FEDERAL REPUBLIC OF NIGERIA

NATIONAL GHG INVENTORY REPORT
NIR1
2000 - 2017

March 2021

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Foreword

Nigeria has remained at the forefront of responding to its obligations to the United Nations Framework Convention on Climate Change (UNFCCC) since the ratification of the Convention. Among such obligations is the requirement by Articles 4 and 12 of the Convention and Decision 2/CMP.8, that all Parties to the Convention and the Kyoto Protocol should summit National Inventories of Greenhouse Gas (GHG) Emissions and Removals. The UNFCCC stipulates that Non-Annex 1 countries are required to submit inventory reports every two years as part of their Biennial Update Report (BUR) or as a component in their National Communication (NC) report.

Dr. Mohammad Mahmood Abubakar
Honourable Minister
Federal Ministry of Environment

The Federal Ministry of Environment, as the UNFCCC Focal Point for Nigeria, is the National Entity directly responsible for the management of the entire national GHG inventory process and ensures that delivery of an inventory is of good quality that meets international standards.

With a National GHG Inventory Management System (NGHGIMS) established in 2018, an institutional arrangement, made up of Sectorial Working Groups – Data Compilers and providers from relevant Ministries, Departments and Agencies of Government was put in place. As the “single national entity”, the Ministry collaborates with the inventory stakeholders in the various sectors to undertake management of activity data and emission factors, compilation of emission estimates, quality control/quality assurance, improvement planning, and preparation of the National Inventory Report (NIR).

Through this improved structure, the Government of the Federal Republic of Nigeria has been able to produce its first stand-alone National Inventory Report (NIR1) of national emissions by sources and removals by sinks for direct and indirect GHGs for the period 2000 to 2017. The subsisting inventory arrangement approved by the Federal Government was used in planning and implementation of all activities which support the preparation of the report. Similarly, the IPCC in-depth methodologies in the four sectors based on the 2006 IPCC guidelines, and the IPCC CRF formed the basis for cross-sectoral data collection, emission computation and reporting. It contains the emissions by sources and removals by sinks of carbon dioxide (CO_2), the emissions of methane (CH_4), nitrous oxide (N_2O); and the emissions of the CO_2 precursors, including oxides of nitrogen oxides (NO_x = NO_2+NO_2), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs), and sulphur dioxide (SO_2).

The Report gives an 18-year trend for full sectorial national inventories based on the IPCC procedures for above direct and indirect GHGs. Chapter 1 of the report provides the background to the UNFCCC and reporting obligations of Parties. In Chapter 2, the report presents the inventory process, highlighting how the preparation was planned, its commencement in 2019, the inventory framework and activity cycle, the steps adopted in the implementation, the direct and indirect GHGs included, the broad data sources, methodologies adopted, and elements included in reporting the emissions, including key category analysis, QA/QC and results of uncertainty assessment. Chapter 3 presents the results of national emissions, first in CO_2-equivalent for the direct GHGs by sector and as aggregated total emissions. Subsequently the emissions of each direct GHG emitted are also presented by sector and as national emissions. Chapters 4 to 7 are devoted to details of the inventory in the Energy, IPPU, AFOLU and Waste sectors respectively.

These estimates will be used in evolving the story lines and the scenarios for mitigation, as part of the effort to review and update the Nationally Determined Contributions (NDCs), to provide the latest scenarios reverberating economic development plans under implementation to ensure an integrated process for living up to the terms of the Paris Agreement.

Dr Mohammed Mahmood Abubakar
Honourable Minister, Federal Ministry of Environment
March 2021

Acknowledgements

The Federal Ministry of Environment expresses its appreciation to all relevant Stakeholders of the Federal Republic of Nigeria who contributed in the preparation of Nigeria's "first stand alone" National Inventory Report. The contributions of all are gratefully acknowledged with a special mention for the National Greenhouse Gas Inventory Management Team established in 2018 within the Department of Climate Change, Federal Ministry of Environment under the leadership of the former Director, Dr Yerima Peter Tarfa (*now Permanent Secretary, Federal Republic of Nigeria*) who spearheaded the whole preparatory process.

Nigeria acknowledges the financial contribution made by the Global Environment Facility through and with the support of the UNDP country office acting as Implementing Agency.

The Federal Republic of Nigeria expresses appreciation to our Experts for the Quality Assurance and also the final compilation of this National Inventory Report of Nigeria to the UNFCCC.

The main contributors are listed below.

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- National Greenhouse Gases Inventory Management Team
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Main Institutional Sectoral Contributors

Energy Sector

- Energy Commission of Nigeria (ECN)
- Nigerian National Petroleum Corporation (NNPC)

Waste Sector

- National Bureau of Statistics

AFOLU Sector

- Department of Forestry, Federal Ministry of Environment
- Federal Ministry of Agriculture & Rural Development
- National Research Space Development Agency (NASDAR)

IPPU Sector

- National Bureau of Statistics

Main Institutional Contributors

- Department of Petroleum Resources
- Energy Commission of Nigeria
- Federal Ministry of Agriculture and Rural Development
- Federal Ministry of Budget and National Planning
- Federal Ministry of Transport
- Federal Ministry of Water Resources
- Federal Ministry of Power, Works & Housing
- Federal Ministry of Education
- Federal Ministry of Environment
- Federal Ministry of Finance
- Federal Ministry of Foreign Affairs
- Federal Ministry of Health
- Federal Ministry of Justice
- Federal Ministry of Science and Technology
- Federal Ministry of Trade and Investment
- Federal Ministry of Women Affairs and Social Development
- National Space Research and Development Agency
- National Bureau of Statistics
- National Emergency Management Agency
- National Planning Commission
- Nigerian National Petroleum Corporation
- Nigerian Maritime Administration and Safety Agency
- Nigerian Meteorological Agency

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Abbreviations, Acronyms and Symbols

Abbreviation, Acronyms and Symbols	Definition
AD	Activity Data
AFOLU	Agriculture, Forest and Other Land Use
AGO	Automotive Gas Oil
AR5	Fifth Assessment Report
ASB	Annual Statistics Bulletin
ATK	Aviation Turbine Kerosene
BCEF	Biomass Conversion and Expansion Factors
Bm	biomass
BOD	Biological Oxygen Demand
BUR	Biennial Update Report
C	Carbon
$CaSO_4$	Calcium Sulphate
CC	Carbon Content
CFC	Chlorofluorocarbon
CH_4	Methane
CMAN	Cement Manufacturer’s Association of Nigeria
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2-eq	Carbon dioxide equivalent
COF	Carbon Oxidation Factor
COP	Conference of Parties
CS	Country-specific
DCC	Department of Climate Change
DPR	Department of Petroleum Resources
E	Estimated
ECN	Energy Commission of Nigeria
IEPCL	Indorama Eleme Petrochemicals Company Limited
EMEP / EEA	European Monitoring and Evaluation Program / European Environment Agency
FAO	Food and Agricultural Organisation
FL	Forestland
FOLU	Forestry and Other Land Use
FRA	Global Forest Resources Assessment 2010
g	gram
GDP	Gross Domestic Product
GEF	Global Environment Facility
Gg	Gigagram (1000 t)
GHG	Greenhouse gas
GHGIMS	GHG inventory management system

Abbreviation, Acronyms and Symbols	Definition
GL	Guidelines
GPG	Good Practice Guidance
GWP	Global Warming Potential
HFC	Hydrofluorocarbon
HHK	Household Kerosene
HWP	Harvested Wood Products
IE	Included Elsewhere
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
KCA	Key Category Analysis
kg	kilogram
LAWMA	Lagos State Waste Management Authority
LPG	Liquefied Petroleum Gas
MCF	Methane Conversion Factor
m	metre
mg	milligram
Mg	Megagram
MMS	Manure Management System
MRV	Measurement, Reporting and Verification
MSW	Municipal Solid Waste
N_2O	Nitrous Oxide
NA	Not Applicable
NC	National Communication
ND	Not Determined
NC3	Third national communication
NE	Not Estimated
NGO	Non-Governmental Organization
NH_3	Ammonia
NIIP	National Inventory Improvement Plan
NIR	National Inventory Report
NMVOC	Non-Methane Volatile Organic Compound
NNPC	Nigeria National Petroleum Company
NO	Not Occurring
NO_X	Oxides of nitrogen
NBS	Nigeria Bureau of Statistics
OL	Other Land
OPEC	Organization of Petroleum Exporting Countries
OWL	Other Wooded Land
PMS	Prime Motor Spirit

Abbreviation, Acronyms and Symbols	Definition
PJ	Peta Joule
PRP	Pasture Range and Padlock
QA	Quality assurance
QC	Quality Control
REDD	Reducing Emissions from Deforestation and Degradation
RFO	Residual Fuel Oil
SF_6	Sulphur Hexafluoride
SO_2	Sulphur dioxide
SWDS	Solid Waste Disposal Sites
t	Tonnes
TACCC	Transparency, Accuracy, Consistency, Completeness, and Comparability
TJ	Tera joule
TOW	Organically degradable material in domestic wastewater
UN	United Nations
UNDP	United Nations Development Programme
UNE	United Nations Environment
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
USGS	United States Geological Survey
WET	Wetland

1. Introduction

1.1. Commitments under the Convention

The United Nations Framework Convention on Climate Change (UNFCCC) is one of the three Conventions that were proposed from the resolutions at the UN Conference on Environment and Sustainable Development in Rio de Janeiro, Brazil in 1992. It came into force on 21 March 1994. The Federal Republic of Nigeria ratified the Convention on 29th August 1994 as a Non-Annex 1 Party.

Under Article 4.1 (a) of the Convention, each Party has to develop, periodically update, publish and make available to the Conference of the Parties, in accordance with Article 12, national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, to the extent its capacities permit, using comparable methodologies to be promoted and agreed upon by the Conference of the Parties.

Moreover, the submissions should also include the following elements amongst others:

a. A general description of steps taken or envisaged by the Party to implement the Convention; and
b. Any other information that the Party considers relevant to the achievement of the objective of the convention and suitable for inclusion in its communication, including, if feasible, material relevant for calculations of global emission trends.

Nigeria has submitted four national GHG inventories to-date as components of national reports, three in national communications and one in its first Biennial Update Report (BUR1) to meet its reporting obligations. The latest GHG inventory was presented in the third national communication (NC3) earlier this year. This GHG inventory is being compiled within the framework of the preparation of the second Biennial Update Report (BUR2). It builds up on the one presented in the NC3 and includes an additional year as well as recalculations as appropriate for the period 2000 to 2016. Nigeria is presenting its first national inventory report (NIR1) on a stand-alone basis in line with the new reporting requirements for maximizing transparency as advocated under the Paris Agreement. These four GHG inventories detailed the emissions and sinks of the country. All these reports have been prepared with support from the Global Environment Facility (GEF) through the United Nations Development Programme (UNDP) as implementing agency.

2. The inventory process

2.1. Background

The preparation of the present inventory started in 2019, the activities running concurrently with completion of the one contained in the NC3 which started two years before. Two years were allocated to implement and complete the different steps of the inventory cycle as depicted in Figure 2.. However, the process was not successful due to limited capacity and the lack of a robust GHG inventory management system (GHGIMS). In fact, all previous GHG inventories were compiled by local consultancy firms. In light of the higher frequency of preparation and submission of national reports, the higher standard and quality, and the enhanced transparency required under the Paris Agreement, Nigeria decided to transition from contracting to in-house production of the national reports including the GHG inventories. However, because the existing GHGIMS is not well structured and robust enough to undertake the full compilation of the inventory due to serious lack of capacity, Nigeria resorted to consultants to support staff of the Department of Climate Change (DCC) while providing capacity building to prepare for future reporting. This challenge is being addressed presently within the framework of the UNFCCC project *Setting-Up Sustainable National GHG Inventory Management Systems* supporting developing countries.

The Initial and Second National Communications of the Republic of Nigeria provided information on the National Inventory of GHG for base years 1994 and 2000. These inventories were compiled at Tier 1 level using the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC, 1997). The activity areas covered were somewhat limited in the first inventory and more categories were gradually addressed as the compilation progressed from one inventory to the next. The third Inventory presented in the first Biennial Report and the fourth inventory in the NC3 were submitted to the UNFCCC in 2018 and 2020, respectively. These also have also been compiled at the Tier 1 level. The 2006 IPCC Guidelines and software were used for compiling the last two inventories.

This fourth GHG inventory is presented as a stand-alone national inventory report to the UNFCCC and provides information on GHG emissions by sources and removals by sinks for all years within the period 2000 to 2017, the latter year being additional to those of the previous inventory. Improvements over the previous inventory consisted in the inclusion of additional activity areas and recalculations with the availability of better national activity data (AD).

2.2. Framework and cycle for inventory preparation

Nigeria kick-started the in-house production of its GHG inventory through DCC which was supported by other institutions concerned with the compilation of the inventory. An international company was contracted to provide support and backup on the compilation process while providing capacity building to DCC staff and other national experts on the technical aspects of the inventory. The country also benefited from the services of an international consultant made available by the UNFCCC to support development and implementation of the GHGIMS for sustainable compilation of GHG inventories. The UNFCCC project followed a quality assurance exercise done by the secretariat. The transition was not fully successful, but some progress was recorded in the development and implementation of the GHGIMS.

The existing GHGIMS, inclusive of the institutional arrangements for compiling the inventory, is being strengthened. Daunting challenges still exist as the target now is to attempt at compiling the inventory at State level and summing the results to obtain national estimates at the Federal level. The existing institutional arrangements which is under review are depicted in Figure 2.1 and are also provided in the MRV chapter of the BUR2 under the latter system for tracking emissions.

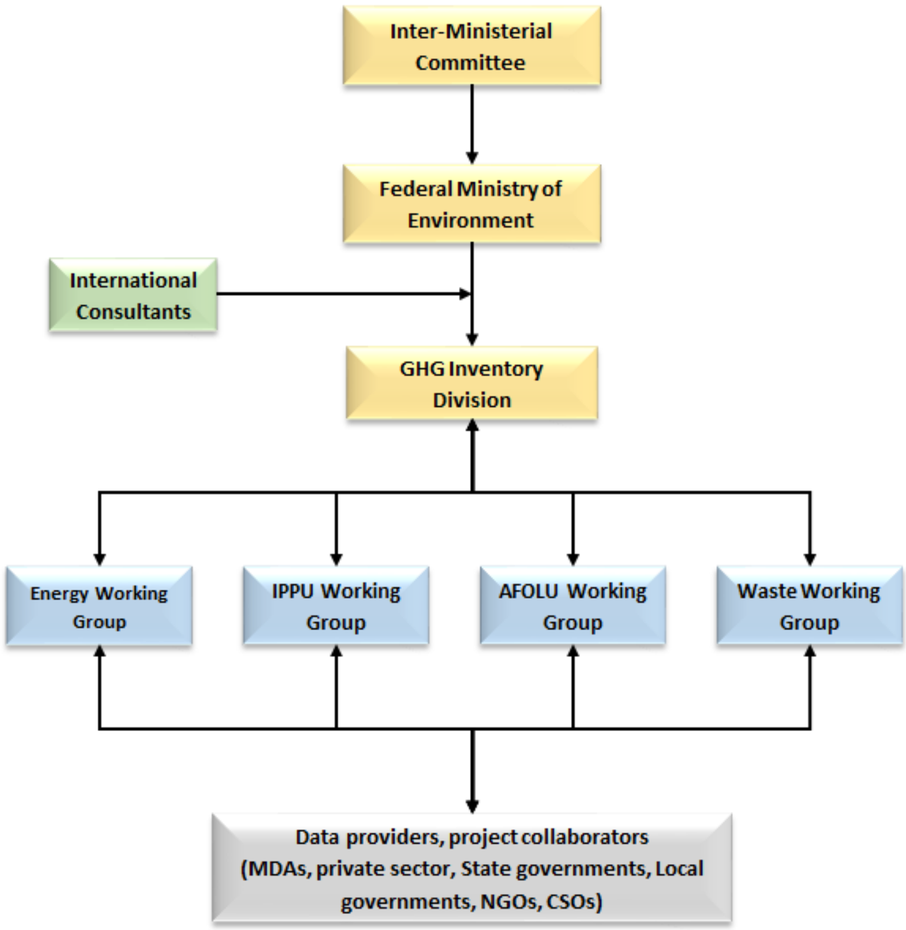


Figure 2.1 - Institutional arrangements for preparing GHG inventories

The compilation and production of a national GHG inventory requires the successful implementation of well-defined steps through a well-structured, robust GHGIMS. Ideally, the GHGIMS should cater for the following:

- Smooth management and coordination of the inventory process
- Institutional arrangements inclusive of clearly agreed responsibilities of stakeholders participating in the process.
- Allocation of tasks to teams for activities of the inventory cycle.
- A National data collection framework to ensure an automatic flow as per the timing of the inventory cycle.
- Necessary arrangements such as memorandum of understanding (MoU) and legislations to guarantee timely availability of the required data.
- A functional QA / QC system including the plan for its implementation
- Systematic documentation of all data and other information used during the process
- An appropriate archiving system for storage of all information pertaining to all inventories compiled by the country

Though Nigeria lacked a fully-fledged GHGIMS and appropriate institutional arrangements, the inventory for the BUR2 offered the platform for the GHG inventory team members to understand and implement the steps of the inventory cycle. This was done within the existing framework, the objective being to capacitate the national experts in implementing the steps provided in Figure 2.2 as part of the GHGIMS.

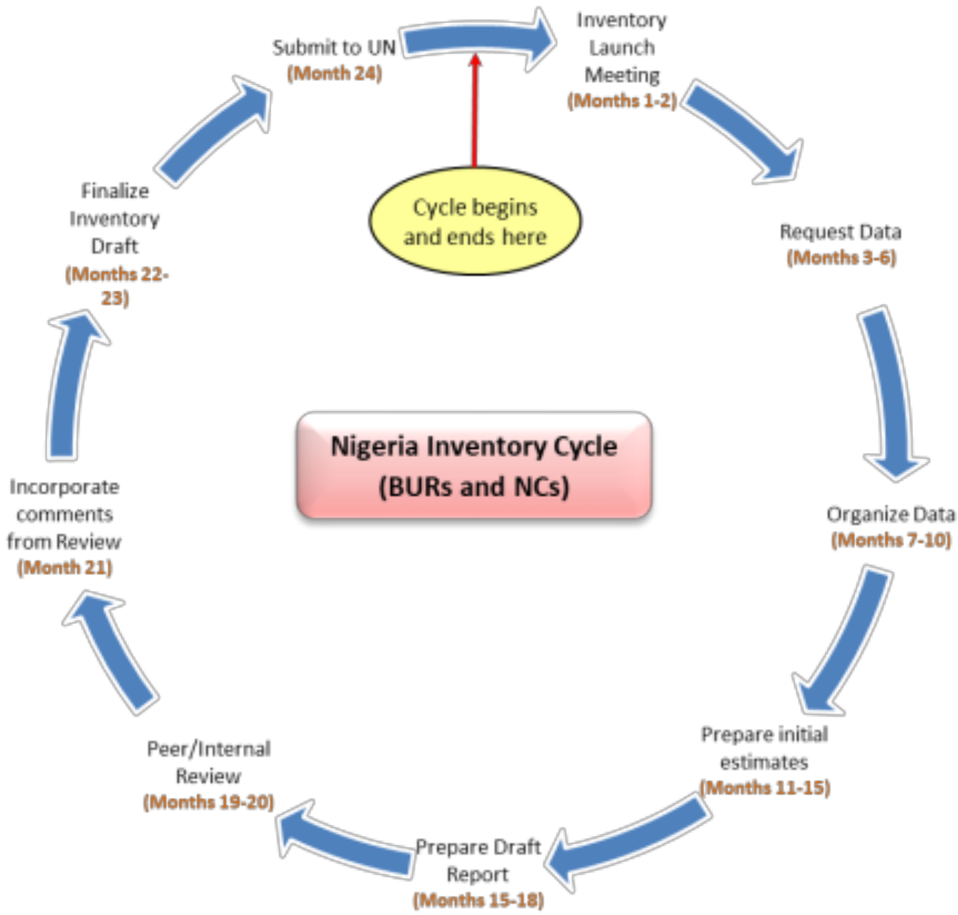


Figure 2.2 - The inventory cycle of Nigeria

The different steps adopted for the preparation of the inventory were:

- Review previous inventory and prioritise resources
- Collection, quality control and validation of AD
- Selection of Method - Tier level within each category and sub-category
- Selection of emission factors (EFs) and Derivation of local EFs wherever possible
- Validation of AD and EFs during a workshop serving for capacity building concurrently
- Computation of GHG emissions
- Key Category Analysis
- Uncertainty analysis
- QA / QC of emission computations and outputs
- Assessment of completeness
- Recalculations
- Trend analysis
- Identification of gaps, constraints and needs
- National Inventory Improvement Plan
- Draft NIR
- Circulate draft NIR to stakeholders for comments
- Integration of stakeholder’s comments
- Validation of NIR, and
- Submission of NIR to UNFCCC as a stand-alone document and as a component of the BUR2

2.3. Overview of the inventory

2.3.1. Coverage

This GHG inventory covers the whole territory of the Federal Republic of Nigeria and estimates are computed at the national scale.

The national GHG inventory includes estimates for the four IPCC sectors, Energy; Industrial Processes and Product Use (IPPU); Agriculture, Forestry and Other Land Use (AFOLU) and Waste. However, the categories and subcategories have not been fully exhausted due to lack of AD in some cases. The coverage of activity areas is provided under the completeness section of this report.

The GHG inventory includes emissions of the direct GHGs carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Additionally, estimates of the GHG precursors oxides of nitrogen (NO_X), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs), and sulphur dioxide (SO_2) were possible when AD were available.

Estimates have been made for the year 2017. In line with the requirement to provide a trend of estimates, the period 2000 to 2017 has been adopted. Furthermore, for the sake of consistency for reporting, estimates for the years 2000 to 2016 have been recalculated whenever required, and using the same methodology and data sources to reflect improved AD or EFs as appropriate.

Global Warming Potentials (GWPs) adopted for providing a consistent basis for comparing the relative effect of the emissions of all GHGs uniformized over a period of 100 years by converting the emissions of the other GHGs to that of CO_2 were from the IPCC Fifth Assessment Report (AR5). The GWPs used in this report for the direct GHGs are given in Table 2.4 further in this report.

2.3.2. Method

Estimates of GHG emissions provided in this report have been compiled using the 2006 IPCC Guidelines for National GHG Inventories (IPCC 2007) and the IPCC Good Practice Guidance (GPG) and Uncertainty Management in National GHG Inventories (IPCC 2000). The purpose of adopting these guidelines and GPG is to ensure that the GHG emission estimates are Transparent, Accurate, Complete, Consistent and Comparable (TACCC) as far as possible.

A key category analysis (KCA) was conducted to identify activities in the four IPCC sectors responsible for 95% of the emissions and sinks within the economy, the objective being to identify which sources should be given priority for refining emission estimates. Results of the KCA from the GHG inventory of the NC3, availability of resources, existing capacity and availability of AD dictated the choice of source categories to be included for compilation. A prioritization exercise was conducted, and the highest emitting source categories were privileged, the intent being to improve estimates by moving to Tier 2. Selection of the Tier level was guided by the general decision-tree reproduced in Figure 2.3 and category specific decision trees provided in the Guidelines. Generally, the selection of the Tier level for all sectors was constrained by the limited availability of disaggregated AD (e.g. facility level data) and national EFs. This led to the adoption of the Tier 1 level for all categories estimated except LAND. Stock and EFs were generated for estimating emissions in this category using a mix of Tiers 1 and 2 as appropriate. National AD was complemented with those available in international databases and IPCC default EFs were used. Detailed descriptions of the methods adopted for generating missing data and equations used in each sector, including AD and EFs used, are provided in the relevant sections of this report.

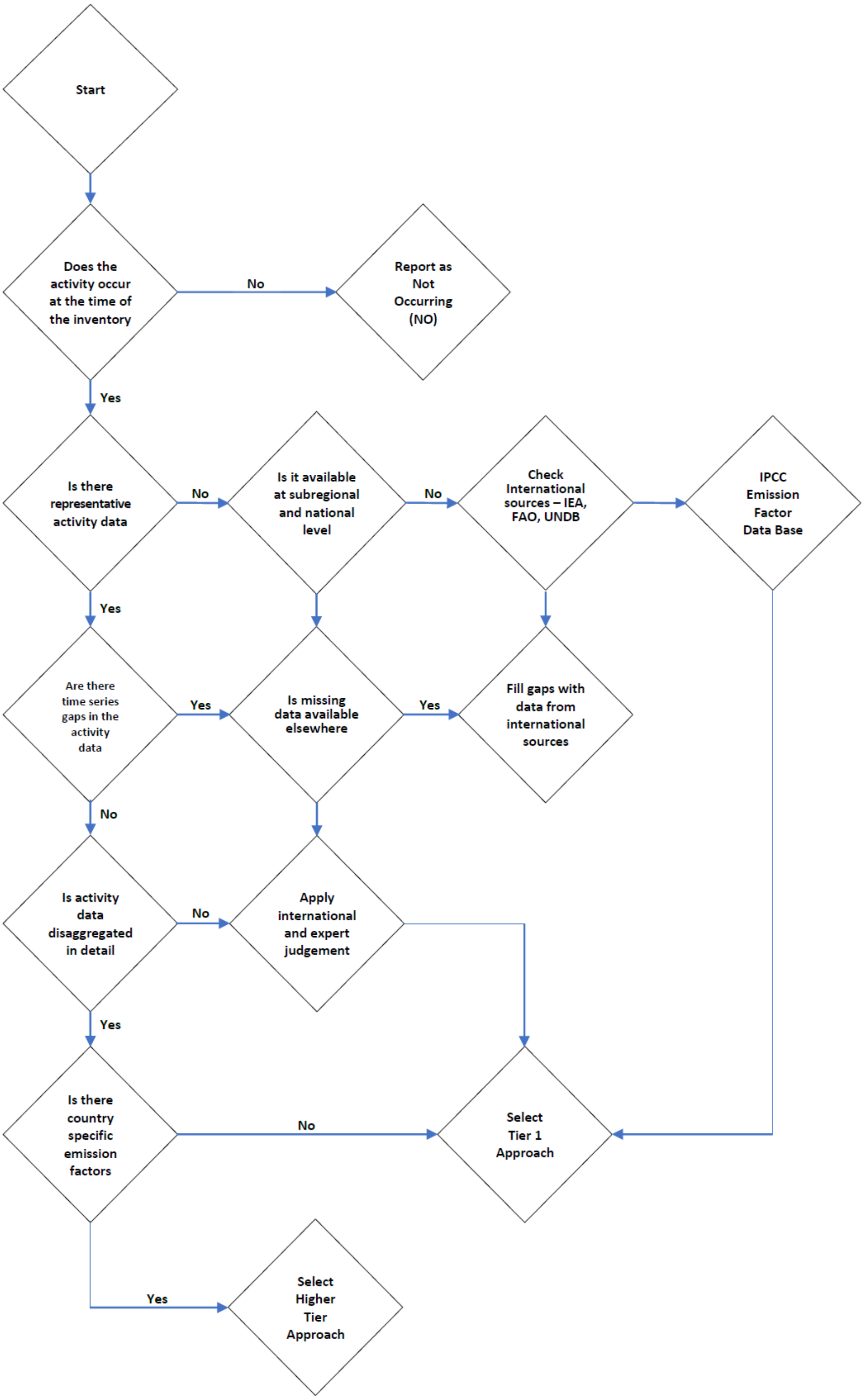


Figure 2.3 - Decision tree used to determine Tier Level method

2.4. Key Category Analysis

Key Category Analysis gives the characteristics of the emission sources and sinks. According to the 2006 IPCC Guidelines (V1_4_Ch4_Method_Choice), key categories are those which contribute 95% of the total annual emissions, when ranked from the largest to the smallest emitter. A key category is one that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of direct GHGs in terms of the absolute level of emissions, the trend in emissions, or both (IPCC, 2000). Thus, it is a good practice to identify key categories, as it helps prioritize efforts and improve the overall quality of the national inventory, while also guiding mitigation policies, strategies, and actions.

The Key Category Analysis was performed using the tool available within the IPCC inventory software for both the level and trend assessments. The results for the level assessment for the year 2017 are presented in Table 2.1 and the trend assessment in Table 2.2.

Table 2.1 - Key Category Analysis for the year 2017 - Approach 1 - Level Assessment

A	B	C	D	E	F	G
IPCC Category code	IPCC Category	GHG	"2017 Ex,t (Gg CO_2-eq)"	"|Ex,t| (Gg CO_2-eq)"	Lx,t	Cumulative Total of Column F
3.B.1.a	Forest land Remaining Forest land	CO_2	319,971	319,971	0.469	0.469
1.B.2.a	Oil	CH_4	60,314	60,314	0.088	0.557
1.A.1	Energy Industries - Gaseous Fuels	CO_2	55,750	55,750	0.082	0.639
1.A.3.b	Road Transportation	CO_2	36,000	36,000	0.053	0.691
3.A.1	Enteric Fermentation	CH_4	35,474	35,474	0.052	0.743
1.B.2.b	Natural Gas	CH_4	31,184	31,184	0.046	0.789
1.A.4	Other Sectors - Biomass	CH_4	18,883	18,883	0.028	0.817
1.A.4	Other Sectors - Liquid Fuels	CO_2	16,997	16,997	0.025	0.842
3.C.4	Direct N_2O Emissions from managed soils	N_2O	16,089	16,089	0.024	0.865
4.D	Wastewater Treatment and Discharge	CH_4	15,332	15,332	0.022	0.888
1.A.2	Manufacturing Industries and Construction - Gaseous Fuels	CO_2	12,771	12,771	0.019	0.906
3.C.7	Rice cultivation	CH_4	9,572	9,572	0.014	0.920
4.A	Solid Waste Disposal	CH_4	7,894	7,894	0.012	0.932
2.C.1	Iron and Steel Production	CO_2	6,360	6,360	0.009	0.941
4.D	Wastewater Treatment and Discharge	N_2O	5,998	5,998	0.009	0.950
3.C.5	Indirect N_2O Emissions from managed soils	N_2O	5,255	5,255	0.008	0.958

There are 16 key categories in the quantitative level assessment for the year 2017, the main one being Forestland remaining Forestland responsible for 46.9 % of emissions, attributed to the combined effect of deforestation and wood removals for various purposes. The other important emitting categories are from the Oil industry (8.8%), Gaseous Fuels under Energy Industries (8.2%), Road Transportation (5.3%), Enteric Fermentation (5.2% and Natural Gas (4.6%). These key categories account for a total of 78.9% of the total emissions. The remaining key categories contribute the difference of 16.1% of the 95% considered under the KCA.

The results change quite drastically when considering the trend assessment covering the period 2000 to 2017 (Table 2.2). There are now only twelve key categories compared to the level assessment. The three main contributors in the trend assessment are Forestland remaining Forestland, Gaseous Fuels under Energy Industries and Oil with more than 20% each, totalling 68.1% of the total emissions.

Table 2.2 - Key Category Analysis (2000 – 2017) - Approach 1 - Trend Assessment

A	B	C	D	E	F	G	H
IPCC Category code	**IPCC Category**	**GHG**	**2000 Year Estimate Ex0 (Gg CO_2-eq)**	**2017 Year Estimate Ext (Gg CO_2-eq)**	**Trend Assessment (Txt)**	**% Contribution to Trend**	**Cumulative Total of Column G**
3.B.1.a	Forest land Remaining Forest land	CO_2	256,674	319,971	0.121	26.3%	0.263
1.A.1	Energy Industries - Gaseous Fuels	CO_2	6,999	55,750	0.097	20.9%	0.472
1.B.2.a	Oil	CH_4	71,970	60,314	0.097	20.9%	0.681
1.A.3.b	Road Transportation	CO_2	14,518	36,000	0.031	6.7%	0.748
1.A.2	Manufacturing Industries and Construction - Gaseous Fuels	CO_2	1,705	12,771	0.022	4.7%	0.795
1.A.4	Other Sectors - Liquid Fuels	CO_2	5,424	16,997	0.019	4.2%	0.837
1.B.2.b	Natural Gas	CH_4	16,118	31,184	0.016	3.5%	0.871
2.A.1	Cement production	CO_2	714	5,240	0.009	1.9%	0.891
2.C.1	Iron and Steel Production	CO_2	1,791	6,360	0.008	1.7%	0.908
1.B.2.a	Oil	CO_2	5,626	4,715	0.008	1.6%	0.924
4.A	Solid Waste Disposal	CH_4	3,069	7,894	0.007	1.6%	0.940
1.A.4	Other Sectors - Biomass	CH_4	14,551	18,883	0.005	1.1%	0.951

The summary of Key Categories based on the quantitative level to the 95% level assessments for the year 2017 and trend, for the period 2000 to 2017, is presented in Table 2.3. Ten categories came out under both the level and trend assessments, two under trend only and the remaining four solely under level assessment.

Table 2.3 - Summary of Key Categories for level (2017) and trend (2000 – 2017) assessments

Number	IPCC category code	IPCC category	GHG	Approach used	Comment
1	1.A.1	Energy Industries - Gaseous Fuels	CO_2	L1 T1	Quantitative
2	1.A.2	Manufacturing Industries and Construction - Gaseous Fuels	CO_2	L1 T1	Quantitative
3	1.A.4	Other Sectors - Liquid Fuels	CO_2	L1 T1	Quantitative
4	1.A.4	Other Sectors - Biomass	CH_4	L1 T1	Quantitative
5	1.B.2.a	Oil	CH_4	L1 T1	Quantitative
6	1.B.2.b	Natural Gas	CH_4	L1 T1	Quantitative
7	2.C.1	Iron and Steel Production	CO_2	L1 T1	Quantitative
8	3.B.1.a	Forest land Remaining Forest land	CO_2	L1 T1	Quantitative
9	4.A	Solid Waste Disposal	CH_4	L1 T1	Quantitative
10	1.A.3.b	Road Transportation	CO_2	L1 T1	Quantitative
11	1.B.2.a	Oil	CO_2	T1	Quantitative
12	2.A.1	Cement production	CO_2	T1	Quantitative
13	3.A.1	Enteric Fermentation	CH_4	L1	Quantitative

Number	IPCC category code	IPCC category	GHG	Approach used	Comment
14	3.C.4	Direct N2O Emissions from managed soils	N_2O	L1	Quantitative
15	3.C.7	Rice cultivation	CH_4	L1	Quantitative
16	4.D	Wastewater Treatment and Discharge	CH_4	L1	Quantitative

Notation keys: L = key category according to level assessment; T = key category according to trend assessment; and Q = key category according to qualitative criteria. The Approach used to identify the key category is included as L1, L2, T1 or T2.

2.5. Methodological issues

This section gives an overview of the methodological approach adopted for all sectors and sub-sectors covered in this inventory report. More details are provided in the respective section covering the individual categories.

The method adopted to compute emissions involved multiplying AD by the relevant appropriate EF, as shown below:

Emissions (E) = Activity Data (AD) x Emission Factor (EF)

All the methods and tools recommended by IPCC for the computation of emissions in an inventory have been used and followed to be in line with Good Practices.

Global Warming Potentials (GWP) as recommended by IPCC AR5 and based on the Annex to Decision 18 / CMA.1 have been used to convert GHGs other than CO_2 to the latter equivalent. The values adopted for the three direct GHGs CO_2, CH_4 and N_2O are provided in Table 2.4. Additional gases, known as indirect gases, which affect global warming, NO_x, CO, NMVOCs and SO_2 have also been computed and reported in the inventory.

Table 2.4 - Global Warming Potential

Gas		Global Warming Potential
Carbon Dioxide	(CO_2)	1
Methane	(CH_4)	28
Nitrous Oxide	(N_2O)	265

Default EFs were assessed for their appropriateness, namely the situations under which they have been developed and the extent to which these were representative of national circumstances, prior to their adoption.

A declared national framework for data collection and archiving to meet the requirements for preparing GHG inventories is still lacking. Such a framework is being developed with the support provided by the UNFCCC Secretariat under the programme *Technical assistance for sustainable national GHG inventory management systems in developing countries*. Thus, derived data and estimates were used to fill gaps in the time series quite frequently. These were considered reliable and sound since they were based on peer reviewed publications and other observations. Estimates used included fuel use for navigation and domestic aviation, and forest areas by type. Most missing AD for the period 2000 to 2017 were generated using the splicing techniques recommended in the 2006 IPCC Guidelines based on related socio-economic factors.

2.6. Quality Assurance and Quality Control (QA / QC)

Availability of good quality AD that have undergone a rigorous Quality Control and Quality Assurance for compiling GHG inventories has been and remains a serious challenge in Nigeria. Usually, data collected by the public sector are quality controlled and archived by the National Bureau of Statistics. The private sector implements their own QC / QA within its data collection and archiving process, but this is not very transparent. Thus, the QA / QC remained beyond the GHG inventory compilation team and the AD collected for the time series presented numerous outliers. This shortcoming is presently being addressed under the GHGIMS consolidation process.

QC and QA procedures, as defined in the *2006 IPCC Guidelines* (IPCC, 2007) is yet to be implemented by Nigeria during the preparation of the inventory. Again, this is being addressed within the UNFCCC project and will be further developed within the contemplated Capacity Building Initiative for Transparency (CBIT) project when funds become available. It is anticipated that a first QA / QC plan as per IPCC standard will be developed and implemented when the next inventory will be compiled. Given these circumstances, the only QC that could be done was through comparison of national data sets with those from international databases.

QA has not been done on a routine basis as per IPCC recommendations for this inventory except for the one by the independent international consultant who was not involved with the preparation of the inventory. The exercise comprised the following steps:

- Confirm data quality and reliability used for computing emissions;
- Compare AD with those available on international websites such as FAO and IEA;
- Review the AD and EFs adopted within each source category as a first step; and
- Review and check the calculation steps in the software to ensure accuracy.

Nigeria volunteered to the UNFCCC and Global Support Programme undertaking a QA exercise on its inventory compilation process adopted for the NC3. The recommendations from the QA exercise, listed below, were addressed but still need further improvement:

- Institutional arrangements to ensure annual provision of AD for preparing the inventory are in progress
- Improve AD for the AFOLU sector, generate land use changes, national stock and EFs to move to Tier 2
- Development of legal arrangements for securing collaboration of other institutions for AD is in progress
- Improved documentation and archiving are being addressed, and
- Capacity building in various areas of inventory compilation is under way.

2.7. Uncertainty assessment

Uncertainty estimation is an essential element of a GHG Inventory in addition to the KCA to provide information on the source categories to be prioritized for maximum resources to be allocated to improve the quality of the inventory. Inventories prepared in accordance with *2006 IPCC guidelines* (IPCC, 2007) will typically contain a wide range of uncertainties in the emission estimates associated with AD and EF used. Estimates may be of good quality with low uncertainties when carefully measured and demonstrably complete data sets are used or of lower quality with higher uncertainty estimates such as with N_2O fluxes from soils and waterways.

For this Inventory, a Tier 1 uncertainty analysis of the aggregated figures as required by the 2006 IPCC Guidelines, Vol. 1 (IPCC, 2007) was performed. Based on the quality of the data and whether the EFs used were defaults or nationally derived, uncertainty levels were assigned to the two parameters and the combined uncertainty calculated. In most cases, the uncertainty values within the range recommended by the IPCC Guidelines were allocated to AD and EFs. Thus, lower uncertainties were allocated to AD obtained from measurements made and recorded, higher values for interpolated and extrapolated AD and the highest ones in the range when the AD have been estimated. Regarding the default EFs, the average value recommended in the IPCC Guidelines were adopted. Whenever there was a need to revert to expert judgement, the protocol was to consult with more than one expert from the typical sector or industry to ascertain on the level of uncertainty to be adopted from within the range provided in the IPCC guidelines. In cases where IPCC has a recommended methodology, the uncertainty level was derived according to the procedure proposed in the IPCC Guidelines and used in the uncertainty analysis. The uncertainty analysis has been performed using the tool available within the IPCC inventory software. Uncertainties in total emissions based on the IPCC tool, including emissions and removals from the Land sector is presented in Table 2.5. Uncertainty levels for the individual years of the period 2000 to 2017 varied from 8.3% to 19.0% while the trend assessment when adding one successive year on the base year 2000 for the years 2001 to 2017 ranged from 10.9% to 13.9%. The complete uncertainty analysis for 2017 is provided as annex 1 in this report.

