions, contrasting with the midwest, which is more agriculture-oriented with an almost inexistent exploitable potential for wood.

Overall, the area covered by forests has decreased by 800 000 ha over ten years, that is 80 000 ha per annum.

However, reforestation attempts have led to planting 162, 573ha with a 55.60% success rate - in other words 90, 390 ha in the period under discussion (1980-1990). The reforested area in 1991, was estimated to be 20, 684 ha. On this area, 7, 129, 390 trees were planted including 6, 043, 597 forest species and over one million fruit trees. Acacias and eucalyptus respectively accounted for 20% and 21% of the total. If one takes into account these reforestation activities, it can be said that, in the 1980-1990 period, the forested area decreased by 709, 610 ha.

IV. ON-SITE BURNING OF CLEARED FORESTS

In zones of agricultural expansion, the biomass from clearing forests is mostly generated by clearing for the expansion of agriculture. The on-site burned fraction varies with the ecological zone and especially with the size, nature and quality of wood.

a) In the pastoral zone (the northern region with a Sahelian, semi-arid to arid climate), the possibilities for expansion of cropland are rather poor and therefore, very few clearing activities take place. The products from the rare clearing activities are used for energy, for the portion burnt is hardly significant.

b) In the mideastern region, which is a transition zone, the forested area is receding in association with the agricultural settlement of people from the groundnut belt, looking for land to cultivate. This region is the one with the highest pressures for cleared land, especially in the NGanda district close to the Gambian border. The government released its control over vast areas of state-controlled forests in the zone, for agricultural purposes (45, 000 ha in Mbégué in 1991, 1, 200 ha in Déali in 1954). Approximately 98% of products generated by clearing activities are burned (production of charcoal or fuelwood).

c) The midwest (with a dense agriculture) is characterized by the absence of clearing activities that could generate a significant biomass.

d) In Lower Casamance (south), areas that are used for agriculture are located along the valleys and hardly experience any inter-annual expansion. However, 80 to 90% of the by-products from clearing are used for timber. Only a small portion - about 10% - composed of small branches, leaves and stumps, is burnt on-site when the fields are cleaned, with the coming of the rainy season. However it has been observed that woods outside the valley areas have a high mortality rate as a result of salinization and the ageing of stands that are not logged. This biomass decomposes on-site.

e) Upper Casamance (south east) and eastern Senegal are areas of agricultural expansion where authorized forest clearing takes place within the framework of development projects. These involve the settlement of new lands to relieve the congestion of the overpopulated groundnut basin, the establishment of companies charged with the expansion of cotton crops and hydro-agricultural development. These by-products of clearing are used for charcoal and timber. On the other hand, almost 90% of the products associated with spontaneous individual clearing activities or clearings authorized by the Forestry Commission, are made into charcoal. The remainder is burnt on-site and a very small portion is used as fuelwood.

According to official estimates, by-products of clearing account every year for 30% of the regularly authorized quotas for charcoal production, for the undeclared objective of many clearing activities is the production of charcoal rather than cultivation. In other words the fraction of on-site burning is relatively insignificant, for wood fuels are becoming a rarer and rarer commodity as they contribute 90% of national energy supply - and 100% in rural areas. However it has been possible to determine the fraction of on-site burning for each type of forest or savanna. The fraction that was collected as fuelwood was even more precisely determined since the data from the national comprehensive survey conducted by ENDA in 1991 was used in the tables for the calculation of emissions.

V. GRASSLAND CONVERSION

Grasslands per se do not exist in Senegal. Hence, the data in this paragraph is more relevant to shrub-covered savannas, which constitute the ecosystem that is closest to grassland. Every year, approximately 20, 000 ha of these savannas close to densely populated (agricultural) areas are converted into cropland. This matches the advancement of the agricultural lands towards the pastoral areas in the north and mideast of the country.

VI. ABANDONMENT OF LANDS

It is generally acknowledged that land is mostly abandoned in moist tropical forests. In view of the limited availability of farmland and of the land regulations that ban spontaneous settlement of farmers, no field studies indicate the existence of shifting cultivation in Senegal.

The only land that is abandoned is the saltinized land in the estuaries which usually covers small areas, as this is a relatively more recent phenomenon (a consequence of the drought which leads to the penetration of saline water into surface water). Therefore, this is not taken into account when calculating gas emissions due to land use changes. However, this process deserves close attention in the future since there is a tendency towards the expansion of abandoned lands.

VII. LOGGED FORESTS

These are protected forests and reforested perimeters. Whereas the former cover 6 671 802 ha (excluding state-controlled forests in which logging is stricly forbidden except when state control is released through presidential decree) the latter cover 162, 573 ha. An assessment was made of the types of wood removed for commercial purposes, the annual reforestation programme, and the number of trees of each species planted.

VIII. APPLICATION OF THE IPCC/OECD METHODOLOGY

ECLAIRCISSEMENT DES FORETS

			Module	Changement d'exploitation des terres et forêts					
			Sous-module	Eclaircissement des forêts. Emissions de CO_2 générées par la combustion de biomasse aérienne sur et hors site					
			Tableau	5.1					
			Feuille	A					
ETAPE 1									ETAPE 2
Types de forêts				A Superficie éclaircie chaque année (kha)	B Biomasse avant l'éclaircissement (t de ms/ha)	C Biomasse après l'éclaircissement (t de ms/ha)	D Changement net dans la biomasse (t de ms/ha)	E Perte annuelle de biomasse (kt de ms)	F Fraction de la biomasse incinérée sur site
							D = (B-C)	E = (A*D)	
Tropicales	Forêts claires	Feuillus	De coupe	30	240	10	230	6900.0	0.5
	Savanes arborées			30	185	10	175	5250.0	0.5
	Savanes arbustives			20	140	10	130	2600.0	0.8
TOTAL				80				14750.0	

			Module	Changement d'exploitation des terres et forêts				
			Sous-module	Eclaircissement des forêts. Emissions de CO2 générées par la combustion de biomasse aérienne sur et hors site				
			Tableau	5.1				
			Feuille	B				
ETAPE 2 (suite)								
Types de forêts				G Quantité de biomasse incinérée sur site (kt de ms)	H Fraction de la biomasse oxydée sur le terrain (efficacité de combustion)	I Quantité de biomasse oxydée sur le terrain (kt de ms)	J Fraction de carbone de la biomasse aérienne (incinérée sur le sur site)	K Quantité de carbone émis (kt C)
				G = (E*F)		I = (G*H)		K = (I*J)
Tropicales	Forêts claires	Feuillus	De coupe	3450.00	0.9	3105.000	0.45	1397.250
	Savanes arborées			2625.00	0.9	2362.500	0.45	1063.125
	Savanes arbustives			2080.00	0.9	1872.000	0.45	842.400
TOTAL				8155.00		7339.500		3302.775

			Module	Changement d'exploitation des terres et forêts							
			Sous-module	Eclaircissement des forêts. Emissions de CO_2 générées par la combustion de biomasse aérienne sur et hors site							
			Tableau	5.1							
			Feuille	C							
ETAPE 3										ETAPE 4	
Types de forêts				L Fraction de la biomasse incinérée hors site	M Quantité de biomasse incinérée hors site (kt de ms)	N Fraction de la biomasse oxydée hors site (efficacité de combustion)	O Quantité de biomasse oxydée hors site (kt de ms)	P Fraction de carbone de la biomasse aérienne (incinérée hors site)	Q Quantité de carbone émise sous forme de CO_2 (à partir de la biomasse incinérée hors site)	R Total de carbone émis sous forme de CO_2 (par combustion sur et hors site)	S Total de CO_2 émis (kt CO_2)
					M = (E*L)		O = (M*N)		Q = (O*P)	R = (K+Q)	S = (R*[44/12])
Tropicales	Forêts claires	Feuillus	De coupe	0.137	945.300	0.9	850.770	0.45	382.847	1780.097	6527.021
	Savanes arborées			0.026	136.500	0.9	122.850	0.45	55.283	1118.408	4100.828
	Savanes arbustives			0.186	483.600	0.9	435.240	0.45	195.858	1038.258	3806.946
TOTAL					1565.400		1408.860		633.987	3936.762	14434.794

Module	Changement d'exploitation des terres et forêts
Sous-module	Eclaircissement des forêts. Emissions de CO_2 générées par la décomposition de la biomasse aérienne
Tableau	5.1
Feuille	D

ETAPE 5

Types de forêts				A Superficie éclaircie chaque année (moyenne annuelle sur 10 ans) (ha)	B Biomasse avant l'éclaircissement (t de ms/ha)	C Biomasse après l'éclaircissement (t de ms/ha)	D Changement net de biomasse (t de ms/ha)	E Perte annuelle moyenne de biomasse (kt de ms)	F Fraction de décomposition	G Quantité de biomasse en décomposition (kt de ms)	H Fraction de carbone dans la biomasse aérienne	I Partie de C émise sous forme de CO2 (kt C)
							D = (B-C)	E = (A*D)		G = (E*F)		I = (G*H)
Tropicales	Forêts claires	Feuillus	De coupe	30.00	240	10	230	6900.0	0.362	1695.329	0.45	762.898
	Savanes arborées			30.00	185	10	175	5250.0	0.473	1704.450	0.45	767.003
	Savanes arbustives			20.00	140	10	130	2600.0	0.013	37.537	0.45	16.892
TOTAL				80.00				14750.0		3437.316		1546.792

Module		Changement d'exploitation des terres et forêts				
Sous-module		Eclaircissement des forêts. Emissions de carbone générées par le sol				
Tableau		5.1				
Feuille		E				
ETAPE 6						
Types de forêts		A Superficie moyenne des forêts éclaircies (moyenne sur 15 ans) (kha)	B Teneur en carbone des sols des forêts (t/ha)	C Perte annuelle potentielle totale de carbone des sols (kt C)	D Fraction de carbone émis	E Emissions de carbone à partir du carbone des sols (kt C)
				C = (A*B)		E = (C*D)
Tropicales	Forêts claires	26.64	60	1598.4	0.5	799.2
	Savanes arborées	26.64	60	1598.4	0.5	799.2
	Savanes arbustives	20.00	60	1200.0	0.5	600.0
TOTAL		73.28		4396.8		2198.4

Module	Changement d'exploitation des terres et forêts
Sous-module	Eclaircissement des forêts. Emissions totales de CO2
Tableau	5.1
Feuille	F

ETAPE 7

A Emission immédiate de la combustion (kt C)	B Emissions différées de la décomposition (kt C)	C Emissions à long terme des sols (kt C)	D Emissions annuelles totales de carbone générées par l'éclaircis-sement des forêts (kt C)	E Emissions annuelles totales de CO2 générées par l'éclaircis-sement des forêts (kt CO2)
			D = (A+B+C)	E = (D*[44/12])
3936.762	1546.792	2198.400	7681.954	28167.165

INCINERATION SUR LE SITE DES FORETS ECLAIRCIES

		Module	Changement d'exploitation des terres et forêts				
		Sous-module	Combustion sur site des forêts éclaircies				
		Tableau	5.2				
		Feuille	A				
ETAPE 1			ETAPE 2				
A Carbone émis (kt C)	B Rapport azote-carbone	C Total d'azote émis (kt N)		D Rapports d'émission de gaz trace	E Emissions de gaz trace (kt C)	F Facteurs de conversion	G Emissions de gaz trace générées par la combustion des forêts éclaircies (kt CH4, CO)
(A partir de la colonne K du tableau 1.B)		C = (A*B)			E = (A*D)		G = (E*F)
3302.775	0.01	33.028	CH4	0.012	39.633	16/12	52.844
			CO	0.060	198.167	28/12	462.389
					(kt N)		(kt N2O, NOx)
		C = (A*B)			E = (C*D)		G = (E*F)
			N2O	0.007	0.231	44/28	0.363
			NOx	0.121	3.996	30/14	8.564

FORETS EXPLOITEES

		Module	Changement d'exploitation des terres et forêts				
		Sous-module	Forêts exploitées				
		Tableau	5.5				
		Feuille	A				
ETAPE 1							
Types de forêts			A Superficie des forêts gérées (kha)	B Taux de croissance annuel (t de ms/ha)	C Augmentation annuelle de la biomasse (kt de ms)	D Teneur en carbone de la matière sèche	E Augmentation totale du carbone (kt C)
					C = (A*B)		E = (C*D)
Tropicales	Plantations	Acacia spp.	4.344	2.75	11.945	0.45	5.375
		Eucalyptus spp.	4.137	3.25	13.445	0.45	6.050
		Tectona grandis	1.034	3.25	3.361	0.45	1.513
		Bois durs mixtes	11.169	2.75	30.716	0.45	13.822
	De coupe	Feuillus	6671.802	2.75	18347.456	0.45	8256.355
			A Nombre d'arbres (milliers d'arbres)	B Croissance annuelle (t de ms/1000 arbres)			
Programmes de reboisement			3360.240	2.875	9660.690	0.45	4347.310
Arbres des villages et des fermes			603.701	2.875	1735.640	0.45	781.038
			3963.941				

Module	**Changement d'exploitation des terres et forêts**
Sous-module	Forêts exploitées
Tableau	5.5
Feuille	B

ETAPE 2

Types de forêts	F Récolte commerciales (km3 bois)	G Facteur d'expansion de la biomasse (t de ms/m3)	H Total de biomasse ramassée dans la récolte commerciale (kt de ms)	I Consommation totale de bois de chauffage traditionnel (kt de ms)	J Autres usages du bois (kt de ms)	K Consommation totale de biomasse (kt de ms)	L Bois ramassé lors de l'éclaircis-sement des forêts (kt de ms)	M Consom-mation totale de biomasse dans les forêts exploitées (kt de ms)
			H = (F*G)	*(A partir du tableau 2 A, colonne H)*		K = (H+I+J)	(A partir du tableau 1 C, colonne M)	M = (K-L)
Bois d'oeuvre	1.5	0.5	0.750					
Bois de service	1225.0	0.5	612.500					
TOTAL			613.250	3386.109		3999.359	1565.400	2433.959

Module	Changement d'exploitation des terres et forêts		
Sous-module	Forêts exploitées		
Tableau	5.5		
Feuille	C		
ETAPE 3		ETAPE 4	
N Fraction de carbone	O Emission annuelle de carbone (kt C)	P Captage (+) ou émission (-) annuelle de carbone (kt C)	Q Conversion en émissions et suppressions annuelles réelles de CO2 (Gg CO2)
	O = (M*N)	P = (E-O)	Q = (P*[44/12])
0.45	1095.282	7187.833	26355.388

IX. COMMENTS

TABLE 5.1 - A :

Following the stratification of the country, the redefinition of the types of savannas, based on the characteristics of the natural environments in Senegal, led to the establishment of three categories: open forests, tree-covered savannas and shrub-covered savannas. This is also valid for worksheets on land use change and forestry.

