REPUBLIC OF NAMIBIA

NATIONAL GHG INVENTORY REPORT
NIR4
1991 - 2015

October 2018

PART 1

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Foreword


Minister of Environment and Tourism

As the minister of the Ministry of Environment and Tourism, it is an honour and privilege for me to present Namibia's Fourth National Inventory Report (NIR4) on a stand-alone basis within the framework of the Fourth National Communication for enhanced transparency in fulfilment of its obligations as a Non-Annex I (NAI) Party to the United Nations Framework Convention on Climate Change (UNFCCC).

Namibia ratified the UNFCCC in 1995 and thus became obligated to prepare and submit national communications. Namibia is also a signatory Party to the Paris Agreement (PA) since 2016. So far Namibia has prepared and submitted the Initial National Communication (INC) in 2002, the Second National Communication (SNC) in 2011, the first BUR (BUR1) in 2014, the Third National Communication (TNC) in 2015 and the Second Biennial Update Report (BUR2) in 2016. Furthermore, Namibia prepared and submitted its Intended Nationally Determined Contributions (INDC) in 2015.

Namibia is currently busy preparing its Third Biennial Update Report (BUR3) which will be submitted in December 2018. Namibia was the first Non-Annex I Party to prepare and submit its first Biennial Update Report at COP 20 and followed by submitting BUR 2 in 2016 making it one of the compliant countries in terms of reporting obligations. The Fourth National Communication (NC4) provides an update on Namibia's Greenhouse Gas (GHG) inventory, mitigation actions and vulnerability and Adaptation and Other Information Relevant to the Convention. BUR3 will be submitted with a stand-alone National GHG Inventory (NIR) making it the third NIR Namibia will submit to the UNFCCC.

At the national level, Namibia has made numerous strides to further engage itself to play its role in fighting climate change as outlined in the INDC. In 2014, the Cabinet of the Republic of Namibia approved the National Climate Change Strategy and Action Plan (NCCSAP). The NCCSAP, which is currently under its mid-term review, aims at facilitating the realisation of the National Climate Change Policy (NCCP), which was passed in 2011. The strategy adopted in the document is cross-sectoral and will be implemented up to the year 2020 and it covers the thematic areas mitigation, adaptation and related cross cutting issues.

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Hon. Pohamba Shifeta
Minister of Environment and Tourism

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- Ministry of Fisheries and Marine Resources
- National Planning Commission
- NamPower
- Namibia Statistics Agency
- Namibia Energy Institute
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- TransNamib Holdings Ltd
- Namibia Airports Company
- Petroleum products dealers
- Namport
- Electricity Control Board
- Meatco Namibia

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Abbreviations and acronyms

Abbreviation / acronym	Definition
AD	Activity Data
AFOLU	Agriculture, Forest and Other Land Use
BCEF	Biomass Conversion and Expansion Factors
BGB	Below Ground Biomass
bm	Biomass
BUR	Biennial Update Report
CCU	Climate Change Unit
CFC	Chlorofluorocarbon
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2-eq	Carbon dioxide equivalent
COP	Conference of Parties
CS	Country-specific
DBH/dbh	Diameter at breast height
DE	Digestible Energy
DEA	Department of Environmental Affairs
dm	Dry Matter
ECB	Electricity Control Board
EE	Estimated Elsewhere
EF	Emission Factor
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
GDP	Gross Domestic Product
GEF	Global Environment Facility
Gg	Gigagram (1000 t)
GHG	Greenhouse gas
GL	Guidelines
GPG	Good Practice Guidance
GWP	Global Warming Potential
HAC	High Activity Clay
HFC	Hydrofluorocarbon
IE	Included Elsewhere
IEA	International Energy Agency