Table 2.5 - Overall uncertainty (%)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
Annual	19.0	8.9	9.0	8.8	8.7	8.6	8.6	8.5	8.5
Trend (base year 2000)	-	10.9	11.0	11.2	11.3	11.5	11.7	11.8	11.9

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
Annual	8.7	8.5	8.5	8.4	8.4	8.3	8.3	8.5	8.4
Trend (base year 2000)	12.1	12.3	12.5	12.6	12.8	13.1	13.3	13.4	13.6

2.8. Assessment of completeness

An assessment of the completeness of the inventory was made for individual activity areas within each source category. The completeness results (Table 2.6) present the coverage and exhaustiveness of this inventory. To simplify the completeness table, the sub-categories within a category where activities are not occurring in the country have not been spelt out fully but kept rather at the category level only. The methodology adopted was according to the *2006 IPCC Guidelines* (IPCC 2007) with the following notation keys used:

- E Estimated
- NA Not Applicable
- NO Not Occurring
- NE Not Estimated
- IE Included Elsewhere

Table 2.6 - Completeness of the 2017 GHG inventory

Categories	Net CO_2 (1)(2)	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4)	NO_x	CO	NMVOCs	SO_2
Total National Emissions and Removals	E	E	E	NE	NE	NE	NE	NE	E	E	E	E
1 - Energy	E	E	E	NA	NA	NA	NA	NA	E	E	E	E
1.A - Fuel Combustion Activities	E	E	E	NA	NA	NA	NA	NA	E	E	E	E
1.A.1 - Energy Industries	E	E	E	NA	NA	NA	NA	NA	E	E	E	E
1.A.2 - Manufacturing Industries and Construction	E	E	E	NA	NA	NA	NA	NA	E	E	E	E
1.A.3 - Transport	E	E	E	NA	NA	NA	NA	NA	E	E	E	E
1.A.4 - Other Sectors	E	E	E	NA	NA	NA	NA	NA	E	E	E	E
1.A.5 - Non-Specified	NE	NE	NE	NA	NA	NA	NA	NA	NE	NE	NE	NE
1.B - Fugitive emissions from fuels	E	E	E	NA	NA	NA	NA	NA	E	E	E	E
1.B.1 - Solid Fuels	NE	E	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.B.2 - Oil and Natural Gas	E	E	E	NA	NA	NA	NA	NA	E	E	E	E
1.B.3 - Other emissions from Energy Production	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NA
1.C - Carbon dioxide Transport and Storage	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.C.1 - Transport of CO_2	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.C.2 - Injection and Storage	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.C.3 - Other	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2 - Industrial Processes and Product Use	E	E	NE	NE	NE	NE	NE	NE	E	E	E	NE
2.A - Mineral Industry	E	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.A.1 - Cement production	E	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.2 - Lime production	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.3 - Glass Production	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.4 - Other Process Uses of Carbonates	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.A.5 - Other (please specify)	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B - Chemical Industry	E	NO	NE	NO	NO	NO	NO	NO	E	E	NO	NO
2.B.1 - Ammonia Production	E	NA	NA	NA	NA	NA	NA	NA	E	E	NO	NO
2.B.2 - Nitric Acid Production	NA	NA	NE	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.B.3 - Adipic Acid Production	NA	NA	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production	NA	NA	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.5 - Carbide Production	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO

Categories	Net CO_2 (1)(2)	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4)	NO_x	CO	NMVOCs	SO_2
2.B.6 - Titanium Dioxide Production	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.7 - Soda Ash Production	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.8 - Petrochemical and Carbon Black Production	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.9 - Fluorochemical Production	NA	NA	NA	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B.10 - Other (Please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C - Metal Industry	E	E	NO	NO	NO	NO	NO	NO	NO	NO	E	NO
2.C.1 - Iron and Steel Production	E	E	NA	NA	NA	NA	NA	NA	NO	NO	E	NO
2.C.2 - Ferroalloys Production	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.C.3 - Aluminium production	NO	NA	NA	NA	NO	NA	NA	NO	NO	NO	NO	NO
2.C.4 - Magnesium production	NO	NA	NA	NA	NA	NO	NA	NO	NO	NO	NO	NO
2.C.5 - Lead Production	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.C.6 - Zinc Production	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.C.7 - Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D - Non-Energy Products from Fuels and Solvent Use	NE	NO	NO	NA	NA	NA	NA	NA	NO	NO	NE	NO
2.D.1 - Lubricant Use	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.2 - Paraffin Wax Use	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.3 - Solvent Use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NE	NA
2.D.4 - Other (please specify)	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.E - Electronics Industry	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA
2.E.1 - Integrated Circuit or Semiconductor	NA	NA	NA	NO	NO	NO	NO	NO	NA	NA	NA	NA
2.E.2 - TFT Flat Panel Display	NA	NA	NA	NA	NO	NO	NO	NO	NA	NA	NA	NA
2.E.3 - Photovoltaics	NA	NA	NA	NA	NO	NA	NA	NO	NA	NA	NA	NA
2.E.4 - Heat Transfer Fluid	NA	NA	NA	NA	NO	NA	NA	NO	NA	NA	NA	NA
2.E.5 - Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA
2.F - Product Uses as Substitutes for Ozone Depleting Substances	NA	NA	NA	NE	NE	NA	NA	NA	NA	NA	NA	NA
2.F.1 - Refrigeration and Air Conditioning	NA	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA
2.F.2 - Foam Blowing Agents	NA	NA	NA	NO	NA	NA	NA	NA	NA	NA	NA	NA
2.F.3 - Fire Protection	NA	NA	NA	NE	NE	NA	NA	NA	NA	NA	NA	NA
2.F.4 - Aerosols	NA	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA
2.F.5 - Solvents	NA	NA	NA	NE	NE	NA	NA	NA	NA	NA	NA	NA
2.F.6 - Other Applications (please specify)	NA	NA	NA	NO	NO	NA	NA	NA	NA	NA	NA	NA
2.G - Other Product Manufacture and Use	NO	NO	NE	NO	NE	NE	NO	NE	NA	NA	NA	NA

Categories	Net CO_2 (1)(2)	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4)	NO_x	CO	NMVOCs	SO_2
2.G.1 - Electrical Equipment	NA	NA	NA	NA	NE	NE	NA	NE	NA	NA	NA	NA
2.G.2 - SF_6 and PFCs from Other Product Uses	NA	NA	NA	NA	NE	NE	NA	NE	NA	NA	NA	NA
2.G.3 - N_2O from Product Uses	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.G.4 - Other (Please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA
2.H - Other	NE	NE	NO	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.H.1 - Pulp and Paper Industry	NE	NE	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.H.2 - Food and Beverages Industry	NE	NE	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.H.3 - Other (please specify)	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
3 - Agriculture, Forestry, and Other Land Use	E	E	E	NA	NA	NA	NA	NA	E	E	NE	NO
3.A - Livestock	NA	E	E	NA	NA	NA	NA	NA	NA	NA	NE	NA
3.A.1 - Enteric Fermentation	NA	E	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.A.2 - Manure Management	NA	E	E	NA	NA	NA	NA	NA	NA	NA	NE	NA
3.B - Land	E	NA	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.B.1 - Forestland	E	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.B.2 - Cropland	NE	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.B.3 - Grassland	NE	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.B.4 - Wetlands	NO	NA	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.B.5 - Settlements	NE	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.B.6 - Other Land	NE	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.C - Aggregate sources and non-CO_2 emissions sources on land	NE	E	E	NA	NA	NA	NA	NA	E	E	NA	NA
3.C.1 - Emissions from biomass burning	NA	E	E	NA	NA	NA	NA	NA	E	E	NA	NA
3.C.2 - Liming	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C.3 - Urea application	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C.4 - Direct N_2O Emissions from managed soils	NA	NA	E	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C.5 - Indirect N_2O Emissions from managed soils	NA	NA	E	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C.6 - Indirect N_2O Emissions from manure management	NA	NA	E	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C.7 - Rice cultivations	NA	E	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C.8 - Other (please specify)	NA	NO	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D - Other	E	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.D.1 - Harvested Wood Products	E	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.2 - Other (please specify)	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
4 - Waste	E	E	E	NA	NA	NA	NA	NA	E	E	E	E

Categories	Net CO_2 (1)(2)	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4)	NO_x	CO	NMVOCs	SO_2
4.A - Solid Waste Disposal	NA	E	NO	NA	NA	NA	NA	NA	NO	NO	E	NA
4.B - Biological Treatment of Solid Waste	NA	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NA
4.C - Incineration and Open Burning of Waste	E	E	E	NA	NA	NA	NA	NA	E	E	E	E
4.D - Wastewater Treatment and Discharge	NA	E	E	NA	NA	NA	NA	NA	NO	NO	E	NA
4.E - Other (please specify)	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
5 - Other	NO	NO	NE	NO	NO	NO	NO	NO	NO	NO	NO	NO
5.A - Indirect N_2O emissions from the atmospheric deposition of nitrogen in NO_X and NH_3	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.B - Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo Items (5)												
International Bunkers	E	E	E	NA	NA	NA	NA	NA	E	E	E	E
1.A.3.a.i - International Aviation (International Bunkers)	E	E	E	NA	NA	NA	NA	NA	E	E	E	E
1.A.3.d.i - International water-borne navigation (International bunkers)	E	E	E	NA	NA	NA	NA	NA	E	E	E	E
1.A.5.c - Multilateral Operations	NE	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

2.9. Recalculations

During the computation of the present inventory, recalculations were done for the Waste sector in line with new data collected on composition and for 2016 whenever new datasets became available. Recalculated emissions for the base years 2000 and 2010 are given in Table 2.7 while for the remaining years of the time series, the recalculations, if any, can be captured in the sectoral results. Original estimates for the year 2000 were made according to the Revised 1996 IPCC Guidelines, Tier 1, lower coverage of activity areas compared to the present inventory while recalculated values are compiled in line with the 2006 IPCC Guidelines and newly derived national stock and EFs for the Land sector. The wide difference between the inventory compiled in 2000 and recalculated in 2017 is primarily attributed to a better coverage of emitting sources while the difference between the inventory of the NC3 recalculated for the BUR2 is due to addition of Coal mining and improved waste composition data.

Table 2.7 - Comparison of original and recalculated emissions of past inventories presented in national communications

Year	2000		2010	
	SNC	BUR2	NC3	BUR2
Net emissions	214,210	458,509	541,191	591,375

2.10. Time series consistency

This inventory now covers the period 2000 to 2017 and AD within each of the categories were abstracted from the same sources for all years. The same EFs have been used throughout the time series and the QA / QC procedures were kept constant for the whole inventory period. This enabled a consistent time series to be built with a good level of confidence in the trends of the emissions.

2.11. Gaps, constraints and needs

Nigeria still faces serious challenges to report to the required standards to the Convention, including the inventory component. To reduce uncertainties and aim at producing an inventory in line with TACCC principles, Nigeria strengthened its personnel of the DCC and its national GHG inventory management system and institutional arrangements. One major challenge for estimating emissions was gaps in AD. The latter are not readily available. Thus, substantial data were sourced from international databases or extrapolated on the basis of existing AD obtained from the Federal Institutions.

For this inventory, one more category, namely coal mining has been included.

The following problems were encountered during the preparation of this national inventory of GHG:

- Information required for the inventory were obtained from various sources even if DCC has taken the responsibility for collection of specific AD needed for the estimation of emissions according to IPCC on an annual basis
- Almost all the AD, including those from the NBS, are still not yet in the required format for feeding in the software to make the emission estimates
- End-use consumption data for some of the sectors and categories are not readily available and had to be generated on the basis of scientific and consumption parameters

- Reliable national biomass (bm) data such as timber, fuelwood, wood waste and charcoal consumed or produced were not available and had to be derived using statistical modelling or adopted from international databases
- There were frequent inconsistencies when data were collected from different sources
- Lack of EFs to better represent national circumstances and provide for more accurate estimates even if this is being addressed for some key categories
- Emissions for a substantial number of categories have not been estimated due to lack of AD, and
- DCC staff are not yet ready to take over the full inventory compilation process because of insufficient capacity which dictated the contracting of consultants.

2.12. National Inventory Improvement Plan (NIIP)

Based on the constraints, gaps and other challenges encountered during the preparation of the present inventory, a list of the most urgent improvements has been identified. These are listed below and have been partially addressed during the preparation of the NIR1 within the framework of the BUR2. However, most of the items still need further improvement and it is planned to cater for them during future inventory cycles and within the framework of the CBIT project in addition to the UNFCCC project providing support for the development and operationalization of the GHGIMS.

- National framework for adequate and proper data capture, QC, validation, storage and retrieval need to be developed to facilitate the compilation of future inventories
- Capacity building of national experts and strengthening of the existing institutional framework within a robust GHG inventory management system to provide improved coordinated action for a smooth implementation of the GHG inventory cycle for annual estimation of emissions
- Development of national EFs to enable adoption of Tier 2 methods for key categories
- Development and implementation of a QA / QC system including a QA / QC plan in order to reduce uncertainty and improve inventory quality
- Access sufficient financial resources to strengthen the present system at the States' level to provide adequate support to DCC for inventory compilation and coordination
- Institutionalisation of an archiving system
- Pursue efforts for collecting the required AD for categories not covered in this exercise, to improve completeness of future inventories
- Conduct new forest inventories to confirm the stock and EFs derived on the basis of data obtained from old forest inventories, scientific publication and other sources
- Produce maps for 1990 to 2020 matching IPCC representation of land classes to refine land use change data over 5 years periods to provide for a better estimate of emissions in the Land sector while supporting implementation of the REDD+ initiative, and
- Add the missing years 1990 to 1999 to complete the full time series 1990 to the latest year for compliance in inventory compilation.

3. National GHG emissions

3.1. Overview

The trends of GHG emissions for the Republic of Nigeria cover the period 2000 to 2017. Unavailability of more disaggregated data prevented the adoption of higher Tier methods for most of the key categories. Thus, the inventory has been compiled mostly at the Tier 1 level except for the LAND sector where national stock and EFs have been used.

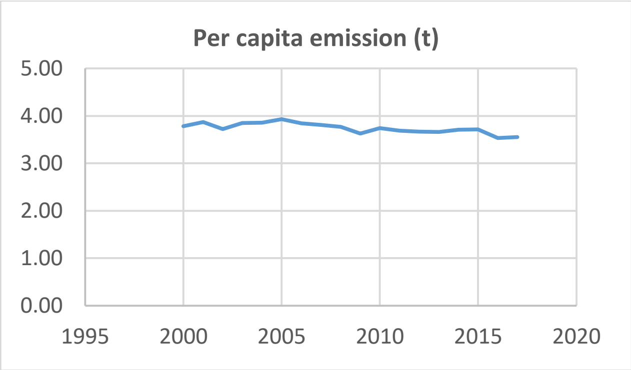
3.2. The period 2000 to 2017

Nigeria remained a net emitter over the period 2000 to 2017 as the Land category emissions exceeded removals from all categories combined. The total emissions increased by 213,768 Gg from 464,416 Gg in 2000 to 678,184 Gg in 2017, representing an increase of 46% over these 18 years. During the same period, the country recorded a regression of 23% in removals, from 5,908 Gg CO_2-eq to 4,543 Gg CO_2-eq. The trend for the period 2000 to 2017 indicates that national net emissions increased from 458,509 Gg CO_2-eq in 2000 to 673,641 Gg CO_2-eq in 2017 (Table 3.1).

Table 3.1 - GHG emissions (Gg CO_2-eq) characteristics (2000 – 2017)

Year	Total emissions	AFOLU removals	Net	Per capita emission (t)	GDP emissions index (Year 1994 = 100)
2000	464,416	-5,908	458,509	3.78	100.0
2001	487,874	-5,786	482,088	3.87	99.2
2002	481,500	-5,651	475,849	3.73	84.9
2003	510,402	-5,623	504,779	3.85	83.8
2004	524,605	-5,551	519,054	3.86	78.9
2005	548,799	-5,339	543,460	3.93	77.5
2006	551,157	-5,226	545,930	3.85	73.4
2007	560,673	-5,225	555,449	3.81	70.0
2008	569,396	-5,069	564,327	3.77	66.6
2009	563,147	-4,925	558,222	3.63	61.0
2010	596,171	-4,796	591,375	3.74	59.8
2011	603,628	-5,336	598,292	3.69	57.5
2012	617,328	-4,277	613,052	3.67	56.4
2013	633,014	-5,021	627,993	3.66	54.2
2014	658,761	-5,345	653,416	3.71	53.1
2015	676,641	-4,830	671,811	3.71	53.1
2016	661,261	-4,791	656,469	3.54	52.7
2017	678,184	-4,543	673,641	3.55	53.7

Per capita emissions of GHG varied between 3.93 and 3.54 during the period 2000 to 2017 with an overall decrease from 3.78 tonnes CO_2-eq in 2000 to 3.55 tonnes in 2017 (Figure 3.1). The GDP emission index decreased almost steadily from 100 in the year 2000 to 53.7 in 2017 (Figure 3.2).



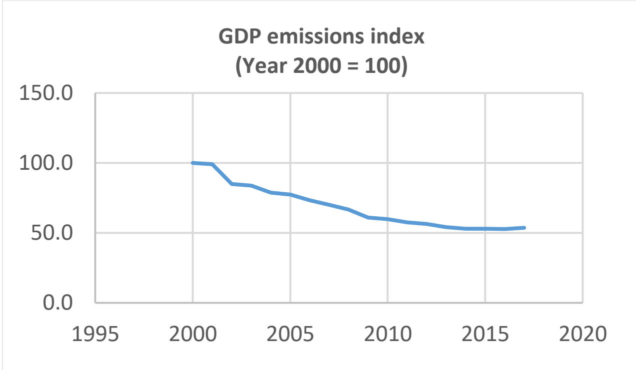


Figure 3.1 - Per capita GHG emissions (2000 – 2017)

Figure 3.2 - GDP emissions index (2000 – 2017)

3.3. Trend of emissions by sector

Total national emissions increased by 46% over these 18 years, through increases in all sectors. The AFOLU sector remained the leading emitter throughout this period followed by Energy, for all years under review. The Waste sector remained the third contributor with the IPPU sector emitting the least over the time series.

Emissions from Energy increased from 142,674 Gg CO_2-eq (31% of national emissions) in 2000 to 245,918 Gg CO_2-eq (36% of national emissions) in 2017 as depicted in Table 3.2. During the period 2000 to 2017, the emissions increased by 72%.

AFOLU emissions over the 2000 to 2017 period increased by 29% from 301,970 Gg CO_2-eq in 2000 to 389,790 Gg CO_2-eq in 2017 (Table 3.2). However, although AFOLU remained the highest contributor to national emissions, its share in these emissions decreased from 65% in 2000 to 57% in 2017.

The contribution of the IPPU sector in total national emissions increased from 2,511 Gg CO_2-eq in 2000 to a peak of 13,271 in 2015 to regress thereafter to 11,618 Gg CO_2-eq in 2017 (Table 3.2). IPPU represented 0.5% of national missions in 2000 and 1.7% in 2017.

Emissions from Waste increased slowly from 3.7% of national emissions in 2000 to 4.5% in 2017. Emissions from the waste sector increased from the 2000 level of 17,261 Gg CO_2-eq to 30,857 Gg CO_2-eq in 2017, representing a 79% increase.

Table 3.2 - National GHG emissions (Gg, CO_2-eq) by sector (2000 – 2017)

Year	Total emissions	Energy	IPPU	AFOLU	Waste
2000	464,416	142,674	2,511	301,970	17,261
2001	487,874	161,275	2,512	306,131	17,956
2002	481,500	150,384	2,481	309,999	18,637
2003	510,402	170,277	5,895	314,851	19,378
2004	524,605	178,980	6,013	319,492	20,121
2005	548,799	196,640	6,181	325,040	20,938
2006	551,157	192,145	6,300	331,070	21,641
2007	560,673	196,041	6,772	335,509	22,351
2008	569,396	199,933	7,360	338,957	23,147
2009	563,147	187,354	7,864	343,968	23,961
2010	596,171	211,571	8,247	351,483	24,870

Year	Total emissions	Energy	IPPU	AFOLU	Waste
2011	603,628	213,507	9,128	355,361	25,632
2012	617,328	218,109	10,835	361,925	26,460
2013	633,014	225,842	12,294	367,524	27,354
2014	658,761	244,136	12,468	373,884	28,273
2015	676,641	254,996	13,271	379,036	29,337
2016	661,261	235,166	12,004	383,882	30,208
2017	678,184	245,918	11,618	389,790	30,857

3.4. Trend in emissions of direct GHGs

The main contributor to the national GHG emissions remained CO_2 followed by CH_4 and N_2O. However, the share of CO_2 and N_2O increased while that of CH_4 regressed over the time series. In 2017, the share of the GHG emissions was as follows: 68% CO_2, 27% CH_4 and 5% N_2O. The trend of the aggregated emissions and removals by gas is given in Table 3.3 and Figure 3.3.

Table 3.3 - Aggregated emissions and removals by gas (2000 – 2017)

Year	Total GHG emissions (CO_2-eq)	Removals (CO_2) (CO_2-eq)	Net emissions (CO_2-eq)	CO_2 (Gg)	CH_4 (CO_2-eq)	N_2O (CO_2-eq)
2000	464,416	-5,908	458,509	296,508	148,086	19,822
2001	487,874	-5,786	482,088	311,818	155,463	20,593
2002	481,500	-5,651	475,849	317,288	143,306	20,906
2003	510,402	-5,623	504,779	331,479	157,217	21,706
2004	524,605	-5,551	519,054	335,562	167,207	21,835
2005	548,799	-5,339	543,460	356,009	169,860	22,930
2006	551,157	-5,226	545,930	358,165	169,310	23,681
2007	560,673	-5,225	555,449	368,726	167,647	24,300
2008	569,396	-5,069	564,327	379,227	164,984	25,186
2009	563,147	-4,925	558,222	376,174	160,906	26,067
2010	596,171	-4,796	591,375	387,708	181,339	27,124
2011	603,628	-5,336	598,292	396,498	180,098	27,032
2012	617,328	-4,277	613,052	404,999	184,422	27,907
2013	633,014	-5,021	627,993	425,326	178,569	29,119
2014	658,761	-5,345	653,416	445,917	183,221	29,623
2015	676,641	-4,830	671,811	459,266	187,304	30,071
2016	661,261	-4,791	656,469	452,099	177,917	31,245
2017	678,184	-4,543	673,641	462,884	182,686	32,614

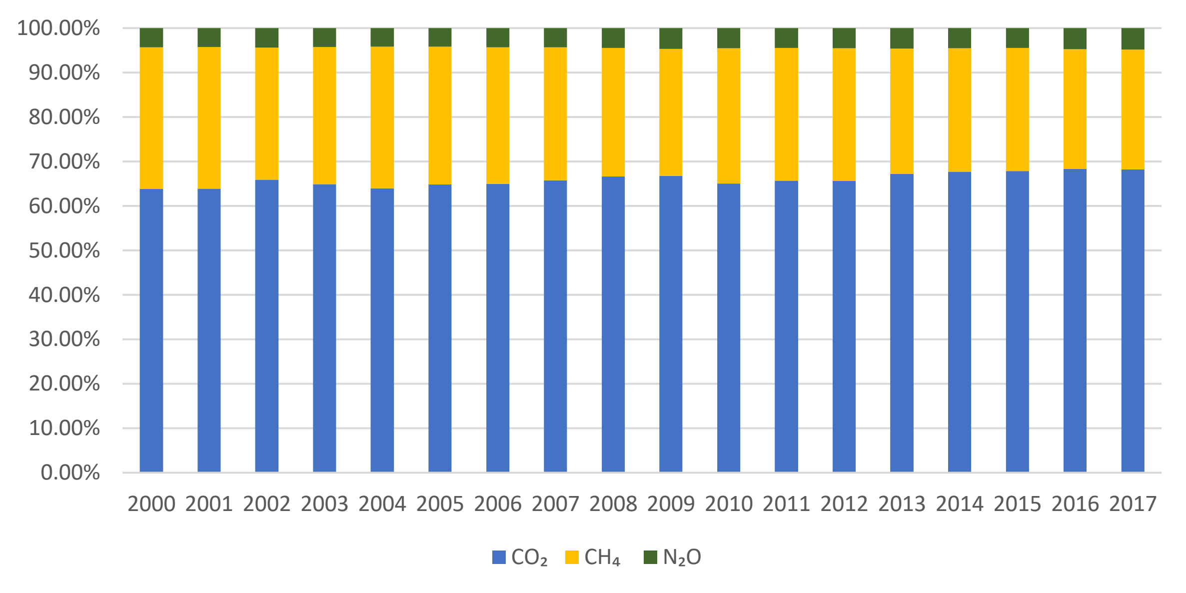


Figure 3.3 - Share of aggregated emissions (Gg CO_2-eq) by gas (2000 – 2017)

3.4.1. Carbon dioxide (CO_2)

National CO_2 emissions increased by 56% from the 2000 level of 296,508 Gg (Table 3.34) to 462,884 Gg in 2017. In the same year, the sector that emitted the highest amount of CO_2 was AFOLU with 319,971 Gg followed by Energy with 131,196 Gg, IPPU with 11,602 Gg and Waste with 115 Gg (Table 3.4).

Table 3.4 - CO_2 emissions (Gg) by source category (2000 – 2017)

Year	Total emissions	Total net emissions	Energy	IPPU	AFOLU - emissions	AFOLU - removals	Waste
2000	296,508	290,600	37,253	2,507	256,674	-5,908	74
2001	311,818	306,032	49,593	2,508	259,641	-5,786	76
2002	317,288	311,637	51,963	2,476	262,771	-5,651	78
2003	331,479	325,856	59,250	5,882	266,267	-5,623	80
2004	335,562	330,011	59,399	5,999	270,082	-5,551	82
2005	356,009	350,670	75,819	6,168	273,939	-5,339	84
2006	358,165	352,939	74,280	6,286	277,513	-5,226	86
2007	368,726	363,502	80,654	6,759	281,226	-5,225	88
2008	379,227	374,157	88,685	7,346	283,105	-5,069	90
2009	376,174	371,249	80,258	7,850	287,973	-4,925	92
2010	387,708	382,911	87,808	8,234	291,571	-4,796	95
2011	396,498	391,162	91,585	9,114	295,704	-5,336	95
2012	404,999	400,722	94,844	10,821	299,235	-4,277	99
2013	425,326	420,305	109,675	12,279	303,270	-5,021	102
2014	445,917	440,572	125,005	12,453	308,355	-5,345	105
2015	459,266	454,436	133,225	13,255	312,676	-4,830	110
2016	452,099	447,307	124,022	11,988	315,977	-4,791	112
2017	462,884	458,341	131,196	11,602	319,971	-4,543	115

3.4.2. Methane (CH_4)

CH_4 was the next contributor in national emissions after CO_2. CH_4 emissions increased by 23% from the 2000 level of 148,086 Gg CO_2-eq to 182,686 Gg CO_2-eq in 2017 (Table 3.5). Energy remained the highest contributor throughout the time series with an average of 66% followed by AFOLU with 23% and Waste with 11%. The contribution of the IPPU sector was insignificant with less than 1%.

Table 3.5 - CH_4 emissions (Gg) by source category (2000 – 2017)

Year	Total (Gg CO_2-eq)	Total	Energy	IPPU	AFOLU - emissions	Waste
2000	148,086	5,289	3,681	0.2	1,114	493
2001	155,463	5,552	3,901	0.2	1,136	515
2002	143,306	5,118	3,425	0.2	1,156	536
2003	157,217	5,615	3,874	0.5	1,184	557
2004	167,207	5,972	4,179	0.5	1,214	578
2005	169,860	6,066	4,221	0.5	1,246	599
2006	169,310	6,047	4,115	0.5	1,311	620
2007	167,647	5,987	4,024	0.5	1,322	641
2008	164,984	5,892	3,875	0.5	1,354	663
2009	160,906	5,747	3,726	0.5	1,336	685
2010	181,339	6,476	4,319	0.5	1,449	708
2011	180,098	6,432	4,251	0.5	1,451	730
2012	184,422	6,587	4,296	0.5	1,536	755
2013	178,569	6,377	4,035	0.5	1,563	779
2014	183,221	6,544	4,139	0.6	1,601	803
2015	187,304	6,689	4,233	0.6	1,626	829
2016	177,917	6,354	3,851	0.6	1,648	855
2017	182,686	6,524	3,976	0.6	1,670	878

3.4.3. Nitrous Oxide (N_2O)

N_2O emissions increased by 65% from 19,822 Gg CO_2-eq in the year 2000 to 32,614 Gg CO_2-eq in 2017 (Table 3.6). The AFOLU sector was the highest emitter of N_2O with more than 70% in all years of the time series.

Table 3.6 - N_2O emissions (Gg) by source category (2000 – 2017)

Year	Total emissions (Gg CO_2-eq)	Total	Energy	IPPU	AFOLU - emissions
2000	19,822	74.8	8.9	53.2	12.7
2001	20,593	77.7	9.2	55.4	13.1
2002	20,906	78.9	9.5	56.0	13.4
2003	21,706	81.9	9.7	58.3	14.0
2004	21,835	82.4	9.7	58.1	14.6
2005	22,930	86.5	9.9	61.2	15.4
2006	23,681	89.4	10.0	63.6	15.8
2007	24,300	91.7	10.3	65.2	16.3
2008	25,186	95.0	10.4	67.7	17.0
2009	26,067	98.4	10.5	70.2	17.7
2010	27,124	102.4	10.7	73.0	18.7
2011	27,032	102.0	11.0	71.8	19.2
2012	27,907	105.3	11.3	74.3	19.7
2013	29,119	109.9	12.0	77.3	20.6
2014	29,623	111.8	12.2	78.2	21.4
2015	30,071	113.5	12.2	78.6	22.7
2016	31,245	117.9	12.5	82.2	23.3
2017	32,614	123.1	12.8	87.0	23.3

3.5. Trends of indirect GHGs and SO_2

Emissions of indirect GHGs (CO, NO_x and NMVOCs) and SO_2, have also been estimated and reported in the inventory. Indirect GHGs have not been included in national total emissions. Emissions of these gases for the period 2000 to 2017 are given in Table 3.7.

Emissions of NO_x increased from 275 Gg in the year 2000 to 495 Gg in 2017. CO emissions also increased from 7,693 Gg in 2000 to 10,959 Gg in 2017. Likewise, for NMVOCs from 1480 Gg in 2000 to 2031 Gg in 2017 whilst emissions of SO_2 varied between 41.6 Gg and 69.0 Gg during the same period.

Table 3.7 - Emissions (Gg) of indirect GHGs and SO_2 (2000 – 2017)

Year	NO_x	CO	NMVOC	SO_2
2000	274.9	7,693	1,480	41.6
2001	303.3	8,009	1,553	54.4
2002	315.1	8,223	1,584	53.0
2003	347.9	8,354	1,626	53.3
2004	316.4	8,431	1,639	47.4
2005	351.4	8,590	1,671	56.8
2006	324.9	8,669	1,665	48.4
2007	336.5	8,936	1,703	45.1
2008	355.4	9,001	1,717	52.3
2009	335.1	8,990	1,715	47.1
2010	346.5	9,084	1,771	50.2
2011	360.8	9,240	1,784	52.1
2012	370.7	9,381	1,822	52.6
2013	431.0	10,063	1,938	68.1
2014	458.4	10,430	1,983	68.1
2015	458.1	10,476	1,977	61.9
2016	474.5	10,735	1,989	64.3
2017	495.1	10,959	2,031	69.0

3.5.1. Oxides of nitrogen (NO_x)

Emissions of NO_x increased over the inventory period from 275 Gg in the year 2000 to 495 Gg in 2017 (Table 3.8). The principal source of NO_x emissions was from the Energy sector. The Energy sector witnessed an increase of 82% and emitted some 95% of total emissions in all years of the time series. The Waste sector contributed about 4.8% of total national. AFOLU and IPPU contributions were insignificant with less than 0.1%.

Table 3.8 - NO_x emissions (Gg) by source category (2000 – 2017)

Year	Total emissions	Energy	IPPU	AFOLU	Waste
2000	275	260	0.001	0.1	15.3
2001	303	288	0.001	0.1	15.6
2002	315	299	0.001	0.1	16.0
2003	348	331	0.001	0.1	16.4
2004	316	299	0.001	0.1	16.8
2005	351	334	0.000	0.2	17.2
2006	325	307	0.000	0.2	17.6
2007	336	318	0.000	0.2	18.0

Year	Total emissions	Energy	IPPU	AFOLU	Waste
2008	355	337	0.001	0.2	18.5
2009	335	316	0.001	0.2	18.9
2010	346	327	0.001	0.1	19.4
2011	361	341	0.001	0.1	19.5
2012	371	350	0.001	0.1	20.4
2013	431	410	0.001	0.1	20.9
2014	458	437	0.001	0.2	21.4
2015	458	435	0.001	0.2	22.5
2016	474	451	0.001	0.2	23.0
2017	495	471	0.001	0.2	23.6

3.5.2. Carbon monoxide (CO)

National CO emissions increased from 7693 Gg in the year 2000 to 10959 Gg in 2017. The major contributor of CO was the Energy sector with some 96% of national emissions for all years of the time series followed by the Waste sector with between 3.5% to 3.8% (Table 3.9). The AFOLU and IPPU sectors contributed the remainder which is less than 1%.

Table 3.9 - CO emissions (Gg) by source category (2000 – 2017)

Year	Total emissions	Energy	IPPU	AFOLU	Waste
2000	7,693	7,423	6.2E-05	2.8	267.9
2001	8,009	7,732	6.2E-05	2.9	274.3
2002	8,223	7,939	6.9E-05	3.7	280.7
2003	8,354	8,063	5.1E-05	3.9	287.4
2004	8,431	8,132	5.5E-05	3.9	294.3
2005	8,590	8,284	4.9E-05	4.1	301.4
2006	8,669	8,355	5.0E-05	4.2	309.0
2007	8,936	8,615	5.0E-05	5.1	316.4
2008	9,001	8,672	5.0E-05	5.4	324.2
2009	8,990	8,653	5.1E-05	5.2	332.3
2010	9,084	8,740	5.1E-05	3.6	340.6
2011	9,240	8,893	5.1E-05	3.7	342.8
2012	9,381	9,019	5.1E-05	4.4	357.9
2013	10,063	9,692	5.2E-05	4.3	366.9
2014	10,430	10,048	5.2E-05	5.6	376.1
2015	10,476	10,074	5.2E-05	6.2	395.4
2016	10,735	10,325	5.3E-05	6.4	403.5
2017	10,959	10,539	5.3E-05	6.3	414.1

3.5.3. Non-Methane Volatile Organic Compounds (NMVOCs)

In 2017, emissions of NMVOCs stood at 2,031 Gg compared to 1,480 Gg in the year 2000. Emissions of NMVOCs increased throughout the inventory period for all sectors. The main emission source was the Energy sector (Table 3.10) which increased from 1,460 in 2000 to 1,997 in 2017. Emissions from the Waste sector increased from 20.1 Gg to 33.6 Gg during the inventory period. A marginal increase of 0.6 Gg is observed over the 2000 emissions of 0.3 Gg of the IPPU sector.

Table 3.10 – Emissions of NMVOCs (Gg) by source category (2000 – 2017)

Year	Total emissions	Energy	IPPU	Waste
2000	1,480	1,460	0.3	20.1
2001	1,553	1,532	0.3	20.7
2002	1,584	1,563	0.3	21.3
2003	1,626	1,603	0.7	21.9
2004	1,639	1,615	0.7	22.5
2005	1,671	1,647	0.7	23.1
2006	1,665	1,640	0.7	23.8
2007	1,703	1,678	0.7	24.5
2008	1,717	1,691	0.7	25.3
2009	1,715	1,688	0.7	26.0
2010	1,771	1,743	0.7	26.8
2011	1,784	1,756	0.7	27.4
2012	1,822	1,793	0.8	28.4
2013	1,938	1,908	0.8	29.2
2014	1,983	1,952	0.8	30.1
2015	1,977	1,944	0.9	31.4
2016	1,989	1,956	0.9	32.2
2017	2,031	1,997	0.9	33.6

3.5.4. Sulphur dioxide (SO_2)

The energy sector remained nearly as the sole emitter of SO_2 (Table 3.11) during the full inventory period, its contribution fluctuating from 41.6 Gg in 2000 to 69.0 Gg in 2017. The Waste sector emitted an insignificant amount varying from 0.5 to 0.8 Gg during the inventory period.

Table 3.11 - SO_2 emissions (Gg) by source category (2000 – 2017)

Year	Total emissions	Energy	Waste
2000	41.6	41.1	0.5
2001	54.4	53.9	0.5
2002	53.0	52.5	0.6
2003	53.3	52.7	0.6
2004	47.4	46.8	0.6
2005	56.8	56.3	0.6
2006	48.4	47.8	0.6
2007	45.1	44.5	0.6
2008	52.3	51.7	0.6
2009	47.1	46.4	0.7
2010	50.2	49.6	0.7
2011	52.1	51.4	0.7
2012	52.6	51.9	0.7
2013	68.1	67.4	0.7
2014	68.1	67.3	0.7
2015	61.9	61.1	0.8
2016	64.3	63.5	0.8
2017	69.0	68.1	0.8

Table 3.12 - Short Summary – Inventory Year 2017

Categories	Emissions (Gg)			Emissions CO_2 Equivalents (Gg)				Emissions (Gg)				
	Net CO_2 (1)(2)	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4)	NO_x	CO	NMVOCs	SO_2
Total National Emissions and Removals	458340.931	6524.494	123.072	NE	NE	NE	NE	NE	495.105	10958.904	2031.493	68.957
1 - Energy	131196.320	3976.360	12.768	NA	NA	NA	NA	NA	471.316	10538.528	1996.990	68.141
1.A - Fuel Combustion Activities	126454.141	707.809	12.697	NA	NA	NA	NA	NA	459.468	10489.084	1674.573	65.616
1.B - Fugitive emissions from fuels	4742.179	3268.551	0.070	NA	NA	NA	NA	NA	11.848	49.444	322.417	2.525
1.C - Carbon dioxide Transport and Storage	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2 - Industrial Processes and Product Use	11601.572	0.600	NE	NE	NE	NE	NE	NE	0.001	5.300E-05	0.900	0.000
2.A - Mineral Industry	5239.845	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B - Chemical Industry	1.727	NO	NE	NO	NO	NO	NO	NO	0.001	5.300E-05	NO	NO
2.C - Metal Industry	6360.000	0.600	NO	NO	NO	NO	NO	NO	NO	NO	0.900	NO
2.D - Non-Energy Products from Fuels and Solvent Use	NE	NO	NO	NA	NA	NA	NA	NA	NO	NO	NE	NO
2.E - Electronics Industry	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA
2.F - Product Uses as Substitutes for Ozone Depleting Substances	NA	NA	NA	NE	NE	NA	NA	NA	NA	NA	NA	NA
2.G - Other Product Manufacture and Use	NO	NO	NE	NO	NE	NE	NO	NE	NA	NA	NA	NA
2.H - Other	NE	NE	NO	NA	NA	NA	NA	NA	NE	NE	NE	NE
3 - Agriculture, Forestry, and Other Land Use	315427.959	1669.820	87.037	NA	NA	NA	NA	NA	0.203	6.296	NE	NO
3.A - Livestock	NA	1327.769	5.278	NA	NA	NA	NA	NA	NA	NA	NE	NA
3.B - Land	319970.583	NA	0.000	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.C - Aggregate sources and non-CO_2 emissions sources on land	NE	342.051	81.760	NA	NA	NA	NA	NA	0.203	6.296	NA	NA
3.D - Other	-4542.625	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
4 - Waste	115.080	877.715	23.267	NA	NA	NA	NA	NA	23.585	414.079	33.603	0.816
4.A - Solid Waste Disposal	NA	281.940	NO	NA	NA	NA	NA	NA	NO	NO	24.481	0.000
4.B - Biological Treatment of Solid Waste	NA	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NA
4.C - Incineration and Open Burning of Waste	115.080	48.209	0.634	NA	NA	NA	NA	NA	23.585	414.079	9.123	0.816
4.D - Wastewater Treatment and Discharge	NA	547.565	22.633	NA	NA	NA	NA	NA	NO	NO	NO	NO
4.E - Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5 - Other	NO	NO	NE	NO	NO	NO	NO	NO	NO	NO	NO	NO
5.A - Indirect N_2O emissions from the atmospheric deposition of nitrogen in NO_x and NH_3	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.B - Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Categories	Emissions (Gg)			Emissions CO_2 Equivalents (Gg)				Emissions (Gg)				
	Net CO_2 (1)(2)	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4)	NO_x	CO	NMVOCs	SO_2
Memo Items (5)												
International Bunkers	1246.484	0.015	0.035	NA	NA	NA	NA	NA	6.552	0.576	0.247	0.821
1.A.3.a.i - International Aviation (International Bunkers) (1)	1176.440	0.008	0.033	NA	NA	NA	NA	NA	4.776	0.410	0.187	0.373
1.A.3.d.i - International water-borne navigation (International bunkers) (1)	70.044	0.006	0.002	NA	NA	NA	NA	NA	1.776	0.166	0.061	0.448
1.A.5.c - Multilateral Operations (1)(2)	NE	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 3.13 - Long Summary – Inventory Year 2017

Categories	Emissions (Gg)			Emissions CO_2 Equivalents (Gg)				Emissions (Gg)				
	Net CO_2 (1)(2)	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4)	NO_x	CO	NMVOCs	SO_2
Total National Emissions and Removals	458340.931	6524.494	123.072	NE	NE	NE	NE	NE	495.105	10958.904	2031.493	68.957
1 - Energy	131196.320	3976.360	12.768	NA	NA	NA	NA	NA	471.316	10538.528	1996.990	68.141
1.A - Fuel Combustion Activities	126454.141	707.809	12.697	NA	NA	NA	NA	NA	459.468	10489.084	1674.573	65.616
1.A.1 - Energy Industries	57052.162	12.146	1.589	NA	NA	NA	NA	NA	120.565	72.365	5.329	10.541
1.A.2 - Manufacturing Industries and Construction	14758.460	4.607	0.598	NA	NA	NA	NA	NA	41.983	89.030	47.921	3.871
1.A.3 - Transport	37646.979	14.353	1.615	NA	NA	NA	NA	NA	157.924	1476.259	273.636	9.595
1.A.4 - Other Sectors	16996.540	676.703	8.895	NA	NA	NA	NA	NA	138.997	8851.429	1347.688	41.609
1.A.5 - Non-Specified	NE	NE	NE	NA	NA	NA	NA	NA	NE	NE	NE	NE
1.B - Fugitive emissions from fuels	4742.179	3268.551	0.070	NA	NA	NA	NA	NA	11.848	49.444	322.417	2.525
1.B.1 - Solid Fuels	NE	0.758	NA	NA	NA	NA	NA	NA	NA	NA	44.204	NA
1.B.2 - Oil and Natural Gas	4742.179	3267.793	0.070	NA	NA	NA	NA	NA	11.848	49.444	278.213	2.525
1.B.3 - Other emissions from Energy Production	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NA
1.C - Carbon dioxide Transport and Storage	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.C.1 - Transport of CO_2	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.C.2 - Injection and Storage	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Categories	Emissions (Gg)			Emissions CO_2 Equivalents (Gg)				Emissions (Gg)				
	Net CO_2 (1)(2)	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4)	NO_x	CO	NMVOCs	SO_2
1.C.3 - Other	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2 - Industrial Processes and Product Use	11601.572	0.600	NE	NE	NE	NE	NE	NE	0.001	5.300E-05	0.900	NE
2.A - Mineral Industry	5239.845	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.A.1 - Cement production	5239.845	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.2 - Lime production	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.3 - Glass Production	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.4 - Other Process Uses of Carbonates	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.A.5 - Other (please specify)	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B - Chemical Industry	1.727	NO	NE	NO	NO	NO	NO	NO	0.001	5.300E-05	NO	NO
2.B.1 - Ammonia Production	1.727	NA	NA	NA	NA	NA	NA	NA	0.001	5.300E-05	NO	NO
2.B.2 - Nitric Acid Production	NA	NA	NE	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.B.3 - Adipic Acid Production	NA	NA	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production	NA	NA	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.5 - Carbide Production	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.6 - Titanium Dioxide Production	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.7 - Soda Ash Production	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.8 - Petrochemical and Carbon Black Production	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.9 - Fluorochemical Production	NA	NA	NA	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B.10 - Other (Please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C - Metal Industry	6360.000	0.600	NO	NO	NO	NO	NO	NO	NO	NO	0.900	NO
2.C.1 - Iron and Steel Production	6360.000	0.600	NA	NA	NA	NA	NA	NA	NO	NO	0.900	NO
2.C.2 - Ferroalloys Production	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.C.3 - Aluminium production	NO	NA	NA	NA	NO	NA	NA	NO	NO	NO	NO	NO
2.C.4 - Magnesium production	NO	NA	NA	NA	NA	NO	NA	NO	NO	NO	NO	NO
2.C.5 - Lead Production	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.C.6 - Zinc Production	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.C.7 - Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D - Non-Energy Products from Fuels and Solvent Use	NE	NO	NO	NA	NA	NA	NA	NA	NO	NO	NE	NO
2.D.1 - Lubricant Use	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.2 - Paraffin Wax Use	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.3 - Solvent Use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NE	NA