The primary data were derived from the Forestry Action Plan Senegal, published in June 1993.

TABLE 5.1 - C:

The fraction of off-site burnt biomass was assessed following a survey conducted in 1991 by the ENDA Energy Programme, within the Project "METHODE D'ANALYSE DU SYSTEME ENERGETIQUE DU SENEGAL (MASENS)". More specifically, the issue investigated was the per capita consumption of fuelwood in Senegal as a whole.

TABLE 5.5 - A:

7, 129, 390 trees - including 1, 085, 793 fruit trees in villages and orchards - were planted as part of the 1991 annual reforestation program. These figures were re-adjusted on the basis of the average survival rate for young plants - 55.6% - thereby reducing the number of trees involved in the annual reforestation programme to 3, 365, 051, especially as the climate in the past two decades was particularly rigorous.

As a result of the deficit of rainfall in terms of quantity and frequency (three months of rainfall per annum), the annual growth rate of woody biomass is extremely low in Sahelian environments with a limited water balance. Experiments carried out as part of the reforestation programme have shown that this growth is much lower than the default growth rate indicated in the IPCC/OECD methodology workbook. For exotic wood species - Eucalyptus spp - which grow quickly, it amounts to 3.25 t of dry matter, as against 2.75t for local species with a much slower growth rate (e.g. Acacia spp).

Chapter V

WASTE

This chapter deals with domestic waste as well as solid and liquid industrial waste.

I. GENERATION OF DOMESTIC WASTE

1.1 System of domestic waste disposal

1.1.1 In the Capital City : Dakar

The Société Industrielle d'Aménagement Urbain du Sénégal (SIAS) is in charge of removing domestic waste. The urban network in Dakar which consists of various zones (from fully-equipped to ill-equipped) includes the following removal system:

- In fully-equipped areas (with tarred roads) such as the Plateau, trucks with a compression system are used for home or door-to-door collection of waste.

- In neighbourhoods without asphalted or passable streets the waste is usually placed in a collective hauling unit that is then pulled away.

All the waste collected is stored at the Pikine transfer station from which it is taken to the Mbeubeuss open dumping ground, the only place where waste disposal is allowed in the Dakar region. Prior to independence, there was another dumping ground around the Hann neighbourhood (a former quarry) which was closed in 1970 because the saturation point was reached and the urban housing that was growing very fast, was very close.

This site in Hann is now inhabited and the dumping area has been moved to Mbeubeuss.

A waste composting plant used to exist in the Bel-Air neighbourhood in Dakar. But it did not last more than two years (outdated equipment and very poor quality of compost).

1.1.2. In Regional, and Departmental Capitals and other Towns

Domestic waste is removed here by local communities; waste disposal containers are placed in specific areas and removed according to a schedule. People with no access to this public service, dispose of their domestic waste somehow or another.

All the waste collected is taken to a dumping ground which is often located at the entrance of, or on the way out from, the commune. Usually the waste management practice consists of scattering on the ground to avoid mountains of waste.

1.1.3. In Villages

In these areas, there is no waste collection system. Populations make use of their waste, depending on their culture. Some pile it up in a corner of the house with a view to turning it into organic fertilizer, others bury it in the ground or throw it on the way out of the village. This is a sort of individual management of waste, for everyone uses their waste to suit their needs.

1.2. Estimation Method

To estimate domestic waste production, the following methodological approach was used :

- field investigations to gather reliable data on the quantities and composition of domestic waste in urban and rural areas. The following localities were visited: Thiès, Khombole, Tiénéba, Bambey, Tivaouane, Diourbel, Fatick, Diakhaw, Kébémer, Saint-Louis, Richard-Toll, Sakal, Louga, Kaolack, Kolda, Ziguinchor, Vélingara, Gossas, Tambacounda, Kédougou, Bignona, Dakar.

- a calculation by extrapolation was done for localities that were not visited or localities without any organized removal system enabling the collection of reliable data.

The methodology focused on an analysis of the domestic waste disposal system, i.e., an analysis of the major means and mechanisms devised by the local communities to ensure a daily waste removal.

The basic data were collected from experts identified in the municipal administration and from a number of technical support agencies (for instance: Service de l'Hygiène - AGETIP - Peace Corps...)

Field visits were made to assess the reliability of the waste disposal system in comparison to the level of waste production, the extent of the service area and the disposal methods. Therefore the analysis of the removal system takes into account the existence of trucks for domestic waste disposal, how operational they are and whether they meet the determined level of service.

The waste removal facilities are made up of the following units :

- tractors;
- haulage unit - tractor engine,
- waste skips or containers.

As a rule, two removal methods are used :

- removal from home;
- the towing of waste skips or containers after they have been filled.

Whatever the waste removal system used, the heads of the relevant facilities were able to assess the level of coverage on the basis of maps of the dumping grounds and of the removal route as well as the population density.

The waste collected is disposed of on dumping grounds in various places in the city. From the loading capacity of the haulage units used and the number of daily trips made, the average daily quantity removed and the estimate of the annual amount dumped were assessed. Furthermore, when the coverage rate is taken into account, it is possible to calculate the daily per capita waste production and hence, the total quantity of solid waste generated every year within a commune. For further details, see the annex.

1.3. Composition of domestic waste

Information was collected on the composition of domestic waste in several localities: Thies, Diourbel, Louga, Dakar and Kaolack, where, after the classification and weighing of waste from samples covering several neighbourhoods, the different components and their percentage in the domestic waste were identified.

Usually, the domestic waste is composed of :

- organic matter from the daily food consumption of households;
- textiles;
- paper and cardboard;
- ferrous metals;

- rubber;
- glass;
- sand and stones.

The most significant components are organic wastes and sand. It should be pointed out that there is no sand screen which enables an isolation of the sand from the domestic waste. Furthermore, both in the rural and urban areas, since means of investigation were not available to identify the quantities of the different waste components, visits to the various dumping grounds were made. From these visits, it can be said that domestic waste in Senegal usually has the same qualitative characteristics with a significant proportion of organic matter.

The high proportion of organic matter - estimated at 50% on average - is due both to people's consumption patterns and to the significant part of plant waste present (tree leaves, grass, fruits... mixed up with domestic waste).

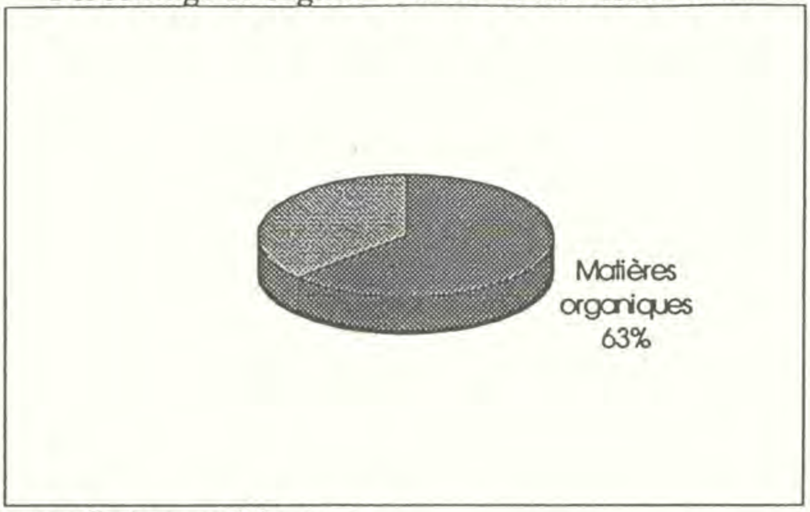
1.3.1. Composition of waste by Region : (see the different annex).

Waste generation and quantity of organic matter (o.m)

Région	Production (t)	Total m.o (t)
Dakar	398 517	282 947
Diourbel	102 515	53 308
Fatick	60 166	30 083
Kaolack	90 755	38 299
Kolda	47 703	23 851
Louga	66 011	33 534
Saint Louis	99 668	49 834
Tambacounda	33 718	16 859
Thiès	115 570	63 563
Ziguinchor	48 544	24 272
Total	1 063 167	616 550

Source : Environment Directorate.

Percentage of organic matter in domestic waste



Source : Environment Directorate.

1.4. Dumped Waste

This refers to the quantity of waste matching the level of coverage provided by the removal system, which usually varies between 50 and 80%. The average coverage, from a sample of areas visited, is 70%. The following table indicates the average daily and annual quantities dumped for all the regions in Senegal.

Région	Quantités mises en décharge	
	tonnes / jour	tonnes / an
Dakar	774.8	278 961.9
Thiès	224.7	80 898.7
Saint Louis	193.7	69 767.6
Louga	128.3	46 207.7
Diourbel	199.3	71 760.5
Kolda	92.7	33 391.9
Ziguinchor	94.3	33 980.6
Tambacounda	65.5	23 602.6
Fatick	116.9	42 116.3
Kaolack	176.4	63 528.7
Total	2 066.6	744 216.6

Source : Environment Directorate.

II. INDUSTRIAL WASTE

2.1. Estimation method

Questionnaires were administered to industries that were likely to generate waste and on which the Environment Directorate had insufficient data. Visits to the industrial companies also contributed to completing the questionnaires with a view to using these and having an in-depth discussion with the managers of industries.

2.2. Waste Generation

The following tables show the primary data for each of the industrial units generating waste. The data on liquid waste are only indicative, for there is still uncertainty about the results of their removal as GHG are released in the environment during the process.

See annexes concerning the types of industrial waste.

2.3. Liquid Waste (m3/year per type of industry)

Types d'industries		Déchets liquides (m^3/an)	DOB5 (kg/l)
Fer		5 000	0.001
Engrais		25 200	0.002
Alimentation et boisson	Conserves	100 000	0.006
	Bières et boissons alcoolisées	187 000	0.002
	Viande		
	Produits laitiers	47 300	0.020
	Sucre	110 425 000	0.006
	Poisson	200 266	0.006
	Huiles / graisses	484 920	0.008
	Autres	3 545	0.035
Papier	Papier		
	Autres		
Raffinage du pétrole		19 342	0.0002
Industrie textile	Teinturerie	550 000	0.001
	Autres	62 772	0.001
Caoutchouc / plastique		4 199	0.001
Autres		92 134	0.002

Source : Environment Directorate.