Abbreviation / acronym	Definition
INC	Initial National Communication
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
Iv	Annual Growth Rate
LAC	Low Activity Clay
LPG	Liquefied Petroleum Gas
MAWF	Ministry of Agriculture, Water Affairs and Forestry
MeatCo	Meat Company of Namibia
MET	Ministry of Environment and Tourism
MMS	Manure Management System
MODIS	Moderate Resolution Imaging Spectroradiometer
MoU	Memorandum of Understanding
N	Nitrogen
N_2O	Nitrous oxide
NA	Not Applicable
NATIS	Namibian Transport Information and Regulatory Services
NC	National Communication
NDP4	Fourth National Development Plan
NE	Not Estimated
NFI	National Forest Inventory
NHIES	Namibia Household Income and Expenditure Survey
NGO	Non-Governmental Organization
NIIP	National Inventory Improvement Plan
NIR	National Inventory Report
NMVOC	Non-Methane Volatile Organic Compound
NNFU	Namibian National Farmers Union
NO	Not Occurring
NO_X	Nitrogen oxides
NPHC	Namibia Population and Housing Census
NSA	Namibia Statistics Agency
ODS	Ozone Depleting Substances
OL	Other Land
OWL	Other Wooded Land
PFC	Perfluorocarbon
PRP	Pasture range and Padlock
QA	Quality assurance
QC	Quality Control
RCMRD	Regional Centre for Mapping Resource for Development
SAN	Sandy Mineral

Abbreviation / acronym	Definition
SF_6	Sulphur Hexafluoride
SME	Small and Medium Enterprises
SNC	Second National Communication
SO_2	Sulphur dioxide
t	Tonne
TACCC	Transparency, Accuracy, Consistency, Completeness, and Comparability
TJ	Tera Joule
UNDP	United Nations Development Programme
UNE	United Nations Environment
UNFCCC	United Nations Framework Convention on Climate Change
WD	Woodland (Or Wooded Land?)
WET	Wetland
X	Emission Estimated

Executive summary

ES 1. Introduction

Namibia has been compliant with the Convention with regards to the submission of national inventories of greenhouse gases (GHGs). Namibia has submitted six inventories as components of its first, second and third national communications and its first second and third Biennial Update Reports. More exhaustive information on the last inventory can be obtained by perusing the full NIR1-3 of the country that has also been submitted to the secretariat of the United Nations Framework Convention on Climate Change (UNFCCC) as accompanying documents of the Biennial Update Reports. These inventories have been compiled and submitted in line with Article 4.1 (a) of the Convention which stipulates that *each party has to develop, periodically update, publish and make available to the Conference of the Parties (COPs), 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*. These inventories have been produced according to the capabilities of the country using recommended methodologies of the IPCC agreed upon by the Conference of the Parties. This exercise of inventory preparation is the sixth one for the country. This NIR4 supersedes previous inventories and provides for the latest and best emission estimates of the country compiled with available data and information.

ES 2. Coverage (period and scope)

Namibia compiled and published GHG inventories for the years 1994, 2000 and 2010, as a chapter for the requirement of national communications. IPCC methodologies have evolved to capture the latest scientific advances and as from the fourth inventory, special efforts have been invested to compile the inventory for a consistent time series and using the latest IPCC 2006 software and Guidelines. This NIR4 covers the period 1991 to 2015, the latter year to be at least 4 years preceding the date of submission of the report to be in line with Decisions 2 CP/17 and recalculated inventories published previously in national communications for the years 1994, 2000 and 2010.

The inventory covered the full territory of the country and the results are presented at the national level. It addressed all the IPCC sectors and categories subject to Activity Data (AD) availability. The latest IPCC 2006 Guidelines, revised version of April 2018 and the IPCC Inventory Software (version 2.54 released on July 6, 2017) have been used to estimate emissions for the four sectors, namely, Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry, and Other Land Use (AFOLU) and Waste.

This seventh GHG inventory provides data on GHG emissions by sources and removals by sinks for a full time series for the period 1991 to 2015. The gases estimated were carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), oxides of nitrogen (NO_x), sulphur dioxide (SO_2), non-methane volatile organic compounds (NMVOCs) and the precursor carbon monoxide (CO), using a mix of Tiers 1 and 2. The IPCC 2006 Guidelines and software were used for compiling these inventories.