Categories	Emissions (Gg)			Emissions CO_2 Equivalents (Gg)				Emissions (Gg)				
	Net CO_2 (1)(2)	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4)	NO_x	CO	NMVOCs	SO_2
2.D.4 - Other (please specify)	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.E - Electronics Industry	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA
2.E.1 - Integrated Circuit or Semiconductor	NA	NA	NA	NO	NO	NO	NO	NO	NA	NA	NA	NA
2.E.2 - TFT Flat Panel Display	NA	NA	NA	NA	NO	NO	NO	NO	NA	NA	NA	NA
2.E.3 - Photovoltaics	NA	NA	NA	NA	NO	NA	NA	NO	NA	NA	NA	NA
2.E.4 - Heat Transfer Fluid	NA	NA	NA	NA	NO	NA	NA	NO	NA	NA	NA	NA
2.E.5 - Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA
2.F - Product Uses as Substitutes for Ozone Depleting Substances	NA	NA	NA	NE	NE	NA	NA	NA	NA	NA	NA	NA
2.F.1 - Refrigeration and Air Conditioning	NA	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA
2.F.2 - Foam Blowing Agents	NA	NA	NA	NO	NA	NA	NA	NA	NA	NA	NA	NA
2.F.3 - Fire Protection	NA	NA	NA	NE	NE	NA	NA	NA	NA	NA	NA	NA
2.F.4 - Aerosols	NA	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA
2.F.5 - Solvents	NA	NA	NA	NE	NE	NA	NA	NA	NA	NA	NA	NA
2.F.6 - Other Applications (please specify)	NA	NA	NA	NO	NO	NA	NA	NA	NA	NA	NA	NA
2.G - Other Product Manufacture and Use	NO	NO	NE	NO	NE	NE	NO	NE	NA	NA	NA	NA
2.G.1 - Electrical Equipment	NA	NA	NA	NA	NE	NE	NA	NE	NA	NA	NA	NA
2.G.2 - SF_6 and PFCs from Other Product Uses	NA	NA	NA	NA	NE	NE	NA	NE	NA	NA	NA	NA
2.G.3 - N_2O from Product Uses	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.G.4 - Other (Please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA
2.H - Other	NE	NE	NO	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.H.1 - Pulp and Paper Industry	NE	NE	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.H.2 - Food and Beverages Industry	NE	NE	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.H.3 - Other (please specify)	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
3 - Agriculture, Forestry, and Other Land Use	315427.959	1669.820	87.037	NA	NA	NA	NA	NA	0.203	6.296	NE	NO
3.A - Livestock	NA	1327.769	5.278	NA	NA	NA	NA	NA	NA	NA	NE	NA
3.A.1 - Enteric Fermentation	NA	1266.914	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.A.2 - Manure Management	NA	60.855	5.278	NA	NA	NA	NA	NA	NA	NA	NE	NA
3.B - Land	319970.583	NA	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.B.1 - Forest land	319970.583	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.B.2 - Cropland	NE	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.B.3 - Grassland	NE	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO

Categories	Emissions (Gg)			Emissions CO_2 Equivalents (Gg)				Emissions (Gg)				
	Net CO_2 (1)(2)	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors (3)	Other halogenated gases without CO_2 equivalent conversion factors (4)	NO_X	CO	NMVOCs	SO_2
3.B.4 - Wetlands	NO	NA	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.B.5 - Settlements	NE	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.B.6 - Other Land	NE	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.C - Aggregate sources and non-CO_2 emissions sources on land	NE	342.051	81.760	NA	NA	NA	NA	NA	0.203	6.296	NA	NA
3.C.1 - Emissions from biomass burning	NA	0.191	0.007	NA	NA	NA	NA	NA	0.203	6.296	NA	NA
3.C.2 - Liming	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C.3 - Urea application	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C.4 - Direct N_2O Emissions from managed soils	NA	NA	60.714	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C.5 - Indirect N_2O Emissions from managed soils	NA	NA	19.831	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C.6 - Indirect N_2O Emissions from manure management	NA	NA	1.208	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C.7 - Rice cultivations	NA	341.860	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C.8 - Other (please specify)	NA	NO	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D - Other	-4542.625	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.D.1 - Harvested Wood Products	-4542.625	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.2 - Other (please specify)	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
4 - Waste	115.080	877.715	23.267	NA	NA	NA	NA	NA	23.585	414.079	33.603	0.816
4.A - Solid Waste Disposal	NA	281.940	NO	NA	NA	NA	NA	NA	NO	NO	24.481	NA
4.B - Biological Treatment of Solid Waste	NA	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NA
4.C - Incineration and Open Burning of Waste	115.080	48.209	0.634	NA	NA	NA	NA	NA	23.585	414.079	9.123	0.816
4.D - Wastewater Treatment and Discharge	NA	547.565	22.633	NA	NA	NA	NA	NA	NO	NO	5.400E-05	NA
4.E - Other (please specify)	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
5 - Other	NO	NO	NE	NO	NO	NO	NO	NO	NO	NO	NO	NO
5.A - Indirect N_2O emissions from the atmospheric deposition of nitrogen in NO_X and NH_3	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.B - Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo Items (5)												
International Bunkers	1246.484	0.015	0.035	NA	NA	NA	NA	NA	6.552	0.576	0.247	0.821
1.A.3.a.i - International Aviation (International Bunkers) (1)	1176.440	0.008	0.033	NA	NA	NA	NA	NA	4.776	0.410	0.187	0.373
1.A.3.d.i - International water-borne navigation (International bunkers) (1)	70.044	0.006	0.002	NA	NA	NA	NA	NA	1.776	0.166	0.061	0.448
1.A.5.c - Multilateral Operations (1)(2)	NE	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

4. Energy

4.1. Description of the Energy sector

The process of fuel combustion to generate heat used directly or to produce energy to drive mechanical and electrical systems releases the direct GHGs CO_2, CH_4 and N_2O, the GHG precursors CO, NO_x and NMVOCs, water and SO_2. Extraction of hydrocarbons such as coal, oil and gas also releases the same direct GHGs, the precursors, water and SO_2.

The activities within the Energy sector, leading to these emissions occur in the different segments of activities. Emissions are associated with energy production, processing for converting primary fuels into secondary fuels, transportation and storage as well as end products utilization. Fuel combustion activities is one of such end products utilization and involves both primary and secondary fuels. Upstream to these are extraction, refining, transportation and storage of primary and secondary hydrocarbons. The activities responsible for emissions are:

- Upstream exploration and exploitation of primary energy sources:
  - Emissions from exploration, mining and all related activities supporting the extraction processes, products storage and transportation.
  - Fugitive emissions resulting from processes such as flaring, venting and leakage from connecting and storage modules of crude oil and natural gas handling.
  - Fugitive emissions of methane during coal mining.
- Transformation of primary energy sources into more usable energy forms in refineries and power plants:
  - Emissions from flaring, cracking of crude oil into component fractions and any fuel combustion to support these activities. It also involves fuel combustions in power plants for steam, heat for use in electricity generation.
- Transmission and distribution of fuels:
  - Fuel combustion to generate electrical power for pipelines.
  - Fuel combustion in transport trucks / vessels.
  - Fugitive emissions during transmission and distribution.
- Use of fuels in stationary and mobile applications:
  - Fuel combustion in the transport sector.
  - On-site power generation plants.
  - Industrial use for heat generation and to power equipment.

Nigeria is a producer and exporter of crude oil, petroleum products and natural gas and produces coal for domestic use. Whenever local production cannot meet local demand, the country resort to importation to bridge the gap between demand and supply. The main secondary sources of liquid, biomass and gaseous fuels are diesel, gasoline, Liquefied Petroleum Gas (LPG), kerosene, Automotive Gas Oil (AGO) / Diesel, Aviation Turbine Kerosene (ATK), fuel wood, charcoal, bagasse, vegetal wastes, natural gas and household kerosene (HHK) amongst others. Natural gas is utilized for public power generation with diesel and Fuel Oil (FO) as back-up fuels as well as in industries for heat and own-use power generation. Transport fuels include gasoline and AGO / Diesel for road transportation, inland water navigation and railway, ATK for civil aviation and FO for international water navigation. Fuels consumed in the Commercial / Institutional and Residential sectors include HHK for cooking and lighting, LPG for cooking, gasoline and AGO / Diesel for auto-generation of electricity and biomass fuels (fuel wood and charcoal).

Table 4.1 presents the total and share of primary and secondary fuels consumed in the country for the period 2000 to 2017.

Table 4.1 - Total and share of Fuels consumed in Nigeria (2000 – 2017)

Year	Total (PJ)	Solid Fossil Fuel (%)	Liquid Fossil Fuel (%)	Gas (%)	Biomass (%)
2000	2578.4	0.02	12.33	6.39	81.27
2001	2797.1	0.08	15.84	8.02	76.06
2002	2893.6	0.14	15.05	10.14	74.67
2003	3020.4	0.06	17.46	9.68	72.80
2004	3083.9	0.04	13.96	13.44	72.55
2005	3402.8	0.05	13.90	19.06	67.00
2006	3450.6	0.01	11.36	21.32	67.31
2007	3652.9	0.02	10.54	23.81	65.63
2008	3801.8	0.03	11.79	24.64	63.54
2009	3689.9	0.03	11.26	22.47	66.24
2010	3871.1	0.03	9.88	25.39	64.71
2011	4001.3	0.02	9.98	25.81	64.19
2012	4145.3	0.03	9.36	26.79	63.82
2013	4330.7	0.03	17.76	20.87	61.34
2014	4583.0	0.03	18.29	23.74	57.94
2015	4808.0	0.03	15.45	28.33	56.19
2016	4690.6	0.03	16.65	24.84	58.47
2017	4865.3	0.03	16.74	25.59	57.64

4.2. Methodology

Emission estimates were computed using the 2006 IPCC Guidelines for National GHG Inventories (IPCC, 2007) for fossil fuel combustion activities and for fugitive emissions. The IPCC Tier 1 Reference and Sectoral approaches were adopted as per the decision trees provided in Figures 2.1 to 2.4 of the guidelines (Vol 2 Energy, Chapter 1, page 1.7).

The Reference Approach (RA) is a Top-Down method which estimates net GHG emissions from combustion of primary and secondary fuels supplied to the economy while the Sectoral Approach (SA) is a Bottom-up method for a more accurate estimation of GHG emissions occurring in each source category from both fuel combustion and fugitive processes.

4.3. The Reference Approach (RA)

4.3.1 Method

The RA, which is a component in the recommended QA / QC procedures, was used to validate the Sectoral approach for the energy sector and involved the following steps:

- Estimation of apparent consumption of fuels by type in the country for the inventory years (2000 to 2016)
- Conversion of fuel amounts to energy units (TJ)
- Computation of total carbon by multiplying apparent consumption by the respective carbon content of each fuel type

- Subtraction of stored carbon (excluded carbon) from fuel carbon
- Conversion of carbon burned to CO_2 emissions

The RA for estimating CO_2 emissions for combustion processes is expressed as follows:

$$CO_2\ Emissions = \sum_{all\ fuels} \left[\begin{array}{l} ((Apparent\ Consumption_{fuel} \bullet Conv\ Factor_{fuel} \bullet CC_{fuel}) \bullet 10^{-3} \\ - Excluded\ Carbon_{fuel}) \bullet COF_{fuel} \bullet 44/12 \end{array} \right]$$

Where:

Apparent Consumption =	production + imports - exports - international bunkers - stock change
Conversion Factor =	factor to convert fuel to energy units (TJ) on net calorific value basis
CC =	Carbon content of fuel (tonne C / TJ)
Excluded Carbon =	carbon in feed stocks and non-energy use excluded from fuel combustion emissions (Gg C)
Carbon oxidation factor (COF) =	fraction of carbon oxidized. For this inventory, the factor is 1, assuming complete oxidation
44 / 22 =	molecular weight ratio of CO_2 to C

4.3.2 Activity data

Estimation of apparent consumption of fuels for the RA requires a supply balance of primary and secondary fuels. That is primary and secondary fuels production, imports, exports, international bunkers, changes in fuels stocks as well as fuels used for non-energy purposes. The AD for computing apparent consumption of primary and secondary fuels (Tables 4.2 and 4.3) were obtained primarily from three sources of energy statistics: the NNPC Annual Statistical Bulletin for the full time series 2000 to 2017, the DPR Annual Statistical Bulletin for 2013 to 2017, and the UN database. Data gaps were filled by interpolations and extrapolations to ensure time-series completeness in accordance with the Good Practice Guidance and Uncertainty Management (IPCC, 2000). The AD for calculating fugitive emissions from Oil and Gas processes by the sectoral approach were also derived from Tables 4.2 and 4.3 when needed. Only activities occurring for each fuel type are presented.

Table 4.2 - Flow of Primary and Secondary Liquid Fuels into the Economy

Fuel / Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Crude Oil (000 bbls)																		
Production	823031	863745	725860	844100	910157	918661	869197	803001	768746	780348	896043	867476	852777	800488	798542	773459	669998	689743.5
Imports																		
Exports	714356	780094	663327	791016	878077	844152	817996	791827	724480	769195	864702	822084	830772	762045	796654	780430	645435	659983.2
Deliveries to Local Refineries	36189	82579	78161	42755	40529	72478	42472	18191	45533	19393	33634	40406	33595	36193	25839	9871	32721	33960.3
Crude Processed	36283	81512	79579	44812	38027	70637	43445	19060	39265	17746	34872	39408	33629	35233	23360	7992	22503	29477.8
Stock Change	72392	2139	-17046	8272	-5948	3872	7755	-7886	5002	-6593	-3530	5983	-11624	3210	-21473	-14963	2059	282.5
LPG (000 t)																		
Deliveries from local refineries (Production)	6	69	81	26	2	6	0	0	46	41	76	120	19	28	22	7	37	84.8
Input from NLNG (Production)	0	0	0	0	0	0	0	41	41	57	107	100	120	136	132	141	250	583.4
Imports	9	0	94	0	170	0	0	0	0	14	18	23	7	39	82	163	48	0
Exports	0	6	17	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International Bunkers																		
Local Consumption	49	43	50	50	58	36	50	60	70	90	110	120	140	162	192	304	390	420
Stock Change	-34	20	108	-27	114	-30	-50	-19	17	22	91	123	6	41	44	7	-55	248.2
PMS (000 t)																		
Deliveries from local refineries (Production)	2134	3013	3230	2460	534	2449	1553	971	1339	911	1249	1206	1413	1214	956	716	737	744.6
Imports	5737	5661	6079	7717	8316	8450	8768	9598	8906	10869	10558	10347	11855	11905	13473	14154	14272	12460.8
Exports	0	0	15	10	10	0	5	0	0	0	0	0	0	0	0	0	0	0
Local Consumption	3524	5287	6431	6459	6073	6398	6149	6558	7032	7036	4703	4211	3714	11765	12879	11765	12886	12831
Stock Change	4346	3386	2863	3709	2767	4500	4167	4011	3212	4744	7105	7342	9554	1354	1550	3105	2124	374

Fuel / Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Household Kerosene (000 t)																		
Deliveries from local refineries (Production)	941	1621	1526	935	630	1272	879	335	675	375	659	733	574	741	500	204	401	502
Imports	1208	522	476	721	515	784	1302	1486	1085	1375	1845	1643	2502	2970	3145	2145	589	265
Exports	0	0	15	2	2	10	8	5	10	0	0	0	0	0	0	0	0	0
International Bunkers																		
Local Consumption	886	1656	155	1113	1133	1127	752	434	795	573	543	731	512	2162	2341	2162	746	1157
Stock Change	1264	487	1832	540	9	919	1421	1382	955	1176	1961	1645	2563	1549	1305	188	244	-390
AGO / Diesel (000 t)																		
Deliveries from local refineries (Production)	1283	2580	2484	1526	1179	2116	1170	590	1222	516	970	1044	817	1032	629	243	702	825
Imports	2277	544	575	1731	2414	865	1052	1280	1557	1894	2304	1663	1775	2199	6410	3768	3828	3652
Exports		42	14	20	0	30	0	11	0	0	0	0	0	0	0	0	0	0
International Bunkers	119	2	0	0	0	13	123	0	109	7	17	71	10	0	0	0	0	0
Local Consumption	2211	2289	2402	2286	1646	2035	1417	1190	1304	971	756	840	581	2432	2766	2432	3352	3357
Stock Change	1231	790	642	951	1947	902	682	669	1366	1431	2502	1796	2000	799	4273	1579	1178	1120
Fuel Oil (000 t)																		
Deliveries from local refineries (Production)	1248	2691	2593	1822	1848	2769	2165	966	1442	625	924	1281	810	1243	774	150	421	715
Imports	0	1	1	2	3	6	12	23	44	84	171	104	88	15	153	64	297	30
Exports	1146	2127	2127	118	879	2060	1870	1245	759	307	498	687	332	721	303	84	154	511
International Bunkers	67	13	0	0	0	0	0	0	0	3344	9	3	6	0	260	0	0	218
Local Consumption	238	232	252	1689	558	289	156	121	483	367	248	291	378	467	577	53	93	453
Stock Change	-202	320	215	17	414	426	151	-377	244	-3310	340	404	182	70	-212	77	471	-437
ATK (000 t)																		

Fuel / Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Deliveries from local refineries (Production)																		
Imports	208	225	244	263	496	308	333	360	389	420	454	479	525	413	344	441	539	517
Exports																		
International Bunkers																		
Local Consumption	149	255	278	321	72	228	230	278	851	645	166	185	44	346	309	346	433	410
Stock Change	60	-29	-34	-58	424	80	102	81	-462	-225	288	294	481	67	36	95	106	106
Returns of Other Products from Local Refineries																		
LRS (000 t)	232	485	354	155	0	-1	0	0	0	0	1	0	0	0	0	12	0	0
Asphalt (000 t)	0	0	0	3	0	42	0	0	22	0	11	33	0	5	0	0	7	16
VGO (000 t)	0	0	0	0	0	19	-1	11	9	2	55	56	47	2	17	80	-11	0
Kero solvent (000 t)	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	5	0
Interm. Products(000t)	125	109	59	249	0	510	130	220	408	200	937	780	375	559	248	298	475	496

Table 4.3 - Natural Gas Accounting Data (MMscm) (2000 – 2017)

Year	Production	Gas Flared	% Flared	Gas Utilized	Re-injection	Gas for Field Use	Gas for LNG	Gas for NGL	Gas Lift	Fuel Gas for EPCL	Domestic Sales
2000	45,282.3	24,999.8	55.2	20,282.5	8488.6	2,220.6	7,168.4	653.1	609.9	203.1	1,886.4
2001	51,644.2	26,080.2	50.5	25,564.1	9483.0	2663.2	8,286.7	1,214.2	740.4	259.4	2,917.3
2002	46,773.1	21,073.1	45.1	25,699.9	7657.8	2036.1	8,214.1	1,351.5	485.7	259.4	5,420.9
2003	51,784.3	23,959.1	46.3	27,825.2	5,302.8	1875.8	13,122.9	1,020.8	550.1	256.0	5,726.1
2004	58,970.3	25,106.8	42.6	33,863.4	9425.1	2,025.8	11,615.9	1,333.9	336.5	282.6	8,843.5
2005	59,291.6	23,005.3	38.8	36,286.3	11,264.1	2,382.8	5,304.0	1,312.3	854.6	292.8	14,904.8
2006	61,806.5	22,656.0	36.7	39,150.5	9,450.0	2,174.9	6,822.7	1,257.7	1,286.8	224.5	17,830.2
2007	68,411.2	22,360.0	32.7	46,051.2	10,042.6	2,167.2	10,439.5	990.7	1,445.8	266.7	21,544.4
2008	64,638.7	17,875.3	27.7	46,763.5	11,075.3	2,277.0	9,390.0	657.7	1,658.4	216.4	23,296.4
2009	52,031.7	14,424.9	27.7	37,606.9	11,606.9	2,281.9	7,620.8	1,200.8	1,584.7	229.0	13,082.8
2010	67,765.2	16,470.0	24.3	51,295.2	13,970.5	2,045.7	4,734.8	732.6	4,787.7	147.4	24,876.5
2011	67,979.4	17,531.0	25.8	50,448.4	9,864.7	2,960.6	8,866.6	1,093.4	2,236.4	267.2	25,159.4
2012	73,070.3	16,671.0	22.8	56,399.3	13,108.7	3,276.0	9,341.7	1,336.3	2,064.7	435.2	26,836.7
2013	65,847.9	11,591.7	17.6	54,256.2	18,082.5	3,639.8	8,520.9	1,588.1	1,328.2	261.1	20,855.7
2014	71,487.3	8,201.5	11.5	63,285.8	18,232.6	4,371.8	11,083.6	1,098.7	2,961.6	311.7	25,225.8
2015	82,973.4	9,667.7	11.7	73,305.8	20,601.5	4,508.3	11,928.2	1,187.0	2,182.6	308.9	32,589.2
2016	78,667.1	8,848.5	11.3	69,818.5	21,176.1	4,175.5	28,544.1	2,569.5	-	1,131.6	12,221.6
2017	82,174.2	10,130.2	12.3	720,44.1	21,412.0	3,949.0	31,708.5	1,294.0	-	1,731.1	11,949.5

4.4. The Sectoral Approach (SA)

4.4.1. Methods

The equations used for the estimation of GHGs under the Tier 1 level, assuming 100% combustion of carbon, for all categories are:

Stationary combustion

$$\text{Emissions}_{GHG,fuel} = \text{Fuel Combustion}_{fuel} * \text{Emission Factor}_{GHG,fuel}$$

where:

Emissions GHG,fuel = emissions of a given GHG by type of fuel (kg GHG)
Fuel Combustion fuel = amount of fuel combusted (TJ)
Emission Factor GHG,fuel = emission factor of a given GHG by type of fuel (kg gas / TJ).

Mobile combustion

$$\text{Emission} = \sum [\text{Fuel}_a * \text{EF}_a]$$

where:

Emissions = emission in kg
EF_a = emission factor kg / TJ
$Fuel_a$ = fuel consumed, (TJ) (as represented by fuel sold)
A = fuel type a (e.g., diesel, ATK, Gasoline, AGO etc.)

Fugitive emissions - Oil & Gas sector

$$E_{gas\,/\,oil,\ industry\ segment} = AD_{industry\ segment} * EF_{gas\,/\,oil,\ industry\ segment}$$

where:

E gas / oil, industry segment = Annual Emissions (Gg)
EF gas / oil, industry segment = emission factor (Gg / unit of activity)
AD industry segment = activity value (units of activity)

4.4.2. Activity data

The AD for the energy sector inventory includes data on energy production, processing (primary and secondary processing), transmission / transportation, and consumption. During the inventory, considerable attention was paid to data - from both national and international sources-, data preparation and documentation. Priority was given to using data sourced directly or estimated from available national sources covering the period 2000 to 2017. Existing gaps were filled either by sourcing for additional data from other public sources recommended by IPCC or by appropriate statistical methods which are provided under the respective categories.

The existing datasets used for compiling the inventory of the BUR1 and NC3 were adopted for the period 2000 to 2015. Data of 2016 were revised for some categories since those used in the NC3 were not the final sets. The main data sources for 2016 and 2017 were the Annual Statistical Bulletins of NNPC, the Annual Reports of the Department of Petroleum Resources (DPR), the United Nations Database and the Organization of Petroleum Exporting Countries (OPEC) Annual Statistical Bulletins.

Patterns of energy consumption by sector and category as appropriate reported in BUR1 and NC3 were maintained. The patterns were obtained primarily from the Energy Commission of Nigeria (ECN) and the missing ones were adopted from other studies and reports, some of which were from national projects.

4.4.2.1. Sectoral Fuel Consumption Activity Data

Energy Industries (1.A.1)

Electricity Generation (1.A.1.a.i)

Emissions in the energy industries category result from fuel combustion in the following:

- Public electricity generation plants,
- Electricity and heat generation in the local petroleum refineries,
- Manufacture of solid fuels (including transformation of fuel wood to charcoal) and
- Fuel consumption in other energy industries such as natural gas for field use in the Upstream Oil and Gas Sector.

Emissions from public electricity generating stations in the country result from the combustion of natural gas in Steam Turbines, Single Cycle Gas Turbines and Combined Cycle Gas Turbine plants. The AD for activities in this category is provided in Table 4.4. Substantial gaps exist in the database of consumption of these fuels in the power sector. The database for Natural gas consumption in the power sector is very weak. However, existing data from NNPC Annual Statistical Bulletin (ASB) showed that about 66% of Natural gas sold for domestic use was used for grid power generation while the balance was sold to industries for heat and own-use power generation. This percentage was used to compute the share of natural gas for years with incomplete data.

Table 4.4 - Consumption of Natural Gas in Public Electricity Generation Facilities[1]

Year	Million SCM	TJ
2000	1,245.04	44,821.32
2001	1,925.41	69,314.67
2002	3,577.76	128,799.28
2003	3,779.21	136,051.57
2004	5,836.73	210,122.39
2005	9,837.16	354,137.76
2006	11,767.92	423,645.15
2007	14,219.28	511,894.12
2008	15,375.60	553,521.64
2009	15,897.06	572,293.94
2010	16,418.51	591,066.24
2011	16,605.23	597,788.21
2012	17,712.24	637,640.75
2013	13,764.73	495,530.14

[1]NNPC Annual Statistical Bulletin (2000-2017)
UNdata: Nigeria datamart (EDATA) 2000-2014, retrieved from
http://data.un.org/Data.aspx?q=Nigeria+datamart%5bEDATA%5d&d=EDATA&f=cmID%3aRF%3bcrID%3a566
http://data.un.org/Data.aspx?q=Nigeria+datamart%5bEDATA%5d&d=EDATA&f=cmID%3aDL%3bcrID%3a566
Energy Commission of Nigeria: Study for the Development of Energy Balance for Nigeria, 2009.
Energy Commission of Nigeria: National Energy Balance 2012-2013, February 2016.

Year	Million SCM	TJ
2014	16,649.05	599,365.89
2015	21,508.84	774,318.15
2016	22,315.55	803,360.00
2017	23,572.39	848,606.00

AD for fuel consumption for electricity and heat generation in upstream and downstream segments of the Oil and Gas Industry, abstracted directly from the NNPC Annual Statistics Abstract for the period 2000 to 2017 is given in Table 4.5.

Table 4.5 - Fuel Consumption for Electricity and Heat Generation in the Oil and Gas Industry[2]

Year	Refinery Fuel Use, Gg					Upstream Fuel Use (Natural Gas)	
	AGO / Diesel	RFO	LPG	Petroleum Coke	Refinery Gas	Million scm	TJ
2000	63.5	217.8	22.2	10.5	125.2	2,220.6	79,941.5
2001	79.9	350.0	33.7	66.1	213.5	2,663.2	95,874.4
2002	88.3	336.0	31.0	89.6	238.7	2,036.1	73,299.0
2003	26.7	261.7	10.2	36.3	135.2	1,875.8	67,527.4
2004	16.4	144.0	5.7	34.3	201.4	2,025.8	72,930.4
2005	18.6	438.5	22.2	42.5	258.0	2,382.8	85,780.4
2006	21.9	226.2	3.3	4.9	100.0	2,174.9	78,296.5
2007	26.7	136.6	2.3	0.1	76.1	2,167.2	78,017.8
2008	29.5	256.2	34.9	6.6	69.4	2,277.0	81,972.5
2009	11.2	160.8	4.7	6.2	35.4	2,281.9	82,146.7
2010	26.9	289.1	11.8	2.8	49.9	2,045.7	73,643.9
2011	45.8	298.3	22.0	1.0	79.3	2,960.6	106,581.9
2012	20.0	317.0	19.0	1.1	65.1	3,276.0	117,935.1
2013	43.9	326.3	33.0	2.1	72.0	3,639.8	131,032.3
2014	24.7	225.9	11.2	9.6	33.9	4,371.8	157,384.0
2015	13.9	122.6	6.9	7.9	16.1	4,508.3	162,298.4
2016	26.7	227.0	19.9	9.5	36.1	4,175.5	150,319.1
2017	35.0	300.0	26.0	12.0	48.0	3,949.0	142,164.0

Energy consumption AD for the manufacture of solid fuels, namely fuel wood for charcoal manufacturing obtained from FAOSTAT (2000 to 2017) which are estimated for most years of the time series, are presented in Table 4.6.

Table 4.6 - Fuel Wood used for Solid Fuel (Charcoal) Manufacture (10^3 mt) (2000 – 2017)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
Fuel Wood	15,565.4	15,940.4	16,328.1	16,798.0	17,314.5	17,813.0	18,318.3	18,836.4	18,933.2

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
Fuel Wood	19,689.9	20,142.3	20,744.9	21,197.7	21,752.7	22,110.9	22,712.7	23,194.3	23,731.3

Manufacturing Industries and Construction (1.A.2)

The Manufacturing Industries and Construction category consumed fuels for electricity generation and heat production for own use in their plants. Available data from the ECN National Energy Balance Studies

[2]NNPC Annual Statistical Bulletin (2000-2016)

(2000 to 2008; 2012 to 2013) and the IEA database (2000 to 2014) indicate that AGO / Diesel used for energy generation in the Manufacturing Industries and Construction category out of the domestic consumption was about 3.1% for the years 2000 to 2005 and about 3.7% for the period 2006 to 2014, while the entire domestic consumption of RFO was for energy generation in the manufacturing sector. Data for 2015 to 2017 were sources from the Annual Statistical Bulletins of NNPC, the Annual Reports of the Department of Petroleum Resources (DPR), the United Nations Database and the Organization of Petroleum Exporting Countries (OPEC) Annual Statistical Bulletins. About 1% of this fraction is used for own-use electricity generation and the balance for industrial steam production. Data for Natural gas used in the Manufacturing and Construction Industries category was obtained by adding values from the NNPC Annual Statistical Abstracts (2000 to 2017)[3] for natural gas fuel sent to the Eleme Petrochemicals Company Limited (EPCL) to values for natural gas sent to the manufacturing sector for own-use electricity generation from the IEA database (2000 to 2017). Data for consumption of coal and other traditional fuels were obtained from ECN and IEA. AD for all fuels consumed in this category are given in Table 4.7.

Table 4.7 - Fuel consumption (Gg) by type in the Manufacturing Industries and Construction category

Year	AGO / Diesel	RFO	LPG	Wood / Wood Waste	Charcoal	Bagasse	Coal	Natural Gas (Dry)	
								MMscm	TJ
2000	68.0	237.5	2.4	5,639.5	15.3	117.0	3.0	844.4	30,399.7
2001	70.4	231.7	2.2	6,178.6	16.4	22.0	3.0	1,251.3	45,046.2
2002	73.9	252.0	2.5	6,784.0	17.2	22.0	43.0	2,102.5	75,689.8
2003	70.3	1689.1	2.5	7,393.0	15.8	0.0	23.0	2,202.8	79,301.5
2004	50.7	557.6	2.9	8,128.3	16.4	0.0	8.0	3,289.4	118,419.2
2005	62.6	289.0	1.8	8,860.1	18.5	0.0	8.0	5,360.5	192,976.1
2006	52.4	156.0	2.5	9,634.3	16.7	98.0	8.0	6,286.7	226,322.4
2007	44.0	120.8	3.0	10,500.7	17.0	179.0	23.0	7,591.8	273,304.5
2008	48.2	482.8	3.5	11,631.8	16.1	68.0	32.0	8,137.1	292,937.0
2009	35.9	367.3	4.5	12,561.8	18.0	122.0	34.0	4,677.2	168,378.0
2010	28.0	248.1	5.5	13,408.8	17.3	98.0	38.0	8,605.4	309,794.7
2011	31.1	290.8	6.0	14,423.4	17.9	98.0	32.0	8,821.4	317,570.4
2012	21.5	378.0	7.0	15,158.7	18.0	35.0	48.0	9,559.7	344,148.9
2013	90.0	466.9	8.1	14,466.0	18.6	35.0	44.0	7,352.0	264,673.5
2014	102.3	576.6	9.6	8,739.5	18.4	20.0	46.0	8,888.5	319,985.1
2015	90.0	52.5	15.2	8,799.4	18.9	48.9	48.1	11,389.2	410,012.5
2016	124.0	93.2	19.5	8,839.3	19.3	50.3	50.3	5,286.9	190,328.9
2017	124.2	453.0	21.0	8,880.7	19.8	65.7	46.0	6,323.7	227,651.7

Transport (1.A.3)

In Nigeria, the transport category comprises civil aviation (domestic and international), road transportation, water-borne navigation (domestic and international) and railway. There are no formal national statistics on the fuel consumption pattern in these transport sub-categories. For this inventory, estimates of the fuel consumption pattern in these sub-categories were made from data on national fuel consumption by type reported in the NNPC Annual Statistical Bulletins for the years 2000 to 2017, and supported with results of studies carried out by the ECN for the National Energy Balance[4] as well as

[3]NNPC Annual Statistical Bulletin (2000-2017)
[4]Energy Commission of Nigeria: National Energy Balance 2012-2013, February 2016

analyses done by the World Bank[5] on fuel consumption in the Nigerian transport sector (2013). The assumptions are:

- 77% of total Prime Motor Spirit (PMS) consumed in the country is used in the transport sector of which 4.2% and 95.8% are allocated to the domestic water navigation and road transport sub-categories respectively.
- 75.3%, 8%, 16.3% and 0.4% of the total PMS used for road transport are used in passenger cars, motorcycles, Light-Duty Trucks / buses and Heavy Duty-Trucks / buses respectively.
- 1.7%, 0.7% and 64.9% of national AGO / Diesel consumption are used for domestic water navigation, rail and other road transport respectively.
- 91% of total ATK supply is consumed in international aviation activities and the balance for domestic aviation.
- The same amount of 22.4 Gg of RFO has been adopted for international marine bunkering for the whole time series until better AD become available.

The AD used in the computation of emissions for the transport sector by subcategory and fuel type is provided in Table 4.8.

Other Sectors (1.A.4) – Commercial / Institutional, Residential and Agriculture / Forestry / Fisheries (CRAFF)

Data for fuel consumption in the commercial, residential and agriculture sectors, obtained from ECN, IEA and UN databases, are presented in Table 4.9. Data gaps were filled by using extrapolation and interpolation methods. In the commercial and residential sectors, PMS and AGO / diesel are consumed for auto-generation of electricity while LPG, fuel wood, vegetal wastes and charcoal are used for cooking and heating. Existing data from ECN and IEA show that 70% of total national LPG consumption was in the residential sector while about 9% was used in the commercial / services sector and the balance was for non-specified industrial use.

In the Agriculture / Forestry / Fisheries sector, about 0.4% of total national diesel consumption is utilized in off-road vehicles such as tractors and other agricultural implements. About 0.6% of total national consumption is used in the Agriculture sector for heating purposes and other non-specified uses.

[5] R. Cervigni, J. A Rogers, & I. Dvorak, (Editors). A WORLD BANK STUDY: Assessing Low-Carbon Development in Nigeria, pp 352-355.http://dx.doi.org/10.1596/978-0-8213-9973-6, Retrieved February 10th, 2017.

Table 4.8 - Fuel Consumption (Gg) by type in the Transport Sector (2000 – 2017)

Year	Civil Aviation		Road Transport							Water-borne Navigation			Rail
	ATK		PMS / Motor Gasoline				AGO / Diesel			AGO / Diesel	PMS	RFO	AGO / Diesel
	International Aviation Bunkers	Domestic Aviation	Cars	LD Trucks	HD Trucks & Buses	Motorcycles	Cars	HD Trucks & Buses	LD Trucks	Domestic Water Navigation		IMB	
2000	135.47	13.40	1,957.50	423.73	10.40	207.97	61.55	1,399.23	590.88	38.40	113.97	22.40	35.11
2001	231.57	22.90	2,936.70	635.70	15.60	312.00	63.73	1,448.84	611.83	39.76	170.98	22.40	36.35
2002	252.53	24.98	3,571.87	773.19	18.97	379.48	66.88	1,520.38	642.04	41.73	207.96	22.40	38.15
2003	291.88	28.87	3,587.63	776.61	19.06	381.16	63.65	1,446.90	611.01	39.71	208.88	22.40	36.30
2004	249.66	24.69	3,373.48	730.25	17.92	358.40	45.83	1,041.82	439.95	28.59	196.41	22.40	26.14
2005	207.44	20.52	3,554.05	769.34	18.88	377.59	56.64	1,287.66	543.76	35.34	206.92	22.40	32.31
2006	209.43	20.71	3,415.38	739.32	18.14	362.86	27.60	6,27.33	264.91	24.09	198.85	22.40	9.92
2007	253.09	25.03	3,642.67	788.52	19.35	387.00	23.17	526.64	222.39	20.23	212.08	22.40	8.33
2008	297.57	29.43	3,906.04	845.53	20.75	414.98	25.38	577.05	243.68	22.16	227.42	22.40	9.13
2009	304.93	30.16	3,908.19	846.00	20.76	415.21	18.91	429.86	181.52	16.51	227.54	22.40	6.80
2010	151.46	14.98	4,469.52	565.46	13.88	277.53	14.71	334.38	141.21	12.84	260.22	22.40	5.29
2011	168.75	16.69	4,696.94	506.27	12.42	248.48	16.36	371.85	157.03	14.28	273.46	22.40	5.88
2012	241.86	23.92	4,924.36	446.56	10.96	219.17	11.32	257.33	108.67	27.81	286.70	22.40	4.07
2013	314.96	31.15	6,534.95	1414.60	34.71	694.28	47.35	1,076.41	454.56	41.34	380.48	22.40	17.02
2014	280.79	27.77	7,153.72	1548.55	38.00	760.02	53.85	1,224.11	516.92	47.02	416.51	22.40	19.36
2015	314.96	31.15	6,534.95	1414.60	34.71	694.28	47.35	1,076.41	454.56	41.34	380.48	22.40	17.02
2016	393.66	38.93	7,157.34	1549.33	38.02	760.41	65.27	1,483.83	626.60	56.99	416.72	22.40	23.47
2017	373.10	36.90	7,127.07	1542.78	37.86	757.19	65.36	1,485.87	627.46	57.10	414.95	22.40	23.50

Table 4.9 - Commercial / Institutional, Residential and Agriculture / Forestry / Fishing (CRAFF) Sectors Fuel Consumption ('000 mt) (2000 – 2017)

Year	Commercial / Institutional Sector						Residential Sector					Agriculture / Forestry / Fish farms	
	AGO / Diesel	LPG	Wood / Wood Waste	Charcoal	PMS	HHK	AGO / Diesel	LPG	Wood / Wood Waste	Charcoal	Vegetal wastes	AGO	HHK
2000	5.5	5.3	3,791.0	475.4	810.6	865.2	3.3	40.8	76,031.6	2,622.3	36,734.3	8.8	5.3
2001	5.7	4.7	3,493.1	463.8	1,216.0	1,617.8	3.4	36.1	76,292.8	2,707.9	38,226.5	9.1	9.9
2002	6.0	5.5	3,023.7	480.9	1,479.0	151.7	3.6	42.0	76,684.9	2,767.5	39,660.8	9.5	0.9
2003	5.7	5.5	2,898.1	451.1	1,485.5	1,087.4	3.4	42.0	76,755.8	2,892.7	41,362.8	9.1	6.7
2004	4.1	6.4	2,214.8	533.0	1,396.9	1,106.8	2.5	48.7	77,284.4	2,913.4	42,953.3	6.5	6.8
2005	5.1	4.0	1,946.1	545.9	1,471.6	1,101.3	3.0	30.2	77,428.7	2,998.2	44,859.0	8.1	6.8
2006	292.0	5.5	1,676.3	568.1	1,414.2	734.7	113.4	42.0	77,435.6	3,078.9	46,822.3	5.7	4.5
2007	245.1	6.6	1,760.8	585.5	1,508.3	424.3	95.2	50.4	77,018.5	3,164.8	51,508.5	4.8	2.6
2008	268.6	7.7	1,603.8	598.9	1,617.4	776.6	104.3	58.8	76,604.0	3,171.7	52,270.3	5.2	4.8
2009	200.1	9.9	1,773.7	625.5	1,618.3	559.6	77.7	75.6	76,086.7	3,294.4	52,486.0	3.9	3.4
2010	155.6	12.1	2,656.0	653.0	1,081.7	530.2	60.4	92.4	74,964.4	3,358.2	56,091.5	3.0	3.3
2011	173.1	13.2	2,968.1	684.9	968.4	714.3	67.2	100.8	74,191.9	3,446.2	59,696.3	3.4	4.4
2012	119.8	15.4	5,140.0	707.1	854.2	500.4	46.5	117.6	71,860.0	3,514.4	64,801.5	2.3	3.1
2013	501.0	17.8	3,993.5	721.8	2,705.9	2,112.3	194.6	136.1	74,296.0	3,610.1	63,916.0	9.7	13.0
2014	569.7	21.1	4,796.1	734.0	2,962.2	2,287.2	221.3	161.3	79,838.3	3,669.8	62,323.0	11.1	14.1
2015	501.0	33.4	4,829.0	753.9	2,705.9	2,112.3	194.6	255.4	80,385.8	3,769.7	64,322.2	9.7	13.0
2016	690.6	42.9	4,850.9	769.9	2,963.7	729.0	268.2	327.6	80,750.0	3,849.6	66,385.5	13.4	4.5
2017	691.5	46.2	4,873.6	787.8	2,951.1	1,150.2	268.6	352.8	81,129.0	3,938.8	70,114.2	13.4	6.9

Fugitive Emissions

Solid fuels (1.B.1)

AD for coal mining and handling was sourced from the UN Database for the whole timeseries.