III. APPLICATION OF THE IPCC/OECD METHODOLOGY

DECHARGES

Module		Déchets								
Sous-module		Emissions de méthane générées par les décharges publiques								
Tableau		6.1								
Feuille		A								
A Quantité annuelle de DSM mis en décharge (spécifier les sous-catégories le cas échéant) (Gg)	B Fraction de COD (Gg de COD / Gg de DSM)	C Quantité annuelle de COD mis en décharge (Gg)	D Fraction qui se dégrade réellement	E Quantité annuelle de carbone émis sous forme de biogaz (Gg)	F Fraction de CH4 (Gg de C-CH4 / Gg de C-Biogaz)	G Emissions de CH4-C (Gg de C)	H Facteur de conversion (16/12)	I Emissions de CH4 (Gg de CH4)	J CH4 récupéré (Gg de CH4)	K Emissions nettes de CH4 (Gg de CH4)
		C = (A*B)		E = (C*D)		G = (E*F)		I = (G*H)		K = (I-J)
Déchets ménagers 744.200	0.150	111.630	*0.582*	64.969	0.500	32.484	1.333	43.312	0.000	43.312
Déchets industriels 1940.849	0.060	116.451	*0.330*	38.429	0.500	19.214	1.333	25.619	0.000	25.619
TOTAL 2685.049		228.081		103.397		51.699		68.932	0.000	68.932

DSM : Déchets Solides Municipaux
COD : Carbone Organique Dégradable

Module		**Déchets**		
Sous-module		Emissions de méthane générées par les décharges publiques		
Tableau		**6.1 (supplémentaire)**		
Feuille		**B**		
A Population (ou population urbaine) (spécifier les sous-catégories le cas échéant) (1000 personnes)	B taux de génération de déchets (Gg de D.S.M/1000 personnes/an)	C Quantité de déchets générée (Gg de D.S.M)	D Fraction mise en décharge	E Déchets solides municipaux mis en décharge (Gg de D.S.M)
		C = (A*B)		E = (C*D)
Population totale *7499*	0.1417	1062.608	0.7	743.826

DSM : Déchets Solides Municipaux

EMISSIONS DE METHANE A PARTIR DES EAUX USEES

	Module	**Déchets**						
	Sous-module	Emissions de méthane générées par les eaux usées municipales						
	Tableau	6.2						
	Feuille	A						
A Population (spécifier les sous-catégories le cas échéant) (1000 personnes)	B Taux de génération de D.O.B des eaux usées (Gg de DOB5/1000/personnes/an)	C BOD générée (Gg de DOB5)	D Fraction traitée en anaérobiose (Gg de DOB5)	E Quantité de BOD traitée en anaérobiose (Gg de DOB5)	F Facteur d'émission de méthane (Gg de CH4/kg DOB5)	G Emissions de CH4 (Gg de CH4)	H Récupération de méthane (Gg de CH4)	I Emissions nettes de CH4 (Gg de CH4)
		C = (A*B)		E = (C*D)		G = (E*F)		I = (G*H)
Dakar station d'épuration 73.847	0.013505	0.826	1	0.826	0.22	0.182	0.209	0.038
Dakar hors station d'épuration 658.552	0.013505	8.894	0	0.000	0.22	0.000	0.000	0.000
Saint Louis 123.778	0.013505	1.672	0	0.000	0.22	0.000	0.000	0.000
Louga 60.028	0.013505	0.811	0	0.000	0.22	0.000	0.000	0.000
Diourbel 84.386	0.013505	1.140	0	0.000	0.22	0.000	0.000	0.000
Kaolack 174.559	0.013505	2.357	0	0.000	0.22	0.000	0.000	0.000
TOTAL		15.699		0.826		0.182	0.209	0.038

DOB : Demande d'Oxygène Biochimique

Module		Déchets					
Sous-module		Emissions de méthane générées par les eaux usées industrielles					
Tableau		6.3					
Feuille		A					
ETAPE 1					ETAPE 2		
		A Décharge annuelle d'eaux usées (M litres)	B Taux de concentration de DOB (kg / litre)	C DOB totale générée (Gg de DOB)	D Fraction d'eaux usées traitées en anaérobiose	E Quantité de DOB traitée en anaérobiose (Gg de DOB)	F Facteur d'émission de méthane (0.22 Gg CH4 / Gg DOB5)
				C = (A*B)		E = (C*D)	
Fer et acier		5.000	0.001	0.005	0.1	0.001	0.22
Engrais		25.200	0.002	0.050	0.1	0.005	0.22
Alimentation et boissons	Fabrique de conserves	100.000	0.006	0.600	0.1	0.060	0.22
	Bières	187.000	0.002	0.374	0.1	0.037	0.22
	Conserves de viande	105.850	0.020	2.117	0.1	0.212	0.22
	Produits laitiers	47.300	0.035	1.656	0.1	0.166	0.22
	Sucre	110425.000	0.006	662.550	0.1	66.255	0.22
	Industries du poisson	200.266	0.006	1.202	0.1	0.120	0.22
	Huiles/graisses	484.920	0.008	3.879	0.1	0.388	0.22
	Autres	3.545	0.035	0.124	0.1	0.012	0.22
Raffinerie de pétrole / produits pétro-chimiques		19.342	0.000	0.004	0.1	0.000	0.22
Industrie textile	Blanchisseries			0.000	0.1	0.000	0.22
	Teintureries	550.000	0.001	0.550	0.1	0.055	0.22
	Autres	62.772	0.001	0.063	0.1	0.006	0.22
Caoutchouc		4.199	0.001	0.004	0.1	0.000	0.22
Autres		92.134	0.002	0.184	0.1	0.018	0.22

	Module	Déchets		
	Sous-module	Emissions de méthane générées par les eaux usées industrielles		
	Tableau	6.3		
	Feuille	B		
		ETAPE 3		
		G Total de méthane émis (Gg de CH4)	H Méthane récupéré (Gg CH4)	I Emissions nettes de méthane (Gg de CH4)
		G = (E*F)		I = (G-H)
Fer et acier		0.000	0	0.000
Engrais		0.001	0	0.001
Alimentation et boissons	Fabrique de conserves	0.013	0	0.013
	Bières	0.008	0	0.008
	Conserves de viande	0.047	0	0.047
	Produits laitiers	0.036	0	0.036
	Sucre	14.576	0	14.576
	Industries du poisson	0.026	0	0.026
	Huiles/graisses	0.085	0	0.085
	Autres	0.003	0	0.003
Raffinerie de pétrole / produits pétro-chimiques		0.000	0	0.000
Industrie textile	Blanchisseries	0.000	0	0.000
	Teintureries	0.012	0	0.012
	Autres	0.001	0	0.001
Caoutchouc		0.000	0	0.000
Autres		0.004	0	0.004
TOTAL				14.814

IV. COMMENTS

TABLE 6.1 - A :

- **Column D:** *(Anaerobically treated fraction, Gg of BOD5)*

* For industrial waste: the actual fraction that decomposes is considered to be 33%, taking into account that on a dumping ground 33% of the waste is recuperated, 33% burnt and 33% decomposes.

TABLE 6.1 - B :

- **Column B:** (*Level of waste generation*)

Source : Directorate for Environment.

TABLE 6.3 - A :

- **Column B:** (*Level of BOD5 concentration, kg/litre*)

* With reference to iron, fertilizers, meat, *others* (food and beverage) and rubber, the factors are specific to Senegal.
* with reference to dairy products: the coefficient used is derived from the heading "general food" in table 6-6, page 6.13.
* with reference to others: the coefficient is derived from the heading "miscellaneous" in table 6-6, page 6.13. "Others" includes: soap factories, companies manufacturing electric components, paint factories, the pharmaceutical industry and the cement industry.

All the national data used in table 6.3-A are derived from the "Survey of Industries" conducted by the Directorate for Environment (1990).

Chapter VI

CONCLUSION : OVERVIEW OF GREENHOUSE GAS EMISSIONS IN SENEGAL (1991)

The global warming phenomenon is one of the many natural reactions that demonstrate the saturation of global ecosystems because of anthropogenic emissions of greenhouse gases (GHGs).

In order to better understand the causes and consequences of global warming, and to assess the need to develop a global strategy for limitating GHG emissions, it is necessary to improve our knowledge of the anthropogenic factors that contribute to the greenhouse phenomenon.

The establishment of a GHG emission inventory should make it possible :

- to identify precisely the interactions between the global environment and the local environment;
- to establish past, present and future responsibilities for global warming;
- to study human reactions and capacities for adjustment to consequences of climatic warming as well as the impact on people and strategies to maintain the radiative equilibrium of the planet;
- to prioritize and select actions according to cost/benefits and other criteria such as opportunity, realism, etc;
- to design new (financial, technical, institutional, political, etc) mechanisms so as to really introduce the concept of sustainability into the development process.

The compilation of accurate, reliable inventories of GHG emissions is a complex activity since it requires the pooling of knowledge from a multiplicity of disciplines: physics, energy, forestry, agriculture, industry, etc.

We intend here to make a synthesis of the inventory of GHG emissions in Senegal in 1991 which hopefully will constitute a basic framework of application for African countries, accessible to non specialists.

Major Anthropogenic Activities that Contribute to the Enhanced Greenhouse Effect

Human activities are a potential source of global warming since they tend to result in the emission of gases that contribute to increasing the concentration of GHG in the atmosphere above natural levels.

The major human activities that contribute to the enhanced greenhouse effect include:

- energy consumption, production, storage and distribution;
- logging, land use change and the combustion of biomass;
- agriculture;
- waste disposals;
- the use of CFCs.

Major Greenhouse Gases

The major types of gas generated by the above mentioned activities are :

- carbon dioxide (CO_2);
- carbon monoxide (CO);
- methane (CH_4);
- non-methane hydrocarbons (NMVOCs)
- nitrous oxide (N_2O);
- oxide of nitrogen (NOx).

Relative Impact of the Various Gases in Terms of Greenhouse Effect: Global Warming Potential (GWP)

The impact of a given quantity of gas in terms of weather warming or global warming potential (GWP) varies with the type of gas. The GWP of a given gas depends mostly on the thermal efficiency of the gas, on various complex physical and chemical parameters and on its lifespan in the atmosphere as a direct or indirect GHG. This concept of lifespan or "duration of stay" in the atmosphere leads us to consider right off various options in terms of duration of integration. As a rule, three possibilities of integration timespan are used: 20 years, 100 years and 500 years.

The first appears to be too brief for an assessment of high inertia phenomena such as those found in climatology. In addition, it may lead to wrong interpretations since the lifespan of many of the greenhouse contributory gases is much longer.

A 500 years integration timespan is very attractive for it helps avoid the constraints of a too short lifespan as shown above. However it lends itself to easy criticism since:

- projections on changes in the physical and chemical phenomena in the atmosphere are still very uncertain;
- we do not have the means to develop predictive models integrating major, especially technological phenomena which would enable us to project the human response to potential environmental problems in the next 500 years.

The intermediate option, 100 years, leads to reasonable analyses; furthermore it makes the last criticisms less justified. Therefore, 100 years is the choice most often made.

With the GWP, the global emissions of one activity, one sector, one country, etc, can be expressed in the same unit (e.g., in CO_2 equivalent) for the sake of aggregation or comparison.

The most recent estimates now available are as follows :

Global Warming Potential of GHGs

Type de gaz	Durée de vie (années)	Intégration sur 20 ans	Intégration sur 100 ans	Intégration sur 500 ans
CO_2	120	1	1	1
CH_4	10.5	35	11	4
CO	Quelques mois	-	-	-
N_2O	132	260	270	170
NOx	Quelques jours	-	-	-
CFC 11	55	4500	3400	1400
CFC 12	116	7100	7100	4100
CFC 13	400	11000	13000	15000
HCFC 22	15.8	4200	1600	540

Source : "IPCC 1992 Supplement : Scientific Assessment".

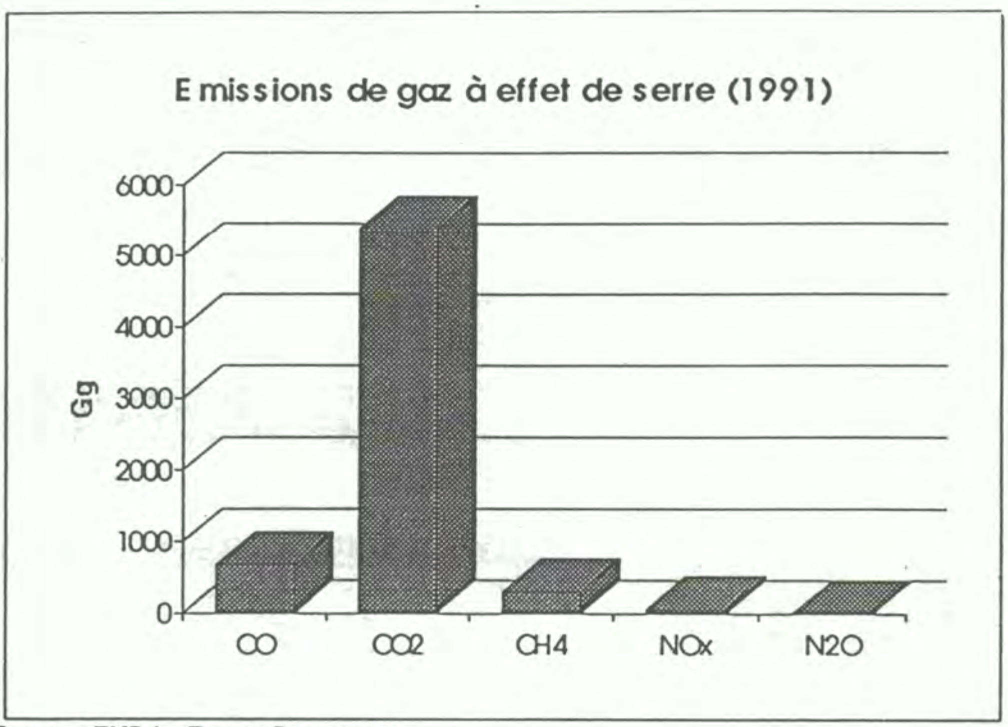
OVERVIEW OF GREENHOUSE GAS EMISSIONS IN SENEGAL (1991)

	Gigagrammes (Gg)				
	Monoxyde de carbone	**Dioxyde de carbone**	**Méthane**	**Oxydes d'azote**	**Oxyde azoteux**
	CO	CO2	CH4	NOx	N2O
MODULE 1 : ENERGIE					
CO2 émis par les sources d'énergie		3346.9			
Combustion de la biomasse traditionnelle pour la production d'énergie	174.9		24.9	2.8	0.1
Emission de méthane lors de la production de pétrole et de gaz			0.1		
Sous-total module 1	***174.9***	***3346.9***	***25.0***	***2.8***	***0.1***
MODULE 2 : PROCEDES INDUSTRIELS					
CO2 émis lors de la production de ciment		234.0			
Sous-total module 2		***234.0***			
MODULE 4 : AGRICULTURE					
Emissions de méthane des animaux et du fumier animal			83.5		
Emissions de méthane générées par la riziculture			58.7		
Incinération de la savane	26.3		0.0	48.4	2.1
Incinération ouverte des résidus agricoles	14.7		0.7	0.5	0.0
Sous-total module 4	***41.0***		***142.9***	***48.9***	***2.1***
MODULE 5 : CHANGEMENT D'EXPLOITATION DES TERRES ET FORETS					
Emissions annuelles totales de CO2 générées par l'éclaircissement des forêts		28167.2			
Emissions de gaz traces générées par la combustion des forêts éclaircies	462.4		52.8	8.6	0.4
Forêts exploitées. Suppressions annuelles réelles de CO2		-26355.4			
Sous-total module 5	***462.4***	***1811.8***	***52.8***	***8.6***	***0.4***
MODULE 6 : DECHETS					
Emissions nettes de méthane générées par les décharges publiques			68.9		
Emissions nettes de méthane générées par les eaux usées municipales			0.0		
Emissions nettes de méthane générées par les eaux usées industrielles			14.8		
Sous-total module 6			***83.8***		
TOTAL	678.3	5392.7	304.5	60.3	2.6
Potentiel de Réchauffement Global (PRG), Intégration sur 100 ans		1	11		270
1000 TECO2		5392.7	3349.5		695.1
%		57.1	35.5		7.4

Source : ENDA - Energy Programme.