ES 3. Institutional arrangements and GHG inventory system

Namibia consolidated the in-house production of its GHG inventory except for the support from a company's services for computation of emissions and report writing and an independent international consultant for performing the QA and capacity building to meet the enhanced transparency and higher standards of reporting, due to lack of financial resources to maintain permanent staff for a full institutionalization of the process.

The Climate Change Unit (CCU) of the Ministry of Environment and Tourism monitored and coordinated the production of the GHG inventories. Capacity building of the inventory working group members continued. The detailed institutional arrangements adopted for the compilation of the inventory and reporting are provided in the inventory chapter of this report.

ES 4. Methods

Guidelines and software

The present national GHG inventory has been prepared in accordance with the latest *2006 IPCC Guidelines for National Greenhouse Gas Inventories* and using the IPCC 2006 software version 2.54 for the compilations. As the IPCC 2006 Guidelines do not extensively cover all GHGs, it has been supplemented with the European Monitoring and Evaluation Program/European Environment Agency (EMEP/EEA) air pollutant emission inventory guidebook 2016 for compiling estimates for nitrogen oxides (NO_x), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO_2).

As the IPCC 2006 software is still under development to address compilations at the Tier 2 level, derivation of national EFs and stock factors for improving estimates to be made at the Tier 2 level for the Livestock and Land sectors have been done through programming in Excel. Thus, the inventory has been compiled using a mix of Tiers 1 and 2. This is good practice, improved the accuracy of the emission estimates and reduced the uncertainty level accordingly.

Gases

The gases covered in this inventory are the direct gases carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) and the indirect gases nitrogen oxides (NO_x), carbon monoxide (CO), non-methane organic volatile compounds (NMVOCs) and sulphur dioxide (SO_2).

AD and important information required to allow on the choice of the EFs on the hydro-fluorocarbons (HFCs) and perfluorocarbons (PFCs) were still lacking and thus estimates of emissions have not been made for these gases. As well, sulphur hexafluoride (SF6) has not been estimated since AD were not available. However, work started in these areas and it is hoped that the next inventory will include these categories.

GWPs

Global Warming Potentials (GWP) as recommended by the IPCC have been used to convert GHGs other than CO_2 to the latter equivalent. Based on decision 17/CP.8, the values adopted were from the IPCC Second Assessment Report for the three direct GHGs, namely;

Gas		GWP
Carbon Dioxide	(CO_2)	1
Methane	(CH_4)	21
Nitrous Oxide	(N_2O)	310

ES 5. Activity data

Country-specific activity data (AD) pertaining to most of the socio-economic sectors are collected, quality controlled and processed to produce official national statistics reports by the National Statistics Agency (NSA) for use by government and the wider public. These data are then entered in a database and archived within the existing data archiving system. Thus, data collected at national level from numerous public and private sector institutions, organizations and companies, and archived by the NSA, provided the basis and starting point for the compilation of the inventory. Additional and/or missing data, required to meet the level of disaggregation for higher than the Tier 1 level, were sourced from both public and private institutions by the inventory team members and coordinators through direct contacts. Data gaps were filled through personal contacts and/or from results of surveys, scientific studies and by statistical modelling. Expert knowledge was resorted to as the last option.

In a few cases, data were derived or estimated to fill in the gaps. These were considered reliable and sound since they were based on scientific findings and other observations. For the Land sector, remote sensing technology was used whereby maps were produced from Landsat satellite imagery for the years 2000 and 2010 data. These maps, the FAO Forest Resource Assessment reports and other national studies and scientific publications were then used to generate land cover and land use changes over the inventory time series.

The methods used to generate missing AD are provided in detail further in this NIR4, under the section for the individual sectors or categories as applicable.