Oil and Gas (1.B.2)

The Primary Energy data for estimating fugitive emissions for the upstream sector in Nigeria was sourced directly from DPR (2013 to 2017), NNPC (2000 to 2017)[6], and OPEC (2011 to 2017). The NNPC Annual Statistical Bulletin (ASB) was the primary source of data for the Oil and Gas industries. Where data was incomplete or inconsistent, the DPR ASB and OPEC ASB were consulted and updating made as required. These AD have already been provided in Tables 4.2 and 4.3 under the Reference Approach section.

4.4.3. Emission Factors

Default EFs for Tier 1 level from the 2006 IPCC Guidelines were used in the estimation of GHGs for the energy sector for the main gases CO_2, CH_4 and N_2O. EFs for other gases and GHG precursors not available in the 2006 IPCC Guidelines were supplemented by those from the European Monitoring and Evaluation Program / European Environment Agency (EMEP / EEA) guidebook as applicable.

Direct Gases

EFs for CO_2, CH_4 and N_2O for activity areas in the Energy Industries category is given in Table 4.10.

Table 4.10 - Emission Factors for the Energy Combustion categories

Fuel	Default Emission Factor (kg of GHG per TJ on a Net Calorific Basis)		
Gas	CO_2	CH_4	N_2O
Energy Industries			
Gas / Diesel Oil	74,100	3	0.6
Residual Fuel Oil	77,400	3	0.6
Liquefied Petroleum Gases	63,100	1	0.1
Petroleum Coke	97,500	3	0.6
Refinery Gas	57,600	1	0.1
Natural Gas	56,100	1	0.1
Wood / Wood Waste	112,000	30	4
Manufacturing Industries & Construction			
Gas / Diesel Oil	74,100	3	0.6
Residual Fuel Oil	77,400	3	0.6
Other Bituminous Coal	94,600	10	1.5
Natural Gas	56,100	1	0.1
Wood / Wood Waste	112,000	30	4
Charcoal	112,000	200	4
Civil Aviation			
Jet Kerosene	71,500	0.5	2
Road Transportation			
Motor Gasoline	69,300	33	3.2
Gas / Diesel Oil	74,100	3.9	3.9
Railway			
Gas / Diesel Oil	74,100	4.15	28.6

[6]NNPC Annual Statistical Bulletin (2000-2017)

Fuel Gas	Default Emission Factor (kg of GHG per TJ on a Net Calorific Basis)		
	CO_2	CH_4	N_2O
Water-borne Navigation			
Gasoline	69,300	7	2
Gas / Diesel Oil	74,100	7	2
Residual Fuel Oil	77,400	7	2
Commercial / Institutional Category			
Motor Gasoline	69,300	10	0.6
Gas / Diesel Oil	74,100	10	0.6
Liquefied Petroleum Gases	63,100	5	0.1
Wood / Wood Waste	112,000	300	4
Charcoal	112,000	200	1
Residential & Agriculture / Forestry / Fish Farms			
Motor Gasoline	69,300	10	0.6
Other Kerosene	71,900	10	0.6
Gas / Diesel Oil	74,100	10	0.5
Liquefied Petroleum Gases	63,100	5	0.1
Wood / Wood Waste	112,000	300	4
Other Primary Solid Biomass	100,000	300	4
Charcoal	112,000	200	1

Source : 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2 Table 2.2 Page 2.16 etc..

Table 4.11 reproduces the values recommended by IPCC (Vol 2_4_Ch4_Fugitive_Emissions) which applies to systems in developing countries and countries with economies in transition where there are greater amounts of fugitive emissions per unit of activity. Nigeria, being a developing country, the EFs from this table have been adopted for computing emissions.

Table 4.11 - Emission Factors for Fugitive Emissions by fuel type

Category	Sub-category	CO_2	CH_4	N_2O
Coal mining and handling (m^3 / tonne)				
Underground mining	Mining	NA*	18	NA
	Post mining seam gas emissions	NA	2.5	NA
Crude oil systems (Gg / 10^3 m^3)				
Venting	Oil Production	0.00215	0.01035	NA
	Oil transport / Loading of offshore production on tanker ships	ND**	ND	NA
	Oil Transport / Tanker trucks and rail cars	2.30E-06	2.50E-05	NA
Flaring	Oil Production	0.0405	2.50E-05	6.40E-07
Production and Upgrading	Oil Production	0.00249	0.0196	ND
Transport	LNG transport	ND	ND	ND
	LPG transport	0.00043	ND	2.20E-09
	Oil pipeline transport	4.90E-07	5.40E-06	ND
Refining	Oil refining	ND	2.18E-05	NA
Distribution of oil products	Refined product distribution	ND	ND	NA
Natural Gas systems (Gg / 10^6 m^3)				

Category	Sub-category	CO_2	CH_4	N_2O
Venting	transmission and storage	5.20E-06	0.000392	NA
Flaring	Gas production	0.0014	8.80E-07	2.50E-08
Production	Gas production	9.7E-05	.01219	NA
Transmission and storage	Storage	1.85E-07	4.50E-05	NA
	Transmission	1.44E-06	0.000633	NA
Distribution	Gas distribution	9.55E-05	0.0018	NA

*NA = Not available, **ND = Not determined

Indirect gases and SO_2

The IPCC guidelines (V1_8_Ch8_Reporting_Guidance) do not provide EFs for indirect GHGs such as NO_X, CO, NMVOCs and SO_X, but proposes the EMEP / EEA Guidebook (2016)[7] default Tier 1 EFs for estimating these emissions. The Guidebook remains the recommended source of methodology and information for computing emissions of indirect GHGs. The EFs used in computing emissions for this inventory are provided in Table 4.12.

Table 4.12 - EMEP / EEA[8] Default Tier 1 Emission Factors for NO_X, CO and NMVOCs (Unit GHG)

Fuel	Default Emission Factor		
	NO_X	CO	NMVOCs
Energy Industries (kg / TJ)			
Gas / Diesel Oil	65	16.2	0.8
Residual Fuel Oil	142	15.1	2.3
Liquefied Petroleum Gases	89	39	2.6
Petroleum Coke	142	15.1	2.3
Refinery Gas	63	12.1	2.6
Natural Gas	89	39	2.6
Wood / Wood Waste	81	90	7.31
Manufacturing Industries & Construction (kg / TJ)			
Gas / Diesel Oil	513	66	25
Residual Fuel Oil	513	66	25
Other Bituminous Coal	173	931	88.8
Natural Gas	74	29	23
Wood / Wood Waste	91	570	300
Charcoal	91	570	300
Aviation (kg / TJ)			
Jet Kerosene (International Aviation)	2.90E-04	2.49E-04	1.13E-05
(Civil Aviation)	2.34E-04	4.54E-05	2.27E-06
Road Transportation: Cars (g / kg fuel)			
Motor Gasoline	8.73	84.7	10.05
Gas / Diesel Oil	12.96	3.33	0.7
Road Transportation: LCV (g / kg fuel)			
Motor Gasoline	13.22	152.3	14.59
Gas / Diesel Oil	14.91	7.4	1.54
Road Transportation: HDV (g / kg fuel)			
Gas / Diesel Oil	33.37	7.58	1.92
Gasoline	13.22	152.3	14.59
Road Transportation: Motorcycles (g / kg fuel)			

[7]EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016
[8]EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016

Fuel	Default Emission Factor		
	NO_X	CO	NMVOCs
Gas / Diesel Oil Gasoline	6.64	497.7	131.4
Railway (g / kg fuel)			
Gas / Diesel Oil	52.4	10.7	4.7
Water-borne Navigation (g / kg fuel)			
Gasoline (Domestic)	9.4	573.9	181.5
Gas /Diesel Oil (Domestic)	78.5	7.4	2.8
Residual Fuel Oil (International)	79.3	7.4	2.7
Commercial / Institutional Category (kg / TJ)			
Gas / Diesel Oil	306	93	20
Liquefied Petroleum Gases	74	29	23
Wood / Wood Waste	91	570	300
Charcoal	91	570	300
Residential (kg / TJ)			
Motor Gasoline	51	57	0.69
Other Kerosene	51	57	0.69
Gas / Diesel Oil	51	57	0.69
Liquefied Petroleum Gases	51	26	1.9
Wood / Wood Waste	50	4,000	600
Other Primary Solid Biomass	50	4,000	600
Charcoal	50	4,000	600
Agriculture / forestry / fishing: stationary other (kg / TJ)			
Gas / Diesel Oil	306	93	20
Kerosene	306	93	20
Fugitive emissions from fuels			
Coal mining and handling			
Underground mining: Mining (kg / ton)	NA	NA	0.8
Underground mining: Post mining seam gas emissions (kg / ton)	NA	NA	0.8
Oil			
Venting: Oil production (Gg / 10^3 m^3) Oil transport (Gg / 10^3 m^3)	NA NA	NA NA	0.0019 0.00025
Flaring: Oil production (Gg / 10^3 m^3)	NA	NA	0.00002
Production and upgrading: Oil production	NA	NA	NA
Transport: LNG (g / m^3) LPG (g / m^3) Pipelines (kg / Mg)	NA NA NA	NA NA NA	0.10 0.10 0.20
Refining (kg / Mg)	0.24	0.09	0.20
Distribution of oil products (kg / Mg)	NA	NA	0.20
Natural Gas			
Venting: Gas transmission and storage (g / m3)	NA	NA	0.1
Flaring: Gas production (kg / Mg)	1.4	6.3	1.8
Production: Gas production (Gg / 10^6 m^3)	NA	NA	7.35E-07
Transmission and storage: Storage (Gg / 10^6 m^3) Transmission (Gg / 10^6 m^3)	 NA NA	 NA NA	 5.95E-07 1.15E-05
Distribution: Gas distribution (Gg / 10^6 m^3)	NA	NA	2.6E-05

SO_2 emissions are directly related to the sulphur content of fuels. Therefore, it is recommended that where countries have data on the sulphur content of fuels, the specific equation provided in the Guidelines should be used to calculate SO_2 emissions. Since the sulphur content of some fuels only are known and this data is not always considered reliable, the Tier 1 EFs from the EMEP / EEA guidebook provided in Table 4.13 have been used to compute emissions.

Table 4.13 - SO_2 emission factors for Nigerian fuels

Category	Fuel type	Unit	EF
Electricity generation	Natural gas	g / GJ	0.281
Petroleum refining	Diesel	g / GJ	46.500
	Residual fuel	g / GJ	495.000
	LPG	g / GJ	0.281
	Petroleum coke	g / GJ	495.000
	Refinery gas	g / GJ	0.281
Manufacture of solid fuels	Wood / wood waste	g / GJ	10.800
Other energy industries	Natural gas	g / GJ	0.281
Manufacturing	Diesel	g / GJ	47.000
	Residual fuel	g / GJ	47.000
	LPG	g / GJ	0.670
	Other bituminous coal	g / GJ	900.000
	Natural gas Dry	g / GJ	0.670
	Wood / wood waste	g / GJ	11.000
	Other primary solid fuels	g / GJ	11.000
	Charcoal	g / GJ	11.000
International aviation	Jet kerosene	kg / ton	1.000
Civil aviation	Jet kerosene	kg / ton	1.000
International marine bunkers	Residual fuel	kg / ton	20.000
Domestic navigation	Gasoline	kg / ton	20.000
	Diesel	kg / ton	20.000
Road transportation	Gasoline (2000 to 2004)	g / kg	0.130
	Gasoline (2005 to 2008)	g / kg	0.040
	Gasoline (2009 to 2017)	g / kg	0.005
	Diesel (2000 to 2004)	g / kg	0.300
	Diesel (2005 to 2008)	g / kg	0.040
	Diesel (2009 to 2017)	g / kg	0.003
Railways	Diesel	kg / ton	0.010
Other sectors			
Commercial	Diesel	g / GJ	94.000
	LPG	g / GJ	0.670
	Wood / wood waste	g / GJ	11.000
	Charcoal	g / GJ	11.000
Residential	Gasoline	g / GJ	70.000
	Other kerosene	g / GJ	70.000
	Diesel	g / GJ	70.000
	LPG	g / GJ	0.300
	Wood / wood waste	g / GJ	11.000
	Other primary solid biomass	g / GJ	11.000
	Charcoal	g / GJ	11.000
Agriculture			
Stationary	Kerosene	g / GJ	94.000
Off road vehicles	Diesel	g / GJ	94.000
Fugitive Emissions			
Oil refining	Crude oil	kg / Mg	0.620
Gas Flaring	Natural gas	kg / Mg	0.013

4.4.4. Emissions from the Energy Sector

Total aggregated emissions from the Energy sector increased from 142,678 Gg CO_2-eq in the year 2000 to 245,918 Gg CO_2-eq in 2017. Of the two main sources, emissions from Fuel Combustion Activities increased more than threefold over the time series while those originating from fugitive sources increased slightly up to the year 2010 to regress afterwards by about 10%. Fuel Combustion Activities contributed 60.8% of total emissions of the Energy sector in 2016 with the remaining 39.2% originating from fugitive processes (Figure 4.1).

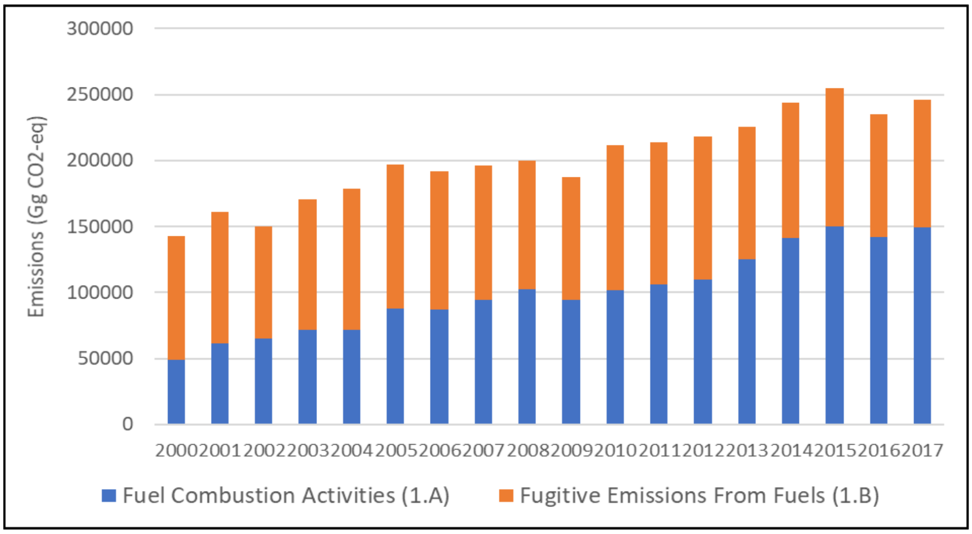


Figure 4.1 - Aggregated GHG emissions (Gg CO_2-eq) of the Energy Sector (2000 – 2017)

Energy Industries was the highest contributor with 38.6% of total emissions of the Fuel Combustion sub-sector followed by Other Sectors with 25.7%, Transport with 25.6% and Manufacturing Industries and Construction with 10.1% (Table 4.14).

Table 4.14 - Aggregated emissions by category in the Energy Sector for period 2000 to 2017 (Gg CO_2-eq)

Year	Total Energy sector	Fuel combustion Activities (1.A)	Energy Industries (1.A.1)	Manufacturing Ind. & Constr. (1.A.2)	Transport (1.A.3)	Other sectors (1.A.4)	Fugitive Emissions Oil & Gas (1.B.2)
2000	142,674	48,896	8,811	2,857	15,425	21,804	93,778
2001	161,275	61,285	12,022	3,682	19,968	25,613	99,989
2002	150,384	64,847	14,227	5,595	23,094	21,931	85,536
2003	170,277	71,576	13,367	10,263	22,817	25,129	98,702
2004	178,980	71,426	17,613	8,833	19,887	25,093	107,554
2005	196,640	88,077	27,595	12,235	21,867	26,381	108,563
2006	192,145	87,063	29,820	13,684	18,034	25,526	105,082
2007	196,041	94,429	34,409	16,258	18,545	25,216	101,612
2008	199,933	102,786	37,454	18,565	19,954	26,813	97,147
2009	187,354	94,322	38,008	11,198	19,246	25,870	93,032
2010	211,571	101,477	39,087	18,777	19,262	24,351	110,093
2011	213,507	105,871	41,530	19,374	19,923	25,044	107,636
2012	218,109	109,810	44,344	21,173	19,916	24,377	108,298
2013	225,842	125,486	37,304	17,180	33,870	37,132	100,356
2014	244,136	141,539	44,099	20,509	37,281	39,650	102,597

Year	Total Energy sector	Fuel combustion Activities (1.A)	Energy Industries (1.A.1)	Manufacturing Ind. & Constr. (1.A.2)	Transport (1.A.3)	Other sectors (1.A.4)	Fugitive Emissions Oil & Gas (1.B.2)
2015	254,996	150,200	53,789	23,906	33,870	38,635	104,796
2016	235,166	142,082	55,231	11,825	38,604	36,422	93,084
2017	245,918	149,638	57,813	15,046	38,477	38,301	96,280

4.4.4.1. Emission Trends by Gas

Emission trends by gas for the period 2000 to 2017 are provided in Table 4.15. Carbon dioxide was the dominant gas emitted in the energy sector with 53.3% of total emissions in 2017 followed by CH_4 with a contribution of 45.3% and N_2O (1.4%). These emissions exclude CO_2 from Biomass burning for energy production which is accounted for under the AFOLU sector and reported also under Memo Items for informative purposes.

In general, there was a steady increase in CO_2 emissions from 37,253 Gg in the year 2000, to an apex level of 131,196 Gg in 2017 after a slight dip in 2016 (Table 4.15). The increase from the year 2000 to 2017 is by some 3.5 times.

CH_4 emissions followed the same pattern as CO_2 over the same time period, from 3681 Gg or 103067 Gg CO_2-eq in 2000 to 3976 Gg or 111,338 Gg CO_2-eq in 2017 (Table 4.15) which represented an 8% increase in emissions.

Likewise, N_2O emissions increased by 44%, from 2,354 Gg CO_2-eq in 2000 to 3,383 Gg CO_2-eq in 2017 (Table 4.15).

Table 4.15 - Absolute (Gg) and CO_2 equivalent (Gg CO_2-eq) emissions by gas for the Energy Sector (2000 – 2017)

Year	CH_4 (Gg)	N_2O (Gg)	CO_2 (Gg)	Total (Gg CO_2-eq)	CH_4 (Gg CO_2-eq)	N_2O (Gg CO_2-eq)
2000	3,681	8.9	37,253	142,674	103,067	2,354
2001	3,901	9.2	49,593	161,275	109,231	2,451
2002	3,425	9.5	51,963	150,384	95,910	2,510
2003	3,874	9.7	59,250	170,277	108,463	2,564
2004	4,179	9.7	59,399	178,980	117,011	2,569
2005	4,221	9.9	75,819	196,640	118,189	2,632
2006	4,115	10.0	74,280	192,145	115,223	2,642
2007	4,024	10.3	80,654	196,041	112,668	2,719
2008	3,875	10.4	88,685	199,933	108,487	2,760
2009	3,726	10.5	80,258	187,354	104,314	2,782
2010	4,319	10.7	87,808	211,571	120,930	2,833
2011	4,251	11.0	91,585	213,507	119,016	2,906
2012	4,296	11.3	94,844	218,109	120,280	2,985
2013	4,035	12.0	109,675	225,842	112,981	3,185
2014	4,139	12.2	125,005	244,136	115,904	3,228
2015	4,233	12.2	133,225	254,996	118,535	3,236
2016	3,851	12.5	124,022	235,166	107,831	3,314
2017	3,976	12.8	131,196	245,918	111,338	3,383

4.4.4.2. Emissions of direct GHGs, GHG precursors (NO_X, CO, NMVOCs) and SO_2

Emissions of all three precursors (Table 4.16) increased over the time series 2000 to 2017, NO_X by 82% from 260 to 471 Gg, CO by 42% from 7423 to 10,325 Gg (34%) and NMVOCs by 37% from 1,460 to 1,956 Gg. SO_2 also increased by 66% from 41 to 64 Gg (Table 4.16).

Table 4.16 - Emissions (Gg) of direct GHGs, its precursors and SO_2 (2000 – 2017)

Year	NO_X	CO	NMVOCs	SO_2
2000	260	7,423	1,460	41
2001	288	7,732	1,532	54
2002	299	7,939	1,563	52
2003	331	8,063	1,603	53
2004	299	8,132	1,615	47
2005	334	8,284	1,647	56
2006	307	8,355	1,640	48
2007	318	8,615	1,678	44
2008	337	8,672	1,691	52
2009	316	8,653	1,688	46
2010	327	8,740	1,743	50
2011	341	8,893	1,756	51
2012	350	9,019	1,793	52
2013	410	9,692	1,908	67
2014	437	10,048	1,952	67
2015	435	10,074	1,944	61
2016	451	10,325	1,956	64
2017	471	10,539	1,997	68

4.4.4.3. Emissions by sub-category

Trend of emissions in the Energy Industries (1.A.1) sub-category

Table 4.17 depicts the trend of emissions by sub-category for the Energy Industries. An increase in emissions is observed for all sub-categories from the year 2000 to 2017 but not uniformly. The highest increase of 1893% is from Electricity production generation followed by 182 % from Other energy industries, 152% from manufacture of solid fuels. Petroleum refining emissions regressed by 3%. Overall, the pooled increase for Energy Industries is 656% from the years 2000 to 2017.

Table 4.17 - Aggregated emissions (Gg CO_2-eq) from Energy Industries (2000 – 2017)

Year	1.A.1 Energy Industries	1.A.1.a.i Electricity Generation	1.A.1.b – Petroleum Refining	1.A.1.c.i – Manufacture of Solid Fuels	1.A.1.c.ii – Other Energy Industries
2000	8,811	2,517	1,343	461	4,489
2001	12,022	3,892	2,274	472	5,384
2002	14,227	7,233	2,394	484	4,116
2003	13,367	7,640	1,438	498	3,792
2004	17,613	11,799	1,205	513	4,095
2005	27,595	19,877	2,373	528	4,817
2006	29,820	23,790	1,091	543	4,397
2007	34,409	28,732	738	558	4,381
2008	37,454	31,068	1,221	561	4,603

Year	1.A.1 Energy Industries	1.A.1.a.i Electricity Generation	1.A.1.b – Petroleum Refining	1.A.1.c.i – Manufacture of Solid Fuels	1.A.1.c.ii – Other Energy Industries
2009	38,008	32,137	675	584	4,613
2010	39,087	33,175	1,179	597	4,135
2011	41,530	33,553	1,377	615	5,985
2012	44,344	35,789	1,304	628	6,623
2013	37,304	27,826	1,475	645	7,358
2014	44,099	33,657	948	655	8,838
2015	53,789	43,481	521	673	9,114
2016	55,231	45,112	990	687	8,441
2017	57,813	47,653	1,306	703	8,151

Emissions from the Energy Industries category by gas and aggregated by sub-category for the year 2017 are presented in Table 4.18. The major contribution came from Electricity Generation activities with 82.4% of total emissions of Energy Industries followed by 15.3% from Manufacture of solid Fuels and Other Energy Industries (fuel use in the up-stream Oil and Gas Sector). Petroleum Refining was responsible for the remaining 2.3%. CO_2 remained the principal GHG emitted for all activities of the Energy Industries category with 98.7% and the remaining two direct gases responsible for the remaining 1.3% of total aggregated emissions. In absolute terms, CH_4 12.1 Gg and N_2O 1.6 Gg only.

Table 4.18 - Absolute (Gg) and Aggregated (Gg CO_2-eq) emissions of direct GHGs for Energy Industries in 2017

Source category	CH_4 (Gg)	N_2O (Gg)	CO_2 (Gg)	CH_4 (Gg CO_2-eq)	N_2O (Gg CO_2-eq)
1.A.1 - Energy Industries	12.1	1.6	57,052	340.1	421.1
1.A.1.a - Main Activity Electricity and Heat Production	0.8	0.1	47,607	23.8	22.5
1.A.1.a.i - Electricity Generation	0.8	0.1	47,607	23.8	22.5
1.A.1.b - Petroleum Refining	0.0	0.0	1,302	1.3	2.3
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries	11.3	1.5	8,143	315.0	396.3
1.A.1.c.i - Manufacture of Solid Fuels	11.1	1.5	0	311.0	392.4
1.A.1.c.ii - Other Energy Industries	0.1	0.0	8,143	4.1	3.8

Emissions of indirect GHGs and SO_2 for 2017 are given in Table 4.19. Electricity Generation was the highest contributor of NO_X with 63%. Manufacture of solid Fuels and Other Energy Industries accounted for 54% of CO, 58% of NMVOCs and 38% of SO_2.

Table 4.19 - Absolute emissions of indirect GHGs (Gg) for Energy Industries for 2017

Categories	NO_X	CO	NMVOCs	SO_2
1.A.1 - Energy Industries	120.6	72.4	5.3	10.5
1.A.1.a - Main Activity Electricity and Heat Production	75.5	33.1	2.2	0.2
1.A.1.a.i - Electricity Generation	75.5	33.1	2.2	0.2
1.A.1.b - Petroleum Refining	2.1	0.3	0.0	6.3
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries	42.9	39.0	3.1	4.0
1.A.1.c.i - Manufacture of Solid Fuels	30.0	33.3	2.7	4.0
1.A.1.c.ii - Other Energy Industries	12.9	5.7	0.4	0.0

Manufacturing Industries and Construction (1.A.2)

Fuel combustion activities for auto production of electricity and heat in the Iron and Steel, Non-Ferrous Metals, Chemicals and Petrochemicals, Pulp, Paper and Print, Non-metallic Minerals, Transport Equipment, Machinery, Mining and Quarrying, Wood and Wood Products, Construction, and Textile and Leather industries were responsible for emissions from this category. The estimates did not include non-energy use of fuel of these industries. Total aggregated emissions from this category increased from 2,857 Gg CO_2-eq in the year 2000, peaking at 23,906 Gg CO_2-eq in 2015 to then decline to 15,046 Gg CO_2-eq in 2017. This decline in emissions levels was a result of lower activity levels in this sector in 2016 and 2017 which is reflected in the drop in natural gas consumption in these years (Table 4.20). CO_2 is the dominant gas (Table 4.20) with 98.1% of total emissions of this category in 2017. CH_4 represented 0.9% and N_2O 1.1%. Further disaggregation of emissions of this category was not possible due to lack of relevant data for the respective subcategories. Emission estimates of NO_X, CO and NMVOCs in 2017 for the Manufacturing Industries and Construction category were 42, 89 and 48 Gg respectively. SO_2 emissions stood at 3.9 Gg.

Table 4.20 - Trends in absolute (Gg) and aggregated (Gg CO_2-eq) emissions of direct and indirect GHGs from Manufacturing Industries and Construction (2000 – 2017)

Year	CO_2 (Gg)	CH_4 (Gg CO_2-eq)	N_2O (Gg CO_2-eq)	Total (Gg CO_2-eq)	CH_4 (Gg)	N_2O (Gg)	NO_X (Gg)	CO (Gg)	NMVOCs (Gg)	SO_2 (Gg)
2000	2,679	80	98	2,857	2.8	0.4	17	53	28	1.7
2001	3,490	86	106	3,682	3.1	0.4	19	58	30	1.8
2002	5,382	96	118	5,595	3.4	0.4	22	65	34	2.8
2003	10,018	108	136	10,263	3.9	0.5	53	74	38	5.2
2004	8,577	115	142	8,833	4.1	0.5	33	78	42	2.8
2005	11,954	126	155	12,235	4.5	0.6	34	86	46	2.5
2006	13,378	137	168	13,684	4.9	0.6	35	94	51	2.4
2007	15,915	151	192	16,258	5.4	0.7	39	104	56	2.9
2008	18,186	166	213	18,565	5.9	0.8	50	115	62	4.0
2009	10,806	175	217	11,198	6.3	0.8	39	120	64	3.8
2010	18,354	189	234	18,777	6.8	0.9	48	131	71	3.9
2011	18,920	203	251	19,374	7.3	0.9	51	140	76	4.1
2012	20,695	213	264	21,173	7.6	1.0	56	148	80	4.7
2013	16,726	203	251	17,180	7.2	0.9	52	139	75	4.8
2014	20,221	129	159	20,509	4.6	0.6	51	90	49	4.1
2015	23,615	131	159	23,906	4.7	0.6	46	92	51	3.2
2016	11,545	126	154	11,825	4.5	0.6	32	87	46	3.3
2017	14,758	129	159	15,046	4.6	0.6	42	89	48	3.9

Transport (1.A.3)

Table 4.21 provides for the emission trends for the sub-categories of this sector for the period 2000 to 2017. Emissions in the transport sub-categories fluctuated between years over the time series due to variations in the intensity of activities. Overall, the Transport sector emissions multiplied by 2.5 from 2000 to 2017. Water-Borne Navigation emissions increase by 3.1 times, followed by Civil Aviation at 2.8 times, Road Transportation at 2.5 times while Railways witnessed a decrease of 30% in emissions.

Table 4.21 - Aggregated emissions (Gg CO_2-eq) for sub-categories of the Transport Sector (2000 – 2017)

Year	1.A.3 - Transport	1.A.3.a - Civil Aviation	1.A.3.b - Road Transportation	1.A.3.c - Railways	1.A.3.d - Water-borne Navigation
2000	15,425	43	14,781	123	477
2001	19,968	73	19,110	128	658
2002	23,094	79	22,101	134	779
2003	22,817	92	21,822	128	776
2004	19,887	78	19,016	92	701
2005	21,867	65	20,932	114	756
2006	18,034	66	17,239	35	694
2007	18,545	80	17,714	29	723
2008	19,954	93	19,053	32	776
2009	19,246	96	18,367	24	759
2010	19,262	48	18,348	19	848
2011	19,923	53	18,955	21	894
2012	19,916	76	18,848	14	978
2013	33,870	99	32,398	60	1,313
2014	37,281	88	35,682	68	1,442
2015	33,870	99	32,398	60	1,313
2016	38,604	124	36,922	83	1,476
2017	38,477	117	36,806	83	1,471

Emission trends by vehicle classes for Road Transportation is given in Table 4.22. Cars remained the highest emitter class throughout the time series. Emissions from Light Duty Trucks, Heavy Duty Trucks and Buses varied in accordance with activity intensity over the time series while Motorcycles always contributed the least. Emissions more than doubled (2.5 times) from the year 2000 to 2017 for the Transport sector. The increase was not uniform between the different vehicle classes with 3.6 times for Motorcycles and cars, 2.1 times for Light Duty Trucks and only 10% for Heavy Duty trucks and Buses.

Table 4.22 - Emission (Gg CO_2-eq) trends for direct gases for Road Transportation vehicle groups (2000 – 2017)

Year	1.A.3.b – Road Transportation	1.A.3.b.i – Cars	1.A.3.b.ii – Light-duty trucks	1.A.3.b.iii – Heavy-duty trucks and buses	1.A.3.b.iv – Motorcycles
2000	14,781	6,362	3,246	4,518	655
2001	19,110	9,452	3,981	4,694	982
2002	22,101	11,462	4,512	4,934	1,193
2003	21,822	11,502	4,422	4,698	1,200
2004	19,016	10,770	3,723	3,396	1,127
2005	20,932	11,373	4,182	4,187	1,190
2006	17,239	10,843	3,185	2,068	1,143
2007	17,714	11,544	3,202	1,749	1,218
2008	19,053	12,380	3,451	1,915	1,307
2009	18,367	12,366	3,251	1,443	1,307
2010	18,348	14,120	2,237	1,116	875
2011	18,955	14,841	2,102	1,231	781
2012	18,848	15,541	1,758	859	690
2013	32,398	20,728	5,925	3,560	2,185
2014	35,682	22,698	6,548	4,044	2,393
2015	32,398	20,728	5,925	3,560	2,185
2016	36,922	22,746	6,905	4,877	2,394
2017	36,806	22,651	6,888	4,883	2,384

Aggregated emissions by subcategory within the transport category for the year 2017 are provided in Table 4.23. Road transportation emitted the major share of this category with 36,806 Gg CO_2-eq (95.7%) out of a total of 38,477 Gg CO_2-eq with cars responsible for 61% in this activity area. Domestic water borne Navigation followed with 1456 Gg CO_2-eq (3.8%), Domestic Aviation with 117 Gg CO_2-eq (0.3%) and Railways with 83 Gg CO_2-eq (0.2%). CO_2 with 37,647 Gg CO_2-eq made up for 98% of the total emissions of the direct GHGs. CH_4 and N_2O represented 1% with emissions of 401 Gg CO_2-eq and 428 Gg CO_2-eq respectively.

In absolute terms the transport category emitted 14.4 Gg of CH_4 and 1.6 Gg of N_2O. The share of the different sub-categories followed the same trend as for aggregated emissions and is provided in Table 4.23.

Table 4.23 - GHG emissions (Gg CO_2-eq) for Transport category for 2017

Category	CH_4 (Gg)	N_2O (Gg)	CO_2 (Gg)	CH_4 (Gg CO_2-eq)	N_2O (Gg CO_2-eq)	Total (Gg CO_2-eq)
1.A.3 Transport	14.4	1.6	37,647	401.9	427.9	38,477
1.A.3.a - Civil Aviation	0.0	0.0	116	0.0	0.9	117
1.A.3.a.ii - Domestic Aviation	0.0	0.0	116	0.0	0.9	117
1.A.3.b - Road Transportation	14.2	1.5	36,000	397.7	408.4	36,806
1.A.3.b.i - Cars	10.4	1.0	22,089	292.0	270.6	22,651
1.A.3.b.ii - Light-duty trucks	2.4	0.3	6,736	66.1	85.8	6,888
1.A.3.b.iii - Heavy-duty trucks and buses	0.3	0.1	4,851	8.5	23.4	4,883
1.A.3.b.iv - Motorcycles	1.1	0.1	2,325	31.0	28.4	2,384
1.A.3.c - Railways	0.0	0.0	75	0.1	7.7	83
1.A.3.d - Water-borne Navigation	0.1	0.0	1,456	4.1	11.0	1,471
1.A.3.d.ii - Domestic Water-borne Navigation	0.1	0.0	1,456	4.1	11.0	1,471

Emissions of the indirect GHGs and SO_2 by activity area within the Transport category are given in Table 4.24. Road Transportation was responsible for the highest share of emissions of NO_X with 93.7%, CO with 83.8% and of NMVOCs with 72.4%. For SO_2 emissions, Domestic Water-Borne navigation emitted most with 98.4%. Under the Road Transportation activity area, cars contributed most NO_X and CO with 43% and 49% respectively. The contribution of cars to NMVOCs emissions under the Road Transportation activity area stood at 36%, with motorcycles topping the list with 50%.

Table 4.24 - Emissions (Gg) of GHG precursors for Transport categories for year 2017

Category	NO_X	CO	NMVOCs	SO_2
1.A.3 - Transport	157.9	1,476.3	273.6	9.6
1.A.3.a - Civil Aviation	0.4	0.1	0.0	0.0
1.A.3.a.ii - Domestic Aviation	0.4	0.1	0.0	0.0
1.A.3.b - Road Transportation	147.9	1,237.4	198.0	0.1
1.A.3.b.i - Cars	63.1	603.9	71.7	0.1
1.A.3.b.ii - Light-duty trucks	29.8	239.6	23.5	0.0
1.A.3.b.iii - Heavy-duty trucks and buses	50.1	17.0	3.4	0.0
1.A.3.b.iv - Motorcycles	5.0	376.9	99.5	0.0
1.A.3.c - Railways	1.2	0.3	0.1	0.0
1.A.3.d - Water-borne Navigation	8.4	238.6	75.5	9.4
1.A.3.d.ii - Domestic Water-borne Navigation	8.4	238.6	75.5	9.4

Other Sectors (1.A.4)

Trends of aggregated emissions for the Other Sectors sub-categories are provided in Table 4.25. Emissions increased from the year 2000 to 2017 for all sub-categories but not uniformly over the years of the time series. Very often, emissions witnessed increase or a decrease from one year to the next as a result of varying intensity in activity. Emissions increased by 375% for Commercial / Institutional, 66% for Residential, 44% for Agriculture / Forestry / Fishing and 30% for Stationary and 53% for Off Road vehicles.

Table 4.25 - GHG emissions (Gg CO_2-eq) for direct gases in Other Sectors (2000 – 2017)

Year	1.A.4 - Other Sectors	1.A.4.a – Commercial / Institutional	1.A.4.b - Residential	1.A.4.c – Agriculture / Forestry / Fishing / Fish Farms	1.A.4.c.i - Stationary	1.A.4.c.ii - Off-road Vehicles and Other Machinery
2000	21,804	675	21,083	45	17	28
2001	25,613	628	24,924	61	31	29
2002	21,931	565	21,332	34	3	31
2003	25,129	540	24,538	50	21	29
2004	25,093	451	24,599	42	22	21
2005	26,381	1,329	25,004	47	21	26
2006	25,526	1,209	24,284	32	14	18
2007	25,216	1,167	24,026	24	8	15
2008	26,813	1,224	25,557	32	15	17
2009	25,870	1,041	24,806	23	11	12
2010	24,351	1,040	23,291	20	10	10
2011	25,044	1,151	23,868	25	14	11
2012	24,377	1,311	23,049	17	10	7
2013	37,132	2,373	34,686	72	41	31
2014	39,650	2,724	36,846	80	45	35
2015	38,635	2,549	36,014	72	41	31
2016	36,422	3,191	33,174	57	14	43
2017	38,301	3,210	35,026	65	22	43

Aggregated and absolute emissions for the Other Sectors category are given in Table 4.26. This category emitted a total of 38301 Gg CO_2-eq in 2017. The highest share came from activities in the Residential sector with 91.4% of emissions. CO_2 contributed most emissions for all three direct GHGs from this activity area, with 16997 Gg CO_2-eq of CO_2, 18948 Gg CO_2-eq of CH_4 and 2,357 Gg CO_2-eq of N_2O. Commercial / Institutional activities followed the Residential sub-category with emissions from Agriculture / Forestry / Fishing / Fish Farms being marginal at 0.2% of the total of this category. In absolute terms also, the same order of contribution is observed for the sub-categories with Residential responsible for the major share of emissions for the three direct GHGs, namely 86% CO_2 and 96% of both CH_4 and N_2O.

Table 4.26 - Absolute (Gg) and Aggregated GHG emissions (Gg CO_2-eq) for Other Sectors for 2017

Category	CH_4 (Gg)	N_2O (Gg)	CO_2 (Gg)	CH_4 (Gg CO_2-eq	N_2O (Gg CO_2-eq	Total (Gg CO_2-eq
1.A.4 - Other Sectors	676.7	8.9	16,996.5	18,947.7	2,357.2	38,301.4
1.A.4.a - Commercial / Institutional	27.8	0.3	2,341.2	777.4	91.5	3,210.2
1.A.4.b - Residential	648.9	8.5	14,590.9	18,170.0	2,265.5	35,026.5
1.A.4.c – Agriculture / Forestry / Fishing / Fish Farms	0.0	0.0	64.4	0.2	0.1	64.8
1.A.4.c.i - Stationary	0.0	0.0	21.7	0.1	0.0	21.9
1.A.4.c.ii - Off-road Vehicles and Other Machinery	0.0	0.0	42.7	0.2	0.1	42.9

The Residential sub-category again vastly dominated emissions of the GHG precursors which stood at 87% for NO_X, 99% for CO, 98% for NMVOCs and 90% for SO_2. The contribution from each sub-category is depicted in Table 4.27.

Table 4.27 - Emissions of GHG precursors (Gg) by sub-category for the Other Sectors category in 2017

Category	NO_X	CO	NMVOCs	SO_2
1.A.4 - Other Sectors	120.12	7,547.08	1,148.20	36.58
1.A.4.a - Commercial / Institutional	16.59	48.85	24.87	3.68
1.A.4.b - Residential	103.30	7,498.16	1,123.32	32.83
1.A.4.c - Agriculture / Forestry / Fishing / Fish Farms	0.24	0.07	0.02	0.07
1.A.4.c.i - Stationary	0.06	0.02	0.00	0.02
1.A.4.c.ii - Off-road Vehicles and Other Machinery	0.18	0.05	0.01	0.05

Fugitive Emissions from Fuel (1.B.) – Solid Fuels (1.B.1) and Oil and Gas (1.B.2)

Trends of aggregated Fugitive emissions for Solid fuels and the Oil and Gas sub-categories are given in Table 4.28. Emissions varied between 85536 and 110093 Gg CO_2-eq over the time series. Most emissions originated from the Oil and Gas sub-categories with more than 99% for all years. Emissions from the Oil extraction activities accounted for twice the emissions from the natural Gas component.

Table 4.28 - Emissions (Gg CO_2-eq) for direct gases from Fugitive Emissions from the Fuels Sector (2000 – 2017)

Year	1.B - Fugitive emissions from fuels	1.B.1 - Solid Fuels	1.B.1.a - Coal mining and handling	1.B.2 - Oil and Natural Gas	1.B.2.a - Oil	1.B.2.b - Natural Gas
2000	93,778	1	1	93,777	77,618	16,159
2001	99,989	1	1	99,988	81,462	18,526
2002	85,536	20	20	85,517	68,459	17,058
2003	98,702	11	11	98,691	79,606	19,085
2004	107,554	4	4	107,550	85,835	21,715
2005	108,563	4	4	108,559	86,640	21,919
2006	105,082	4	4	105,078	81,972	23,106
2007	101,612	11	11	101,601	75,728	25,874
2008	97,147	15	15	97,132	72,499	24,633
2009	93,032	16	16	93,016	73,591	19,425
2010	110,093	18	18	110,076	84,503	25,572
2011	107,636	15	15	107,622	81,694	25,928
2012	108,298	22	22	108,276	80,423	27,853
2013	100,356	20	20	100,335	75,492	24,843
2014	102,597	21	21	102,576	75,308	27,269
2015	104,796	22	22	104,774	72,941	31,833
2016	93,084	21	21	93,063	63,186	29,877
2017	96,280	21	21	96,259	65,048	31,211

Fugitive Emissions for the year 2017 are presented in Table 4.29. Oil and Natural Gas activities were responsible for a total aggregated emissions of 96259 Gg CO_2-eq, the Oil industry contributing 67.6% and the Gas industry 32.4% of this total respectively. The main contributor in the Oil industry was Production and Upgrading with 60460 Gg CO_2-eq which represented 92.98% of this activity while Flaring and Venting emitted respectively 6.7% and 0.05%. On a GHG basis, CH_4 topped the emissions with 95.06% followed by CO_2 with almost all the remaining 4.93% and N_2O with 0.02%.