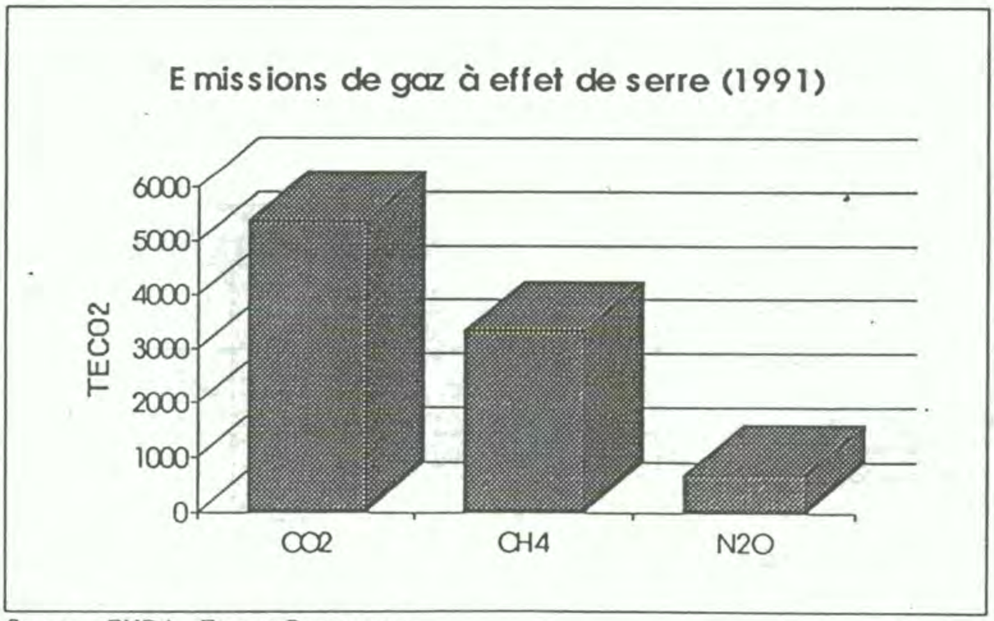
GHG Emissions in Senegal

In 1991, the total anthropogenic emissions from greenhouse gas were as follows :



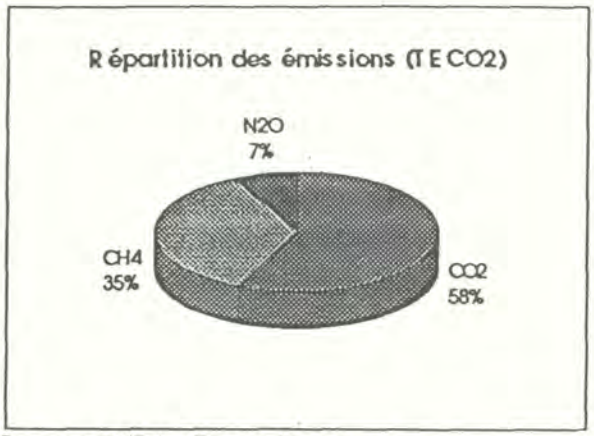
Source : ENDA - Energy Programme.

If one accounts for the GWP of each GHG emitted, the total is 9.437 $MTECO_2$, i.e. 1.3 $TECO_2$/capita/year.



Source : ENDA - Energy Programme.

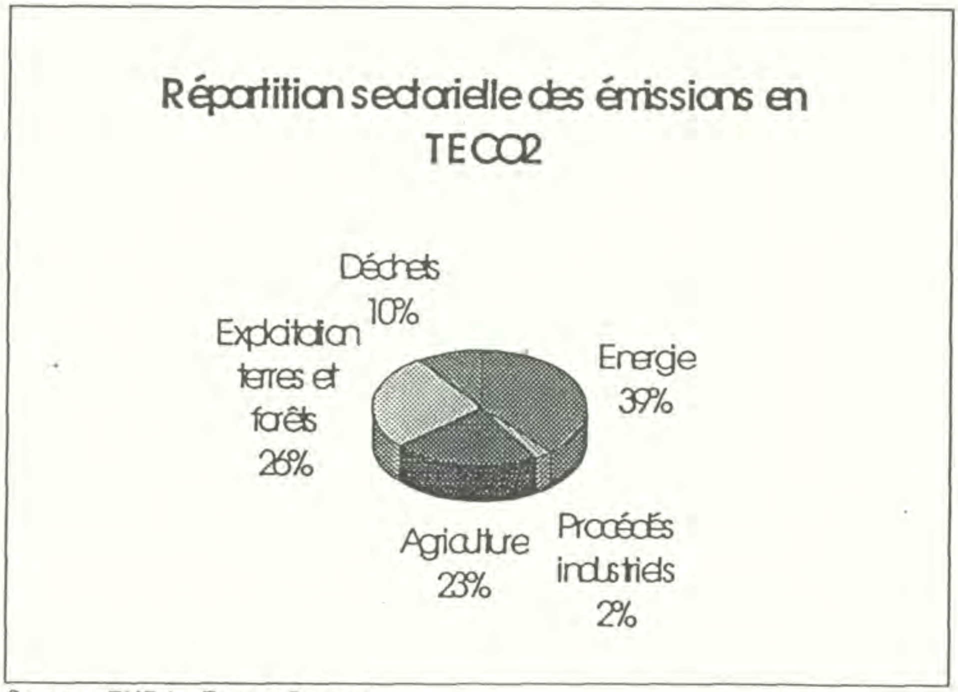
In 1991 CO_2 ranked first among the major GHGs emitted in Senegal with 58% of the total emission (5.394 $MTECO_2$), followed by CH4 with 35% of the emissions (3.349 $MTECO_2$) and finally N_2O with 7% of total emissions (0.695 $MTECO_2$).



Source : ENDA - Energy Programme.

GHG Emissions by Sector

Energy is the major generator of GHG (3.649 $MTECO_2$, i.e. 39% of total emissions), followed by land use change and forestry (2.501 $MTECO_2$ or 26%), agriculture (2.139 $MTECO_2$ or 23%), waste (0.922 $MTECO_2$, or 10%) and finally industrial processes (0.234 $MTECO_2$, or 2%).



Source : ENDA - Energy Programme.

The energy sector mostly emits CO_2 (92% of the $TECO_2$ generated by this sector), similar to industrial processes which only generate carbon dioxide. Emissions from the agricultural sector are however more diversified; and although it does not generate CO_2, CH_4 accounts for 73% of its emissions in $TECO_2$. Despite the fact that the land use change and forestry mostly generates CO_2 (72% of $TECO_2$ released in this sector), it is significant to mention that : the annual emissions of CO_2 generated by forest clearing (28.167 $MTECO_2$) are largely compensated by the annual elimination of CO_2 due to the management of logged forests (26.355 $MTECO_2$), thereby significantly decreasing the net emissions of carbon dioxide down to 1.812 $MTECO_2$. As a result, this sector no longer outranks the others in terms of GHG emission in Senegal. Finally, waste accounts for 83, 800 tonnes of the methane released, i.e. 0.922 $MTECO_2$.

Chapter VII

NATIONAL SEMINAR (DAKAR, 24 - 25 JUNE 1994)

I. PROGRAMME

SEMINAIRE de DAKAR "INVENTAIRE DES EMISSIONS DE GAZ A EFFET DE SERRE AU SENEGAL"

Vendredi 24 Juin

09h00 - 09h30	Allocution de bienvenue et ouverture des travaux (Ministère de l'Environnement). Présentation du projet (ECU).
09h30 - 09h40	Suspension de séance.
09h40 - 10h00	Introduction du séminaire et présentation des participants (Direction de l'Environnement).
10h00 - 11h00	Introduction de la Convention Cadre des Nations Unies sur les Changements Climatiques. Contraintes et perspectives pour le Sénégal. Présentation et discussion (Direction de l'Environnement).
11h00 - 11h30	Pause café.
11h30 - 12h30	Présentation de la méthodologie des inventaires de gaz à effet de serre. Problèmes et difficultés de la collecte des données, de l'adaptation du cadre, et des coefficients proposés par l'IPCC-OCDE (ENDA-Programme Energie).
12h30 - 14h30	Déjeuner.

14h30 - 15h30	Présentation des résultats d'inventaire des émissions du secteur de l'énergie et des procédés industriels. Méthode d'approche. Problèmes et difficultés rencontrés. Discussion. (Direction de l'Energie).
15h30 - 16h00	Pause café.
16h00 - 17h30	Présentation des résultats d'inventaire des émissions dues aux déchets. Méthode d'approche. Problèmes et difficultés rencontrés. Discussion. (Direction de l'Environnement).

Samedi 25 Juin

09h00 - 10h30	Présentation des résultats d'inventaire des émissions dues à l'agriculture. Méthode d'approche. Problèmes et difficultés rencontrés. Discussion. (Centre de Suivi Ecologique).
10h30 - 11h00	Pause café.
11h00 -12h30	Présentation des résultats d'inventaire des émissions dues au changement d'affectation des terres et forêts. Méthode d'approche. Problèmes et difficultés rencontrés. Discussion. (Centre de Suivi Ecologique).
12h30 - 14h30	Déjeuner.
14h30 - 15h30	Présentation des résultats globaux. Perspectives pour le Sénégal. (Direction de l'Environnement).

II. COMMENTS ON THE IPCC/OECD METHODOLOGY

Le séminaire national sur l'inventaire des émissions de gaz à effet de serre a permis de recueillir un certain nombre de remarques formulées sur le rapport du Sénégal qui a été présenté les 24 et 25 juin 1994. Ces remarques ont porté sur la méthodologie et les résultats obtenus.

1 - La méthodologie

L'impression générale qui ressort est que la méthodologie fournie par l'IPCC/OCDE est globale. Les cas spécifiques par pays ne sont pas mis en exergue, en particulier sur le cas des pays tropicaux. Par exemple, l'accent n'est pas mis sur les formations végétales des zones tropicales sèches c'est-à-dire sur les savanes. La production de charbon de bois n'a pas été prise en compte.

Parmi les raisons évoquées, il ressort que les coefficients fournis dans les différents modules ne sont généralement pas adaptés au contexte sénégalais. Ces coefficients sont appropriés dans certains cas, comme le secteur des déchets; mais des taux moyens calculés localement ont été le plus souvent appliqués. C'est le cas du secteur agricole et de l'exploitation des forêts.

Le calcul des émissions n'a pas pris en compte tous les secteurs d'activités humaines. C'est ainsi que les procédés industriels autres que ceux du ciment ne sont pas considérés (engrais azotés, solvants). De plus, le secteur du transport n'a fait l'objet que d'une estimation à partir des consommations énergétiques. Un recensement détaillé du parc automobile n'a pu être effectué, à cause de l'inaccessibilité des données.

Il s'est avéré que la méthodologie de calcul des émissions de gaz à effet de serre n'a pas encore atteint un degré suffisant de fiabilité. Elle sera progressivement remise à jour à partir des remarques, critiques et propositions faites durant les séminaires nationaux.

2 - Les résultats

A la suite des exposés des strctures impliquées dans le projet, il s'est avéré que la contrainte majeure a été la collecte des données. L'accès à l'information est souvent rendue difficile par :

- la non maîtrise des circuits des produits,
- l'absence de mise à jour des statistiques.

Dans le secteur énergétique, des données peuvent s'avérer fausses après recoupement des informations recueillies auprès des importateurs et des distributeurs.

Les méthodologies des différentes structures feront l'objet d'un document annexe.

Pour certains secteurs le gaz considéré n'est pas le seul émis (exemple des déchets : le CH_4 est considéré alors que par combustion le CO_2, le CO... peuvent être émis).

3 - Conclusions

Le document a été apprécié par les différents participants qui ont émis la nécessité de mettre en place des structures de concertation pour permettre l'accès et l'échange de données entre les services.

Le document présenté n'était pas encore définitif. Par la suite, ce rapport sera annuellement remis à jour, comme convenu dans la convention cadre. Le cadre de collecte déjà existant facilitera les études ultérieures au fur et à mesure que la méthodologie sera améliorée.

Les structures de recherche devront dorénavant être mieux impliquées dans la définition de coefficients nationaux mieux adaptés au contexte sahélien.

Le séminaire a été clôturé sur un sentiment de satisfaction générale à la suite des interventions des représentants de l'Environnement, de l'ENDA, de l'IPCC/OCDE et du Directeur du Centre de Suivi Ecologique.