ES 6. Emission factors

Country emission factors (EFs) were derived for the Tier 2 estimation of GHGs for some animal classes for enteric fermentation. Similarly, the same exercise was performed for the Land sector where stock factors have been derived to suit national circumstances. This is Good Practice towards enhancing the quality of the inventory and especially as these activity areas were major emitters on the basis of previous inventory results. Additionally, default IPCC EFs for the remaining source categories were screened for their appropriateness before adoption, on the basis of the situations under which they have been developed and the extent to which these were representative of national ones. More information on the country-specific and default EFs are provided under the respective sections on the different sectors.

ES 7. Recalculations

The inventory for the years covered in the previous time series 2000 to 2012, and 1994 was recalculated to bring them in line with the years 2013 and 2014 being added and to provide for a consistent series in this inventory report. This is essential as there have been new datasets available and a completely new approach has been adopted to better reflect the national circumstances. The scope of the inventory has also been widened to include Solvent Use and Food and Beverages sub-categories of the IPPU sector.

ES 8. Inventory estimates

Aggregated emissions

Namibia remained a net greenhouse gas (GHG) sink over the period 1991 to 2015 as the Land category removals exceeded emissions from the other categories. The net removal of CO_2 increased by 25,258 Gg from 75,239 Gg to 100,497 Gg in 2015, representing an increase of 33.6% over these 25 years. During the same period, the country recorded an increase of 6.2% in emissions, from 19,849 Gg CO_2-eq to 21,554 Gg CO_2-eq. The trend for the period 1991 to 2015 indicates that the total removals from the Land category increased from 95,088 Gg CO_2-eq in 1991 to 121,575 Gg CO_2-eq in 2015 (Figure ES 1).

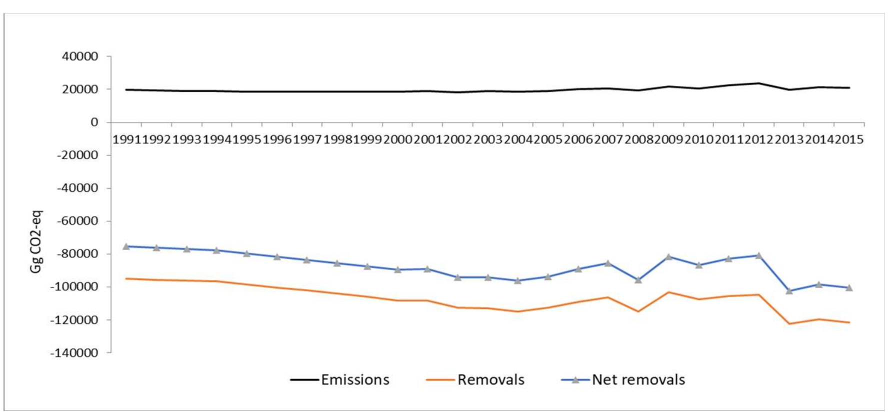

Figure ES 1 - Evolution of national emissions, national removals and the overall (net) situation (Gg CO_2-eq), (1991 - 2015)

Per capita emissions of GHG decreased gradually from 13.3 tonnes CO_2-eq in 1991 to reach 9.9 tonnes in 2002; it then plateaued between 9.8 and 10.0 tonnes up to 2005 after which period it seesawed to reach 9.5 tonnes CO_2-eq in 2015 (Figure ES 2). The GDP emission index decreased almost steadily from 100 in the year 1991 to 44 in 2015 (Figure ES 3).