Table 4.29 - Absolute (Gg) and aggregated (Gg CO_2-eq) of Fugitive Emissions of direct GHGs in 2017

Category	CH_4 (Gg)	N_2O (Gg)	CO_2 (Gg)	CH_4 (Gg CO_2-eq	N_2O (Gg CO_2-eq	Total (Gg CO_2-eq
1.B - Fugitive emissions from fuels	3,268.6	0.1	4,742.2	91,519.4	18.7	96,280.3
1.B.1 - Solid Fuels	0.8	0.0	0.0	21.2	0.0	21.2
1.B.1.a - Coal mining and handling	0.8	0.0	0.0	21.2	0.0	21.2
1.B.1.a.i - Underground mines	0.8	0.0	0.0	21.2	0.0	21.2
1.B.1.a.i.1 - Mining	0.7	0.0	0.0	18.6	0.0	18.6
1.B.1.a.i.2 - Post-mining seam gas emissions	0.1	0.0	0.0	2.6	0.0	2.6
1.B.2 - Oil and Natural Gas	3,267.8	0.1	4,742.2	91,498.2	18.7	96,259.0
1.B.2.a - Oil	2,154.1	0.1	4,715.3	603,14.4	18.6	65,048.3
1.B.2.a.i - Venting	1.1	0.0	0.2	31.8	0.0	32.0
1.B.2.a.ii - Flaring	2.7	0.1	4,441.6	76.8	18.6	4,537.0
1.B.2.a.iii - All Other	2,150.2	0.0	273.5	60,205.8	0.0	60,479.3
1.B.2.a.iii.2 - Production and Upgrading	2,149.5	0.0	273.1	60,186.4	0.0	60,459.5
1.B.2.a.iii.3 - Transport	0.6	0.0	0.4	16.6	0.0	17.0
1.B.2.a.iii.4 - Refining	0.1	0.0	0.0	2.9	0.0	2.9
1.B.2.a.iii.5 - Distribution of oil products	0.0	0.0	0.0	0.0	0.0	0.0
1.B.2.b - Natural Gas	1,113.7	0.0	26.9	31,183.8	0.1	31,210.7
1.B.2.b.i - Venting	18.3	0.0	0.2	512.4	0.0	512.6
1.B.2.b.ii - Flaring	0.0	0.0	14.2	0.2	0.1	14.5
1.B.2.b.iii - All Other	1,095.4	0.0	12.5	30,671.1	0.0	30,683.6
1.B.2.b.iii.2 - Production	1,001.7	0.0	8.0	28,047.7	0.0	28,055.7
1.B.2.b.iii.4 - Transmission and Storage	9.7	0.0	0.0	270.6	0.0	270.6
1.B.2.b.iii.5 - Distribution	84.0	0.0	4.5	2,352.8	0.0	2,357.3

Emissions of the GHG precursors and SO_2 are presented in Table 4.30. Natural gas operations were responsible for the major share of NO_X (92.1%) and CO (99.3%) compared to Oil segment while the latter emitted most of the NMVOC (92.8%) and SO_2 (96.0%). These contributions varied between the sub-categories and according to gas. Flaring of natural gas contributed most of the NO_X and CO while Venting in the Oil industry was responsible for the significant share of NMVOCs. SO_2 emissions were estimated at 2.4 Gg and 0.1 Gg for Oil and Natural gas activities respectively.

Table 4.30 - Emissions (Gg) of GHG precursors by gas for Fugitive Emissions in 2017

Category	NO_X	CO	NMVOCs	SO_2
1.B - Fugitive emissions from fuels	11.8	49.4	322.4	2.5
1.B.1 - Solid Fuels	0.0	0.0	44.2	0.0
1.B.1.a - Coal mining and handling	0.0	0.0	44.2	0.0
1.B.1.a.i - Underground mines	0.0	0.0	44.2	0.0
1.B.1.a.i.1 - Mining	0.0	0.0	0.0	0.0
1.B.1.a.i.2 - Post-mining seam gas emissions	0.0	0.0	44.2	0.0
1.B.2 - Oil and Natural Gas	11.8	49.4	278.2	2.5
1.B.2.a - Oil	0.9	0.4	258.1	2.4
1.B.2.a.i - Venting	0.0	0.0	209.6	0.0

Category	NO_X	CO	NMVOCs	SO_2
1.B.2.a.ii - Flaring	0.0	0.0	2.2	0.0
1.B.2.a.iii - All Other	0.9	0.4	46.3	2.4
1.B.2.a.iii.2 - Production and Upgrading	0.0	0.0	0.0	0.0
1.B.2.a.iii.3 - Transport	0.0	0.0	9.1	0.0
1.B.2.a.iii.4 - Refining	0.9	0.4	0.8	2.4
1.B.2.a.iii.5 - Distribution of oil products	0.0	0.0	36.5	0.0
1.B.2.b - Natural Gas	10.9	49.1	20.1	0.1
1.B.2.b.i - Venting	0.0	0.0	4.7	0.0
1.B.2.b.ii - Flaring	10.9	49.1	14.0	0.1
1.B.2.b.iii - All Other	0.0	0.0	1.4	0.0
1.B.2.b.iii.2 - Production	0.0	0.0	0.1	0.0
1.B.2.b.iii.4 - Transmission and Storage	0.0	0.0	0.2	0.0
1.B.2.b.iii.5 - Distribution	0.0	0.0	1.2	0.0

Memo items

Emissions from fuels used for International aviation and international marine bunkers (IMB) are excluded from the nation's totals and reported as memo items. Emissions of CO_2, CH_4 and N_2O from the international bunkers (marine and aviation bunkers) increased from 501 Gg CO_2-eq in 2000 to 1,256 Gg CO_2-eq in 2017 (Table 4.31) with ups and downs between the years. In the year 2000, international aviation bunkers contributed 85.9% of total emissions from International Bunkers, while the balance came from IMB. This increased and in the year 2017, international aviation contributed 94.4% of the emissions of international bunkering with that of IMB being only 5.6% for that year.

In order to avoid double counting, CO_2 emissions from biomass combustion for energy production are also reported under the memo items and not included in the Energy sector emissions. They are estimated and reported in the AFOLU sector as part of emissions from the Forest land sub-category (3.B.1.a). This includes CO_2 emissions from transformation of fuel wood to charcoal in energy industries, as well as CO_2 emissions from the use of biomass for energy purposes in the residential and commercial / institutional sectors. CO_2 emissions from this activity which amounted to 229548 Gg CO_2 in 2000, increased by 33% to 304334 Gg CO_2 in 2017.

Table 4.31 - Emissions (Gg CO_2-eq) trend for International Bunkers and Biomass consumption (2000 – 2017)

Year	Total International Bunkers	International Aviation Bunkers	International Marine Bunkers	CO_2 from biomass combustion for energy production
2000	501	430	71	229,548
2001	806	736	71	232,950
2002	873	802	71	236,470
2003	998	927	71	240,519
2004	864	793	71	244,622
2005	730	659	71	249,094
2006	736	665	71	253,595
2007	875	804	71	261,305
2008	1,016	946	71	263,271
2009	1,039	969	71	266,424
2010	552	481	71	272,729
2011	607	536	71	279,329
2012	839	769	71	287,274

Year	Total International Bunkers	International Aviation Bunkers	International Marine Bunkers	CO_2 from biomass combustion for energy production
2013	1,071	1,001	71	288,626
2014	963	892	71	288,704
2015	1,071	1,001	71	293,624
2016	1,321	1,251	71	297,923
2017	1,256	1,185	71	304,334

The GHG precursors and SO_2 were computed for International Aviation and Marine Bunkers and are presented in Table 4.32. NO_X was the main indirect GHG emitted followed by CO and NMVOCs.

Table 4.32 - Emissions (Gg) trends of GHG precursors for International Marine Bunker fuels (2000 – 2017)

Year	NO_X	CO	NMVOCs	SO_2
2000	3.51	0.31	0.13	0.58
2001	4.74	0.42	0.18	0.68
2002	5.01	0.44	0.19	0.70
2003	5.51	0.49	0.21	0.74
2004	4.97	0.44	0.19	0.70
2005	4.43	0.39	0.16	0.66
2006	4.46	0.40	0.17	0.66
2007	5.02	0.44	0.19	0.70
2008	5.59	0.49	0.21	0.75
2009	5.68	0.50	0.21	0.75
2010	3.71	0.33	0.14	0.60
2011	3.94	0.35	0.14	0.62
2012	4.87	0.43	0.18	0.69
2013	5.81	0.51	0.22	0.76
2014	5.37	0.47	0.20	0.73
2015	5.81	0.51	0.22	0.76
2016	6.82	0.60	0.26	0.84
2017	6.55	0.58	0.25	0.82

The absolute and aggregated direct GHGs emitted in 2017 are presented in Table 4.33. Total aggregated emissions were 1256.1 Gg CO_2-eq with CO_2 contributing 99.24%, CH_4, 0.03% and N_2O, 0.73% in the year 2017.

Table 4.33 - Absolute (Gg) and aggregated (Gg CO_2-eq) emissions from International Aviation Bunkers in 2017

Category	CO_2 (Gg)	CH_4 (Gg CO_2-eq)	N_2O (Gg CO_2-eq)	Total (Gg CO_2-eq)	CH_4 (Gg)	N_2O (Gg)
International Bunkers	1,246.5	0.41	9.20	1,256.1	0.01	0.03
1.A.3.a.i - International Aviation (International Bunkers) (1)	1,176.4	0.23	8.72	1,185.4	0.01	0.03
1.A.3.d.i - International water-borne navigation (International bunkers) (1)	70.0	0.18	0.48	70.7	0.01	0.00

4.4.4.4. Comparison of the IPCC Tier 1 Reference and Sectoral Approaches

The Reference Approach (RA) is a top-down approach which used Nigeria's total energy supply to calculate CO_2 emissions from fuel combustion rather than the IPCC source categories as obtained when adopting the bottom-up Sectoral Approach (SA). It is good practice to compare emissions from these two approaches as significant differences may indicate possible inconsistencies with AD, large statistical differences between energy supply and energy consumption, significant mass imbalances and the approximate net calorific value and carbon content values adopted, unrecorded consumption of fuels, high distribution losses and missing information on stock changes. A relatively small gap (5% or less) is typically expected between the two approaches.

The differences in total energy consumption between the RA and SA approaches ranged from -7.2% in 2012 to 10.6% in 2001 when the mass of all fuels is considered. In fact, the differences stemmed from liquid fuels only and stood at -27.7% in 2012 and 15.5% in 2001 as the same data were used for the gaseous and solid fuels. These were due to high statistical differences between the supply and consumption of liquid fuels since transformation and distribution losses were not considered in both the RA and SA approaches due to lack of relevant data. Table 4.34 provides a comparison of the data adopted for computing emissions by the reference and sectoral approaches.

Table 4.34 - Fuel consumption under the Reference and Sectoral Approaches (2000 – 2017)

Year	Reference Approach (RA)				Sectoral Approach (SA)				RA / SA difference			
	Liquid (TJ)	Gaseous (TJ)	Solid (TJ)	Total (TJ)	Liquid (TJ)	Gaseous (TJ)	Solid (TJ)	Total (TJ)	Liquid (%)	Gaseous (%)	Solid (%)	Total (%)
2000	292,124	155,162	77	447,363	320,914	155,163	77	476,154	-9.0	0.0	0.0	-6.0
2001	517,873	210,235	77	728,185	448,236	210,235	77	658,548	15.5	0.0	0.0	10.6
2002	505,774	277,788	1,109	784,672	442,038	277,788	1,109	720,935	14.4	0.0	0.0	8.8
2003	509,551	282,881	593	793,025	524,291	282,881	593	807,765	-2.8	0.0	0.0	-1.8
2004	496,238	401,472	206	897,916	432,820	401,472	206	834,498	14.7	0.0	0.0	7.6
2005	521,458	632,894	206	1154,558	479,826	632,894	206	1,112,927	8.7	0.0	0.0	3.7
2006	425,016	728,264	206	1153,486	389,450	728,264	206	1,117,921	9.1	0.0	0.0	3.2
2007	373,883	863,216	593	1237,693	379,746	863,216	593	1,243,555	-1.5	0.0	0.0	-0.5
2008	501,178	928,431	826	1430,435	442,835	928,431	826	1,372,092	13.2	0.0	0.0	4.3
2009	426,731	822,819	877	1250,427	407,690	822,819	877	1,231,386	4.7	0.0	0.0	1.5
2010	304,681	974,505	980	1280,167	383,116	974,505	980	1,358,601	-20.5	0.0	0.0	-5.8
2011	313,346	1,021,941	826	1336,112	401,838	1,021,941	826	1,424,604	-22.0	0.0	0.0	-6.2
2012	279,977	1,099,725	1,238	1380,940	387,250	1,099,725	1238	1,488,213	-27.7	0.0	0.0	-7.2
2013	784,522	891,236	1,135	1676,893	766,997	891,236	1135	1,659,368	2.3	0.0	0.0	1.1
2014	850,128	1,076,735	1,187	1928,049	836,561	1,076,735	1187	1,914,483	1.6	0.0	0.0	0.7
2015	724,451	1,346,629	1,241	2072,321	743,638	1,346,629	1241	2,091,508	-2.6	0.0	0.0	-0.9
2016	804,635	1,144,008	1,298	1949,940	784,388	1,144,008	1297	1,929,693	2.6	0.0	0.0	1.0
2017	879,354	1,221,414	1,187	2101,955	820,869	1,221,414	1187	2,043,470	7.1	0.0	0.0	2.9

The differences in CO_2 emissions between RA and SA ranged from -8.0% in 2012 to 17.3% in 2001 (Table 4.35 and Figure 4.2). Negative values indicate that SA CO_2 emissions / fuel consumption is higher than RA CO_2 emissions / fuel consumption. Emissions from RA were generally higher, 11 years out of the 18 reviewed in this inventory, than emissions from SA. These results reflect the differences in the energy consumption reported in the previous paragraph. This may be due to losses of liquid petroleum products in pipeline transport which were not available when computing the inventory.

Table 4.35 - CO_2 emissions and difference between the Reference and Sectoral Approaches (2000 – 2017)

Year	Reference Approach (RA)				Sectoral Approach (SA) (1.A)				RA / SA difference			
	Liquid	Gaseous	Solid	Total	Liquid	Gaseous	Solid	Total	Liquid	Gaseous	Solid	Total
	Emissions Gg CO_2								%			
2000	22,384	8,705	7	31,096	22,875	8,705	7	31,587	-2.1	0.0	0.0	-1.6
2001	39,410	11,794	7	51,211	31,844	11,794	7	43,646	23.8	0.0	0.0	17.3
2002	36,302	15,584	105	51,991	31,277	15,584	105	46,966	16.1	0.0	0.0	10.7
2003	36,627	15,870	56	52,552	37,514	15,870	56	53,440	-2.4	0.0	0.0	-1.7
2004	35,152	22,523	20	57,694	30,593	22,523	20	53,135	14.9	0.0	0.0	8.6
2005	37,168	35,505	20	72,693	33,974	35,505	20	69,499	9.4	0.0	0.0	4.6
2006	30,014	40,856	20	70,889	27,422	40,856	20	68,298	9.5	0.0	0.0	3.8
2007	26,273	48,426	56	74,755	26,641	48,426	56	75,123	-1.4	0.0	0.0	-0.5
2008	35,545	52,085	78	87,708	31,232	52,085	78	83,395	13.8	0.0	0.0	5.2
2009	30,125	46,160	83	76,368	28,653	46,160	83	74,896	5.1	0.0	0.0	2.0
2010	21,643	54,670	93	76,406	26,887	54,670	93	81,650	-19.5	0.0	0.0	-6.4
2011	22,311	57,331	78	79,720	28,220	57,331	78	85,629	-20.9	0.0	0.0	-6.9
2012	20,060	61,695	117	81,872	27,168	61,695	117	88,980	-26.2	0.0	0.0	-8.0
2013	55,464	49,998	107	105,570	54,072	49,998	107	104,177	2.6	0.0	0.0	1.3
2014	60,139	60,405	112	120,656	59,007	60,405	112	119,524	1.9	0.0	0.0	0.9
2015	50,985	75,546	117	126,648	52,248	75,546	117	127,911	-2.4	0.0	0.0	-1.0
2016	58,552	64,179	123	122,854	55,115	64,179	123	119,417	6.2	0.0	0.1	2.9
2017	64,393	68,521	112	133,026	57,821	68,521	112	126,454	11.4	0.0	0.0	5.2

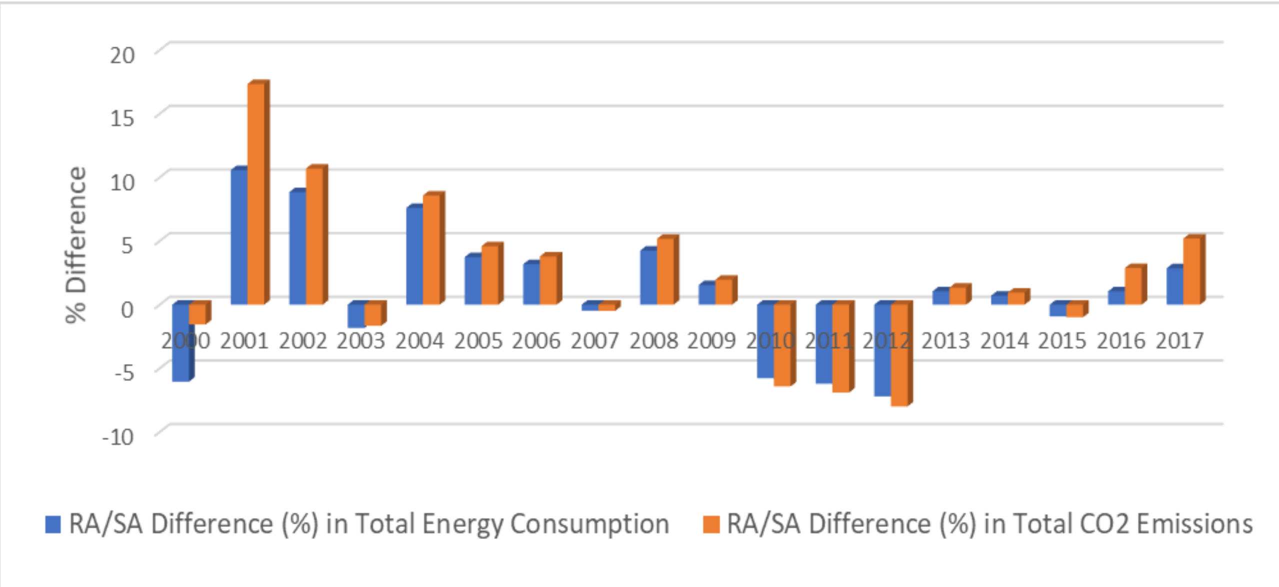


Figure 4.4 - Difference (%) between Reference and Sectoral Approaches in total energy consumption and CO_2 emissions (2000 – 2017)

Results of the estimates for the Energy Sector from the IPCC inventory software for the inventory year 2017 are presented in Table 4.36.

Table 4.36 - Energy Sectoral Table – Inventory Year 2017

Categories	Emissions (Gg)						
	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1 - Energy	131196.320	3976.360	12.768	471.316	10538.528	1996.990	68.141
1.A - Fuel Combustion Activities	126454.141	707.809	12.697	459.468	10489.084	1674.573	65.616
1.A.1 - Energy Industries	57052.162	12.146	1.589	120.565	72.365	5.329	10.541
1.A.1.a - Main Activity Electricity and Heat Production	47606.797	0.849	0.085	75.526	33.096	2.206	0.239
1.A.1.a.i - Electricity Generation	47606.797	0.849	0.085	75.526	33.096	2.206	0.239
1.A.1.a.ii - Combined Heat and Power Generation (CHP)	NO	NO	NO	NO	NO	NO	NO
1.A.1.a.iii - Heat Plants	NO	NO	NO	NO	NO	NO	NO
1.A.1.b - Petroleum Refining	1302.091	0.046	0.009	2.133	0.290	0.039	6.263
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries	8143.274	11.251	1.495	42.906	38.980	3.084	4.039
1.A.1.c.i - Manufacture of Solid Fuels	NO	11.106	1.481	29.987	33.319	2.706	3.998
1.A.1.c.ii - Other Energy Industries	8143.274	0.145	0.015	12.919	5.661	0.377	0.041
1.A.2 - Manufacturing Industries and Construction	14758.460	4.607	0.598	41.983	89.030	47.921	3.871
1.A.2.a - Iron and Steel	IE	IE	IE	IE	IE	IE	IE
1.A.2.b - Non-Ferrous Metals	NO	NO	NO	NO	NO	NO	NO
1.A.2.c - Chemicals	IE	IE	IE	IE	IE	IE	IE
1.A.2.d - Pulp, Paper and Print	IE	IE	IE	IE	IE	IE	IE
1.A.2.e - Food Processing, Beverages and Tobacco	IE	IE	IE	IE	IE	IE	IE
1.A.2.f - Non-Metallic Minerals	IE	IE	IE	IE	IE	IE	IE
1.A.2.g - Transport Equipment	NO	NO	NO	NO	NO	NO	NO
1.A.2.h - Machinery	NO	NO	NO	NO	NO	NO	NO
1.A.2.i - Mining (excluding fuels) and Quarrying	IE	IE	IE	IE	IE	IE	IE
1.A.2.j - Wood and wood products	IE	IE	IE	IE	IE	IE	IE
1.A.2.k - Construction	IE	IE	IE	IE	IE	IE	IE
1.A.2.l - Textile and Leather	IE	IE	IE	IE	IE	IE	IE
1.A.2.m - Non-specified Industry	IE	IE	IE	IE	IE	IE	IE
1.A.3 - Transport	37646.979	14.353	1.615	157.924	1476.259	273.636	9.595
1.A.3.a - Civil Aviation	116.351	0.001	0.003	0.380	0.074	0.004	0.037
1.A.3.a.i - International Aviation (International Bunkers) (1)							
1.A.3.a.ii - Domestic Aviation	116.351	0.001	0.003	0.380	0.074	0.004	0.037
1.A.3.b - Road Transportation	35999.766	14.202	1.541	147.929	1237.372	198.048	0.116
1.A.3.b.i - Cars	22088.510	10.430	1.021	63.066	603.881	71.673	0.072
1.A.3.b.i.1 - Passenger cars with 3-way catalysts	IE	IE	IE	IE	IE	IE	IE
1.A.3.b.i.2 - Passenger cars without 3-way catalysts	IE	IE	IE	IE	IE	IE	IE
1.A.3.b.ii - Light-duty trucks	6735.784	2.361	0.324	29.751	239.609	23.475	0.022
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts	IE	IE	IE	IE	IE	IE	IE
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts	IE	IE	IE	IE	IE	IE	IE
1.A.3.b.iii - Heavy-duty trucks and buses	4850.876	0.305	0.088	50.084	17.029	3.405	0.015
1.A.3.b.iv - Motorcycles	2324.596	1.107	0.107	5.028	376.854	99.495	0.008

Categories	Emissions (Gg)						
	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1.A.3.b.v - Evaporative emissions from vehicles	NE	NE	NE	NE	NE	NE	NE
1.A.3.b.vi - Urea-based catalysts	NE	NE	NE	NE	NE	NE	NE
1.A.3.c - Railways	74.878	0.004	0.029	1.231	0.252	0.111	0.000
1.A.3.d - Water-borne Navigation	1455.984	0.146	0.042	8.383	238.562	75.473	9.441
1.A.3.d.i - International water-borne navigation (International bunkers) (1)							
1.A.3.d.ii - Domestic Water-borne Navigation	1455.984	0.146	0.042	8.383	238.562	75.473	9.441
1.A.3.e - Other Transportation	IE	IE	IE	IE	IE	IE	IE
1.A.3.e.i - Pipeline Transport	IE	IE	IE	IE	IE	IE	IE
1.A.3.e.ii - Off-road	IE	IE	IE	IE	IE	IE	IE
1.A.4 - Other Sectors	16996.540	676.703	8.895	138.997	8851.429	1347.688	41.609
1.A.4.a - Commercial/Institutional	2341.216	27.765	0.345	18.294	59.411	30.425	3.889
1.A.4.b - Residential	14590.898	648.930	8.549	120.433	8791.936	1317.245	37.638
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	64.426	0.009	0.001	0.270	0.082	0.018	0.083
1.A.4.c.i - Stationary	21.730	0.003	0.000	0.093	0.028	0.006	0.029
1.A.4.c.ii - Off-road Vehicles and Other Machinery	42.696	0.006	0.000	0.177	0.054	0.012	0.054
1.A.4.c.iii - Fishing (mobile combustion)	IE	IE	IE	IE	IE	IE	IE
1.A.5 - Non-Specified	IE	IE	IE	IE	IE	IE	IE
1.A.5.a - Stationary	IE	IE	IE	IE	IE	IE	IE
1.A.5.b - Mobile	IE	IE	IE	IE	IE	IE	IE
1.A.5.b.i - Mobile (aviation component)	IE	IE	IE	IE	IE	IE	IE
1.A.5.b.ii - Mobile (water-borne component)	IE	IE	IE	IE	IE	IE	IE
1.A.5.b.iii - Mobile (Other)	IE	IE	IE	IE	IE	IE	IE
1.A.5.c - Multilateral Operations (1)(2)							
1.B - Fugitive emissions from fuels	4742.179	3268.551	0.070	11.848	49.444	322.417	2.525
1.B.1 - Solid Fuels	NE	0.758	NA	NA	NA	44.204	NA
1.B.1.a - Coal mining and handling	NE	0.758	NA	NA	NA	44.204	NA
1.B.1.a.i - Underground mines	NE	0.758	NA	NA	NA	44.204	NA
1.B.1.a.i.1 - Mining	NE	0.666	NA	NA	NA	0.044	NA
1.B.1.a.i.2 - Post-mining seam gas emissions	NE	0.092	NA	NA	NA	44.160	NA
1.B.1.a.i.3 - Abandoned underground mines	NO	NO	NA	NA	NA	NA	NA
1.B.1.a.i.4 - Flaring of drained methane or conversion of methane to CO_2	NO	NO	NA	NA	NA	NA	NA
1.B.1.a.ii - Surface mines	NO	NO	NA	NA	NA	NA	NA
1.B.1.a.ii.1 - Mining	NO	NO	NA	NA	NA	NA	NA
1.B.1.a.ii.2 - Post-mining seam gas emissions	NO	NO	NA	NA	NA	NA	NA
1.B.1.b - Uncontrolled combustion and burning coal dumps	NO	NA	NA	NO	NO	NO	NO
1.B.1.c - Solid fuel transformation	NO	NO	NO	NO	NO	NO	NO
1.B.2 - Oil and Natural Gas	4742.179	3267.793	0.070	11.848	49.444	278.213	2.525
1.B.2.a - Oil	4715.299	2154.086	0.070	0.938	0.352	258.078	2.424
1.B.2.a.i - Venting	0.236	1.136	NA	NA	NA	209.554	NA

Categories	Emissions (Gg)						
	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1.B.2.a.ii - Flaring	4441.599	2.742	0.070	NE	NE	2.193	NA
1.B.2.a.iii - All Other	273.464	2150.209	NO	0.938	0.352	46.331	2.424
1.B.2.a.iii.1 - Exploration	NO	NO	NO	NO	NO	NO	NO
1.B.2.a.iii.2 - Production and Upgrading	273.076	2149.514	NE	NE	NE	NE	NA
1.B.2.a.iii.3 - Transport	0.388	0.592	0.000	NA	NA	9.093	NA
1.B.2.a.iii.4 - Refining	NO	0.102	NA	0.938	0.352	0.782	2.424
1.B.2.a.iii.5 - Distribution of oil products	NO	NO	NA	NA	NA	36.456	NA
1.B.2.a.iii.6 - Other	NO	NO	NO	NO	NO	NO	NO
1.B.2.b - Natural Gas	26.880	1113.707	0.000	10.909	49.093	20.134	0.101
1.B.2.b.i - Venting	0.243	18.300	NA	NA	NA	4.668	NA
1.B.2.b.ii - Flaring	14.182	0.009	0.000	10.909	49.093	14.026	0.101
1.B.2.b.iii - All Other	12.455	1095.398	NA	NA	NA	1.439	NE
1.B.2.b.iii.1 - Exploration	NA	NA	NA	NA	NA	NO	NE
1.B.2.b.iii.2 - Production	7.971	1001.703	NA	NA	NA	0.060	NE
1.B.2.b.iii.3 - Processing	NA	NA	NA	NA	NA	NO	NE
1.B.2.b.iii.4 - Transmission and Storage	0.026	9.665	NA	NA	NA	0.165	NE
1.B.2.b.iii.5 - Distribution	4.458	84.030	NA	NA	NA	1.214	NE
1.B.2.b.iii.6 - Other	NA	NA	NA	NA	NA	NO	NE
1.B.3 - Other emissions from Energy Production	NO	NO	NO	NO	NO	NO	NO
1.C - Carbon dioxide Transport and Storage	NO	NA	NA	NA	NA	NA	NA
1.C.1 - Transport of CO_2	NO	NA	NA	NA	NA	NA	NA
1.C.1.a - Pipelines	NO	NA	NA	NA	NA	NA	NA
1.C.1.b - Ships	NO	NA	NA	NA	NA	NA	NA
1.C.1.c - Other (please specify)	NO	NA	NA	NA	NA	NA	NA
1.C.2 - Injection and Storage	NO	NA	NA	NA	NA	NA	NA
1.C.2.a - Injection	NO	NA	NA	NA	NA	NA	NA
1.C.2.b - Storage	NO	NA	NA	NA	NA	NA	NA
1.C.3 - Other	NO	NA	NA	NA	NA	NA	NA

Categories	Emissions (Gg)						
	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
Memo Items (3)							
International Bunkers	1246.484	0.015	0.035	6.552	0.576	0.247	0.821
1.A.3.a.i - International Aviation (International Bunkers) (1)	1176.440	0.008	0.033	4.776	0.410	0.187	0.373
1.A.3.d.i - International water-borne navigation (International bunkers) (1)	70.044	0.006	0.002	1.776	0.166	0.061	0.448
1.A.5.c - Multilateral Operations (1)(2)	C	C	C	C	C	C	C
Information Items							
CO_2 from Biomass Combustion for Energy Production	304333.889						

5. Industrial Processes and Product Use (IPPU)

5.1. Description of IPPU sector

GHG emissions occur during the process of production of a wide range of industrial products. Emissions arise during the chemical or physical transformation of materials (for example, in the blast furnace in the iron and steel industry, ammonia and other chemical products manufactured when fossil fuels are used as chemical feedstock). The cement industry is another notable example of an industrial process that releases a significant amount of CO_2. During these processes, many different greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), can be produced (2006 IPCC Guidelines V3_1, Ch 1). GHGs are also emitted during non-energy use of hydrocarbons such as thinners and lacquers while HFCs and PFCs are lost from installed equipment. Other gases are also emitted in different sub-categories and include SF_6 and NMVOCs.

Due to data challenges, emissions have not been estimated for most categories of this sector. Full details on the coverage of the IPPU sector can be obtained from the IPCC inventory software results table provided at the end of this section.

The categories and activity areas covered are:

- Mineral Industry - Cement Production
- Chemical Industry - Ammonia Production
- Metal Industry - Iron and Steel Production

5.2. Methods

The 2006 IPCC Guidelines for National GHG Inventories, Volume 3 (IPCC, 2007) were used for computing emissions in conjunction with the IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories (IPCC, 2001). The decision tree in each source category was applied to determine the tier level to be adopted for computing the GHG emissions. Eventually, Tier 1 level was adopted due to data scarcity and the unavailability of national EFs. Hence, IPCC default EFs were adopted. AD for the IPPU categories covered in this inventory were obtained mainly from the National Bureau of Statistics (NBS) supplemented with those from the manufacturers of the products.

The formula used for computing emissions is

$$\text{Emissions} = \sum Aj * Efi$$

Where:

A = Activity is Production Process Input or output (tonnes / year);
J = Industrial Activity
EF = Emission factor (t / kt) and i is GHG or precursor.

5.2.1 Mineral category (2A) - Cement production (2.A.1)

Lime is produced by the thermal decomposition of limestone, which is mainly calcium carbonate ($CaCO_3$). This process, also known as calcination (equation below), produces lime (CaO) and CO_2 as by-product.

$$CaCO_3 + \text{Heat} \leftrightarrow CaO + CO_2$$

The CaO then reacts with silica (SiO_2), alumina (Al_2O_3), and iron oxide (Fe_2O_3) as other raw materials to make the clinker minerals (chiefly calcium silicates). This product is finely ground and mixed with a small proportion of calcium sulphate [gypsum ($CaSO_4 \cdot 2H_2O$) or anhydrite ($CaSO_4$) to produce hydraulic (typically Portland) cement. CO_2 is the main GHG emitted during cement production and it is emitted during calcination. Based on the decision tree in the IPCC 2006 GL (V3_2_Ch2_p 2.9), Tier 1 methodology was used in the estimation of CO_2 due to data constraints.

5.2.2 Chemical industry (2.B) - Ammonia production (2.B.1)

Ammonia (NH_3) is produced by catalytic steam reforming of natural gas or other fuels. When natural gas (CH_4) is used as feedstock, nitrogen and hydrogen undergo chemical reaction in the ratio 1:3. CO_2 is the only direct GHG emitted during ammonia production. The basic equations are:

Overall Reaction: $$\mathbf{0.88\,CH_4 + 1.26\,Air + 1.24\,H_2O \rightarrow 0.88\,CO_2 + N_2 + 3H_2}$$

Ammonia Synthesis: $$\mathbf{N_2 + 3H_2 \rightarrow 2NH_3}$$

Based on the decision tree in the 2006 IPCC Guidelines (V3_3_Ch3_p 3.14) and due to lack of information on the quantity of feedstock fuel used for ammonia production, the Tier 1 methodology was adopted. In this method, it is recommended that the average value of fuel requirement stated in Table 3.1 of the 2006 IPCC Guidelines (IPCC, 2007); (42.5 GJ(NCV) / tonne NH_3) be used. The corresponding values of carbon content of fuel used for production and carbon oxidation factors of the fuel according to the Tier 1 method are 21 kg / GJ and 1 respectively.

The general equation using Tier 1 method used to estimate the emissions associated with ammonia production is:

$$\mathbf{ECO_2 = AP * FR * CCF * COF * 44 / 12 - RC0_2}$$

Where:

- ECO_2 = Emission of CO_2 (kg)
- AP = Ammonia production, tonnes
- FR = Fuel requirement per unit of output (GJ / tonne NH_3 produced)
- CCF = Carbon content of the fuel (kg C / GJ)
- COF = Carbon oxidation factor of the fuel (fraction)
- RCO_2 = CO_2 recovered for downstream use in urea production (kg)

The emissions of the precursor GHGs were calculated using methods prescribed by the EMEP / EEA air pollutant guidebook for Chemical Industry. A Tier 1 method was used to estimate emissions of CO and NO_X.

5.2.3 Metal industry (2.C) - Iron and Steel production (2.C.1)

Three GHGs (CO_2, CH_4 and N_2O) are emitted during the production of Iron and Steel but only CO_2 and CH_4 have been computed as there is no EF in the IPCC 2006 GL for N_2O. The EMEP / EEA air pollutant emission inventory guidebook could not be used as alternative method since the technology adopted in the manufacturing process is not known. Based on the decision tree of the 2006 IPCC Guidelines (V3_4_Ch4_p 4.20), a Tier 1 approach was adopted due to lack of plant specific data. The Global Average Factor of 1.06 based on 65% BOF, 30% EAF and 5% OHF) was used to estimate CO_2 emissions from steelmaking. The equation is

$$\mathbf{E_{CO_2} = EF * AM_{I\,\&\,S}}$$

Where:

ECO_2 = Emission of CO_2 (Gg)
EF = Emission factor (tonne CO_2 / tonnes produced)
AM = Amount of iron and steel produced (tonnes)

The 2006 IPPC guidelines recommend a default EF of 0.1 for coke production when adopting Tier 1 estimation method. This EF is used in the estimation of CH_4 emissions.

The estimation of NMVOCs was carried out using the Tier 1 method provided in the 2016 EMEP / EEA air pollutant emission inventory guidebook. The 2016 EMEP / EEA air pollutant emission inventory guidebook recommended default EF of 150g / mg for NMVOCs for Iron and Steel production was used. The general equation presented below was used to estimate NMVOCs emissions in Iron and Steel production:

$$E\ pollutant = AR\ production * EF\ pollutant$$

Where:

E pollutant = Emission of NMVOCs
AR production = Amount of iron and steel produced yearly in tonnes
EF pollutant = Emission factor for NMVOCs

5.3. Activity Data

5.3.1. Cement production

AD on the production of cement for the period 2000 to 2017 were obtained from the Cement Manufacturer's Association of Nigeria (CMAN). The data are presented in Table 5.1. For the period under review, there was no import or export of clinker.

Table 5.1 - Production of cement (10^3 tonnes) between 2000 and 2017

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
Production	2,165	2,168	2,071	1,981	2,337	2,849	3,209	4,642	6,425

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
Production	7,955	10,100	12,001	16,412	20,068	19,828	21,494	17,650	15,900

Source: Cement Manufacturer's Association of Nigeria

5.3.2. Ammonia production

Data obtained from the National Bureau of Statistics (NBS) on ammonia production was incomplete for the time series of this inventory as it only covered the period 2000 to 2008. It also contained several outliers. Statistical techniques, namely averaging and trending were used with the available data to produce a full timeseries from 2000 to 2016. Data on ammonia production used for estimating emissions are given in Table 5.2.

Table 5.2 - Production (t) of Ammonia (2000 – 2017)

Year	2000	2001	2002	2003	2005	2005	2006	2007	2008
Production	615.46	615.46	694.78	506.41	550.08	494.22	496.94	499.69	502.47

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
Production	505.26	508.07	510.89	513.73	516.58	519.45	522.34	525.03	527.84

Source: National Bureau of Statistics for period 2000 to 2008

5.3.3. Iron and steel production

AD on Iron and Steel production for the period 2000 to 2008, except for 2005 was provided by the NBS. The timeseries was amended and completed for missing years using statistical techniques, namely averaging and linear extrapolation to obtain a full set of data for the period 2000 to 2017. GHG emissions from Iron and Steel production were estimated by using the data presented in Table 5.3.

Table 5.3 - Production of Iron and Steel (t) (2000 – 2017)

Year	2000	2001	2002	2003	2005	2005	2006	2007	2008
Production	1,689,647	1,689,647	1,689,647	4,931,257	4,931,257	4,931,257	4,931,257	4,931,257	4,931,257

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
Production	4,931,257	4,626,679	4,865,468	5,104,257	5,343,046	5,581,835	5,820,624	5,820,624	6,000,000

Source: National Bureau of Statistics for periods (2000-2004 and 2006-2008)

5.4. Emission factors

All EFs used for computing emissions in the IPPU sector were the IPCC defaults adopted from the 2006 IPCC Guidelines. They are listed in Table 5.4 for the three categories estimated.

Table 5.4 - EFs and their sources for the IPPU sector

Category	EF adopted	2006 IPPC Guidelines	Page No.
Cement	0.65 clinker fraction and 0.507 t CO_2 / t clinker	V3_2_Ch2 Mineral Industry	Chapter 2.2.1.2 Page 2.11
Ammonia	3.273 t CO_2 / t NH_3	V3_3_Ch3 Chemical Industry	Table 3.1 Page 3.15
Iron and Steel	1.06 t CO_2 / t produced	V3_4_Ch4 Metal Industry	Table 4.1 Page 4.25

5.5. Trends of national emissions

Total aggregated emissions for the IPPU sector (Table 5.5), increased from 2,511 Gg CO_2-eq in 2000 to 13,271 Gg CO_2-eq in 2015 to regress to 11,618 in 2017. In 2017, the iron and steel industry was responsible for 54.9% of the aggregated emissions followed by the cement industry with 45.1%. The contribution of the ammonia industry was marginal.

Table 5.5 - Emissions (Gg CO_2-eq) by sub-category for the IPPU sector (2000 – 2017)

Year	Cement (CO_2)	Ammonia (CO_2)	Iron and Steel (CO_2)	Iron and steel (CH_4)	Total
2000	714	2.01	1,791	4.73	2,511
2001	714	2.01	1,791	4.73	2,512
2002	682	2.27	1,791	4.73	2,481
2003	653	1.66	5,227	13.81	5,895
2004	770	1.80	5,227	13.81	6,013
2005	939	1.62	5,227	13.81	6,181
2006	1,058	1.63	5,227	13.81	6,300
2007	1,530	1.64	5,227	13.81	6,772
2008	2,117	1.64	5,227	13.81	7,360
2009	2,622	1.65	5,227	13.81	7,864

Year	Cement (CO_2)	Ammonia (CO_2)	Iron and Steel (CO_2)	Iron and steel (CH_4)	Total
2010	3,328	1.66	4,904	12.95	8,247
2011	3,955	1.67	5,157	13.62	9,128
2012	5,409	1.68	5,411	14.29	10,835
2013	6,613	1.69	5,664	14.96	12,294
2014	6,534	1.70	5,917	15.63	12,468
2015	7,083	1.71	6,170	16.30	13,271
2016	5,817	1.72	6,170	16.30	12,004
2017	5,240	1.73	6,360	16.80	11,618

Aggregated emissions by gas are given in Table 5.6. CO_2 emissions multiplied by more than 4 times during the period 2000 to 2017, from 2,507 Gg in the year 2000 to 11602 Gg in 2017 while CH_4 emissions more than tripled from 4.7 Gg CO_2-eq to 16.8 Gg CO_2-eq over the same time period. Otherwise, CO_2 represented 99.9% of all GHG emissions of the IPPU sector in 2016, the remaining 0.14% being CH_4.