III. LIST OF PARTICIPANTS

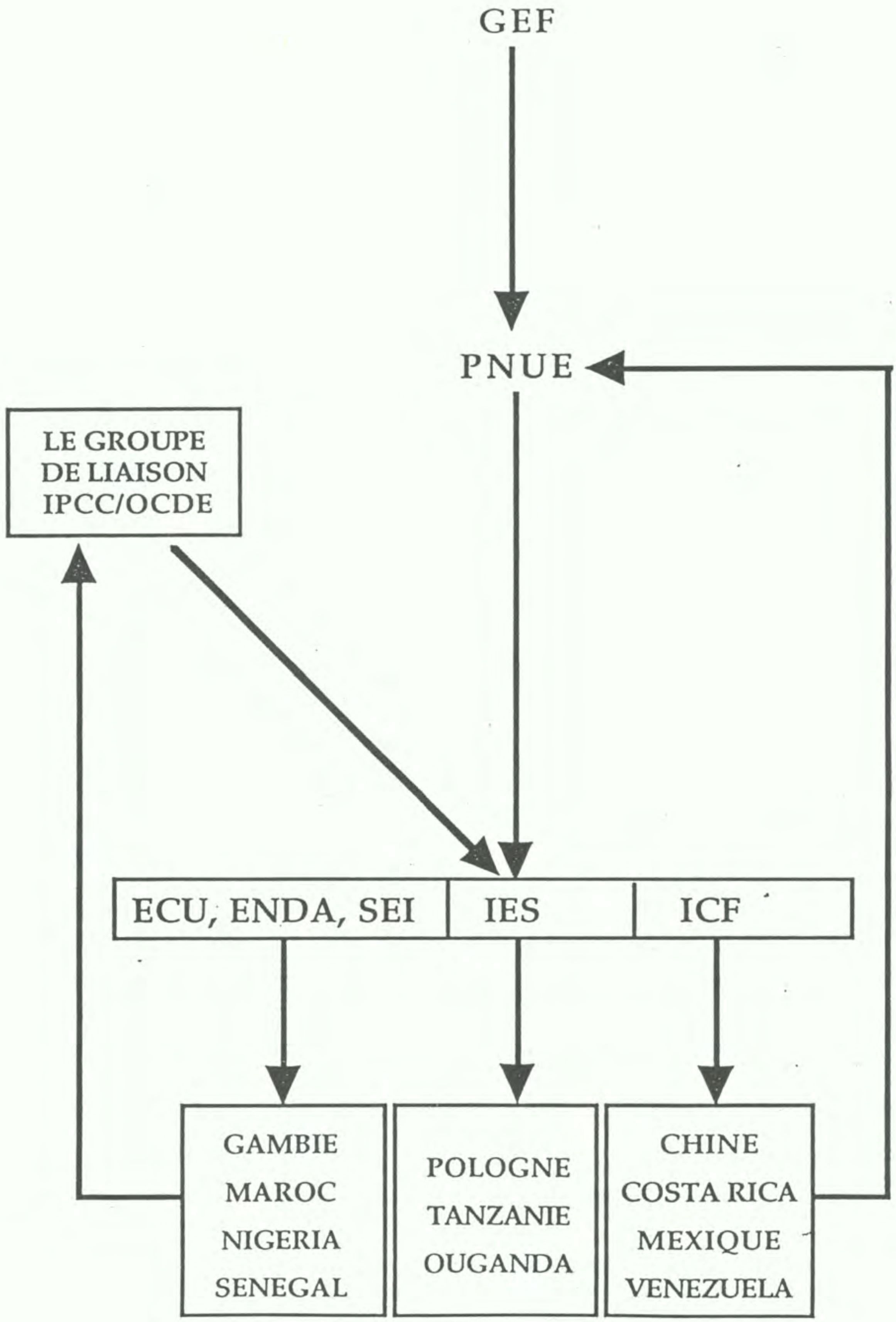
Nom et Prénoms :	*Organismes :*
1. Melle Claudine SEGALAS	ENDA - Programme Energie
2. Mr Dominique REVET	ENDA - Programme Energie
3. Melle Yacine DIAGNE	ENDA - Programme Energie
4. Mr Mass LO	ENDA - Programme Energie
5. Mr Libasse BA	ENDA - Programme Energie
6. Mr Nanasta DJIMINGUE	ENDA - Programme Energie
7. Mr Sékou SARR	ENDA - Programme Energie
8. Mr Thomas Jean Philippe	ENDA - Programme Energie
9. Mr Abdou DIOP	Direction de l'Agriculture
10. Mr Martin PRICE	ECU - Université d'Oxford
11. Mr Bakary KANTE	Direction de l'Environnement
12. Mr Pathé BALDE	Direction de l'Environnement
13. Mme Fagamou SY	Direction de l'Environnement
14. Mr NDIAYE Cheikh SYLLA	Direction de l'Environnement
15. Mr Birane SARR	Direction de l'Environnement
16. Melle Reine Marie COLY	Direction de l'Environnement
17. Mr Elimane BA	Direction de l'Environnement
18. Mr Amadou Mactar NIANG	Centre de Suivi Ecologique
19. Mr Papa Boubacar SOUMARE	Centre de Suivi Ecologique

20. Mr Racine KANE	Centre de Suivi Ecologique
21. Mr Peter GILRUTH	UNSO
22. Melle Isabelle NIANG DIOP	Département de Géographie - UCAD
23. Mr SOW Cheikh Sadibou	Météorologie Nationale
24. Melle DIOP	Météorologie Nationale
25. Mr Alassane Ségou NDIAYE	Direction de l'Energie
26. Mr Ibra Sounkarou NDIAYE	Direction des Eaux, Forêts, Chasses et Conservation des Sols

IV. SOME SEMINAR PRESENTATIONS

Vendredi 24 Juin

09h00 - 09h30 Présentation du projet (*Martin PRICE*)


GEF
PNUE
LE GROUPE DE LIAISON IPCC/OCDE
ECU, ENDA, SEI
IES
ICF
GAMBIE
MAROC
NIGERIA
SENEGAL
POLOGNE
TANZANIE
OUGANDA
CHINE
COSTA RICA
MEXIQUE
VENEZUELA

Projet Pilote PNUE/GEF:

Inventaires nationaux des Gaz à effet de serre

Les **buts**:

⇨ Les meilleurs **inventaires**

⇨ Des améliorations de la **méthodologie** IPCC/OCDE

3 équipes, 13 pays

ECU (Oxford) + ENDA (Dakar) + SEI (Londres/Boston):

Le Sénégal, La Gambie, Le Maroc, Le Nigéria

IES (Amsterdam):

La Tanzanie, L'Ouganda, La Pologne

ICF (Washington D.C.):

La Chine, Le Costa Rica, Le Mexique, Le Vénézuela

Les étapes du projet

1. La mission préliminaire (*novembre 1992*)

2. La préparation de la proposition au PNUE (*janvier - mai 1993*)

3. Le séminaire de formation (*mai 1993*)

4. L'aide technique pendant l'inventarisation (*juin 1993 - juin 1994*)

(L'atelier africain, *mars 1994*)

5. L'atelier national (*juin 1994*)

6. La finalisation de l'inventaire et soumission au PNUE (*juillet 1994*)

Vendredi 24 Juin

11h30 - 12h30 Présentation de la méthodologie des inventaires de gaz à effet de serre. Problèmes et difficultés de la collecte des données, de l'adaptation du cadre, et des coefficients proposés par l'IPCC-OCDE (*Dominique REVET*).

La méthodologie développée par l'IPCC-OCDE, et que nous avons tenté d'appliquer au Sénégal, est décrite dans le Volume 2 (document vert) de la documentation que l'on vous a remis tout à l'heure.

Ce qu'il est important de retenir, en fait, ce sont les deux points suivants :

De quoi s'agit-il?

Transparent n°1:

A quoi sert donc cette méthodologie développée par l'IPCC-OCDE?

Transparent n°2:

Quels sont, maintenant, les principes généraux de cette méthodologie?

Transparent n°3:

Quels sont les principaux GES concernés par l'inventaire national?

Transparent n°4:

Au cours du travail qui a débouché sur le rapport final d'inventaire des émissions de GES au Sénégal, nous avons pu constater que cette méthodologie (encore provisoire, car un processus de révision est en cours, et ne devrait déboucher sur un **document définitif que mi-1996**) possède des **limites**. La principale d'entre elles étant qu'elle ne reflète pas les spécificités propres à certaines régions du monde, et plus particulièrement en ce qui concerne les pays africains. Nous le verrons plus tard, certains facteurs d'émission propres au Sénégal ont été retenus à la place des coefficients par défaut proposés par l'IPCC. L'ensemble des remarques et changements apportés aux coefficients proposés dans la méthodologie pour les pays en développement sont exposées sous forme de notes et de commentaires, à la fin de chaque chapitre du rapport.

Nous allons maintenant faire quelques commentaires sur les différents aspects de l'étude, en reprenant l'ordre du rapport, c'est-à-dire :

- Energie,
- Procédés industriels (cimenterie),
- Agriculture,
- Changement d'exploitation des terres et forêts,
- Déchets.

Toutefois, nous allons seulement évoquer ici les problèmes rencontrés au cours de l'application de cette méthodologie au Sénégal, car plus de détails vous seront fournis par mes collègues cette après-midi et demain matin.

❖❖❖❖❖❖❖❖

ENERGIE :

➔ Nous avons suggéré à l'OCDE (pages 12, 13 et 14) que la présentation des tableaux soit modifiée : mieux vaudrait mettre les *"soutes"* en colonne, car elles viennent en déduction de la *"consommation apparente"*.

➔ Des facteurs de conversion (des tonnes en Gj...) n'étaient pas indiqués dans le manuel de référence;

- nous avons donc du les calculer pour (page 20) :
  - le *"fioul"*,
  - la *"biomasse"*,
- et prendre des coefficients fournis par d'autres sources (Banque Mondiale), pour :
  - le *"bois"*,
  - le *"charbon de bois"*.

AGRICULTURE :

➔ Le dénombrement du *"bétail"* pose problème (estimations aériennes, doubles comptes/statistiques...).

➔ Aucun coefficient ne figure dans le manuel de référence concernant la *"fraction de carbone"* contenue dans le *coton* : nous avons donc du retenir celui de la plante indiquée dans la liste des informations disponibles qui avait les caractéristiques s'en approchant le plus.

➔ La *"densité de la biomasse"*, et la *"biomasse exposée à l'incinération"* : ont été directement calculées à partir des images satellitaires, et non pas en multipliant la biomasse moyenne à l'hectare (ha) par la superficie brûlée comme indiqué dans le manuel de référence.

CHANGEMENT D'EXPLOITATION DES TERRES ET FORETS :

→ Les *types de savanes* retenus pour le Sénégal ne sont pas exactement ceux figurant dans le manuel de référence. Ils ont été redéfinis à la suite de la stratification du territoire en 3 catégories, suivant les caractéristiques des milieux narturels sénégalais : forêts claires, savanes arborées, et savanes arbustives.

→ "*Augmentation annuelle de la biomasse des ligneux*" : plutôt que les coefficients figurant dans le manuel de référence, nous avons opté pour des chiffres issus des expériences de reboisement menées au Sénégal, soit : **3,25 t de ms** pour les espèces exotiques à croissance rapide, et **2,75 t de ms** pour les espèces locales à croissance plus lente (contre des chiffres **3 à 4 fois plus** importants dans le manuel de référence!).

→ Ces modifications ont eu un gros impact au niveau des émissions globales (- → +).

DECHETS :

→ On a du procéder à certaines estimations ("*fraction des déchets industriels qui se dégrade*" : 1/3, ...).

→ Des chiffres propres au Sénégal ont pu être retenus : cela a été le cas pour le "*taux de DOB5 (kg/l)*" pour les engrais, la viande et le fer.

Transparent n°1:

DE QUOI S'AGIT-IL ?

1 - Le **PRINCIPE** de la méthode est très **simple** :

1 activité (tonnes...) **x** 1 coefficient d'émission (Gg C/t...) = 1 type d'émission de GES (CO_2...)

2 - L'**APPLICATION DU PRINCIPE** est plus **délicate**, il y a des problèmes de :

- ⇨ collecte des données
- ⇨ recoupement des catégories à analyser
- ⇨ détermination de coefficients pertinents pour le Sénégal

Transparent n°2:

IMPORTANCE DE L'INVENTAIRE NATIONAL DES GES

Fondamental, aux niveaux national et international, pour les réponses à apporter au changement climatique/développement durable

COMPREHENSION SCIENTIFIQUE AMELIOREE

⇨ Futures estimations de l'IPCC
⇨ Développement des capacités nationales

FORMATION ET MISE EN OEUVRE DE POLITIQUES

⇨ Réponse aux obligations de la Convention Cadre sur les Changements Climatiques
⇨ Plans et stratégies nationales
⇨ Evaluation et progrès

DECISIONS D'INVESTISSEMENTS

⇨ Fonds pour l'Environnement Mondial (FEM/GEF)
⇨ Investissements privés (Joint Implementation...)

Transparent n°3:

PRINCIPES GENERAUX
de la méthodologie IPCC-OCDE

①- Elaborer une information disponible

②- Développer un cadre d'analyse détaillé mais flexible

- couvrir l'ensemble des activités nationales
- établir des priorités par types de gaz et sources/puits
- choisir entre une approche détaillée ou simple (par défaut)

③- Rapport et documentation standardisés

④- Besoin d'une coopération technique transversale

⑤- Programme encore provisoire - Applicabilité sur le long terme

Transparent n°4:

LES GES ETUDIES LORS DE L'INVENTAIRE NATIONAL

⇨ L'étude a porté sur les 5 principaux GES suivants :

- CO : Monoxyde de carbone
- CO_2 : Dioxyde de carbone
- CH_4 : Méthane
- NO_x : Oxydes d'azote
- N_2O : Oxyde azoteux

⇨ Les principaux secteurs concernés par types de GES:

	CO	CO_2	CH_4	NO_x	N_2O
Energie					
Procédés industriels					
Agriculture					
Changement d'exploitation des terres et forêts					
Déchets					

(pour plus de détails, cf: Chapitre VI : Synthèse).

ANNEX 1
Baseline data from the Energy Sector

PRODUCTION DE PRODUITS PETROLIERS

tonne	1985	1986	1987	1988	1989	1990	1991	1992
Pétrole brut	-	215	1413	2563	1730	1130	579	234
GPL	1327	3034	3702	6698	4886	6347	4747	8840
Essence super	15744	58543	63689	76070	62240	58878	49019	71387
Essence ordinaire	14892	19800	30439	34225	28699	37084	38839	29900
Total Essence	30636	78343	94128	110295	90939	95962	87858	101287
Pétrole lampant	7302	9946	13477	12696	10732	12069	12362	13100
Carburéacteur	18264	66744	71374	87600	72853	73566	70794	89210
Kerozene	25566	76690	84851	100296	83585	85635	83156	102310
Gazole	3963	110249	105100	123028	102033	129254	103685	156572
Diesel	17760	45500	65133	86648	66051	71253	61025	76200
Diesel+Gazole	21723	155749	170233	209676	168084	200507	164710	232772
Fioul	97102	161106	209521	272523	224234	275733	184181	218898

Source : Direction de l'Energie / ENDA - Programme Energie.

PRODUCTION DE GAZ NATUREL

m3	1985	1986	1987	1988	1989	1990	1991	1992
Gaz naturel			343255	9388282	8939404	5540057	5070505	2243035

Source : Direction de l'Energie / ENDA - Programme Energie.

PRODUCTION BRUTE D'ENERGIE ELECTRIQUE

MWh	1985	1986	1987	1988	1989	1990	1991	1992
Centrales SENELEC	755181	749975	811868	842766	877894	900894	915731	
Centrales autoproducteurs	82369	134676	158291	160448	9094	19785	8711	
Autoconsommation des autoproducteurs							67965	
Pertes de transport et distribution							156579	
TOTAL	837550	884651	970159	1003214	886988	920679	1148986	0

Source : Direction de l'Energie / ENDA - Programme Energie.

IMPORTATIONS DES FORMES D'ENERGIE

tonne	1985	1986	1987	1988	1989	1990	1991	1992
- Pétrole brut	132622	647772	528651	757171	584738	641975	505829	695400
- Essence super	47441	13693	11796	1000	6897	6001		10784
- Essence ordinaire	30278	10143	750	71	577			
- Essence avion	561	1518	414	798				
Total Essence	78280	25354	12960	1869	7474	6001	505829	10784
- Pétrole lampant	7530	3483	1849	406				
- Carburéacteur	117930	63347	50566	42690	89520	63581	70764	58886
Total Kerozène et carburéacteur	125460	66830	52415	43096	89520	63581	70764	58886
- Gazole	222104	142998	125035	104662	64679	70930	84180	99647
- Diesel	55036	17365	11385	363				
Gazole+Diesel	277140	160363	136420	105025	64679	70930	84180	99647
- Fioul	273216	149422	169388	65420	136098	77541	147561	184849
- Butane	16657	15977	17127	18441	24369	27614	33230	39588

Source : Direction de l'Energie / ENDA - Programme Energie.

EXPORTATION DES FORMES D'ENERGIE

tonne	1985	1986	1987	1988	1989	1990	1991	19[illegible]
- Essence super	2140	4951	5495	12671	11877	2213	1836	1700
- Essence ordinaire	22928	11994	9534	13613	7681	16057	18627	236[illegible]
Total essence	25068	16945	15029	26284	19558	18270	20463	25387
- Pétrole lampant	4091	3092	4854	2096	1222	2543	3055	3000
- Carburéacteur	2933	2562	2871	420	1707	5281	5551	5600
Total Kerozène et carburéacteur	7024	5654	7725	2516	2929	7824	8606	8600
- Gazole	43617	34899	37964	30956	34358	31194	17060	145[illegible]
- Diesel	14311	13875	16499	19856	21983	18638	15761	14756
Diesel+Gazole	57928	48774	54463	50812	56341	49832	32821	29268
- Fioul	8518	1245	10299	6025	18151	18237	2665	40[illegible]
- Butane	2892	2925	2548	300	251	71	259.9	2400

Source : Direction de l'Energie / ENDA - Programme Energie.

SOUTES MARITIMES INTERNATIONALES

tonne	1985	1986	1987	1988	1989	1990	1991	19[illegible]
- Fioul	34605	19861	22272	19269	18151	14815	9189	9189
- Diesel	2538	2060	865	140	8737	5911		
- Gazole	60616	62724	74998	62146		6868	1066	

Source : Direction de l'Energie / ENDA - Programme Energie.

SOUTES MARITIMES NATIONALES

tonne	1985	1986	1987	1988	1989	1990	1991	1992
- Fioul	542	38	38	-			9189	
- Diesel	1068	80	20	-				
- Gazole	30436	25786	14118	38137				

Source : Direction de l'Energie / ENDA - Programme Energie.

VARIATIONS DE STOCKS

tonne	1985	1986	1987	1988	1989	1990	1991	1992
- Pétrole brut	-91588	151319	-62783	27712	-20380.5	51127	43271	
- Butane	-345	-183	1149	-404	-362.5	548	-258	
- Essence super	-4046	48	406	412	3752.7	5351	-5701.4	
- Essence ordinaire	-1939	-2027	48	625	3955.8	199	-4613.1	
Total essence	-97918	149157	-61180	28345	-13034.5	57225	32698.5	
- Pétrole lampant	-102	-141	-67	161				
- Carburéacteur	3166	-7559	-1506	2665	8172.2	-9954	1732	
Kerozène	3064	-7700	-1573	2826	8172.2	-9954	1732	
- Gazole	-1269	2774	-1361	5949	-1589.3	2236	-5128	
- Diesel	-2646	-1131	1599	446	421	1844	-1625.5	
Diesel+Gazole	-3915	1643	238	6395	-1168.3	4080	-6753.5	
- Fioul	422	-13262	-242	11963	-14.5	2570	-983.5	

Source : Direction de l'Energie / ENDA - Programme Energie.

TRANSFORMATION : PRODUITS PETROLIERS

tonne	1985	1986	1987	1988	1989	1990	1991	1992
RAFFINERIE								
Quantité de pétrole brut traité	224120	496723	592848	731905	605118	694083	549617	6954[illegible]

Source : Direction de l'Energie / ENDA - Programme Energie.

COMBUSTIBLES ENTRANT DANS LES CENTRALES THERMIQUES

	1985	1986	1987	1988	1989	1990	1991	1992
Centrales SENELEC								
- Diesel (tonne)	27522	19722	24429	29577	24803	22031	25767	
- Fioul (tonne)	222417	221879	236208	238914	248898	248036	235407	
- Gaz naturel (1000 m3)	-	-	-	7816	8886	6540	5071	
Centrales autoproducteurs								
- Diesel (tonne) / SONACOS	5585	6094	5654	5962			867	
- Fioul (tonne) / CSS	16928	17929	17378	15786			5498	
- Bagasse (tonne)		251000	250000	263000			309049	
- Coque d'arachide (tonne)	39094	57058	90333	110316			127141	
- Méthane (1000 m3) SONEES							65.674	
- Vapeur (Tjoules)	353	442	471	443			714	

Source : Direction de l'Energie / ENDA - Programme Energie.

CONSOMMATION DU SECTEUR DE L'ENERGIE

	1985	1986	1987	1988	1989	1990	1991	1992
Electricité (MWh)	54203	56602	57736	60002	49255	58361	31332	
Fioul (tonne)							3179	

Source : Direction de l'Energie / ENDA - Programme Energie.

PERTES DANS LE TRANSPORT ET LA DISTRIBUTION

MWh	1985	1986	1987	1988	1989	1990	1991	1992
Electricité	87849	82045	110862	107100	142585	120696	156579	

Source : Direction de l'Energie / ENDA - Programme Energie.

CONSOMMATION FINALE DE L'ENERGIE

	1985	1986	1987	1988	1989	1990	1991	1992
- Essence super (tonne)	67049	67988	67415	63748	59835	57557	58687	56057
- Essence pirogue (tonne)	25873	21003	19880	19871	20192	21198	20151	21199
- Total Essence (tonne)	92922	88991	87295	83619	80027	78755	78838	77256
- Pétole lampant (tonne)	10719	10554	10354	10558	9921	9813	9565	10337
- Carburéacteur (tonne)	133084	133444	113460	130856	148384	143882	128237	126127
- Kerozène (tonne)	**143803**	**143998**	**123814**	**141414**	**158305**	**153695**	**137802**	**136464**
- Gazole (tonne)	105311	107069	114095	128044	136331	149716	160191	177249
- Diesel (tonne)	58276	51011	57391	64711	60627	61755	42055	76021
- Diesel + Gazole (tonne)	**163587**	**158080**	**171486**	**192755**	**196958**	**211471**	**202246**	**253270**
- Fioul (tonne)	**86951**	**63230**	**66769**	**79125**			**94935**	**350638**
- Butane (tonne)	**15931**	**15851**	**17865**	**25625**	**29205**	**33518**	**37962**	**41916**
- Electricité (MWh)	**695498**	**746004**	**801561**	**836112**	**685994**	**721837**	**736653**	
- Charbon de bois (tonne)			**110583**	**109461**	**152942**	**162227**	**135596**	**114115**
- Bois (tonne)			**28300**	**25012**	**22094**	**29399**	**23585**	**29665**

Source : Direction de l'Energie / ENDA - Programme Energie.

CONSOMMATION FINALE D'ESSENCE

tonne	1985	1986	1987	1988	1989	1990	1991	1992
Essence transport routier	73671	73768	71860	67756	62905	59949	58687	58139
Transport aérien	569	1129	514	705				
Essence pêche	19251	15233	15435	15863	17122	18806	20151	19117
TOTAL	93491	90130	87809	84324	80027	78755	78838	77256

Source : Direction de l'Energie / ENDA - Programme Energie.

CONSOMMATION FINALE DE KEROSENE

tonne	1985	1986	1987	1988	1989	1990	1991	199
Ménages et autres	10843	10478	10539	10846	9942	9788	9565	
Transport aérien	133084	133444	112103	130380	149092	141754	128237	
TOTAL	143927	143922	122642	141226	159034	151542	137802	

Source : Direction de l'Energie / ENDA - Programme Energie.

CONSOMMATION FINALE DE DIESEL/GAZOLE

tonne	1985	1986	1987	1988	1989	1990	1991	1992
Industries extractives	11033	15133	15108	16632			19766	
Cimenterie	1061	855	469	464			769	
Chimie	182	842	1013	1008				
Huileries							1237	
Pêche et industries de la pêche	31504	25866	14138	38137			102	
Industrie textile							386	
Eau (SONEES)							2861	
Autres industries	8396	10080	6724	7592			63440	
Transport routier	128627	120362	104113	91252			107535	
Transport ferroviaire	4740	3638	4054	5663			4843	
Grande hotellerie							1307	
TOTAL	185543	176776	145619	160748			202246	

Source : Direction de l'Energie / ENDA - Programme Energie.

CONSOMMATION FINALE DE FIOUL

tonne	1985	1986	1987	1988	1989	1990	1991	199
Industries extractives	25576	19875	22787	25046			27683	
Cimenterie	26029	23434	27253	33731				
Huileries							793	
Industries de la pêche							1974	
Industrie textile							1190	
Autres industries	31475	18055	5689	8753			63295	
TOTAL	83080	61364	55729	67530			94935	

Source : Direction de l'Energie / ENDA - Programme Energie.

CONSOMMATION FINALE DE GPL

tonne	1985	1986	1987	1988	1989	1990	1991	199
Ménages			15936	24077			34237	
Industries			480	569				
Grande hotellerie			419	466			3725	
Autres			215	234				
TOTAL	0	0	17050	25346	28899	32847	37962	

Source : Direction de l'Energie / ENDA - Programme Energie.

CONSOMMATION FINALE D'ELECTRICITE

MWh	1985	1986	1987	1988	1989	1990	1991	199
Industries extractives	105019	109290	114212	123323			105759	
Cimenterie	41441	34629	38508	44420			50481	
Chimie	57129	61132	66793	63880			3514	
Industrie sucrière		33560	35343	34201				
Industries de la pêche	18596	18007	13690	10510			15126	
Huileries	23385	31036	36279	54074			1912	
Industrie textile	27448	22281	18670	14796			7514	
Eau (SONEES)	22472	23476	27705	32262			38824	
Ménages	160078	157055	171698	167526			274971	
Grande hotellerie	13940	15622	18363	15579			30314	
Autres	225990	239916	260300	275641			208238	
TOTAL	695498	746004	801561	836212			736653	

Source : Direction de l'Energie / ENDA - Programme Energie.

ANNEX 2
Domestic waste

Méthode de calcul

Les sorties sur le terrain ont permis d'avoir certaines données sur la production de déchets en 1993 des Capitales régionales, de deux (2) à (3) chefs-lieux de Département et d'un (1) à deux (2) arrondissements selon la région.