Table 5.6 - Trends of aggregated emissions (Gg CO_2-eq) of CO_2 and CH_4 for IPPU sector (2000 – 2017)

Year	CO_2	CH_4	Total
2000	2,507	4.7	2,511
2001	2,508	4.7	2,512
2002	2,476	4.7	2,481
2003	5,882	13.8	5,895
2004	5,999	13.8	6,013
2005	6,168	13.8	6,181
2006	6,286	13.8	6,300
2007	6,759	13.8	6,772
2008	7,346	13.8	7,360
2009	7,850	13.8	7,864
2010	8,234	13.0	8,247
2011	9,114	13.6	9,128
2012	10,821	14.3	10,835
2013	12,279	15.0	12,294
2014	12,453	15.6	12,468
2015	13,255	16.3	13,271
2016	11,988	16.3	12,004
2017	11,602	16.8	11,618

Emissions of the GHG precursors CO, NO_X and NMVOCs were insignificant during the period under review as depicted in Table 5.7. Emissions fluctuated between years for the three gases, CO between 0.00049 and 0.00069 Gg, NOx between 0.00005 to 0.00007 and NMVOCs between 0.25 to 0.90 Gg in 2016 (Table 5.6).

Table 5.7 - Emissions of GHG precursors (Gg) of the IPPU sector (2000 – 2017)

Year	CO (Gg)	NO_X (Gg)	NMVOCs (Gg)
2000	0.00062	0.00006	0.25345
2001	0.00062	0.00006	0.25345
2002	0.00069	0.00007	0.25345

Year	CO (Gg)	NO_X (Gg)	NMVOCs (Gg)
2003	0.00051	0.00005	0.73969
2004	0.00055	0.00006	0.73969
2005	0.00049	0.00005	0.73969
2006	0.00050	0.00005	0.73969
2007	0.00050	0.00005	0.73969
2008	0.00050	0.00005	0.73969
2009	0.00051	0.00005	0.73969
2010	0.00051	0.00005	0.69400
2011	0.00051	0.00005	0.72982
2012	0.00051	0.00005	0.76564
2013	0.00052	0.00005	0.80146
2014	0.00052	0.00005	0.83728
2015	0.00052	0.00005	0.87309
2016	0.00053	0.00005	0.87309
2017	0.00053	0.00005	0.90000

5.5.1. Emissions from cement production

Emissions of CO_2 (Gg) from Cement Production for the period 2000 to 2017 are presented in Figure 5.1. Emissions increased from 714 Gg in the year 2000 to 7,083 Gg in 2015 and regressed to 5,240 in 2017. The lowest emissions of 653 Gg CO_2 occurred in 2003 from 1,981,000 tonnes of cement (CMAN, 2012).

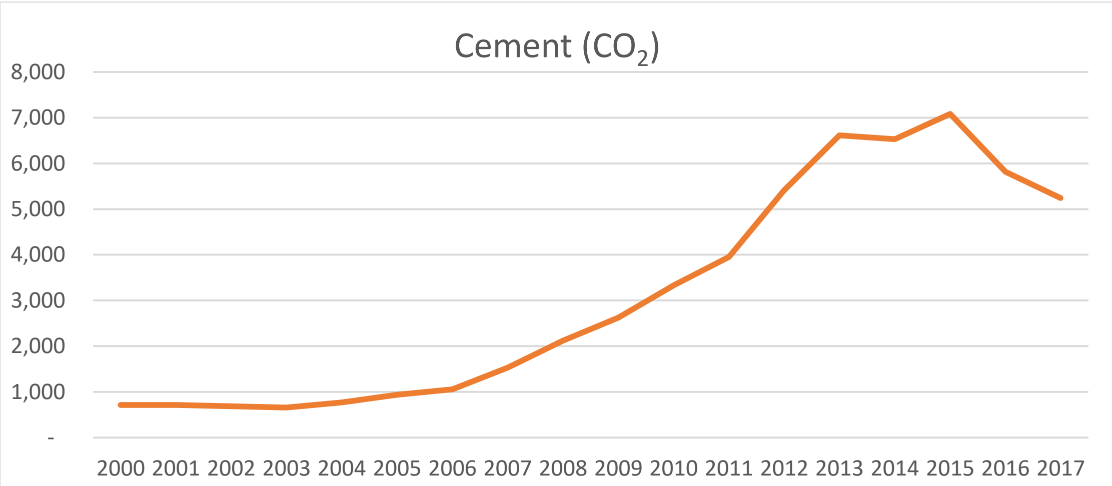


Figure 5.1 - CO_2 Emission (Gg) from Cement Production (2000 – 2017)

5.5.2. Emissions of direct and indirect GHGs (Gg) from ammonia production

Emissions of CO_2 and the GHG precursors CO and NO_X fluctuated over the time series and the amounts emitted during the production of ammonia are presented in Table 5.8. The highest CO_2 emissions of 2.27 Gg CO_2 resulted from the production of 694 tonnes of NH_3 in 2002. The lowest emissions 1.62 Gg of CO_2 was associated with 2005 from a production of only 550 tonnes of ammonia. The highest emissions of CO and NO_X were also associated with the year 2002 with emission of 0.00006 Gg and 0.00069 Gg respectively.

Table 5.8 - Emissions of CO_2, CO and NO_X (Gg) for NH_3 production (2000 – 2017)

Year	CO_2	CO	NO_X
2000	2.014	0.00006	0.00062
2001	2.014	0.00006	0.00062
2002	2.274	0.00007	0.00069
2003	1.657	0.00005	0.00051
2004	1.800	0.00006	0.00055
2005	1.617	0.00005	0.00049
2006	1.626	0.00005	0.00050
2007	1.635	0.00005	0.00050
2008	1.644	0.00005	0.00050
2009	1.653	0.00005	0.00051
2010	1.663	0.00005	0.00051
2011	1.672	0.00005	0.00051
2012	1.681	0.00005	0.00051
2013	1.691	0.00005	0.00052
2014	1.700	0.00005	0.00052
2015	1.709	0.00005	0.00052
2016	1.718	0.00005	0.00053
2017	1.727	0.00005	0.00053

5.5.3. Emissions from Iron and Steel production

Generally, the emissions of the three gases increased by 3.6 times over the time series, inclusive of some variations between years due to fluctuations in the production. CO_2 emissions (Table 5.9) varied between 1791 Gg in 2000 and 6,360 Gg in 2017. CO_2 represented about 93% of emissions in 2017 with CH_4 contributing the remaining 7%. CH_4 emissions increased from 4.73 Gg CH_4, equivalent to 132.47 Gg CO_2-eq. in 2000 to 16.80 Gg, equivalent to 470.40 Gg CO_2-eq in 2017. Emissions of NMVOCs increased from 0.253 Gg in the year 2000 to 0.900 in the year 2017.

Table 5.9 - Emissions of CO_2 and CH_4 from Iron and Steel production (2000 – 2017)

Year	CO_2 (Gg)	CH_4 (Gg)	CH_4 (Gg CO_2-eq)	Total CO_2 and CH_4 (Gg CO_2-eq)	NMVOCs (Gg)
2000	1,791	4.73	132.47	1,923	0.253
2001	1,791	4.73	132.47	1,923	0.253
2002	1,791	4.73	132.47	1,923	0.253
2003	5,227	13.81	386.61	5,614	0.740
2004	5,227	13.81	386.61	5,614	0.740
2005	5,227	13.81	386.61	5,614	0.740
2006	5,227	13.81	386.61	5,614	0.740
2007	5,227	13.81	386.61	5,614	0.740
2008	5,227	13.81	386.61	5,614	0.740
2009	5,227	13.81	386.61	5,614	0.740
2010	4,904	12.95	362.73	5,267	0.694
2011	5,157	13.62	381.45	5,539	0.730
2012	5,411	14.29	400.17	5,811	0.766
2013	5,664	14.96	418.89	6,083	0.801
2014	5,917	15.63	437.62	6,354	0.837
2015	6,170	16.30	456.34	6,626	0.873
2016	6,170	16.30	456.34	6,626	0.873
2017	6,360	16.80	470.40	6,830	0.900

Results of the estimates from the IPCC inventory software for the inventory year 2017 are presented in Table 5.10.

Table 5.10 - Sectoral IPPU table – Inventory Year 2017

Categories	(Gg)			CO2 Equivalents(Gg)					(Gg)			
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors (1)	Other halogenated gases without CO_2 equivalent conversion factors (2)	NO_x	CO	NMVOCs	SO_2
2 - Industrial Processes and Product Use	11601.572	0.600	NE	NE	NE	NE	NE	NE	0.001	5.300E-05	0.900	0.000
2.A - Mineral Industry	5239.845	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.1 - Cement production	5239.845	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.2 - Lime production	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.3 - Glass Production	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.4 - Other Process Uses of Carbonates	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.A.4.a - Ceramics	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.4.b - Other Uses of Soda Ash	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.A.4.c - Non Metallurgical Magnesia Production	NO	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.4.d - Other (please specify) (3)	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.A.5 - Other (please specify) (3)	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B - Chemical Industry	1.727	NO	NO	NO	NO	NO	NO	NO	0.001	5.300E-05	NO	NO
2.B.1 - Ammonia Production	1.727	NA	NA	NA	NA	NA	NA	NA	0.001	5.300E-05	NO	NO
2.B.2 - Nitric Acid Production	NA	NA	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.3 - Adipic Acid Production	NA	NA	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production	NA	NA	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.5 - Carbide Production	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.6 - Titanium Dioxide Production	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.7 - Soda Ash Production	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.8 - Petrochemical and Carbon Black Production	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.8.a - Methanol	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.8.b - Ethylene	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.8.c - Ethylene Dichloride and	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO

Categories	(Gg)			CO2 Equivalents(Gg)					(Gg)			
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors (1)	Other halogenated gases without CO_2 equivalent conversion factors (2)	NO_x	CO	NMVOCs	SO_2
Vinyl Chloride Monomer												
2.B.8.d - Ethylene Oxide	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.8.e - Acrylonitrile	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.8.f - Carbon Black	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.9 - Fluorochemical Production	NA	NA	NA	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B.9.a - By-product emissions (4)	NA	NA	NA	NO	NA	NA	NA	NA	NO	NO	NO	NO
2.B.9.b - Fugitive Emissions (4)	NA	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.10 - Other (Please specify) (3)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C - Metal Industry	6360.000	0.600	NO	NO	NO	NO	NO	NO	NO	NO	0.900	NO
2.C.1 - Iron and Steel Production	6360.000	0.600	NA	NA	NA	NA	NA	NA	NO	NO	0.900	NO
2.C.2 - Ferroalloys Production	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.C.3 - Aluminium production	NO	NA	NA	NA	NO	NA	NA	NA	NO	NO	NO	NO
2.C.4 - Magnesium production (5)	NO	NA	NA	NA	NA	NO	NA	NA	NO	NO	NO	NO
2.C.5 - Lead Production	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.C.6 - Zinc Production	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.C.7 - Other (please specify) (3)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D - Non-Energy Products from Fuels and Solvent Use (6)	NE	NO	NO	NA	NA	NA	NA	NA	NO	NO	NE	NO
2.D.1 - Lubricant Use	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.2 - Paraffin Wax Use	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.3 - Solvent Use (7)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NE	NA
2.D.4 - Other (please specify) (3), (8)	NE	NE	NE	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.E - Electronics Industry	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA
2.E.1 - Integrated Circuit or Semiconductor (9)	NA	NA	NA	NO	NO	NO	NO	NO	NA	NA	NA	NA
2.E.2 - TFT Flat Panel Display (9)	NA	NA	NA	NA	NO	NO	NO	NO	NA	NA	NA	NA
2.E.3 - Photovoltaics (9)	NA	NA	NA	NA	NO	NA	NO	NO	NA	NA	NA	NA
2.E.4 - Heat Transfer Fluid (10)	NA	NA	NA	NA	NO	NA	NO	NO	NA	NA	NA	NA

Categories	(Gg)			CO2 Equivalents(Gg)					(Gg)			
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors (1)	Other halogenated gases without CO_2 equivalent conversion factors (2)	NO_x	CO	NMVOCs	SO_2
2.E.5 - Other (please specify) (3)	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA
2.F - Product Uses as Substitutes for Ozone Depleting Substances	NA	NA	NA	NE	NE	NA	NA	NA	NA	NA	NA	NA
2.F.1 - Refrigeration and Air Conditioning	NA	NA	NA	NE	NE	NA	NA	NA	NA	NA	NA	NA
2.F.1.a - Refrigeration and Stationary Air Conditioning	NA	NA	NA	NE	NE	NA	NA	NA	NA	NA	NA	NA
2.F.1.b - Mobile Air Conditioning	NA	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA
2.F.2 - Foam Blowing Agents	NE	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA
2.F.3 - Fire Protection	NE	NA	NA	NE	NE	NA	NA	NA	NA	NA	NA	NA
2.F.4 - Aerosols	NA	NA	NA	NE	NE	NA	NA	NA	NA	NA	NA	NA
2.F.5 - Solvents	NA	NA	NA	NE	NE	NA	NA	NA	NA	NA	NA	NA
2.F.6 - Other Applications (please specify) (3)	NA	NA	NA	NO	NO	NA	NA	NA	NA	NA	NA	NA
2.G - Other Product Manufacture and Use	NO	NO	NE	NO	NE	NE	NO	NE	NA	NA	NA	NA
2.G.1 - Electrical Equipment	NA	NA	NA	NA	NE	NE	NA	NE	NA	NA	NA	NA
2.G.1.a - Manufacture of Electrical Equipment	NA	NA	NA	NA	NO	NO	NA	NO	NA	NA	NA	NA
2.G.1.b - Use of Electrical Equipment	NA	NA	NA	NA	NE	NE	NA	NE	NA	NA	NA	NA
2.G.1.c - Disposal of Electrical Equipment	NA	NA	NA	NA	NE	NE	NA	NE	NA	NA	NA	NA
2.G.2 - SF6 and PFCs from Other Product Uses	NA	NA	NA	NA	NE	NE	NA	NE	NA	NA	NA	NA
2.G.2.a - Military Applications	NA	NA	NA	NA	NE	NE	NA	NE	NA	NA	NA	NA
2.G.2.b - Accelerators	NA	NA	NA	NA	NE	NE	NA	NE	NA	NA	NA	NA
2.G.2.c - Other (please specify) (3)	NA	NA	NA	NA	NO	NO	NA	NO	NA	NA	NA	NA
2.G.3 - N2O from Product Uses	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.G.3.a - Medical Applications	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.G.3.b - Propellant for pressure and aerosol products	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA

Categories	(Gg)			CO2 Equivalents(Gg)					(Gg)			
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors (1)	Other halogenated gases without CO_2 equivalent conversion factors (2)	NO_x	CO	NMVOCs	SO_2
2.G.3.c - Other (Please specify) (3)	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.G.4 - Other (Please specify) (3)	NA	NA	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.H - Other	NE	NE	NE	NA	NA	NA	NA	NA	NO	NO	NE	NO
2.H.1 - Pulp and Paper Industry	NE	NE	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.H.2 - Food and Beverages Industry	NE	NE	NA	NA	NA	NA	NA	NA	NO	NO	NE	NO
2.H.3 - Other (please specify) (3)	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO

6. Agriculture, Forestry and Other Land Use (AFOLU)

6.1 Description of AFOLU sector

Based on the NC3 (2020), activities in the AFOLU sector are among the highest contributors to emissions of greenhouse gases in Nigeria, which makes it a key category.

The AFOLU sector comprises four subcategories:

- Livestock (3.A)
- Land (3.B)
- Aggregate sources and non-CO_2 emissions from land (3.C)
- Other (3.D)

For this inventory, only livestock (3.A) was fully covered while biomass burning in grassland and crop land as well as use of synthetic fertilizers and rice cultivation were the ones covered for Aggregate sources and non-CO_2 emissions from land (3.C) subcategories. For land (3.B), emissions from changes within Forest land only were estimated due to unavailability of land use change data. This is currently being addressed and it is anticipated that activities within and between all land classes will be covered in the next inventory. Under Other (3.D), removals for harvested wood products (HWP) only were estimated. Due to the characteristics of this sector, a slightly different reporting approach has been adopted compared to the other three sectors.

Reporting does not necessarily follow the sequence description, methods, AD, EFs and results used for Energy, IPPU and Waste but is adapted to suit the categories while keeping it as per the same sequence as far as possible.

6.2 Methods

A mix of Tiers 1 and 2 were adopted for the estimation of emissions and removals in the AFOLU sector as there were no complete set of country-specific data to enable computation at the Tier 2 level solely. AD here refer to the intensity or level of activity that led to emissions / removals of GHGs while EF represents the rate at which a particular GHG is emitted or removed because of use of, change of and level of intensity / frequency of use / number of activity under certain defined conditions. Therefore, the product of AD and EF gives the total GHG emission for a particular activity. The equation is:

$$E = AD * EF$$

Where
E = Emission
AD = Activity Data
EF = Emission factor

Extrapolation and interpolation techniques were used in line with the IPCC good practice guidance (GPG) to generate missing data and replace outliers in the time series. In cases where there were no data, expert judgment was applied, and the assumption was documented. Generally, a few experts in the discipline are called upon to discuss the issue concerned and to provide the best agreed upon data or information to the team leader of this sector for adoption.

6.3 Activity Data

The data needed for this inventory were sourced from different relevant national and international institutions as presented in Table 6.1.

Table 6.1 - Activity Data sources of the AFOLU sector

Category	Sub-category	Data Type	Data Source	Principal Data Provider
Livestock	Enteric Fermentation Manure Management	Animal population (Cattle, goats, sheep, asses and mules, camels, swine, horses and poultry)	FAOSTAT	FAO
Land	Forest Land	Forest area	USGS 2016 Report FRA 2015 NBS report	USGS FAO NBS
		Climate zone and soil classification	IPCC GL	IPCC
		Biomass estimate for 5 IPCC pools (above-ground biomass, below-ground biomass, deadwood, herb, litter and soil	IPCC GL	IPCC
		Harvested Wood Products	FAOSTAT	FAO
		Wood / Fuel wood removal	FAOSTAT	FAO
Aggregate and non-CO_2 emissions on land	Biomass burning	Actual mass of savanna and crop residues burnt	FAOSTAT	FAO
	Direct N_2O emission from managed soil	Synthetic fertilizer consumption	FAOSTAT	FAO
	Indirect N_2O emission from managed soil	Crop land area	FAOSTAT	FAO
	Indirect emissions from manure management	Animal population (Cattle, goats, sheep, asses and mules, camels, swine, horses and poultry)	FAOSTAT	FAO
	Rice cultivation	Area of land under rice	FAOSTAT	FAO

Source: http://faostat.fao.org/ (Accessed April 2020)

Gaps identified in the inventory were filled using appropriate IPCC methodologies. The specific method employed in filling the gaps was selected based on the nature and type of gaps. Data from FAOSTAT was analysed and outliers were replaced using statistical techniques such as averages and trending.

6.3.1 Livestock

Emissions from livestock are generated through enteric fermentation and management of manure from domestic animals such as cattle, sheep, goats, horses, swine, donkeys (asses and mules), camels and poultry. Significant amounts of CH_4 are produced by herbivores during the normal digestive process as microorganisms break down carbohydrates into simpler molecules for absorption. CH_4 is produced as a by-product. Ruminant animals such as cattle generate the most methane while non-ruminant animals such as swine generate minimal amounts. It was estimated that there exists no dairy cattle activity solely for milk production in Nigeria as most of the herd is owned by pastoral Fulani (Obadina, 1999) farmers.

CH_4 and N_2O are the two direct GHGs emitted during handling and storage of livestock manure. The magnitude of emissions depends on the quantity of manure handled, its characteristics, and the manure management system. Generally, poorly aerated manure management systems generate more CH_4 than well-aerated systems. The manure management systems assigned in this inventory are paddock, range and pasture (PRP) and solid storage. All the animals listed for enteric fermentation plus poultry were considered for estimating emissions for manure management.

Emissions from enteric fermentation were calculated using IPCC Tier 1 methodology and default EFs. This was done by multiplying the individual animal population with the default EF of the respective animal type for the specific activity. AD used for computing the emissions for both enteric fermentation and manure management are provided in Table 6.3.

Emissions from manure management were calculated using IPCC Tier 1 methodology and default EFs. This was done by multiplying the individual animal population with the default EF of the respective animal type according to manure management system. The fraction of manure treated under the different manure management systems for each livestock species is given in Table 6.2.

Table 6.2 - Manure management systems (MMS) assigned

Livestock	Manure Management Systems (MMS)		
	PRP	Solid storage	Poultry with litter
Cattle	90%	10%	0%
Sheep	70%	30%	0%
Goats	70%	30%	0%
Camels	90%	10%	0%
Horses	70%	30%	0%
Mules	70%	30%	0%
Swine (market)	60%	40%	0%
Swine (breeding)	60%	40%	0%
Poultry	0%	0%	100%

Table 6.3 - Livestock Population (2000 – 2017)

Year	Livestock category									
	Other cattle	Goat	Sheep	Horses	Asses	Camel	Swine (Breeding)	Swine (Market)	Poultry (broilers)	Poultry (layers)
2000	15,118,300	42,500,000	26,000,000	204,000	1,000,000	80,000	504,762	4,542,862	37,728,000	125,280,000
2001	15,133,400	45,260,400	28,692,600	205,000	1,000,000	100,000	524,954	4,724,586	41,212,800	138,240,000
2002	15,148,600	46,400,000	29,400,000	205,000	1,000,000	120,000	611,182	5,500,642	47,700,000	141,120,000
2003	15,602,601	47,517,330	30,086,406	205,000	949,084	139,716	610,294	5,492,654	52,415,744	144,329,067
2004	15,738,343	48,740,532	30,808,479	204,426	950,033	159,432	609,407	5,484,666	56,864,048	149,718,003
2005	15,875,267	49,959,046	31,547,883	203,215	950,983	179,148	608,519	5,476,678	58,581,844	158,329,309
2006	16,475,622	53,097,487	32,305,000	160,592	951,934	198,864	607,632	5,468,690	62,403,038	165,353,673
2007	17,075,976	56,235,928	33,080,353	147,157	952,886	218,579	606,744	5,460,702	64,961,601	174,182,946
2008	17,676,331	59,374,370	33,874,281	104,053	953,839	238,295	605,857	5,452,714	68,282,339	182,819,435
2009	18,276,685	62,512,811	34,687,264	102,492	954,793	258,011	604,969	5,444,726	69,321,561	194,335,302
2010	18,877,040	65,651,252	37,440,022	101,509	970,610	277,727	604,082	5,436,738	40,765,933	98,452,703
2011	19,041,270	67,292,533	38,376,023	101,611	971,581	278,005	628,245	5,654,208	9,892,989	138,999,854
2012	19,206,929	68,974,847	39,335,423	101,713	972,552	278,283	653,375	5,880,376	19,254,033	140,000,240
2013	19,374,029	70,699,218	40,318,809	101,715	973,525	278,561	679,510	6,115,591	28,959,933	141,392,616
2014	19,542,583	72,466,698	41,326,780	101,817	974,499	278,840	706,690	6,360,215	30,980,956	151,259,967
2015	19,712,604	74,278,367	42,359,948	102,018	975,472	279,118	734,958	6,614,622	46,961,626	148,014,910
2016	19,884,104	76,135,326	43,418,947	102,120	976,447	279,397	764,356	6,879,207	53,162,911	160,126,720
2017	20,057,095	78,038,709	44,504,420	102,222	977,424	279,677	794,930	7,154,376	58,154,909	175,162,618

Source: FAOSTAT, National Statistics - Ministry of Agriculture

6.3.2 Land (3B)

CO_2 is emitted from human activities leading to land use changes. The land use change is the result of conversion of land categories amongst the various IPCC land classes, namely (a) Forest land (FL), (b) Crop land, (c) Grassland, (d) Wetlands, (e) Settlements and (f) Other land. Due to data constraints, only activities within FL have been assessed and emissions estimated. However, in this inventory, data on land use changes were not available and thus emissions stemming from this activity have not been computed.

On the basis of available data from different sources, a land use table with areas of the different IPCC land classes has been constructed with no movement between them. The total area of the country was balanced with corrections made to the Other land category. Information obtained from USGS (2016) together with other sources including FRA (2015), FAO Aquastat and NBS were used to validate the different areas adopted for the period 2000 to 2017. The information is summarized in Table 6.4. The default soil type Low Activity Clay and climate Tropical moist short dry season were adopted since these were considered as being most appropriate to represent the country.

Two categories of forestland were considered, forestland and other wooded land. The areas of land classified in the USGS 2016 report and FRA 2015 were reassigned to fall within the six different IPCC land classes. The area of forestland declined during the timeseries on account of deforestation and wood removals for both merchantable wood and wood fuel.

Cropland was assumed to fall under three subclasses: Cropland Annual for annual crops, Cropland perennial for perennial crops such as coffee, rubber, palm, tea, etc. and rice paddy. Annual cropland relates to rainfed crops produced during part of the year and thereafter used for production of fodder and grazing during the remaining part of the same year. Cultivation of rice paddy is mainly done in wetlands but due to scarcity of information and confirmation of the different areas involved, for this inventory they have been considered as a separate entity as per the 2006 IPCC Guidelines.

There is a mix of permanent grazing land and grassland and these have been summed as area of the Grassland land class.

With the rapidly increasing population of Nigeria, an important change in the area of settlement has been identified, but it has not been possible to track from which land category they originated over the time period under consideration.

Work is under way to improve the estimates of the Land sector by moving to Tier 2 level through the inclusion of land use changes between the IPCC land classes over the full time series as well as confirming the national stock and EFs derived for the country. The land occupation by the six IPCC classes are given in Table 6.4.

Table 6.4 - Land occupation (ha) by the different land classes (2000 – 2017)

Year	Forestland	Cropland Annual	Cropland perennial	Rice paddy	Grassland	Wetland	Settlements	Other land	Area of country
2000	15,796,400	29,029,000	188,800	2,199,000	39,310,800	3,387,600	1,205,200	1,260,100	92,376,900
2001	15,681,908	29,756,138	188,277	2,117,000	38,734,185	3,382,585	1,256,708	1,260,100	92,376,900
2002	15,567,415	30,333,277	187,754	2,185,000	38,157,569	3,377,569	1,308,215	1,260,100	92,376,900
2003	15,452,923	30,953,415	187,231	2,210,000	37,580,954	3,372,554	1,359,723	1,260,100	92,376,900
2004	15,338,431	31,460,554	186,708	2,348,000	37,004,338	3,367,538	1,411,231	1,260,100	92,376,900
2005	15,223,938	31,959,692	186,185	2,494,000	36,427,723	3,362,523	1,462,738	1,260,100	92,376,900
2006	15,109,446	32,373,831	185,662	2,725,000	35,851,108	3,357,508	1,514,246	1,260,100	92,376,900

Year	Forestland	Cropland Annual	Cropland perennial	Rice paddy	Grassland	Wetland	Settlements	Other land	Area of country
2007	14,994,954	33,292,969	185,138	2,451,000	35,274,492	3,352,492	1,565,754	1,260,100	92,376,900
2008	14,880,462	34,007,108	184,615	2,382,000	34,697,877	3,347,477	1,617,262	1,260,100	92,376,900
2009	14,765,969	35,197,366	184,092	1,836,880	34,121,262	3,342,462	1,668,769	1,260,100	92,376,900
2010	14,651,477	35,246,755	183,569	2,432,630	33,544,646	3,337,446	1,720,277	1,260,100	92,376,900
2011	14,536,985	36,055,113	183,046	2,269,410	32,968,031	3,332,431	1,771,785	1,260,100	92,376,900
2012	14,422,492	36,105,847	182,523	2,863,815	32,391,415	3,327,415	1,823,292	1,260,100	92,376,900
2013	14,308,000	36,683,400	182,000	2,931,400	31,814,800	3,322,400	1,874,800	1,260,100	92,376,900
2014	14,193,508	37,178,015	181,477	3,081,923	31,238,185	3,317,385	1,926,308	1,260,100	92,376,900
2015	14,079,015	37,783,515	180,954	3,121,562	0,661,569	3,312,369	1,977,815	1,260,100	92,376,900
2016	13,964,523	38,428,653	180,431	3,121,562	30,084,954	3,307,354	2,029,323	1,260,100	92,376,900
2017	13,700,310	39,917,434	179,224	3,121,562	28,754,303	3,295,780	2,148,187	1,260,100	92,376,900

Wood removals 2000 – 2017

Data for wood removal was available from FAOSTAT. As the data covers different types of wood removed, these were regrouped for calculating the AD for round wood and fuel wood removal in forestland (Table 6.5).

Table 6.5 - Wood removal (m^3) from Forestland (2000 – 2017)

Year	Wood removals	
	Round Wood	Fuel wood
2000	33,709,129	59,348,652
2001	34,229,593	59,697,552
2002	34,784,384	60,064,328
2003	35,437,913	60,449,216
2004	36,175,297	60,852,440
2005	36,907,380	61,274,260
2006	37,616,038	61,629,309
2007	38,353,258	62,000,000
2008	38,486,081	62,388,600
2009	39,558,741	62,793,234
2010	40,208,291	63,214,728
2011	41,065,787	63,599,551
2012	41,716,039	63,999,115
2013	42,512,672	64,413,551
2014	43,629,823	64,843,002
2015	44,487,732	65,287,615
2016	45,167,990	65,583,432
2017	45,953,991	65,891,233

Source: FAOSTAT

Carbon stock factors in different land representations

Default stock factors were used in the different land classes except for forestland where a weighted average based on the area of woodland and forestland were adopted. Different values assigned from the IPPC guidelines, were used to calculate a single value for this land class for the country, as follows:

- Above ground biomass (tdm / ha) = 144.14
- Above ground biomass growth (tdm / ha / yr) = 1.02
- Ratio above to below ground = 0.26
- BCEF (Wood Removal) = 1.44

6.3.3 Aggregate sources and non-CO_2 emissions on land

Aggregate sources and non-CO_2 emissions on land in Nigeria originated from five of the IPCC categories and all activities occurring were covered in this inventory. The categories are

- 3.C.1 Biomass burning
- 3.C.4 Direct N_2O emissions from managed soils
- 3.C.5 Indirect N_2O emissions from managed soils
- 3.C.6 Indirect N_2O emissions from manure management, and
- 3.C.7 CH_4 emissions from rice cultivation.

AD used for estimating the emissions for all these activities obtained from the FAOSTAT database are provided in Table 6.6. Crop residues from maize, wheat and rice are considered burnt as a source of fuel and are thus accounted for in the Energy sector for non-CO_2 gases.

Table 6.6 - Synthetic N-fertilisers used, crop residues burned, and rice cultivated areas (2000 – 2017)

Year	N fertilisers	Crop residues burned	Rice
	Amount (kg N)	Sugar cane (kg dm)	Area (ha)
2000	145,017,450	15,600,000	2,199,000
2001	150,476,550	14,950,000	2,117,000
2002	125,131,000	26,000,000	2,185,000
2003	167,778,000	27,300,000	2,210,000
2004	116,343,000	27,950,000	2,348,000
2005	213,221,000	28,600,000	2,494,000
2006	216,854,000	30,550,000	2,725,000
2007	183,231,150	40,950,000	2,451,000
2008	188,690,250	46,728,500	2,382,000
2009	194,149,350	47,489,000	1,836,880
2010	263,151,000	29,692,000	2,432,630
2011	138,428,000	26,689,481	2,269,410
2012	192,598,730	39,420,645	2,863,815
2013	269,528,610	47,247,582	2,931,400
2014	242,150,990	53,216,800	3,081,923
2015	196,103,730	57,287,904	3,121,562
2016	288,746,460	59,142,350	3,121,562
2017	444,698,540	57,861,133	3,121,562

Source: FAOSTAT [http://faostat.fao.org/ (Accessed April 2020)]

The method used for estimating emissions for these sub-categories is in accordance with the 2006 IPCC Guidelines using default emission and stock factors.

6.3.4 Other (3D) - Harvested Wood Products (3.D.1)

Merchantable wood harvested from Forest Land remain as wood products for differing lengths of time after their transformation. This constitutes a carbon reservoir. HWP includes all wood (including bark) that leaves harvest sites. Slash and other material left at harvest sites were regarded as dead organic matter. The time during which carbon is held in products varies according to the product and its uses. For example, fuel wood and mill residue may be burned in the year of harvest; many types of paper are likely to have a useful life of less than 5 years which may include recycling of paper; and sawn wood or panels used in buildings may be held for decades to over 100 years.

All the data on production, imports and exports of round wood, sawn wood, wood-based panels, paper and paper board, wood pulp and recycled paper, industrial round wood, chip and particles, wood charcoal and wood residues were obtained from FAOSTAT database (http://faostat.fao.org/). Most data were available since 1960 but there existed some gaps. All data from 1961 from the FAO time series were used and categorized in their required field for calculations. The data from FAOSTAT was summarized according to the classification given in Table 6.7.

Table 6.7 - Reclassification of information available from FAOSTAT

FAOSTAT Classification	Reclassification for inventory
Wood fuel, coniferous	Roundwood
Wood fuel, non-coniferous	Roundwood
Industrial roundwood, non-coniferous tropical (export / import)	Industrial roundwood
Sawnlogs and veneer logs, non-coniferous	Sawnwood
Other industrial roundwood, non-coniferous (production)	Other Industrial Roundwood
Wood charcoal	Wood charcoal
Wood residues	Wood residues
Sawnwood, coniferous	Sawnwood
Sawnwood, non-coniferous all	Sawnwood
Veneer sheets	Wood-based panels
Plywood	Wood-based panels
Particle board and OSB (1961-1994)	Wood-based panels
Other fibreboard	Wood-based panels
Fibreboard, compressed (1961-1994)	Wood-based panels
Semi-chemical wood pulp	Wood Pulp (1875)+ recycled paper
Chemical wood pulp	Wood Pulp (1875)+ recycled paper
Chemical wood pulp, sulphate, unbleached	Wood Pulp (1875)+ recycled paper
Chemical wood pulp, sulphate, bleached	Wood Pulp (1875)+ recycled paper
Chemical wood pulp, sulphite, bleached	Wood Pulp (1875)+ recycled paper
Recovered paper	Wood Pulp (1875)+ recycled paper
Newsprint	Paper+Paperboard
Printing and writing papers	Paper+Paperboard
Other paper and paperboard	Paper+Paperboard
Wrapping and packaging paper and paperboard	Paper+Paperboard
Other paper and paperboard n.e.s. (not elsewhere specified)	Paper+Paperboard

6

Only data for round wood export had to be amended as the increase in export values exceeded the concurrent increase in production. Thus, the average of export data for the other years of the timeseries plus a nominal increase of 100,000 m^3 based on increase in production was adopted as AD for 2014 to 2016 and 200,000 m^3 for 2017. The AD used for the estimation are provided in Tables 6.8 and 6.9.

Table 6.8 - Activity data for HWP (1961 – 2017)

Year	Roundwood (m^3)			Sawnwood (m^3)			Wood-based panels (m^3)			Paper+Paperboard (t)			Wood Pulp (1875)+ recycled paper (t)		
	Production	Import	Export	Production	Import	Export	Production	Import	Export	Production	Import	Export	Production	Import	Export
1961	36,237,496	0	0	1,596,000	0	794,900	20,000	10,300	18,000	0	20,300	0	0	0	0
1962	36,526,920	0	0	1,379,000	0	651,100	26,000	10,200	23,000	0	20,500	0	0	0	0
1963	36,818,660	0	0	6,284,000	6,400	743,800	30,000	9,900	21,000	0	28,600	0	0	0	0
1964	37,112,728	0	0	1,639,000	2,200	859,500	34,000	10,600	22,000	0	34,600	0	0	0	0
1965	37,409,148	0	0	1,660,000	1,700	667,000	31,000	10,550	24,000	0	51,900	0	0	0	0
1966	37,707,936	0	0	1,736,000	100	634,600	25,000	7,407	21,000	0	56,000	200	0	0	0
1967	38,009,104	0	0	1,699,000	0	385,200	23,000	6,433	14,900	0	51,700	400	0	0	0
1968	38,312,684	0	0	1,507,000	0	372,900	24,000	3,559	16,800	0	55,400	400	0	1,700	0
1969	38,618,684	0	0	1,756,000	0	418,700	28,000	7,770	12,100	0	74,400	0	0	2,700	0
1970	38,927,132	0	0	1,966,000	0	266,100	23,000	13,019	21,000	0	118,700	0	0	6,400	0
1971	38,456,528	0	0	1,966,000	0	248,800	46,800	13,019	20,500	0	146,500	0	0	6,400	0
1972	39,120,820	0	0	1,966,000	0	227,600	50,900	13,019	20,500	0	114,500	0	0	6,400	0
1973	39,079,844	0	0	2,415,201	0	362,300	60,800	15,768	17,000	0	131,700	0	0	4,300	0
1974	38,684,456	0	0	1,957,101	4,600	281,900	72,600	13,546	29,600	0	167,600	0	0	6,700	0
1975	39,881,944	0	0	3,144,000	3,000	105,300	65,500	35,825	1,000	0	156,700	0	0	11,800	0
1976	39,727,676	0	0	3,144,000	3,500	28,300	67,700	52,900	0	0	224,800	0	0	12,200	0
1977	39,919,640	0	0	3,144,000	17,700	11,100	67,700	129,000	0	0	210,700	0	0	5,100	0
1978	41,526,896	0	0	5,384,000	0	11,100	88,100	119,500	0	0	224,300	0	5,000	5,100	0
1979	41,664,504	0	0	5,968,000	0	11,100	102,400	118,200	0	0	204,500	0	3,000	5,100	0
1980	42,150,384	0	0	7,756,000	0	11,100	94,000	168,500	0	24,000	175,300	0	3,000	4,700	0
1981	44,266,220	0	0	9,163,000	2,400	26,700	149,000	157,500	0	22,000	403,500	0	3,000	4,700	0
1982	45,324,120	0	0	8,272,000	700	102,400	147,000	129,500	0	20,000	287,800	0	3,000	4,700	0
1983	47,251,696	0	0	7,448,000	1,600	51,500	144,000	117,000	0	18,000	287,400	0	3,000	5,100	0
1984	48,402,404	0	0	7,790,000	1,700	60,900	144,000	23,100	0	32,000	188,800	0	6,000	3,200	0
1985	48,040,816	0	0	8,867,000	1,100	60,400	104,000	23,100	0	80,000	180,800	0	30,800	3,200	0
1986	49,243,784	0	0	8,301,000	1,100	60,400	102,000	23,100	0	102,000	94,600	0	36,600	3,200	0
1987	50,822,432	0	0	8,595,000	1,100	17,200	102,000	6,000	0	76,000	32,500	0	37,600	3,200	0
1988	50,645,764	0	0	8,595,000	173	16,482	102,000	11,798	0	82,000	116,811	0	38,600	2,100	0

Year	Roundwood (m^3)			Sawnwood (m^3)			Wood-based panels (m^3)			Paper+Paperboard (t)			Wood Pulp (1875)+ recycled paper (t)		
	Production	Import	Export	Production	Import	Export	Production	Import	Export	Production	Import	Export	Production	Import	Export
1989	50,786,024	0	0	8,595,000	68	11,288	102,000	3,234	0	61,000	63,273	0	18,600	2,100	0
1990	50,916,960	0	0	8,713,000	225	29,074	102,000	3,308	0	55,000	99,757	0	18,600	4,200	0
1991	51,733,968	0	0	8,703,000	225	29,074	105,000	3,308	0	37,000	99,757	0	18,600	0	0
1992	52,854,280	0	0	8,699,000	536	41,366	112,000	19,328	159	29,000	170,771	29,369	18,600	4,155	0
1993	54,030,624	0	0	8,695,000	200	35,280	105,000	9,055	371	7,000	156,646	19	18,600	7,832	0
1994	55,524,128	0	0	8,517,000	273	46,819	103,000	4,579	892	6,000	161,388	19	18,600	4,127	0
1995	56,765,876	0	0	8,340,000	255	14,443	100,000	12,855	189	8,500	102,152	19	18,600	6,741	0
1996	57,672,528	0	0	8,378,000	500	25,300	98,000	19,920	372	1,376	85,000	19	18,600	6,908	0
1997	58,661,088	0	266	8,800,000	2,862	46,010	95,000	11,925	260	1,000	130,793	19	32,000	6,764	650
1998	58,456,792	0	266	9,100,000	400	60,600	95,000	11,925	260	19,000	217,982	0	45,000	6,764	650
1999	58,912,676	0	1,060	9,100,000	1,300	50,000	95,000	89,100	0	19,000	234,331	0	45,000	23,900	0
2000	59,387,652	0	1,060	9,100,000	900	54,000	95,000	49,300	0	19,000	292,200	3,200	45,000	19,500	0
2001	59,736,552	0	1,060	9,100,000	1,300	38,300	95,000	73,800	300	19,000	299,100	3,200	45,000	17,900	0
2002	60,103,328	0	1,060	9,100,000	2,220	38,300	95,000	76,139	78	19,000	315,100	3,200	45,000	17,900	0
2003	60,488,216	0	1,060	9,100,000	998	21,779	95,000	54,299	83	19,000	410,608	3,200	45,000	17,900	0
2004	60,891,440	0	1,060	9,100,000	1,616	20,710	95,000	42,302	96	19,000	496,428	3,200	45,000	18,100	0
2005	61,313,260	0	1,060	9,102,000	335	39,916	96,000	42,450	125	19,000	496,428	3,200	45,000	18,100	0
2006	61,668,309	0	1,060	9,102,000	680	26,365	96,000	80,415	76	19,000	496,428	3,200	45,000	18,100	0
2007	62,039,000	0	1,060	9,102,000	122	24,057	97,000	126,232	81	19,000	565,952	3,200	45,000	18,100	0
2008	62,427,600	434	1,883	9,102,000	2,918	15,677	97,000	114,059	2,795	19,000	574,675	1,858	45,000	71,966	5,319
2009	62,832,234	434	1,883	9,102,000	2,751	7,561	97,000	94,930	2,616	19,000	585,928	473	45,000	44,763	3,683
2010	63,253,728	434	28	9,102,000	2,399	11,192	97,000	141,654	76	19,000	559,277	363	45,000	70,329	4,266
2011	63,638,551	434	28	9,102,000	4,600	5,616	97,000	269,453	310	19,000	927,261	1,022	45,000	51,629	2,992
2012	64,038,115	165	74	9,102,000	5,959	7,666	97,000	200,152	247	19,000	409,375	495	45,000	34,861	12,522
2013	64,452,551	28	74	9,102,000	10,132	7,226	97,000	337,390	104	19,000	835,205	651	57,000	41,088	23,414
2014	64,865,002	919	297	9,602,000	10,287	8,586	97,000	285,581	286	19,000	872,655	2,263	57,000	67,813	10,894
2015	65,309,615	919	407	9,602,000	985	16,061	97,000	303,659	378	19,000	644,951	3,738	57,000	62,410	7,660
2016	65,605,432	919	371	9,602,000	3,139	6,108	97,000	260,121	5,227	19,000	797,046	2,264	57,000	135,820	3,151
2017	65,912,862	0	371	9,602,000	699	27,435	97,000	252,177	8,137	19,000	752,629	4,221	57,000	158,489	984