Pour couvrir tout le territoire, il a fallu faire des interpolations pour les localités non enquêtées;

Pour ces localités, une estimation de la production de 1991 est faite sur la base de la production per capita et à partir des paramètres suivants: productions de déchets ménagers, population de 1991 et de 1993 et production per capita des localités enquêtées.

Exemple de calcul : Région de Saint-Louis

Les enquêtes dans cette région ont eu lieu à Saint-Louis, Dagana, Richard-Toll. Cette sortie a permis d'avoir des données de terrain 1993 et d'apprécier la méthode de collecte et des lieux de décharge.

Les estimations ont portées sur les localités non enquêtées à savoir : Podor, Matam et le reste de la Région.

Le tableau suivant présente les résultats de terrains :

Région / **Paramètres**		St-louis	Chef-lieu de Département			Autre ville	* Reste
		733 587 661 791	Podor	Matam	Dagana	Richard-Toll	
Population	93	129 505	7 597	11 390	18 902	42 766	523 427
	91	123 778	7 537	11 249	17 581	37 185	464 461
Production/cap kg/j		0,5					
Production nette	93	106 m^3/j			29	72	
	91	101 m^3/j			27	63	

Source : Direction de l'Environnement.

1°) Calcul de la production nette en 1991 de Dagana

En 1993, avec une population de 18902 habitants, la production est de 29 m^3/j.
En 1991, avec une population de 17582 habitants, la production est de P :

$$P = \frac{17581}{18902} * 29 = 27 m3$$

2°) <u>Calcul de Matam et Podor</u>

Pour Dagana, la production/capita en 1991 (P/cap) est :

$$P / cap = \frac{27}{17581} * 300 = 0,46$$

Avec 1 m^3 = 300 kg de déchets.

<u>P/cap = 0,46 kg/hab/j</u>. On estime que Matam, Podor et Dagana ont la même p/cap. Ce qui donne :

- P_{Matam} = 0,46 * Population de Matam en 1991
- P_{Podor} = 0,46 * Population de Podor en 1991

- P_{Matam} = 5174,5 kg/j ou 1862,8 tonnes/an
- P_{Podor} = 3467,0 kg/j ou 1248 tonnes/an

3°) <u>Calcul de la production de déchets du reste</u>

<u>Nota</u>: le reste est essentiellement constitué du milieu rural, par conséquent la P/cap doit être inférieure aux P/cap des Chefs-lieux de département et de Saint-Louis.

$P_{reste} = P_{totale\ région} - (P_{St-Louis} + P_{Chef-Lieux} + P_{Richard-Toll})$

$P_{reste\ 1993}$ = 523 427 Habitants

$P_{reste\ 1991}$ = 464 461 Habitants

G : taux d'augmentation de la population entre 1991 et 1993

G_{reste} = (523427 - 464461) * 100 /464461 = **12,7 %**

G_{Dagana} = **7,51 %** pour une P/cap de 0,46

$G_{St-Louis}$ = **4,63 %** pour une P/cap de 0,5

Par régression linéaire, o obtient:

P/cap= -0,021 * G + 0,55

P/cap $_{reste}$ = 0,39 kg/hab/j

Production reste = 0,39 * 464461 * 360 = **65 210 tonnes/an**

Tableau récapitulatif

Région / Paramètres		St-louis	Chef-lieu de Département			Autre ville	*Reste	Total
		733 587 661 791	Podor	Matam	Dagana	Richard Toll		
Population	93 91	129 505 123 778	7 597 7 537	11 390 11 249	18 902 17 581	42 766 37 185	523 427 464 461	733 587 661 791
Product/cap/kg/j		0.5	0.46	0.46	0.46	0.46	0.39	
Production t/an en 1991		22 280	1 248	1 862	2 911	6 157	65 210	99 668

Source : Direction de l'Environnement.

Pour les autres régions, le même mode de calcul a été utilisé pour trouver les productions de déchets ménagers pour l'ensemble des zones du pays.

Thiès :

Localités / Paramètres	Thiès	MBour	Tivaouane et Khombole	Mékhé et Joal	Reste	Total
Production kg/j/hab	0.6	0.5	0.5	0.38	0.1	
Production t/an en 1991	42 169.3	16 341.1	6 859.6	4 766.1	45 433.6	115 569.7

Source : Direction de l'Environnement.

Diourbel :

Localités Paramètres	Diourbel	MBacké	Bambey	Reste	Total
Production/cap /kg/j	0.5	0.46	0.43	0.4	
Production t/an en 1991	15 189.4	7 477.4	2 841.2	77 007	102 515

Source : Direction de l'Environnement.

Tambacounda :

Localités Paramètres	Tamba counda	Bakel	Kédougou	Reste	Total
Production /hab/kg/j	0,4	0,3	0,3	0,2	
Production t/an en 1991	6 070.3	872.8	1 153	25 622	33 718.1

Source : Direction de l'Environnement.

Kolda :

Localités Paramètres	Kolda	Sédhiou	Vélingara	Reste	Total
Production/cap/ kg/j	0.3	0.22	0.22	0.22	
Production t/an en 1991	4 301.7	1 145.2	1 237.1	41 018.8	47 702.8

Source : Direction de l'Environnement.

Fatick :

Localités Paramètres	Fatick	Foundiougne et Gossas	Sokone	Guing uinéo	Reste	Total
Production/cap/ kg/j	0.52	0.3	0.3	0.3	0.3	
Production t/an en 1991	4 499.5	1 386.6	1 021.2	1 448	51 810.9	60166.2

Source : Direction de l'Environnement.

Ziguinchor :

Localités Paramètres	Ziguinchor	Bignona	Oussouye	Reste	Total
Production kg/hab/j	0.5	0.4	0.4	0.2	
Production t/an en 1991	25 515	3 636.1	633.1	18 759.6	48 543.8

Source : Direction de l'Environnement.

Kaolack :

Localités Paramètres	Kaolack	Kaffrine	Nioro	Reste	Total
Production hab/kg/j	0.6	0.4	0.4	0.2	
Production t/an en 1991	37 707.7	2 786.4	1 901.8	48 362.4	90 755.3

Source : Direction de l'Environnement.

Louga :

Localités Paramètres	Louga	Kébémer	Linguère	Reste	Total
Production kg/hab/j	0.5	0.37	0.37	0.34	
Production t/an en 1991	10 850.4	1 475.7	1 320.8	52 364.1	66 011

Source : Direction de l'Environnement.

Dakar :

Localités Paramètres	Dakar	Pikine	Rufisque	Bargny	Reste	Total
Production kg/hab/j	0.7	0.65	0.6	0.6	0.5	
Production t/an en 1991	184 564.5	171 130.2	26 080.7	6 234.6	10 507.1	398517.1

Source : Direction de l'Environnement.

Composition des ordures par région

Dakar :

Types de déchets	Taux (%)
Déchets organiques	71.5
Autres (*)	13.5
Sable	15

(*) : métaux ferreux, plastiques, verre, autres déchets non organiques.
Source : Direction de l'Environnement.

Diourbel :

Types de déchets	Taux (%)
Déchets organiques	52
Autres	12
Sable	36

Source : Direction de l'Environnement.

Thiès :

Types de déchets	Taux (%)
Déchets organiques	55
Autres	3.5
Sable	45.6

Source : Direction de l'Environnement.

Louga :

Types de déchets	Taux (%)
Déchets organiques	50.8
Autres	3.6
Sable	45.6

Source : Direction de l'Environnement.

Kaolack :

Types de déchets	Taux (%)
Déchets organiques	42.4
Autres	6.4
Sable	51.2

Source : Direction de l'Environnement.

ANNEX 3
Industrial waste

Types de déchets industriels

INDUSTRIES	DECHETS SOLIDES	DECHETS LIQUIDES	DECHETS GAZEUX	SOUS-PRODUITS
NIPPON SEN	Brisure de craie	Eaux de toilette		
SOTEXKA	Celluloses organiques		Fumées de chaudières	Déchets de coton
SOPICA	Peaux de soles, Tripes, écailles, Carapaces et têtes de crevettes		Fréon	
SIPAO				
BISCUITERIE WEHBE	Polyéthylène Aggloméré			
SAF	Terre, Sable		Fumée générateur vapeur combustible fuel 180	Glycérinerie
MOULINS SENTENAC	Balayures			Issues de céréales
PHOSPHATES DE THIES			Fumées de combustion	Sous forme de fines
DAKAR MARINE	Ordure ménagère/ferraille/ sable			
SIEMEX	Chutes/ Malformations			
LES GRANDS MOULINS	Poussières de blé			Son issu des blés
SENAC	Amiante ciment			
SIPOA	Cartons laize aluminium fûts en carton	40 m^3/j		
SISPA	Scories de poisson et crevettes	500 m^3/j		
RUFSAC	Papier	Encre		
CSS	Ecumes	110 425 000 m^3/an	Fumées de chaudières	Bagasse
COMPLEXE AVICOLE DE M'BAO	Coquille d'oeufs à couver, poussins morts nés, papier			
COTONNIERE DU CAP-VERT	Déchets coton		Groupe électrogène 125 kVA-	

SENELEC	Cendres, sédiments, vanadium, asphaltènes		CO_2, SO_2, SO_3	Boues huileuses (dérivés du mazout)
SAR		1600 m^3/mois	H_2 et CH_4 -> CO_2 et H_2O	
NESTLE	cartons, fer blanc, papier, toile plastique	Eau de nettoyage : 40 000 m^3/an	Fumées de combustion de fuel 1500 dans 2 chaudières	Fût d'huile de beurre, papier d'emballage de lait
SNCDS	8 000 t d'arrêtes, viscères, peau et traces sanguines	100 000 m^3/an d'eau + sang	Gaz de combustion de 2 chaudières	8 000 t de têtes, peau, queues arrêtes et parties sanguines
SITRAF	pulpes, écorces et noyaux de fruit	eaux usées riches en nutriments		pulpe de fruit pour confiture et alimentation bétail
SOTIBA	2 camions/semaine d'ordures	300 000 m^3/an eaux colorés et résidus de produits chimiques et colorants dans Baie de Hann	Gaz de 7 chaudières de 53 t/h	
SRH	terre activée à Mbeubeuss	200 m^3/mois	Gaz d'une chaudière	300 l/j solvant utilisé comme combustible
SEIB	terres décolorantes raffinage, cendre chaudière, rebroyés polyéthylène : décharge commune Diourbel	toutes eaux de lavage usine avec mélange de graisse	Gaz de 4 cheminées	pâtes de neutralisation raffinage
SIPASEN				
CCIS	sacs vides déchirés, camion de poubelle /15 jours			
SEIGNEURIE AFRIQUE	papier-carton-sac papier, boîte cabossée ->SIAS			
SODEFITEX		2 500m^3/an		
XAMAL	Rognures de papier	15 m^3/mois		
SNP	Déchets plastiques			

PROCHIMAT		Eaux usées des blocs sociaux		
ARMEMENT DAK PECHE	Ordures déchets poissons			
ICS Mbao		200 m^3/h	Gaz de combustion plus vapeur d'eau	
ICS Darou	Gypse	30 m^3/h	Vapeur d'eau fluorés Anhydride sulfureux (SO_2)	Gypse- jus fluos
Société nouvelle des salins du Sine Saloum				
Sopica	Peaux de soles, tripes, écailles, carapaces et têtes de crevettes	750 m^3/mois	Fréon F12 et F22	
Delta 2000 agro-industrie	Balle de riz			Son de riz
ICOTAF	2 camions/semaine d'ordures	250 000 m^3/an eaux colorés et résidus de produits chimiques et colorants dans Baie de Hann	Gaz de 7 chaudières de 53 t/h	
SOBOA	Ordures, verres cassés, étiquette	eaux usées 400 m^3/jour		Drêche 1500 t

Source : Direction de l'Environnement.

ESTIMATION DES DECHETS SOLIDES (TONNES/AN)

INDUSTRIE	DECHETS SOLIDES (tonnes/an)		DECHETS LIQUIDES (m^3/an)	
	Total	Proportion organique	Total	Proportion organique
NIPPON SEN	64	64	180	180
SOTEXKA	162	162	9 072	2 760
SOPICA	1 944	1 944	15 750	15 750
BISCUITERIE WEHBE	60	0	144	144
SAF	3	3	1 095	129
MOULINS SENTENAC	12	12	365	365
SS PHOSPHATES DE THIES	0	0	0	0
DAKAR-MARINE	10 000	3 000	5 000	5 000
SIEMEX	100	0	109	109
LES GRANDS MOULINS	146	146	2 920	2 920
SENAC	13	0	1 200	1 200
SIPOA	5	5	15	15
SISPA	1 095	1 095	182 500	182 500
RUFSAC	960	10	0	0
CSS	15 000	15 000	110 4 25 000	3 000 000
COMPLEXE AVICOLE DE M'BAO	26	26	116	116
COTONNIERE DU CAP-VERT	40	40	51100	51 100
SENELEC	30 000	15 000	17 082	17 082
SAR	0	0	19 342	19 342
NESTLE	624	624	40 000	40 000
SNCDS	8 000	8 000	100 000	100 000
SITRAF	400	400	43 000	43 000
SOTIBA	624	624	300 000	150 000
SRH	52 221	52 221	2 400	2 400
SEIB	17 300	17 300	122 520	122 520
SIPASEN	0	0	0	0
CCIS	47	47	3 348	3 240
SEIGNEURIE AFRIQUE	600	600	36	36
SODEFITEX	80	80	2 500	2 500
COSELECA	0	0	346	346
XAMAL	3	3	100	100

SSNP	0	0	742	742
PROCHIMAT	0	0	720	720
ARMEMENT DAKAR PECHE	100	100	2 016	2 016
ICOTAF	620	620	250 000	115 000
SOBOA	600	580	144	142
ICS Darou / ICS Mbao	1 800 000	0	25 200	0
TOTAL	1 940 849	117 706	1 105 449 062	3 766 474

Source : Direction de l'Environnement.