Table 6.9 - Activity data for HWP (1961 – 2017)

	Industrial roundwood (m^3)			Chips and particles (m^3)		Wood charcoal (t)			Wood residues (m^3)	
	Production	Import	Export	Import	Export	Production	Import	Export	Import	Export
1961	1,095,000	400	200	0	0	771,261	0	0	0	0
1962	1,128,000	900	0	0	0	794,540	0	0	0	0
1963	1,185,000	0	6,700	0	0	818,523	0	0	0	0
1964	1,235,000	0	8,400	0	0	843,229	0	0	0	0
1965	1,239,000	0	3,900	0	0	868,680	0	0	0	0
1966	1,583,000	0	0	0	0	894,900	0	0	0	0
1967	1,626,000	0	0	0	0	921,912	0	0	0	0
1968	1,675,000	0	0	0	0	949,739	0	0	0	0
1969	1,722,000	0	0	0	0	978,405	0	0	0	0
1970	1,762,000	0	0	0	0	1,007,937	0	0	0	0
1971	1,805,000	0	0	0	0	1,014,300	0	0	0	0
1972	1,850,000	0	0	0	0	1,055,688	0	0	0	0
1973	1,898,000	0	4,500	0	0	1,076,642	0	0	0	0
1974	1,863,000	0	6,900	0	0	1,087,104	0	0	0	0
1975	1,914,000	0	1,900	0	0	1,149,970	0	0	0	0
1976	1,968,000	0	0	0	0	1,168,026	0	0	0	0
1977	2,025,000	0	0	0	0	1,198,482	0	0	0	0
1978	2,089,000	0	0	0	0	1,279,394	0	0	0	0
1979	2,151,000	0	0	0	0	1,311,257	0	0	0	0
1980	2,279,000	0	0	0	0	1,357,001	0	0	0	0
1981	2,279,000	0	0	0	0	1,469,004	0	0	0	0
1982	2,279,000	0	0	0	0	1,545,258	0	0	0	0
1983	2,279,000	0	0	0	0	1,658,896	0	0	0	0
1984	2,279,000	0	0	0	0	1,745,863	0	0	0	0
1985	2,279,000	0	0	0	0	1,773,315	0	0	0	0
1986	2,279,000	0	0	0	0	1,867,006	0	0	0	0
1987	2,279,000	0	0	0	0	1,980,778	0	0	0	0
1988	2,279,000	0	0	0	0	2,020,427	0	0	0	0
1989	2,279,000	0	0	0	0	2,075,513	0	0	0	0
1990	2,279,000	0	7,678	0	0	2,131,778	0	0	0	0
1991	2,279,000	658	19,875	0	0	2,210,445	0	0	0	0
1992	2,279,000	0	4,193	0	0	2,314,797	41	8,234	0	
1993	2,279,000	0	999	0	0	2,420,873		11,843	0	970

	Industrial roundwood (m^3)			Chips and particles (m^3)		Wood charcoal (t)			Wood residues (m^3)	
	Production	Import	Export	Import	Export	Production	Import	Export	Import	Export
1994	2,279,000	1,950	3,210	0	0	2,542,902	21	11,492	0	53
1995	2,279,000	1,950	11,292	0	0	2,646,794	21	1,394	0	53
1996	2,279,000	1,950	11,239	0	0	2,763,475	21	16,800	0	53
1997	2,279,000	1,950	11,376	0	0	2,872,535	22	16,858	0	31
1998	2,279,000	500	10,947	0	0	2,922,971	22	16,000	0	0
1999	2,279,000	0	7,300	0	0	3,006,209	200	11,700	0	0
2000	2,279,000	0	7,300	0	0	3,085,072	-	28,000	0	0
2001	2,279,000	500	3,800	0	0	3,165,781	-	22,298	0	0
2002	2,279,000	288	2,000	0	0	3,248,602	-	17,019	0	0
2003	2,279,000	64	2,119	0	0	3,333,589	-	26,010	0	0
2004	2,279,000	500	40,000	0	0	3,420,800	-	42,096	0	0
2005	2,279,000	723	38,255	0	0	3,510,292	-	52,306	0	0
2006	2,279,000	60	32,420	0	0	3,592,327	-	71,332	0	0
2007	2,279,000	742	69,868	0	0	3,676,300	-	90,971	0	0
2008	2,279,000	1,365	64,506	0	0	3,762,200	136	24,312	5,498	0
2009	2,279,000	630	58,348	0	0	3,850,113	9	87,858	122	0
2010	2,279,000	54	109,950	0	0	3,940,089	24	88,345	25	2
2011	2,279,000	1,491	106,268	0	0	4,022,763	16	126,201	25	15
2012	2,279,000	116	108,226	6,409	0	4,107,172	88	132,278	206	1,000
2013	2,279,000	810	127,673	1,246	0	4,193,352	193	156,999	33	2,000
2014	2,400,000	2,144	213,029	1,246	0	4,281,341	346	140,486	1	2,000
2015	2,400,000	1,009	213,029	1,246	0	4,371,175	213	171,148	1	56
2016	2,400,000	716	213,029	600	0	4,444,581	138	194,145	0	5
2017	2,400,000	1,129	313,029	252	0	4,519,220	301	226,739	0	68

Source: - FAOSTAT accessed on 12 Mar 2019

6.4 Trend of national emissions

Emissions and removals by category of the AFOLU sector are given in Table 6.10. Total emissions stood at 389,790 Gg CO_2-eq in 2017 with a removal of 4,543 Gg CO_2-eq under HWP to give net emissions of 385,248 Gg CO_2-eq which is the highest emissions for the entire period under consideration. Compared to emissions of 301,970 Gg CO_2-eq for the year 2000, those of 2017 represented an increase of about 28%. The highest emitter of the AFOLU sector is the Land category, Forestland remaining Forestland which is the only activity area computed in this inventory, with 82.1% of total emissions. Livestock followed with 9.9% and Aggregate sources and non-CO_2 emissions on land with 8.0%. HWP removed 1.2 % of total emissions.

Net emissions increased from 296,062 Gg CO_2-eq in the year 2000 to 385,248 Gg CO_2-eq in 2017, an increase of 30.0%. Emissions from Land (Forestland remaining Forestland) represented about 83.1% of 2016 net emissions of 366,734 Gg CO_2-eq. Livestock and Aggregated sources and non-CO_2 source on land contributed 10.0 % and 8.1 % of net emissions respectively.

Table 6.10 - Emissions and removals (Gg CO_2-eq) by source categories (2000 – 2017)

Year	Total emissions	Livestock (3A)	Land (3B)	Aggregate sources and non-CO_2 emissions on land (3C)	Other (3D) (HWP)	Net emissions
2000	301,970	25,296	256,674	20,000	-5,908	296,062
2001	306,131	26,205	259,641	20,284	-5,786	300,345
2002	309,999	26,598	262,771	20,630	-5,651	304,348
2003	314,851	27,303	266,267	21,282	-5,623	309,228
2004	319,492	27,760	270,082	21,650	-5,551	313,940
2005	325,040	28,220	273,939	22,881	-5,339	319,701
2006	331,070	29,376	277,513	24,182	-5,226	325,844
2007	335,509	30,552	281,226	23,731	-5,225	330,284
2008	338,957	31,714	283,105	24,138	-5,069	333,887
2009	343,968	32,905	287,973	23,090	-4,925	339,043
2010	351,483	34,292	291,571	25,620	-4,796	346,687
2011	355,361	34,867	295,704	24,791	-5,336	350,025
2012	361,925	35,450	299,235	27,240	-4,277	357,648
2013	367,524	36,047	303,270	28,207	-5,021	362,504
2014	373,884	36,657	308,355	28,872	-5,345	368,538
2015	379,036	37,280	312,676	29,081	-4,830	374,206
2016	383,882	37,920	315,977	29,985	-4,791	379,090
2017	389,790	38,576	319,971	31,244	-4,543	385,248

Aggregated emissions by gas for the AFOLU sector is presented in Table 6.11. Emissions increased over the time series for all 3 gases, namely by 25% for CO_2, 50% for CH_4 and 64% for N_2O. In 2017, CO_2 contributed 319,971 Gg, CH_4 46,755 Gg CO_2-eq and N_2O 23,065 Gg CO_2-eq. CO_2 remained the main gas emitted over the entire period 2000 to 2017 with 82.1% of total annual emissions followed by CH_4 with about 12.0% and N_2O with about 5.9% in 2017.

Table 6.11 - Emissions by gas (Gg CO_2-eq) for the AFOLU sector (2000 – 2017)

Year	CO_2	CH_4	N_2O	Total
2000	256,674	31,201	14,095	301,970
2001	259,641	31,807	14,683	306,131
2002	262,771	32,380	14,848	309,999
2003	266,267	33,141	15,443	314,851
2004	270,082	34,002	15,408	319,492
2005	273,939	34,890	16,211	325,040
2006	277,513	36,714	16,843	331,070
2007	281,226	37,009	17,274	335,509
2008	283,105	37,919	17,932	338,957
2009	287,973	37,395	18,600	343,968
2010	291,571	40,579	19,333	351,483
2011	295,704	40,622	19,036	355,361
2012	299,235	42,999	19,691	361,925
2013	303,270	43,774	20,481	367,524
2014	308,355	44,814	20,714	373,884
2015	312,676	45,528	20,832	379,036
2016	315,977	46,135	21,770	383,882
2017	319,971	46,755	23,065	389,790

Emissions of the precursor gas NO_X increased by 67%, from 0.122 Gg in 2000 to 0.203 in 2017. Emissions of CO increased 2.25 times from the year 2000 to the year 2017 and that of N_2O by 64% (Table 6.12).

Table 6.12 - Emissions and removals (Gg) by precursor gas for the AFOLU sector (2000 – 2017)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
NO_X emissions	0.122	0.128	0.142	0.15	0.149	0.161	0.158	0.18	0.181
CO emissions	2.811	2.884	3.679	3.868	3.882	4.127	4.165	5.062	5.367

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
NO_X emissions	0.171	0.126	0.133	0.143	0.118	0.173	0.201	0.206	0.203
CO emissions	5.236	3.598	3.7	4.369	4.347	5.569	6.241	6.414	6.296

6.4.1 Livestock

Total emissions from livestock increased from 23,340 Gg CO_2-eq in 2000 to 35,474 Gg CO_2-eq in 2017 which represented an increase of 52%. Enteric fermentation contributed of 92% of the total emissions from livestock in 2017 and manure management added the remaining 8% (Table 6.13).

Table 6.13 - Emissions (Gg CO_2-eq) from livestock

Year	Enteric fermentation	Manure management	Total
2000	23,340	1,956	25,296
2001	24,148	2,057	26,205
2002	24,470	2,128	26,598
2003	25,127	2,175	27,303
2004	25,543	2,217	27,760
2005	25,961	2,260	28,220

Year	Enteric fermentation	Manure management	Total
2006	27,031	2,345	29,376
2007	28,119	2,434	30,552
2008	29,194	2,520	31,714
2009	30,293	2,612	32,905
2010	31,668	2,625	34,292
2011	32,179	2,688	34,867
2012	32,700	2,750	35,450
2013	33,232	2,815	36,047
2014	33,775	2,882	36,657
2015	34,330	2,950	37,280
2016	34,896	3,025	37,920
2017	35,474	3,103	38,576

6.5.1.1 Enteric Fermentation (3.A.1)

In 2017, total emissions of CH_4 from enteric fermentation were 35,474 Gg CO_2-eq, making up for about 92% of the total livestock emissions for that year. This was 52% higher than emissions of the year 2000. In 2017, cattle contributed 49% of the total emissions of enteric fermentation, closely followed by goats (31%) and sheep (18%). Camels, mules, swine and horses made up for the remaining 2% (Table 6.14).

Table 6.14 - Emissions (Gg CO_2-eq) from enteric fermentation by animal type (2000 – 2017)

Year	Cattle	Sheep	Goat	Camels	Horses	Mules and Asses	Swine	Total
2000	13,123	3,640	5,950	103	103	280	141	23,340
2001	13,136	4,017	6,336	129	103	280	147	24,148
2002	13,149	4,116	6,496	155	103	280	171	24,470
2003	13,543	4,212	6,652	180	103	266	171	25,127
2004	13,661	4,313	6,824	205	103	266	171	25,543
2005	13,780	4,417	6,994	231	102	266	170	25,961
2006	14,301	4,523	7,434	256	81	267	170	27,031
2007	14,822	4,631	7,873	282	74	267	170	28,119
2008	15,343	4,742	8,312	307	52	267	170	29,194
2009	15,864	4,856	8,752	332	52	267	169	30,293
2010	16,385	5,242	9,191	358	51	272	169	31,668
2011	16,528	5,373	9,421	358	51	272	176	32,179
2012	16,672	5,507	9,656	358	51	272	183	32,700
2013	16,817	5,645	9,898	359	51	273	190	33,232
2014	16,963	5,786	10,145	359	51	273	198	33,775
2015	17,111	5,930	10,399	360	51	273	206	34,330
2016	17,259	6,079	10,659	360	51	273	214	34,896
2017	17,410	6,231	10,925	360	52	274	223	35,474

6.5.1.2 Manure Management (3.A.2)

Total aggregated emissions increased from 1,956 Gg CO_2-eq in 2000 to 3103 Gg CO_2-eq in 2017 representing an increase of 59% (Table 6.15). In 2017, N_2O contributed about 45% of the total aggregated emissions from manure management and methane the remaining 55%.

Table 6.15 - Trend of aggregated CH_4 and N_2O emissions (2000 - 2017) from manure management (Gg CO_2-eq)

Year	Nitrous Oxide	Methane	Total
2000	841	1,115	1,956
2001	893	1,164	2,057
2002	922	1,206	2,128
2003	942	1,234	2,175
2004	962	1,256	2,217
2005	982	1,278	2,260
2006	1,022	1,323	2,345
2007	1,063	1,370	2,434
2008	1,104	1,416	2,520
2009	1,147	1,465	2,612
2010	1,176	1,448	2,625
2011	1,207	1,481	2,688
2012	1,236	1,514	2,750
2013	1,266	1,548	2,815
2014	1,298	1,584	2,882
2015	1,329	1,621	2,950
2016	1,363	1,661	3,025
2017	1,399	1,704	3,103

Emissions by animal type for manure management is given in Table 6.16. The highest emission was from Goats throughout the timeseries under consideration and it stood at 1212 Gg CO_2-eq in 2017. In the same year, emissions from cattle made up for 23.5% of the total emissions from manure management. The contributions of the other animal types were sheep (18.7%), goats (39.1%). The remaining animal species made up for the remaining 18.7%.

Table 6.16 - Emission (Gg CO_2-eq) trend by animal type for manure management systems (2000 – 2017)

Year	Cattle	Sheep	Goat	Camels	Horses	Mules and Asses	Swine	Poultry	Total
2000	549	340	660	6	24	47	204	125	1,956
2001	549	375	703	8	25	47	213	138	2,057
2002	550	384	721	10	25	47	248	145	2,128
2003	566	393	738	11	25	45	247	150	2,175
2004	571	403	757	13	24	45	247	158	2,217
2005	576	412	776	14	24	45	246	166	2,260
2006	598	422	825	16	19	45	246	174	2,345
2007	620	432	873	17	18	45	246	183	2,434
2008	641	443	922	19	12	45	245	192	2,950
2009	663	453	971	20	12	45	245	202	2,612
2010	685	489	1,020	22	12	46	245	106	2,625
2011	691	502	1,045	22	12	46	254	116	2,688
2012	697	514	1,071	22	12	46	265	123	2,750
2013	703	527	1,098	22	12	46	275	131	2,815
2014	709	540	1,125	22	12	46	286	141	2,882
2015	715	554	1,154	22	12	46	298	149	2,950
2016	721	567	1,182	22	12	46	310	163	3,025
2017	728	582	1,212	22	12	46	322	179	3,103

6.4.2 Emissions from Land (3B)

The estimated CO_2 emissions from land (FL) increased from 256,674 Gg CO_2 in 2000 to reach 319,971 Gg CO_2 in 2017 (Figure 6.1). In 2017, CO_2 emissions from land contributed about 85% of the total emissions in the AFOLU sector. Though forestland is a natural sink of CO_2, the situation at the national level is not so, as emissions exceeded removals. A general increase in net CO_2 emissions is observed, due to deforestation and increased wood removals in the existing areas.

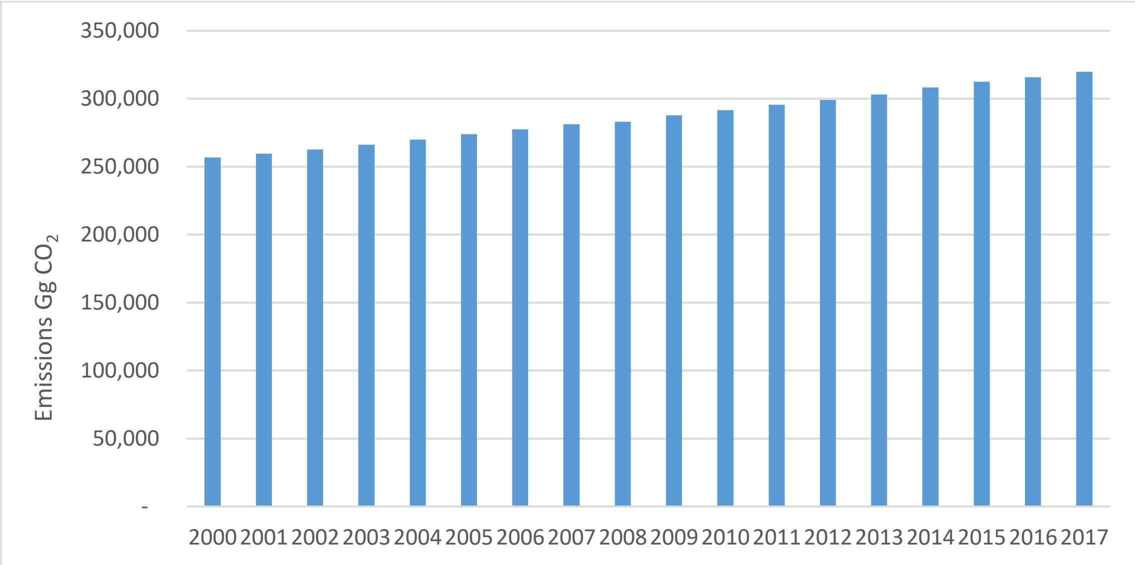


Figure 6.1 - Trend of emissions in Forestland

In 2017, the total aggregated emissions amounted to 31,244 Gg CO_2-eq, representing 10% of the total emissions of the AFOLU sector for that year (Table 6.17). Compared to the year 2000 (20,000 Gg CO_2-eq), total emissions increased by 49.9%. Direct and indirect emissions of N_2O from managed soils added to indirect emissions from manure management contributed about 69.3% of the overall emissions from this category in 2017 while rice cultivation contributed about 30.6%. The contribution from savannah and crop residues burning was insignificant at 0.1%. Emissions from sub-categories evolved from 2000 to 2016 at varying degrees with 54% increase from Agricultural soils, 42% for Rice Cultivation and nearly a 4-fold increase for crop residue burning. Savannah burning on the other hand decreased by 29.5 % during the same period.

Table 6.17 - Aggregate sources and non-CO_2 emissions (Gg CO_2-eq) on land (2000 – 2017)

Year	Rice Cultivation	Agricultural soils	Savanna burning	Crop residues burning	Total
2000	6,743	13,253	2.5	1.5	20,000
2001	6,492	13,789	2.8	1.4	20,284
2002	6,700	13,924	2.5	2.4	20,630
2003	6,777	14,500	2.6	2.6	21,282
2004	7,200	14,445	2.4	2.6	21,650
2005	7,648	15,228	2.8	2.7	22,881
2006	8,356	15,820	2.5	2.9	24,182
2007	7,516	16,209	2.4	3.9	23,731
2008	7,304	16,827	2.0	4.4	24,138
2009	5,633	17,451	1.6	4.5	23,090
2010	7,460	18,156	1.6	2.8	25,620
2011	6,959	17,828	1.4	3.0	24,791
2012	8,782	18,453	1.4	3.7	27,240

Year	Rice Cultivation	Agricultural soils	Savanna burning	Crop residues burning	Total
2013	8,989	19,213	1.1	4.4	28,207
2014	9,451	19,415	1.2	5.0	28,872
2015	9,572	19,501	1.8	5.4	29,081
2016	9,572	20,405	1.8	5.6	29,985
2017	9,572	21,664	1.8	5.4	31,244

Emissions of precursor gases from this category is given in Table 6.18. These gases, NOx and CO, were emitted from savannah burning and burning of crop residues. NO_X emissions increased by 69.9% from 0.122 Gg in year 2000 to reach 0.203 in 2017. CO emissions more than doubled, increasing by 124% from 2.811 Gg to 6.296 Gg from 2000 to 2017.

Table 6.18 - Emissions of precursor gases (Gg) from Aggregate sources and non-CO_2 emissions on Land (2000 – 2017)

Year	NO_X	CO
2000	0.122	2.811
2001	0.128	2.884
2002	0.142	3.679
2003	0.150	3.868
2004	0.149	3.882
2005	0.161	4.127
2006	0.158	4.165
2007	0.180	5.062
2008	0.181	5.367
2009	0.171	5.236
2010	0.126	3.598
2011	0.133	3.700
2012	0.143	4.369
2013	0.118	4.347
2014	0.173	5.569
2015	0.201	6.241
2016	0.206	6.414
2017	0.203	6.296

6.5.3 Direct and indirect emissions of N_2O from managed soils (3.C.4 and 3.C.5)

Direct N_2O emissions from managed soils, the major share of this category, increased by 62.2% from 9918 Gg CO_2-eq in 2000 to 16,089 Gg CO_2-eq in 2016 (Figure 6.2). Indirect emissions reached 5,575 Gg CO_2-eq in 2016 from 3,335 Gg CO_2-eq in 2000, representing an increase of 67.2% over that period.

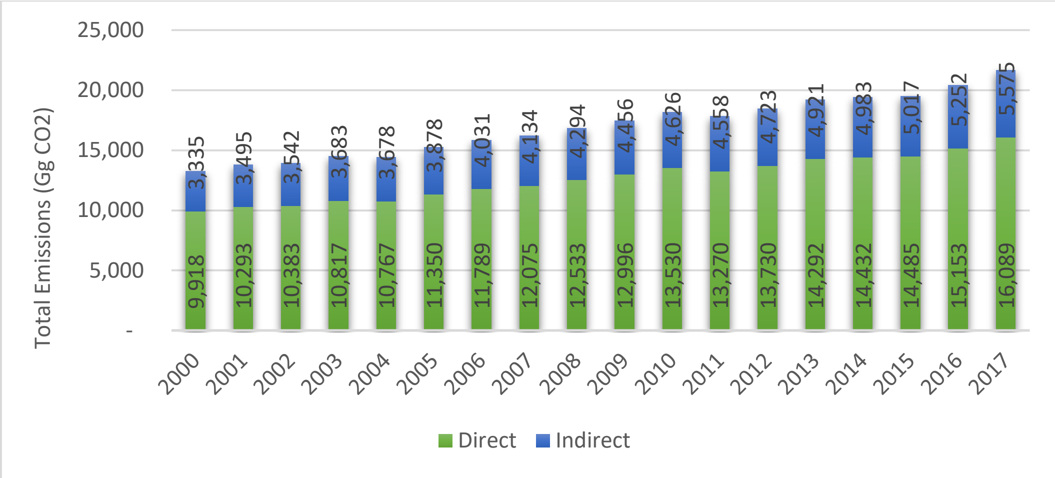


Figure 6.2 - Emission trends by direct and indirect emissions of N_2O from soil management

6.4.5 Rice cultivation (3.C.7)

The IPCC Tier 1 methodology with default EFs was used for estimating emissions from rice cultivation. AD for area under rice were those used for generating the land matrix. Defaults EFs were used for management practices.

CH_4 emissions from rice cultivation varied from year to year during the time series on account of fluctuating areas under cultivation. Overall, emissions increased by 42% from 241 Gg in 2000 to 342 Gg in 2017. That is from 6,743 in 2000 to 9,571 in 2017 Gg CO_2-eq. Emissions from rice cultivation constituted about 30% of the total emissions from Aggregate sources and non-CO_2 emission from land (3.C) over the time series. Figure 6.3 depicts the trend of aggregated emissions from rice cultivation.

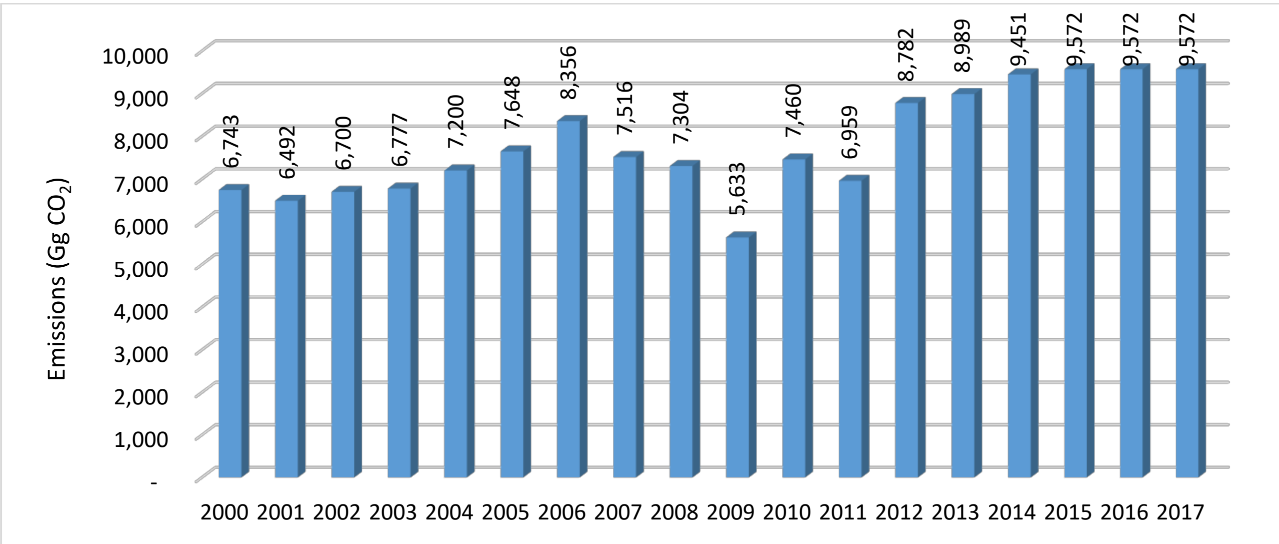


Figure 6.3 - Emissions trend in rice cultivation

HWPs represented a sink of CO_2 which fluctuated during the period 2000 and 2017. The evolution of removals through HWP is given in Figure 6.4. There was an overall tendency for removals to decrease between 2000 and 2016 from -5958 to -4288 Gg CO_2.

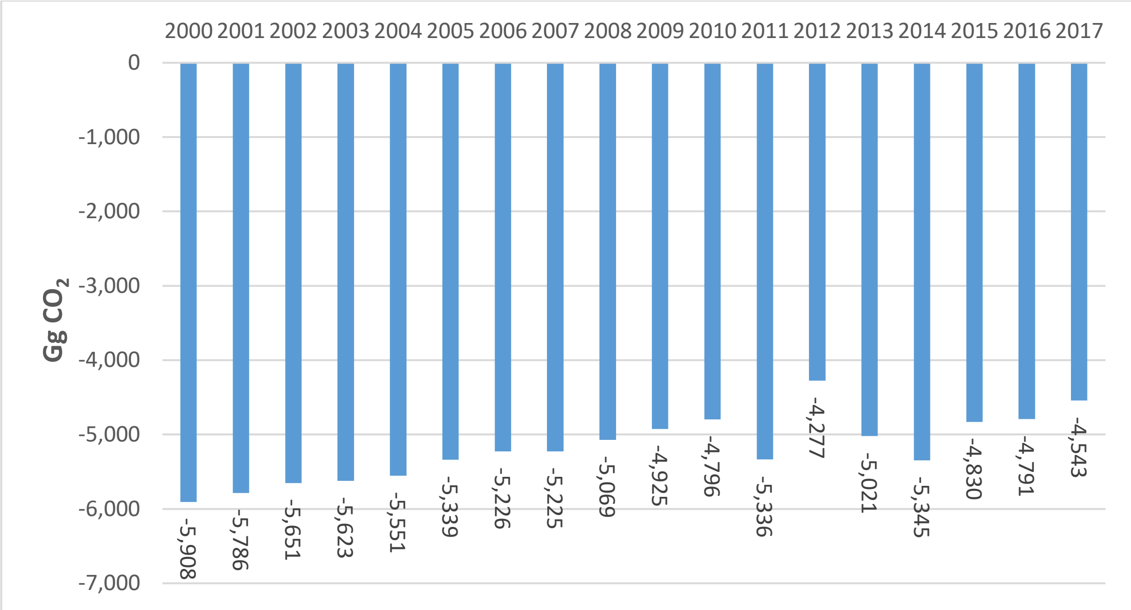


Figure 6.4 - CO_2 removed and stored in HWP

Results of estimates from the IPCC inventory software are presented in Table 6.19.

Table 6.19 - AFOLU sector results – Inventory year 2017

Categories	Emissions (Gg)					
	Net CO_2 emissions / removals	Emissions				
		CH_4	N_2O	NOx	CO	NMVOCs
3 - Agriculture, Forestry, and Other Land Use	315427.959	1669.820	87.037	0.203	6.296	NE
3.A - Livestock	NA	1327.769	5.278	NA	NA	NE
3.A.1 - Enteric Fermentation	NA	1266.914	NA	NA	NA	NA
3.A.1.a - Cattle	NA	621.770	NA	NA	NA	NA
3.A.1.a.i - Dairy Cows	NA	0.183	NA	NA	NA	NA
3.A.1.a.ii - Other Cattle	NA	621.770	NA	NA	NA	NA
3.A.1.b - Buffalo	NA	NO	NA	NA	NA	NA
3.A.1.c - Sheep	NA	222.522	NA	NA	NA	NA
3.A.1.d - Goats	NA	390.194	NA	NA	NA	NA
3.A.1.e - Camels	NA	12.865	NA	NA	NA	NA
3.A.1.f - Horses	NA	1.840	NA	NA	NA	NA
3.A.1.g - Mules and Asses	NA	9.774	NA	NA	NA	NA
3.A.1.h - Swine	NA	7.949	NA	NA	NA	NA
3.A.1.j - Other (please specify)	NO	NO	NO	NO	NO	NO
3.A.2 - Manure Management (1)	NA	60.855	5.278	NA	NA	NE
3.A.2.a - Cattle	NA	20.057	0.627	NA	NA	NE
3.A.2.a.i - Dairy cows	NA	0.002	0.002	NA	NA	NE
3.A.2.a.ii - Other cattle	NA	20.057	0.627	NA	NA	NE
3.A.2.b - Buffalo	NA	NO	NO	NA	NA	NO
3.A.2.c - Sheep	NA	8.901	1.254	NA	NA	NE
3.A.2.d - Goats	NA	17.169	2.760	NA	NA	NE
3.A.2.e - Camels	NA	0.716	0.008	NA	NA	NE
3.A.2.f - Horses	NA	0.224	0.022	NA	NA	NE
3.A.2.g - Mules and Asses	NA	1.173	0.050	NA	NA	NE
3.A.2.h - Swine	NA	7.949	0.375	NA	NA	NE
3.A.2.i - Poultry	NA	4.666	0.181	NA	NA	NE
3.A.2.j - Other (please specify)	NO	NO	NO	NO	NO	NO
3.B - Land	319970.583	NE	NE	NE	NE	NE

Categories	Emissions (Gg)					
	Net CO_2 emissions / removals	Emissions				
		CH_4	N_2O	NOx	CO	NMVOCs
3.B.1 - Forest land	319970.583	NE	NE	NE	NE	NE
3.B.1.a - Forest land Remaining Forest land	319970.583	NE	NE	NE	NE	NE
3.B.1.b - Land Converted to Forest land	NE	NE	NE	NE	NE	NE
3.B.1.b.i - Cropland converted to Forest Land	NE	NE	NE	NE	NE	NE
3.B.1.b.ii - Grassland converted to Forest Land	NE	NE	NE	NE	NE	NE
3.B.1.b.iii - Wetlands converted to Forest Land	NE	NE	NE	NE	NE	NE
3.B.1.b.iv - Settlements converted to Forest Land	NE	NE	NE	NE	NE	NE
3.B.1.b.v - Other Land converted to Forest Land	NE	NE	NE	NE	NE	NE
3.B.2 - Cropland	NE	NE	NE	NE	NE	NE
3.B.2.a - Cropland Remaining Cropland	NE	NE	NE	NE	NE	NE
3.B.2.b - Land Converted to Cropland	NE	NE	NE	NE	NE	NE
3.B.2.b.i - Forest Land converted to Cropland	NE	NE	NE	NE	NE	NE
3.B.2.b.ii - Grassland converted to Cropland	NE	NE	NE	NE	NE	NE
3.B.2.b.iii - Wetlands converted to Cropland	NE	NE	NE	NE	NE	NE
3.B.2.b.iv - Settlements converted to Cropland	NE	NE	NE	NE	NE	NE
3.B.2.b.v - Other Land converted to Cropland	NE	NE	NE	NE	NE	NE
3.B.3 - Grassland	NE	NE	NE	NE	NE	NE
3.B.3.a - Grassland Remaining Grassland	NE	NE	NE	NE	NE	NE
3.B.3.b - Land Converted to Grassland	NE	NE	NE	NE	NE	NE
3.B.3.b.i - Forest Land converted to Grassland	NE	NE	NE	NE	NE	NE
3.B.3.b.ii - Cropland converted to Grassland	NE	NE	NE	NE	NE	NE
3.B.3.b.iii - Wetlands converted to Grassland	NE	NE	NE	NE	NE	NE
3.B.3.b.iv - Settlements converted to Grassland	NE	NE	NE	NE	NE	NE
3.B.3.b.v - Other Land converted to Grassland	NE	NE	NE	NE	NE	NE
3.B.4 - Wetlands	NE	NE	NE	NE	NE	NE
3.B.4.a - Wetlands Remaining Wetlands	NE	NE	NE	NE	NE	NE
3.B.4.a.i - Peatlands remaining peatlands	NE	NE	NE	NE	NE	NE
3.B.4.a.ii - Flooded land remaining flooded land	NE	NE	NE	NE	NE	NE
3.B.4.b - Land Converted to Wetlands	NE	NE	NE	NE	NE	NE
3.B.4.b.i - Land converted for peat extraction	NE	NE	NE	NE	NE	NE
3.B.4.b.ii - Land converted to flooded land	NE	NE	NE	NE	NE	NE
3.B.4.b.iii - Land converted to other wetlands	NE	NE	NE	NE	NE	NE
3.B.5 - Settlements	NE	NA	NA	NA	NA	NA
3.B.5.a - Settlements Remaining Settlements	NE	NA	NA	NA	NA	NA
3.B.5.b - Land Converted to Settlements	NE	NA	NA	NA	NA	NA

Categories	Emissions (Gg)					
	Net CO_2 emissions / removals	Emissions				
		CH_4	N_2O	NOx	CO	NMVOCs
3.B.5.b.i - Forest Land converted to Settlements	NE	NA	NA	NA	NA	NA
3.B.5.b.ii - Cropland converted to Settlements	NE	NA	NA	NA	NA	NA
3.B.5.b.iii - Grassland converted to Settlements	NE	NA	NA	NA	NA	NA
3.B.5.b.iv - Wetlands converted to Settlements	NE	NA	NA	NA	NA	NA
3.B.5.b.v - Other Land converted to Settlements	NE	NA	NA	NA	NA	NA
3.B.6 - Other Land	NE	NA	NA	NA	NA	NA
3.B.6.a - Other land Remaining Other land	NE	NA	NA	NA	NA	NA
3.B.6.b - Land Converted to Other land	NE	NA	NA	NA	NA	NA
3.B.6.b.i - Forest Land converted to Other Land	NE	NA	NA	NA	NA	NA
3.B.6.b.ii - Cropland converted to Other Land	NE	NA	NA	NA	NA	NA
3.B.6.b.iii - Grassland converted to Other Land	NE	NA	NA	NA	NA	NA
3.B.6.b.iv - Wetlands converted to Other Land	NE	NA	NA	NA	NA	NA
3.B.6.b.v - Settlements converted to Other Land	NE	NA	NA	NA	NA	NA
3.C - Aggregate sources and non-CO_2 emissions sources on land (2)	NE	342.051	81.760	0.203	6.296	NA
3.C.1 - Emissions from biomass burning	NA	0.191	0.007	0.203	6.296	NA
3.C.1.a - Biomass burning in forest lands	NA	NE	NE	NE	NE	NA
3.C.1.b - Biomass burning in croplands	NA	0.156	0.004	0.145	5.325	NA
3.C.1.c - Biomass burning in grasslands	NA	0.034	0.003	0.058	0.971	NA
3.C.1.d - Biomass burning in all other land	NA	NO	NO	NO	NO	NA
3.C.2 - Liming	NE	NA	NA	NA	NA	NA
3.C.3 - Urea application	NE	NA	NA	NA	NA	NA
3.C.4 - Direct N2O Emissions from managed soils (3)	NA	NA	60.714	NA	NA	NA
3.C.5 - Indirect N2O Emissions from managed soils	NA	NA	19.831	NA	NA	NA
3.C.6 - Indirect N2O Emissions from manure management	NA	NA	1.208	NA	NA	NA
3.C.7 - Rice cultivation	NA	341.860	NA	NA	NA	NA
3.C.8 - Other (please specify)	NE	NO	NO	NA	NA	NA
3.D - Other	-90.347	NO	NO	NO	NO	NO
3.D.1 - Harvested Wood Products	-90.347	NA	NA	NA	NA	NA
3.D.2 - Other (please specify)	NO	NO	NO	NO	NO	NO

7. Waste

7.1. Description of Waste Sector

Economic activities lead to the generation of both solid and liquid wastes. These wastes can be further divided into domestic and industrial wastes as listed below:

- Solid waste: Municipal solid waste and industrial solid waste
- Wastewater: Domestic wastewater and industrial wastewater.

Daily anthropogenic activities produce wastes consisting of different materials, including plastics, wood, paper, food remains, etc. which must be dealt with in safe manners to prevent environmental pollution and degradation which can cause waste related diseases.

Currently in Nigeria, waste is often disposed of in very inefficient ways. Nigeria currently has very limited or no engineered landfills where proper techniques used to reduce potential contamination of water tables via leachate or where the generated methane can be captured and possibly used to produce energy or flared. Solid wastes are mostly disposed of at unmanaged land fill sites. Some of the dump sites are subject to minimal management even if they are not the engineered landfill sites required for proper storage of municipal waste. On the other hand, liquid waste is disposed of into open sewers, septic tanks, sea, rivers, lakes and latrines.

GHG emissions from the Waste sector result largely from disposal of solid wastes through landfilling, dumping, incineration, open burning and treatment of domestic and industrial liquid wastes. The emissions, from solid waste are CH_4 from disposal sites and predominantly CO_2 from open burning of waste. Wastewater can also be a source of methane (CH_4) when treated or disposed of anaerobically as well as of nitrous oxide (N_2O) emissions. Key factors that affect emissions generation are population growth, rural-urban drift and improper management of waste both at its source of generation and its final fate.

The 2006 IPCC Guidelines divide the Waste sector into the following source categories: Solid Waste Disposal (4A), Biological Treatment of solid waste (4B), Incineration and Open Burning (4C) and Wastewater Treatment and Discharge (4D). Each source category is further divided into sub-categories that take into account different waste attributes, management practices and approaches.

Analysis of solid waste disposal led to the choice of 2 categories for computing emissions of the Waste sector in Nigeria. These are Unmanaged Waste Disposal and Open Burning.

During the period under review, the waste categories from which emission data were captured were as follows:

- 4.A.2 - Unmanaged Waste Disposal Sites;
- 4.C.2 - Open Burning of Waste; and
- 4.D.1 - Domestic Wastewater Treatment and Discharge.

7.1.1. Solid Waste Disposal (4.A)

Anaerobic decomposition of MSW high in carbon content, emits mainly CH_4 while aerobic treatment and open burning or incineration yields mostly CO_2. In Nigeria, there are no engineered or sanitary landfills. Thus, municipal solid wastes either find their way into managed dump sites where compaction and sand filling of waste occurs or unmanaged ones where non-segregated waste is often heaped and occasionally the waste is burned to reduce the volume and health hazards. The latter constitutes most dump sites. Solid waste disposal activities are further categorized into: Managed Waste Disposal Sites (4.A.), Unmanaged Waste Disposal Sites (4.A.2) and Uncategorized Waste Disposal Sites (4.A.3).

7.1.2. Unmanaged Waste Disposal Sites (4.A.2)

The available data on the quantity of municipal solid waste (MSW) generated in major cities in Nigeria were utilized together with key socioeconomic data to estimate waste generation during the study period for the national inventory of solid waste. This data and characterisation of MSW using the estimation protocol specified by the IPCC for the unmanaged waste disposal sites were utilized to estimate GHG emissions from MSW in Nigeria.

7.1.3. 7.3 Open Burning (4.C.2)

Emissions of CO_2 and CH_4 emanate from open burning of municipal solid wastes which is presently practised in Nigeria due to the inability to collect all waste generated, especially in the rural areas, insufficient resources in the urban areas and the inexistence of managed engineered landfill sites.

7.1.4. Domestic Wastewater Treatment and Discharge (4.D.1)

Wastewater treatment is divided into Domestic wastewater treatment and discharge (4.D.1), and Industrial wastewater treatment and discharge (4.D.2). Both situations are encountered in the country. However, due to lack of AD, Industrial Wastewater Treatment and Discharge subcategory has not been covered in this inventory. Domestic wastewater in Nigeria is yet to be treated efficiently in reticulated networks on the municipal scale and often ends up in septic tanks and latrines while a portion is also discharged through closed sewers / channels and into rivers, lakes and the sea.

7.2. Methods

The decision tree of the 2006 IPCC Guidelines was used to choose the most appropriate method for computing emissions of this sector. There is a paucity of data on specificity and management of waste, such as annual information on the amount and composition of waste generated, the specifics of waste management practices in both the rural and urban areas of the country, the waste generation rate in the industry and other relevant data. This resulted in the adoption of Tier 1 methodology.

Under this Tier 1 methodology waste emission is computed by the formula:

$$E = AD * EF$$

Where:
E = emissions (tonne CO_2-eq)
AD is the activity data (population and waste generation rate)
EF is emission factor (tonne CO_2-eq / tonne waste.

7.3. Activity Data

7.3.1 Solid waste

7.3.1.1 Solid Waste Disposal (4.A) - Unmanaged Waste Disposal Sites (4.A.2)

Data used in the estimation of GHG emissions from solid waste handling include: national and state population figures; waste generation rate per capita; solid waste stream characteristics; etc. Sources of these data included the National Bureau of Statistics (NBS), National Population Commission (NPC) for urban and rural population fraction, Central Bank of Nigeria for GDP, Energy Commission of Nigeria (ECN), the Department of Climate Change (DCC) of the Federal Ministry of Environment, Literature, published statistics in national reports and Waste Management Authorities such as the Lagos Waste Management Authority (LAWMA), amongst others. Factors used in the calculation of the GHG contribution from the waste sector include dry matter content, fraction of carbon in dry matter, fraction of fossil carbon and oxidation factor. The information provided in Table 7.1 was adopted for generating AD for computing emissions from solid waste. The following assumptions were also adopted for computing emissions in the Waste sector:

- Default values for methane generation rate constant k, degradable organic content and other variables are based on default values for a tropical wet climate country in the West Africa region available in the software.
- 100% of collected waste ends up in unmanaged shallow dumps less than 5 m deep.
- Waste generation data for the country are based on the urban waste amount collected in the state capitals and urban areas for the year 2005.
- The waste generation rate is constant for the entire time series.
- Waste generated by 30% of the rural fraction of the population and 55% of the urban are collected and sent to the dump sites. This represented between 40.7 to 43.9 % from 2000 to 2017 being sent to solid waste disposal sites on average for the country.
- AD for Solid Waste for the period 1990 to 1999 was generated using the trending technique for the % of waste disposed in Solid Waste Disposal Sites (SWDS) in order to capture decomposition happening from solid waste disposed of prior to the year 2000, the starting point of the time series of this inventory
- Per capita waste generation rate is set at an increasing rate from 119.02 in 1990 reaching 182.5 kg / annum in 2000. It was kept at this constant value of 182.5 kg / annum up to 2017.

Table 7.1 - MSW generated and treatment data (2000 – 2017)

Year	Population ($x10^3$)	Urban fraction of Population	Rural fraction of Population	Total MSW [Gg]	% sent to SWDS	Total MSW sent to unmanaged dumpsites [Gg]
2000	122,880	0.43	0.57	22,425	40.7	9,118
2001	126,010	0.43	0.57	22,997	40.8	9,382
2002	129,250	0.44	0.56	23,588	41.0	9,671
2003	132,580	0.45	0.55	24,196	41.2	9,969
2004	136,030	0.45	0.55	24,825	41.3	10,253
2005	139,610	0.46	0.54	25,479	41.5	10,573
2006	143,320	0.47	0.53	26,156	41.7	10,907
2007	147,150	0.48	0.52	26,855	41.9	11,252
2008	151,120	0.48	0.52	27,579	42.1	11,611
2009	155,210	0.49	0.51	28,326	42.3	11,982
2010	159,420	0.50	0.50	29,094	42.5	12,365
2011	163,770	0.51	0.49	29,888	42.6	12,732
2012	168,240	0.51	0.49	30,704	42.8	13,141
2013	172,820	0.52	0.48	31,536	43.0	13,560
2014	177,480,	0.53	0.47	32,390	43.2	13,993
2015	182,200	0.53	0.47	33,252	43.7	14,531
2016	187,050	0.54	0.46	34,136	43.8	14,952
2017	195,870	0.55	0.45	35,746	43.9	15,693

Another set of assumptions was used to generate industrial waste. These are provided below, and the AD generated from industrial activities is depicted in Table 7.2.

70% of the industrial solid waste makes its way to the unmanaged dump sites with about 30% unaccounted for due to collection inefficiencies.

Industrial waste generation rate is indexed on GDP data from World Bank (2020). The rate of production was fixed at 8 kg per 1000 USD GDP throughout the time series.

Industrial solid waste has the same final fate as MSW.

Table 7.2 - Industrial solid waste generated (2000 – 2017)

Year	GDP [million]	Total Industrial Waste [Gg]	Total waste sent to SWDS [Gg]
2000	169,200	1,353.6	947.5
2001	179,213	1,433.7	1,003.6
2002	206,685	1,653.5	1,157.4
2003	221,870	1,775.0	1,242.5
2004	242,394	1,939.2	1,357.4
2005	258,001	2,064.0	1,444.8
2006	273,634	2,189.1	1,532.4
2007	291,670	2,333.4	1,633.4
2008	311,400	2,491.2	1,743.8
2009	336,427	2,691.4	1,884.0
2010	363,360	2,906.9	2,034.8
2011	382,647	3,061.2	2,142.8
2012	398,833	3,190.7	2,233.5
2013	425,440	3,403.5	2,382.5
2014	452,285	3,618.3	2,532.8
2015	464,282	3,714.3	2,600.0
2016	456,775	3,654.2	2,557.9
2017	460,457	3,683.7	2,578.6

7.3.1.2 Incineration and Open Burning of Waste (4.C.2)

The decision tree of the 2006 IPCC Guidelines (Vol 5 Ch5 p5.9) guided the choice of method for estimating emissions from Open Burning. The Tier 1 approach was adopted due to scarcity of AD and lack of country specific EFs. AD for Open Burning was generated from available information and based on the following assumptions.

- 30% of the urban fraction of the population and 40% of the rural fraction of the population engage in open burning of waste.
- The fraction of waste burned relative to the amount of waste treated is assumed to be 0.6 for all years. This is based on the example in the 2006 IPCC Guidelines Chapter Volume 5, Chapter 5 - Incineration and Open Burning of Waste.

Required information, namely population, fraction of urban and rural population, total MSW generated and the fraction burned are captured in Table 7.3.

Table 7.3 - Annual open burning at solid waste disposal sites (fraction of population burning waste) (2000 – 2017)

Year	Population (x103)	Urban Fraction of Population	Rural Fraction of population	MSW Waste (Gg / year)	Fraction of population burning waste Pfrac	Amt of waste open burned (Gg / yr)
2000	122,880	0.43	0.57	22,425	0.359	4,799
2001	126,010	0.43	0.57	22,997	0.356	4,913
2002	129,250	0.44	0.56	23,588	0.356	5,028
2003	132,580	0.45	0.55	24,196	0.356	5,148
2004	136,030	0.45	0.55	24,825	0.353	5,271
2005	139,610	0.47	0.53	25,479	0.356	5,398
2006	143,320	0.47	0.53	26,156	0.353	5,535
2007	147,150	0.48	0.52	26,855	0.353	5,667
2008	151,120	0.48	0.52	27,579	0.351	5,807
2009	155,210	0.49	0.51	28,326	0.351	5,952
2010	159,420	0.50	0.50	29,094	0.351	6,101
2011	163,770	0.51	0.49	29,888	0.351	6,140
2012	168,240	0.51	0.49	30,704	0.348	6,411
2013	172,820	0.52	0.48	31,536	0.348	6,572
2014	177,480	0.53	0.47	32,390	0.348	6,736
2015	182,200	0.53	0.47	33,252	0.345	7,083
2016	187,050	0.54	0.46	34,136	0.345	7,227
2017	195,870	0.55	0.45	35,746	0.345	7,417

7.3.2 Wastewater Handling (4D) – Domestic Wastewater Treatment and Discharge (4.D.1)

Domestic wastewater releases CH_4 when organic components in the wastewater biodegrade anaerobically while they release N_2O as an intermediate product when nitrogen components in wastewater undergo nitrification (an aerobic process) and denitrification (an anaerobic process). Production of CH_4 associated with wastewater depends primarily on the quantity of degradable organic matter in the wastewater, the temperature, and the type of treatment system. It is important to note that wastewater in closed underground sewers is not believed to be a significant source of CH_4.

The decision tree of the 2006 IPCC Guidelines (Vol5-Ch6-p6.10) guided the estimation of GHG emissions from this subcategory. Domestic wastewater in the software is allocated as three categories of population based on income: rural, urban low and urban high. The degree of adoption and fraction of population income are applied to generate the organically degradable material in wastewater. AD generated based on the assumptions listed below and used in the computation of emissions from wastewater are presented in Table 7.4.

Domestic wastewater is not efficiently treated in wastewater treatment plants.

Latrines of the pit type in Nigeria are mostly communal and ground water table are often higher than latrine. This is consistent with the wet climate assumed for the country.

Treatment methods selected were sea, river and lake discharge, stagnant sewer, latrine (wet climate) and septic system.

Table 7.4 - Average organically degradable material in domestic wastewater (Kg BOD / Yr) (2000 – 2017)

Year	Population (x103)	Average protein content in diet (kg / person / year)	Organically degradable material in domestic wastewater (TOW) (kg)
2000	122,880	58	1,659,494,400
2001	126,010	58	1,701,765,050
2002	129,250	58	1,745,521,250
2003	132,580	59	1,790,492,900
2004	136,030	60	1,837,085,150
2005	139,610	62	1,885,433,050
2006	143,320	62	1,935,536,600
2007	147,150	62	1,987,260,750
2008	151,120	63	2,040,875,600
2009	155,210	64	2,096,111,050
2010	159,420	66	2,152,967,100
2011	163,770	66	2,211,713,850
2012	168,240	66	2,272,081,200
2013	172,820	67	2,333,934,100
2014	177,480	68	2,396,867,400
2015	182,200	70	2,460,611,000
2016	187,050	70	2,526,110,250
2017	195,870	70	2,577,699,350

[7]

Adoption rate of different types of waste treatment method provided for Nigeria in Table 6.5 of 2006 IPCC Guidelines Volume 5 Chapter 6 were used for all years in the time series. Table 7.5 summarizes the information used for calculations.

Table 7.5 - Use rate of different types of wastewater treatment across Nigeria

Region	Septic tank	Latrine	Other	Sewer	None
Rural	0.02	0.28	0.04	0.10	0.56
Urban High income	0.32	0.31	0.00	0.37	0.00
Urban low income	0.17	0.24	0.05	0.34	0.20

[8]

The computation of emissions is based on the available degradable organic component in the wastewater, TOW, which is multiplied by the EF according to treatment type. The emissions factors adopted, based on the maximum CH_4 producing capacity and CH_4 correction factor for each treatment type, are presented in Table 7.6.

Table 7.6 - Emission factor for domestic wastewater calculations

Type of Treatment / discharge	Maximum Methane producing capacity-BO [kg CH_4 / kg BOD]	Methane correction factor for each treatment system - MCFj	Emission Factor [kg CH_4 / kg BOD]
Stagnant sewer	0.6	0.5	0.30
Latrine, wet climate	0.6	0.7	0.42
Septic System	0.6	0.5	0.30
Sea, river and lakes	0.6	0.1	0.06

7.4 Trend of national emissions

7.4.1 Aggregated emissions by source category

Table 7.7 summarizes the annual emissions from the Waste sector for the years 2000 to 2017. The Waste sector emitted 30,857 Gg CO_2-eq in 2017. This represents an increase of 78.8 % from year 2000 when 17,261 Gg CO_2-eq were emitted.

Table 7.7 - Aggregated emissions (Gg CO_2-eq) of the waste sector (2000 – 2017)

Year	SWDS	Open Burning	Wastewater	Total
2000	3,069	1,057	13,135	17,261
2001	3,405	1,082	13,470	17,956
2002	3,714	1,107	13,816	18,637
2003	4,012	1,133	14,233	19,378
2004	4,295	1,161	14,665	20,121
2005	4,570	1,188	15,179	20,938
2006	4,840	1,219	15,583	21,641
2007	5,104	1,248	15,999	22,351
2008	5,368	1,278	16,500	23,147
2009	5,633	1,310	17,018	23,961
2010	5,901	1,343	17,625	24,870
2011	6,174	1,352	18,106	25,632
2012	6,448	1,412	18,600	26,460
2013	6,723	1,447	19,184	27,354
2014	7,005	1,483	19,785	28,273
2015	7,300	1,559	20,478	29,337
2016	7,594	1,591	21,023	30,208
2017	7,894	1,633	21,330	30,857

In 2017, emissions from Wastewater handling represented 69% (21,326 Gg CO_2-eq) of total Waste sector emissions followed by the SWDS category with 26% (7,469 Gg CO_2-eq) and the remaining 5% (1633 Gg CO_2-eq) came from open burning (Figure 7.1). From 2000 to 2017, the highest increase in emissions occurred under SWDS with 257% followed by 162% in Wastewater handling and 154% from Open Burning.

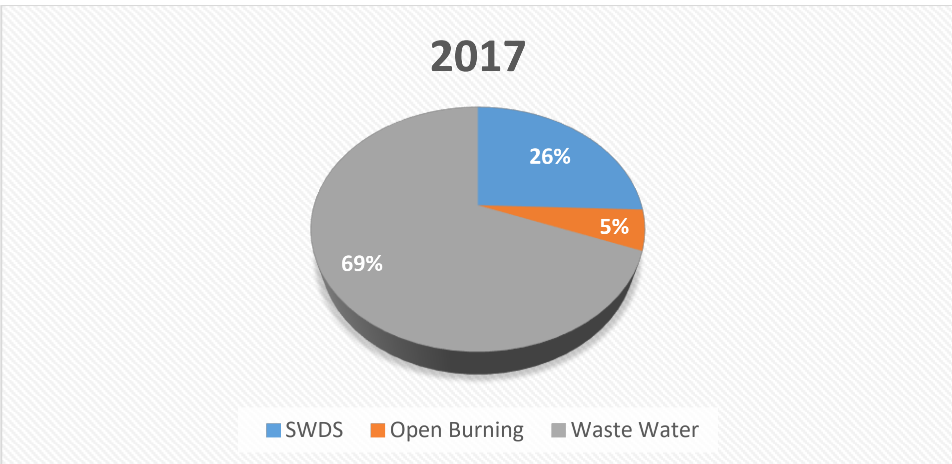


Figure 7.1 - Contribution (%) by source category in emissions of the Waste sector in 2017

7.4.2 Emissions by gas

Emissions by gas for the Waste sector are given in Table 7.8. In 2017, the emissions were 115 Gg of CO_2, 878 Gg of CH_4 and 23 Gg of N_2O compared with 75 Gg, 493 Gg and 13 Gg respectively for these three GHGs in 2000. N_2O recorded the highest increase of 83% when comparing emissions of 2017 over those of the year 2000. CH_4 emissions increased by 78 % while CO_2 increased by 55% over the same period.

Table 7.8 - Aggregated and absolute emissions by gas (2000 – 2017)

Year	CO_2	CH_4		N_2O		Total
	(Gg)	(Gg)	(Gg CO_2-eq)	(Gg)	(Gg CO_2-eq)	(Gg CO_2-eq)
2000	74.5	493.3	13,813.1	12.7	3,373.4	17,261
2001	76.2	515.0	14,420.9	13.1	3,459.2	17,956
2002	78.0	536.1	15,011.1	13.4	3,547.9	18,637
2003	79.9	557.1	15,598.3	14.0	3,699.8	19,378
2004	81.8	577.9	16,180.9	14.6	3,858.1	20,121
2005	83.8	598.8	16,767.2	15.4	4,087.3	20,938
2006	85.9	620.0	17,359.4	15.8	4,195.7	21,641
2007	87.9	641.3	17,955.8	16.3	4,307.5	22,351
2008	90.1	663.0	18,563.9	17.0	4,492.7	23,147
2009	92.3	685.1	19,183.4	17.7	4,685.1	23,961
2010	94.7	707.8	19,817.5	18.7	4,957.9	24,870
2011	95.3	730.2	20,446.3	19.2	5,090.3	25,632
2012	99.5	754.6	21,128.4	19.7	5,231.6	26,460
2013	102.0	778.5	21,799.1	20.6	5,452.9	27,354
2014	104.5	803.1	22,487.1	21.4	5,680.9	28,273
2015	109.9	829.5	23,224.7	22.7	6,002.7	29,337
2016	112.1	854.8	23,934.3	23.3	6,161.5	30,208
2017	115.1	877.7	24,576.0	23.3	6,165.8	30,857

When taking into consideration the GWP of CH_4 and N_2O, the aggregated emissions of 2017 were 24,576 Gg CO_2-eq and 6,166 Gg CO_2-eq respectively. In 2017, and on the same basis of equivalence, CH_4 topped the emissions with 79.7% followed by N_2O with 20.0% and CO_2 with 0.4% of total aggregated emissions.

Emissions of the precursor gases are given in Table 7.9. NO_X emissions increased from 15.3 Gg in year 2000 to reach 23.6 Gg in 2017 while CO followed the same trend from 268 Gg to 414 Gg during the same period. Emissions of SO_2 reached 33.6 Gg in 2017 representing an increase of 55 % over the year 2000. There was an increase of 70% in emissions of NMVOCs from year 2000 to 2017, from 20 Gg to 33.6 Gg.

Table 7.9 - Emissions by gas of precursors (2000 – 2017)

Year	NO_X	CO	SO2	NMVOCs
2000	15.3	267.9	0.5	20.1
2001	15.6	274.3	0.5	20.7
2002	16.0	280.7	0.6	21.3
2003	16.4	287.4	0.6	21.9
2004	16.8	294.3	0.6	22.5
2005	17.2	301.4	0.6	23.1
2006	17.6	309.0	0.6	23.8
2007	18.0	316.4	0.6	24.5
2008	18.5	324.2	0.6	25.3

Year	NO_X	CO	SO2	NMVOCs
2009	18.9	332.3	0.7	26.0
2010	19.4	340.6	0.7	26.8
2011	19.5	342.8	0.7	27.4
2012	20.4	357.9	0.7	28.4
2013	20.9	366.9	0.7	29.2
2014	21.4	376.1	0.7	30.1
2015	22.5	395.4	0.8	31.4
2016	23.0	403.5	0.8	32.2
2017	23.6	414.1	0.8	33.6

7.4.1.1 Solid Waste Disposal Systems

Solid waste amounts for the component not estimated to be burned will decay based on its carbon content. It also considers the carbon stored in harvested wood products which can be discarded as part of the waste which may emit stored CO_2 during decomposition. GHG emissions for direct and indirect GHGs from SWDS (2000 to 2017) is presented in absolute and aggregated values in Table 7.10. CH_4 emissions increased from 109.6 Gg or 3069 Gg CO_2-eq in 2000 to reach 266.8 Gg or 7469 Gg CO_2-eq in 2017. Emissions of NMVOCs from this source category increased by 70 % over the time series, from 14.2 Gg in the year 2000 to reach 24.5 Gg in 2017.

Table 7.10 - Emissions of CH_4 from solid waste disposal systems (2000 – 2017)

Year	CH_4 (Gg)	CH_4 (Gg CO_2 eq)	NMVOCs (Gg)
2000	109.6	3,069.2	14.2
2001	121.8	3,410.7	14.6
2002	132.9	3,721.9	15.1
2003	143.2	4,010.6	15.6
2004	152.9	4,280.8	16.0
2005	162.1	4,538.0	16.5
2006	171.0	4,786.7	17.0
2007	179.6	5,029.4	17.6
2008	188.2	5,268.3	18.1
2009	196.6	5,504.2	18.7
2010	205.0	5,740.0	19.3
2011	213.4	5,974.5	19.9
2012	221.8	6,210.3	20.5
2013	230.3	6,448.6	21.2
2014	238.9	6,690.0	21.8
2015	247.9	6,941.2	22.7
2016	257.0	7,195.1	23.3
2017	266.8	7,469.1	24.5

7.4.1.2 Open Burning of waste

Emissions from open burning, consisting of CO_2, CH_4 and N_2O are given in absolute and aggregated values in Table 7.11. Emissions in the year 2000 were 74.5 Gg of CO_2, 31.2 Gg or 873.5 Gg CO_2-eq CH_4 and 0.4 Gg or 108.7 Gg CO_2-eq of N_2O. All three GHGs increased by about 54% over the period 2000 to 2017. On a comparable basis in CO_2-eq, CH_4 was the major GHG emitted with 82.7%. N_2O and CO_2 emissions represented 10.3 % and 7.0 % respectively.

Table 7.11 - Emissions from open burning (2000 – 2017)

Year	CO_2 (Gg)	CH_4 (Gg)	CH_4 (Gg CO_2eq)	N_2O (Gg)	N_2O (Gg CO_2-eq)
2000	74.5	31.2	873.5	0.4	108.7
2001	76.2	31.9	894.2	0.4	111.3
2002	78.0	32.7	915.2	0.4	113.9
2003	79.9	33.5	936.9	0.4	116.6
2004	81.8	34.3	959.4	0.5	119.4
2005	83.8	35.1	982.4	0.5	122.3
2006	85.9	36.0	1,007.3	0.5	125.4
2007	87.9	36.8	1,031.4	0.5	128.4
2008	90.1	37.7	1,056.8	0.5	131.6
2009	92.3	38.7	1,083.2	0.5	134.9
2010	94.7	39.7	1,110.4	0.5	138.2
2011	95.3	39.9	1,117.6	0.5	139.1
2012	99.5	41.7	1,166.8	0.5	145.3
2013	102.0	42.7	1,196.0	0.6	148.9
2014	104.5	43.8	1,225.9	0.6	152.6
2015	109.9	46.0	1,289.1	0.6	160.5
2016	112.1	47.0	1,315.4	0.6	163.8
2017	115.1	48.2	1,349.9	0.6	168.0

Open burning also results in emissions of precursor gases which are depicted in Table 7.12. The method adopted for estimation is based on information from the EMEP / EEA Air Pollution Guidebook 2016, Open Burning of Waste. Emissions for the year 2017 were 23.6 Gg of NO_X, 414.1 Gg of CO, 0.8 Gg of SO_2, and 9.1 Gg of NMVOCs. The values for the precursor gases in 2000 were 15.3 Gg of NO_X, 267.9 Gg of CO, 0. 5 Gg of SO_2, and 5.9 Gg of NMVOCs. The growth in emissions from 2000 to 2017 for these precursor gases is by some 54 % for NO_X, CO and NMVOCs.. SO_2 emissions increased by 60% over the time series.

Table 7.12 - Precursor gases from open burning (Gg)

Year	NO_X	CO	SO_2	NMVOCs
2000	15.3	267.9	0.5	5.9
2001	15.6	274.3	0.5	6.0
2002	16.0	280.7	0.6	6.2
2003	16.4	287.4	0.6	6.3
2004	16.8	294.3	0.6	6.5
2005	17.2	301.4	0.6	6.6
2006	17.6	309.0	0.6	6.8
2007	18.0	316.4	0.6	7.0
2008	18.5	324.2	0.6	7.1
2009	18.9	332.3	0.7	7.3
2010	19.4	340.6	0.7	7.5
2011	19.5	342.8	0.7	7.6
2012	20.4	357.9	0.7	7.9
2013	20.9	366.9	0.7	8.1
2014	21.4	376.1	0.7	8.3
2015	22.5	395.4	0.8	8.7
2016	23.0	403.5	0.8	8.9
2017	23.6	414.1	0.8	9.1

7.4.1.3 Domestic Wastewater

The annual absolute (Gg) and aggregated (Gg CO_2-eq) emissions of direct GHGs and NMVOCs from Domestic Wastewater (2000 to 2017) are presented in Table 7.13. Domestic Wastewater in Nigeria generated more emissions as CH_4 (72%) than N_2O (28%) when compared in CO_2-eq in 2017. Emissions for CH_4 in 2000 were 352 Gg which translates to 9871 Gg CO_2-eq and for N_2O, 12.3 Gg or 3264 Gg CO_2-eq. The increase over the review period is 83.7% for N_2O and 55.3% for CH_4. Emissions of NMVOCs from this sub-category increased from 0.00003 Gg in year 2000 to reach 0.00005 Gg in 2017.

Table 7.13 - Emissions from the Domestic Wastewater sub-category (2000 – 2017)

Year	CH_4 (Gg)	CH_4 (Gg CO_2-eq)	N_2O (Gg)	N_2O (Gg CO_2-eq)	Total (Gg CO_2-eq)	NMVOCs (Gg)
2000	352.5	9,870.5	12.3	3,264.7	13,135.2	0.00003
2001	361.5	10,121.9	12.6	3,347.9	13,469.7	0.00004
2002	370.8	10,382.1	13.0	3,433.9	13,816.1	0.00004
2003	380.3	10,649.6	13.5	3,583.1	14,232.8	0.00004
2004	390.2	10,926.7	14.1	3,738.7	14,665.4	0.00004
2005	400.5	11,214.3	15.0	3,965.0	15,179.3	0.00004
2006	411.2	11,512.3	15.4	4,070.3	15,582.7	0.00004
2007	422.1	11,820.0	15.8	4,179.1	15,999.1	0.00004
2008	433.5	12,138.9	16.5	4,361.1	16,500.0	0.00004
2009	445.3	12,467.4	17.2	4,550.2	17,017.6	0.00004
2010	457.3	12,805.6	18.2	4,819.7	17,625.3	0.00004
2011	469.8	13,155.0	18.7	4,951.2	18,106.2	0.00005
2012	482.6	13,514.0	19.2	5,086.4	18,600.4	0.00005
2013	495.7	13,880.3	20.0	5,304.0	19,184.3	0.00005
2014	509.2	14,256.3	20.9	5,528.3	19,784.6	0.00005
2015	522.7	14,635.4	22.0	5,842.2	20,477.6	0.00005
2016	536.6	15,025.0	22.6	5,997.8	21,022.7	0.00005
2017	547.6	15,331.8	22.6	5,997.8	21,329.6	0.00005

Results of estimates from the IPCC inventory software are presented in Table 7.14.

Table 7.14 - Waste sector sectoral table – Inventory Year 2017

Categories	Emissions (Gg)						
	CO_2	CH_4	N_2O	NOx	CO	NMVOCs	SO_2
4 - Waste	115.1	877.7	23.3	23.6	414.1	33.6	0.8
4.A - Solid Waste Disposal	NA	281.9	NA	NO	NO	24.5	NA
4.A.1 - Managed Waste Disposal Sites	NA	IE	NA	NO	NO	NO	NA
4.A.2 - Unmanaged Waste Disposal Sites	NA	IE	NA	NO	NO	24.5	NA
4.A.3 - Uncategorised Waste Disposal Sites	NA	IE	NA	NO	NO	IE	NA
4.B - Biological Treatment of Solid Waste		NO	NO	NO	NO	NO	NA
4.C - Incineration and Open Burning of Waste	115.1	48.2	0.6	23.6	414.1	9.1	0.8
4.C.1 - Waste Incineration	NE	NE	NE	NE	NE	NE	NE
4.C.2 - Open Burning of Waste	115.1	48.2	0.6	23.6	414.1	9.1	0.8
4.D - Wastewater Treatment and Discharge	NA	547.6	22.6	NE	NE	NE	NA
4.D.1 - Domestic Wastewaster Treatment and Discharge	NA	547.6	22.6	NE	NE	NE	NA
4.D.2 - Industrial Wastewater Treatment and Discharge	NA	NE	NE	NE	NE	NE	NA
4.E - Other (please specify)	NO	NO	NO	NO	NO	NO	NO

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ANNEX 1: Results of the Uncertainty Analysis

Base year for assessment of uncertainty in trend: 2000, Year T: 2017

2006 IPCC Categories	Gas	Base Year emissions or removals (Gg CO2 equivalent)	Year T emissions or removals (Gg CO2 equivalent)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in Year T	Inventory trend in national emissions for year t increase with respect to base year (% of base year)	Uncertainty introduced into the trend in total national emissions (%)
1 - Energy									
1.A.1 - Energy Industries - Gaseous Fuels	CO2	6999.19	55750.07	7.07	9.90	12.17	0.18	796.52	0.44
1.A.1 - Energy Industries - Gaseous Fuels	CH4	3.49	27.83	7.07	106.07	106.30	0.00	796.52	0.00
1.A.1 - Energy Industries - Gaseous Fuels	N2O	3.31	26.33	7.07	420.02	420.08	0.00	796.52	0.00
1.A.1 - Energy Industries - Liquid Fuels	CO2	1339.88	1302.09	5.00	7.00	8.60	0.00	97.18	0.00
1.A.1 - Energy Industries - Liquid Fuels	CH4	1.20	1.28	5.00	75.00	75.17	0.00	106.51	0.00
1.A.1 - Energy Industries - Liquid Fuels	N2O	2.08	2.32	5.00	297.00	297.04	0.00	111.75	0.00
1.A.1 - Energy Industries - Biomass	CO2	27195.80	41463.33	5.00	7.00	8.60	0.13	152.46	0.18
1.A.1 - Energy Industries - Biomass	CH4	203.97	310.97	5.00	75.00	75.17	0.00	152.46	0.00
1.A.1 - Energy Industries - Biomass	N2O	257.39	392.42	5.00	297.00	297.04	0.01	152.46	0.00
1.A.2 - Manufacturing Industries and Construction - Liquid Fuels	CO2	966.68	1874.93	5.00	7.00	8.60	0.00	193.96	0.00
1.A.2 - Manufacturing Industries and Construction - Liquid Fuels	CH4	1.05	2.01	5.00	75.00	75.17	0.00	190.89	0.00
1.A.2 - Manufacturing Industries and Construction - Liquid Fuels	N2O	1.99	3.79	5.00	297.00	297.04	0.00	189.86	0.00
1.A.2 - Manufacturing Industries and Construction - Solid Fuels	CO2	7.32	112.27	5.00	7.00	8.60	0.00	1533.33	0.00
1.A.2 - Manufacturing Industries and Construction - Solid Fuels	CH4	0.02	0.33	5.00	75.00	75.17	0.00	1533.33	0.00
1.A.2 - Manufacturing Industries and Construction - Solid Fuels	N2O	0.03	0.47	5.00	297.00	297.04	0.00	1533.33	0.00
1.A.2 - Manufacturing Industries and Construction - Gaseous Fuels	CO2	1705.42	12771.26	5.00	7.00	8.60	0.01	748.86	0.03
1.A.2 - Manufacturing Industries and Construction - Gaseous Fuels	CH4	0.85	6.37	5.00	75.00	75.17	0.00	748.86	0.00
1.A.2 - Manufacturing Industries and Construction - Gaseous Fuels	N2O	0.81	6.03	5.00	297.00	297.04	0.00	748.86	0.00
1.A.2 - Manufacturing Industries and Construction - Biomass	CO2	10039.70	15657.91	5.00	7.00	8.60	0.02	155.96	0.03
1.A.2 - Manufacturing Industries and Construction - Biomass	CH4	77.57	120.28	5.00	75.00	75.17	0.00	155.05	0.00
1.A.2 - Manufacturing Industries and Construction - Biomass	N2O	95.17	148.28	5.00	297.00	297.04	0.00	155.80	0.00
1.A.3.a - Civil Aviation - Liquid Fuels	CO2	469.41	1292.79	7.07	7.07	10.00	0.00	275.41	0.00
1.A.3.a - Civil Aviation - Liquid Fuels	CH4	0.09	0.25	7.07	818.99	819.02	0.00	275.41	0.00
1.A.3.a - Civil Aviation - Liquid Fuels	N2O	3.48	9.58	7.07	7.07	10.00	0.00	275.41	0.00
1.A.3.b - Road Transportation - Liquid Fuels	CO2	14518.02	35999.77	10.00	7.00	12.21	0.02	247.97	0.06
1.A.3.b - Road Transportation - Liquid Fuels	CH4	116.04	397.66	10.00	19.24	21.68	0.00	342.68	0.00

2006 IPCC Categories	Gas	Base Year emissions or removals (Gg CO2 equivalent)	Year T emissions or removals (Gg CO2 equivalent)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in Year T	Inventory trend in national emissions for year t increase with respect to base year (% of base year)	Uncertainty introduced into the trend in total national emissions (%)
1.A.3.b - Road Transportation - Liquid Fuels	N2O	147.38	408.37	10.00	24.00	26.00	0.00	277.09	0.00
1.A.3.b - Road Transportation	CO2	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
1.A.3.c - Railways - Liquid Fuels	CO2	111.87	74.88	5.00	1.50	5.22	0.00	66.93	0.00
1.A.3.c - Railways - Liquid Fuels	CH4	0.18	0.12	5.00	250.00	250.05	0.00	66.93	0.00
1.A.3.c - Railways - Liquid Fuels	N2O	11.44	7.66	5.00	125.00	125.10	0.00	66.93	0.00
1.A.3.d - Water-borne Navigation - Liquid Fuels	CO2	542.29	1526.03	11.18	4.24	11.96	0.00	281.41	0.00
1.A.3.d - Water-borne Navigation - Liquid Fuels	CH4	1.49	4.26	11.18	70.71	71.59	0.00	285.93	0.00
1.A.3.d - Water-borne Navigation - Liquid Fuels	N2O	4.03	11.52	11.18	127.28	127.77	0.00	285.93	0.00
1.A.4 - Other Sectors - Liquid Fuels	CO2	5423.61	16996.54	10.00	12.62	16.10	0.02	313.38	0.03
1.A.4 - Other Sectors - Liquid Fuels	CH4	21.25	65.16	10.00	87.14	87.71	0.00	306.67	0.00
1.A.4 - Other Sectors - Liquid Fuels	N2O	11.95	36.00	10.00	156.35	156.67	0.00	301.27	0.00
1.A.4 - Other Sectors - Biomass	CO2	192312.65	247212.65	7.07	9.90	12.17	4.31	128.55	5.95
1.A.4 - Other Sectors - Biomass	CH4	14551.08	18882.53	7.07	70.71	71.06	0.87	129.77	0.05
1.A.4 - Other Sectors - Biomass	N2O	1795.85	2321.21	7.07	127.28	127.48	0.04	129.25	0.00
1.B.1 - Solid Fuels	CO2	0.00	0.00	5.00	0.00	5.00	0.00	100.00	0.00
1.B.1 - Solid Fuels	CH4	1.38	21.23	7.07	5.00	8.66	0.00	1533.33	0.00
1.B.2.a - Oil	CO2	5626.14	4715.30	10.00	163.94	164.24	0.12	83.81	0.12
1.B.2.a - Oil	CH4	71969.89	60314.41	10.00	163.94	164.24	0.00	83.81	0.00
1.B.2.a - Oil	N2O	22.19	18.60	10.00	612.88	612.96	0.00	83.81	0.00
1.B.2.b - Natural Gas	CO2	40.40	26.88	10.00	325.96	326.11	0.00	66.54	0.00
1.B.2.b - Natural Gas	CH4	16118.04	31183.78	10.00	325.96	326.11	0.37	193.47	0.36
1.B.2.b - Natural Gas	N2O	0.17	0.07	10.00	500.00	500.10	0.00	40.52	0.00
1.C - Carbon dioxide Transport and Storage	CO2	0.00	0.00	12.25	0.00	12.25	0.00	100.00	0.00
2 - Industrial Processes and Product Use									
2.A.1 - Cement production	CO2	713.60	5239.85	10.00	5.00	11.18	0.00	734.29	0.01
2.A.2 - Lime production	CO2	0.00	0.00	15.00	0.00	15.00	0.00	100.00	0.00
2.A.3 - Glass Production	CO2	0.00	0.00	5.00	0.00	5.00	0.00	100.00	0.00
2.A.4 - Other Process Uses of Carbonates	CO2	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2.B.1 - Ammonia Production	CO2	2.01	1.73	5.00	0.00	5.00	0.00	85.76	0.00
2.B.2 - Nitric Acid Production	N2O	0.00	0.00	2.00	0.00	2.00	0.00	100.00	0.00

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2.B.3 - Adipic Acid Production	N2O	0.00	0.00	5.00	0.00	5.00	0.00	100.00	0.00
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production	N2O	0.00	0.00	10.00	0.00	10.00	0.00	100.00	0.00
2.B.5 - Carbide Production	CO2	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2.B.5 - Carbide Production	CH4	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2.B.6 - Titanium Dioxide Production	CO2	0.00	0.00	5.00	0.00	5.00	0.00	100.00	0.00
2.B.7 - Soda Ash Production	CO2	0.00	0.00	5.00	0.00	5.00	0.00	100.00	0.00
2.B.8 - Petrochemical and Carbon Black Production	CO2	0.00	0.00	24.49	0.00	24.49	0.00	100.00	0.00
2.B.8 - Petrochemical and Carbon Black Production	CH4	0.00	0.00	24.49	0.00	24.49	0.00	100.00	0.00
2.C.1 - Iron and Steel Production	CO2	1791.03	6360.00	10.00	25.00	26.93	0.03	355.10	0.04
2.C.1 - Iron and Steel Production	CH4	4.73	16.80	10.00	25.00	26.93	0.00	355.10	0.00
2.C.2 - Ferroalloys Production	CO2	0.00	0.00	5.00	0.00	5.00	0.00	100.00	0.00
2.C.2 - Ferroalloys Production	CH4	0.00	0.00	5.00	0.00	5.00	0.00	100.00	0.00
2.C.3 - Aluminium production	CO2	0.00	0.00	2.00	0.00	2.00	0.00	100.00	0.00
2.C.4 - Magnesium production	CO2	0.00	0.00	5.00	0.00	5.00	0.00	100.00	0.00
2.C.5 - Lead Production	CO2	0.00	0.00	10.00	0.00	10.00	0.00	100.00	0.00
2.C.6 - Zinc Production	CO2	0.00	0.00	10.00	0.00	10.00	0.00	100.00	0.00
2.D - Non-Energy Products from Fuels and Solvent Use	CO2	0.00	0.00	14.14	0.00	14.14	0.00	100.00	0.00
2.G - Other Product Manufacture and Use	N2O	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
3 - Agriculture, Forestry, and Other Land Use									
3.A.1 - Enteric Fermentation	CH4	23339.87	35473.60	0.00	0.00	0.00	0.00	151.99	0.00
3.A.2 - Manure Management	CH4	1115.17	1703.94	0.00	0.00	0.00	0.00	152.80	0.00
3.A.2 - Manure Management	N2O	840.65	1398.59	0.00	0.00	0.00	0.00	166.37	0.00
3.B.1.a - Forest land Remaining Forest land	CO2	256674.25	319970.58	20.00	10.00	22.36	53.39	124.66	173.17
3.B.1.b - Land Converted to Forest land	CO2	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
3.B.2.a - Cropland Remaining Cropland	CO2	0.00	0.00	20.00	10.00	22.36	0.00	100.00	0.00
3.B.2.b - Land Converted to Cropland	CO2	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
3.B.3.a - Grassland Remaining Grassland	CO2	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
3.B.3.b - Land Converted to Grassland	CO2	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
3.B.4.a.i - Peatlands remaining peatlands	CO2	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
3.B.4.a.i - Peatlands remaining peatlands	N2O	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

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3.B.4.b - Land Converted to Wetlands	N2O	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
3.B.4.b - Land Converted to Wetlands	CO2	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
3.B.5.a - Settlements Remaining Settlements	CO2	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
3.B.5.b - Land Converted to Settlements	CO2	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
3.B.6.b - Land Converted to Other land	CO2	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
3.C.1 - Emissions from biomass burning	CH4	2.54	5.34	28.28	14.14	31.62	0.00	209.92	0.00
3.C.1 - Emissions from biomass burning	N2O	1.47	1.90	28.28	14.14	31.62	0.00	129.80	0.00
3.C.2 - Liming	CO2	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
3.C.3 - Urea application	CO2	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
3.C.4 - Direct N2O Emissions from managed soils	N2O	9917.81	16089.16	20.00	20.00	28.28	0.22	162.22	0.44
3.C.5 - Indirect N2O Emissions from managed soils	N2O	3116.29	5255.14	20.00	20.00	28.28	0.02	168.63	0.05
3.C.6 - Indirect N2O Emissions from manure management	N2O	218.93	320.12	0.00	0.00	0.00	0.00	146.22	0.00
3.C.7 - Rice cultivation	CH4	6743.10	9572.08	20.00	1.50	20.06	0.04	141.95	0.15
3.D.1 - Harvested Wood Products	CO2	-5882.18	-4542.62	0.00	0.00	0.00	0.00	0.00	0.00
4 - Waste									
4.A - Solid Waste Disposal	CH4	3069.16	7894.33	60.00	60.00	84.85	0.47	257.21	1.04
4.B - Biological Treatment of Solid Waste	CH4	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
4.B - Biological Treatment of Solid Waste	N2O	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
4.C - Incineration and Open Burning of Waste	CO2	74.47	115.08	200.00	40.00	203.96	0.00	154.54	0.00
4.C - Incineration and Open Burning of Waste	CH4	873.48	1349.86	200.00	100.00	223.61	0.10	154.54	0.31
4.C - Incineration and Open Burning of Waste	N2O	108.74	168.05	200.00	100.00	223.61	0.00	154.54	0.00
4.D - Wastewater Treatment and Discharge	CH4	9870.46	15331.83	35.00	40.00	53.15	0.69	155.33	1.22
4.D - Wastewater Treatment and Discharge	N2O	3264.69	5997.76	35.00	500.00	501.22	9.42	183.72	1.15
5 - Other									
Total									
		Sum(C): 688583.531	Sum(D): 979230.940			Sum(H): 70.482		Sum(M): 184.818	
					Uncertainty in total inventory: 8.395			Trend uncertainty: 13.595	