INDUSTRIES PAR TYPE D'ACTIVITE

ACTIVITE		TYPE D'INDUSTRIE
Fer		Dakar Marine
Engrais		ICS
Alimentation et bois sons	Conserves	SNCDS
	Bières et boissons	SOBOA, SITRAF
	Viandes	
	Prod. laitiers	NESTLE, SOCA
	Sucre	CSS
	Poissons	SOPICA, ARMEMENT DAKAR PECHE
	Huiles/ graisses	SRH, SEIB
	Céréales	GRANDS MOULINS, SENTENAC
	Autres	BISCUITERIE WEHBE, C. AVICOLE M'BAO
Papiers	Papiers	RUFSAC
	Autres	
Raffinerie de pétrole		SAR
Indust ries textiles	Teinture ries	SOTIBA, ICOTAF,
	Autres	COTONNIERE CAP-VERT, SOTEXKA, SODEFITEX, XAMAL
Caoutchouc/plastiques		CCIS, SSNP, SIEMEX
Savonneries		SAF
Sociétés electriques		SENELEC, COSELECA
Autres		SENAC, SIPOA, PROCHIMAT, PHOSPHATES DE THIES, SIPASEN

Source : Direction de l'Environnement.

Questionnaire : la gestion des déchets industriels et des rejets dans l'environnement en 1991.

I. IDENTIFICATION DE L'INDUSTRIE

1.1 Nom...
1.2 Adresse...
1.3 Description de la zone de localisation......................
....
....

2. MATIÈRE PREMIÈRE

pour chaque type de matière première, indiquer la quantité par an.

Type de produit	Max	Min	Moyenne	Année
....	......	....	....	....
....	......	....	....	....
....	......	....	....	....
....	......	....	....	....
....	......	....	....	....

Type de produit	Max	Min	Moyenne	Année
....	......	....	....	....
....	......	....	....	....
....	......	....	....	....
....	......	....	....	....
....	......	....	....	....

Type de produit	Max	Min	Moyenne	Année
....	......	....	....	....
....	......	....	....	....
....	......	....	....	....
....	......	....	....	....
....	......	....	....	......
Type de produit	Max	Min	Moyenne	Année
....	......	....	....	....
....	......	....	....	....
....	......	....	....	....
....	......	....	....	....
....	......	....	....	....

4.EMPLOYES

4.1 Staff : ....
4.2 Ouvriers :
permanents : ....
journaliers : ....
4.3 Administratif : ....

6.EAUX USEES

5.1 Lieu de rejet................................
5.2 Quantité : ....
5.3 Composition......................................
5.4 Existence de système d'épuration..................
5.5 Traitement effectué..............................

5.DECHETS SOLIDES

7.1 Nature............... ....
7.2 Quantité............. ....
7.3 Lieu de rejet...............................
7.4 Traitement recyclage ou utilisation...............
..

7.5 Fraction combustible

7.6 Fraction organique

8.REJETS GAZEUX

8.1 Nature...
8.2 Quantité...
8.3 Traitement utilisé:
Filtre..
Precipitation.....................................
Scrubbers...

Type de produit	Max	Min	Moyenne	Année
....	......	....	....	....
....	......	....	....	....
....	......	....	....	....
....	......	....	....	....
....	......	....	....	....

Type de produit	Max	Min	Moyenne	Année
....	......	....	....	....
....	......	....	....	....
....	......	....	....	....
....	......	....	....	....
....	......	....	....	....

4.EMPLOYES

4.1 Staff : ....
4.2 Ouvriers :
permanents : ....
journaliers : ....
4.3 Administratif : ....

6.EAUX USEES

5.1 Lieu de rejet.............................
5.2 Quantité : ....
5.3 Composition...................................
5.4 Existence de système d'épuration...................
5.5 Traitement effectué..............................

5.DECHETS SOLIDES

7.1 Nature............... ....
7.2 Quantité............ ....
7.3 Lieu de rejet..............................
7.4 Traitement recyclage ou utilisation...................
...

7.5 Fraction combustible

7.6 Fraction organique

8.REJETS GAZEUX

8.1 Nature.......................................
8.2 Quantité.....................................
8.3 Traitement utilisé:
Filtre.......................................
Precipitation................................
Scrubbers.............................

9. SOUS PRODUITS

9.1 Type...
9.2 Quantité...
9.3 Lieu de réutilisation : interne, précisez..............................
Externe..

10. INSTALLATIONS UTILISANT DES COMBUSTIBLES

	Chaudières	Cuves sous pression	Sealine ou autres
Nombre			
Capacité			
Liquide ou gaz stocké ou transporté			

10.2 Liste des autres appareils et installations utilisés
1...
2...
3...
4...
5...

11. PROCESS

11.1 Description sommaire du process
....
....
....
....
....
....
....
....
....
....
....
....
....

12. ASSISTANCE APPORTS EXTERIEURS

12.1 Plan d'aménagement pour la protection de l'environnement.
....
....
....
....
....

12.2 Coût estimatif..

12.3 Assistance nationale ou exterieure souhaitée..........................
....
....
....

14. AUTRES CONSIDERATIONS - COMMENTAIRES

ANNEX 4
Chlorofluorocarbons

As no study on solvents is included in the IPCC/OECD methodologies, a survey of CFCs, although not requested, was made. It should be considered that, under the Montreal Protocol, consideration is given to such substances, as they seriously undermine the ozone layer.

I. CFC IMPORTERS AND DISTRIBUTORS

No CFC producing industry exists in Senegal. However, there are threee major CFC importers: SEGOA, COTOA, and SAEC. Current imports of CFC by these firms is indicated in the following table :

CFC Imports

Substances	COTOA (t/an)	SEGOA (t/an)	SAEC (t/an)
CFC-11	-	0.375	0.49
CFC-12	7.5	45.0	36.0
CFC-114	-	0.5	-
HCFC-22 et CFC-115	0.5	7.078	9.31
Total	8.0	52.95	45.80

Source : Environment Directorate.

1.1 CFC Users

Major refrigeration users (hotels and agro-businesses) and refrigeration maintenance industries and repairers, are the main customers of CFC importers and distributors. CFCs are still being used in Senegal by industries for inflating plastic foam which is used in the manufacturing of mattresses; while CFC 12, HCFC 22 and R 502, are used respectively for recharging refrigerators, domestic air conditioners and cold storage rooms.

Based on several interviews with CFC distributors and repairers, it is estimated that there are 200 repairers of refrigerators and air-conditioners in the country.

1.2. The Foam Sector

PES (plastiques Elastomères du Sénégal) is one of the industries using CFC 11 for foam inflation. PES is a private enterprise which produces both flexible and inflexible foam. Its CFC 11 consumption is 1.2 t/year. Other equally important industries also use CFC 11 for the same purposes.

1.3. The Refrigeration Equipment Repairs

CFCs are stored in gas cylinders for repair (recharging). During the recharging operation, these cylinders are connected to the gas appliance through a pipe equipped with a valve and a pressure gauge.

In case of leakage, (which is very common), the gas is sucked up and released into the atmosphere, while detecting the flaws. There are risks involved both at the beginning and at the end of the process. A few maintenance shops reclaim gas residues they re-use to detect leakages.

II. SURVEY METHODOLOGY

A survey of the three main CFC importers, SEGOA, COTOA, and SAEC, was conducted.

The quantitative data thus collected were complemented by information from Direction des Recettes Douanières (a body centralizing import statistiques) and from Direction de la Prévision et de la Statistique (DPS).

For the demographic, political and economic data, the team used the available literature, including "Plan d'Orientation pour le Développement Economique et Social 1989-1995 (VIIth Plan), and "Plan National d'Action pour l'Environnement (PNAE)" prepared for the UNCED held in Rio de Janeiro in June 1992.

The data collected in the various sectors previously mentioned were heterogeneous. Consequently, we had to make some approximations in order to have a homogeneous quantitative presentation.

Indeed, regarding industries (fish merchants), importers, maintenance workers and certain hotels, the information given was in the form of tonnage of CFC substances per annum. This renders the identification of controlled quantities nearly impossible.

At the customs department, statistics were given in terms of annual tonnage of imported equipment.

In order to convert these data, we started by estimating the number of appliances (refrigerators, air conditioners) by dividing the total weight of such appliances by the average weight of a single refrigerator or air conditioner estimated at fifty (50) kilos; which allowed the estimation of the number of imported appliances.

According to repairers and maintenance entreprises, the recharge of a refrigerator or an air conditioner requires about 1000 grams.The annual additional recharge for a room or vehicle air conditioner: 500 grams. The total weight of CFC in imported appliances can hence be verified. Data from DPS were converted using the same method, with the assumption that 35% of the number of cars on the Senegalese roads are air conditioned.

In order to get the total quantities of CFC consumed annually, we cross-checked the customs statistics, the quantities distributed by the main gas importers, and the quantities of gas contained in the various appliances and existing facilities.

III. CFC CONSUMPTION

3.1. Current leve

The following two tables provide a global and approximative approach regarding the current use of CFCs. These data were obtained through :

- a review of the customs registers whose computer files date back only to 1989. The information obtained were extracted from customs statistics on the imports of refrigerators and air conditioners;

- information collected from Direction de la Prévision et de la Statistique. These data relate to the following sectors :

  * transport (road, sea and railway)
  * storage (household, industrial)

- surveys involving CFC distributors, users of refrigeration equipment (hotels,industries, agro-businesses), industries (foam, aerosols, solvents, painting, etc.), refrigeration repairers.

More details about all these figures are included in the annexes attached to this report.

3.2 Projected level

The statistics available on the use of CFC date back only to 1989.

CFC Consumption

Substance	Consommation (t/an)		
	1989	1990	1991
CFC 11	1.89	1.99	2.06
CFC 12	87.74	90.68	93.68
CFC 114	0.47	0.48	0.50
R 502	5.43	5.60	5.79
Total	96.60	96.77	102.03

Source : Environment Directorate.

Substance	Consommation (t/an)		
	1991	1992	1993
CH3Br	269.28	351.27	254.02
CCl4	552.12	550.08	444.67
Total	821.40	901.35	698.69

Source : Environment Directorate.

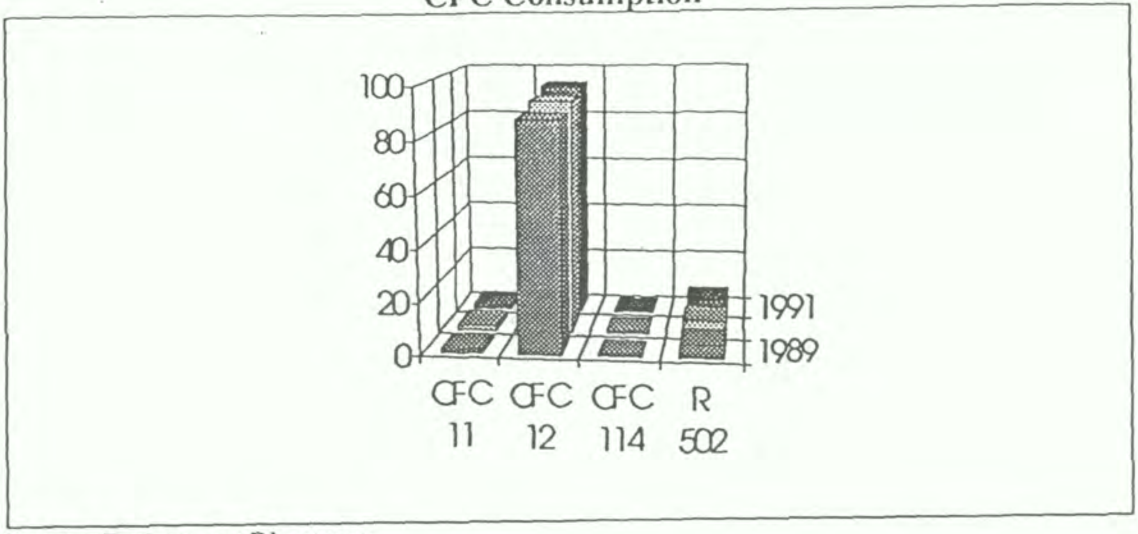
There is an upward trend in the consumption of CFC 12, CFC 114 and HCFC-22 and CFC 115, in the repair and maintenance sector. This is due to the increase (associated with modernity and population growth) in use of refrigerators, freezers and air conditioners at the household level, as well as to the creation of new agro-business units (fish shops) and the expansion of cold storage rooms in hotels, following the development of tourism, a key sector in the Senegalese economy.

Both Methylene bromide and carbon tetrachloride are expected to increase in their respective applications.

Concerning CFC 11, the trend is towards its removal. The foam industry, as the main CFC 11 user, will certainly susbtitute it for methylene chloride (CH2C12).

According to the table below, and a confirmation by CFC importers and users, the theory of a decline in the consumption of CFC 11 and 114 and an increase in the consumption of CFC 12 and R 502, can be supported.

CFC Consumption



Source : Environment Directorate.

Project No. GF/0103-92-33

Global
Environment
Facility

UNEP

United Nations
Environment Programme

undp

United Nations
Development Programme

World Bank