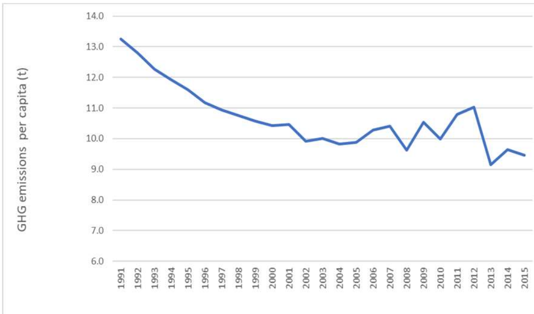

Figure ES 2 - Per capita GHG emissions (1991 - 2015)

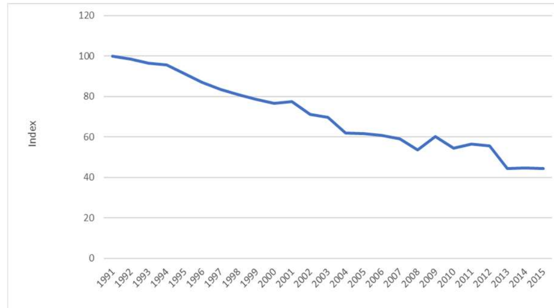

Figure ES 3 - GDP emissions index (1991 - 2015)

Total national emissions increased by 6.2% over these 25 years. The AFOLU sector remained the leading emitter throughout this period followed by Energy, for all years under review. Following the setting up of new industries, the IPPU sector took over as the third emitter in lieu of the Waste sector as from the year 2003. Emissions from the AFOLU sector decreased from 18,574 Gg CO_2-eq in 1991 to 16,856 in 2015, representing a decrease of 9% from the 1991 level. The share of GHG emissions from the AFOLU sector out of total national emissions regressed from 93.5% in 1991 to 80.0% in 2015.

Energy emissions increased from 1,177 Gg CO_2-eq (6.0%) of national emissions in 1991 to 3,541 Gg CO_2-eq (16.8%) in 2015 as depicted in Table ES 1. During the period 1991 to 2015, the emissions increased by three times.

The contribution of the IPPU sector in total national emissions increased from 21 Gg CO_2-eq in 1991 to 518 Gg CO_2-eq in 2015 (Table ES 1). The very sharp increase in GHG emissions in the IPPU sector is due to the commencement of the production of Zinc in 2003 and cement in 2011.

Waste emissions on the other hand varied slightly over this period with the tendency being for a slight increase over time. Emissions from the waste sector increased from the 1991 level of 76 Gg CO_2-eq to 163 Gg CO_2-eq in 2015, representing a 115% increase.

In 2015, Energy contributed 16.8% of emissions, IPPU 2.5%, AFOLU 80.0% and Waste 0.8%.

Table ES 1 - National GHG emissions (Gg, CO_2-eq) by sector (1991 - 2015)

Year	Total emissions	Energy	IPPU	AFOLU	Waste
1991	19,849	1,177	21	18,574	76
1992	19,469	1,252	22	18,117	79
1993	19,049	1,350	23	17,595	81
1994	18,898	1,464	23	17,328	83
1995	18,762	1,473	24	17,183	81
1996	18,447	1,566	24	16,777	80
1997	18,450	1,617	25	16,726	82
1998	18,502	1,759	26	16,633	85
1999	18,560	1,893	26	16,551	89
2000	18,691	1,934	26	16,637	94

Year	Total emissions	Energy	IPPU	AFOLU	Waste
2001	19,164	2,116	26	16,927	95
2002	18,399	2,163	28	16,112	96
2003	18,848	2,454	112	16,176	106
2004	18,748	2,521	239	15,879	108
2005	19,141	2,671	262	16,094	114
2006	20,200	2,823	257	17,003	116
2007	20,730	2,907	295	17,415	113
2008	19,422	2,752	293	16,256	121
2009	21,554	2,832	305	18,289	129
2010	20,726	2,923	303	17,365	135
2011	22,705	2,796	440	19,326	142
2012	23,548	3,004	517	19,875	152
2013	19,835	2,862	530	16,291	152
2014	21,186	3,235	525	17,271	155
2015	21,078	3,541	518	16,856	163

Emissions by gas

The share of emissions by gas did not change during the period 1991 to 2015. The main contributor to the national GHG emissions remained CO_2 followed by CH_4 and N_2O. However, the share of CO_2 increased while those of CH_4 and N_2O regressed over the time series. In 2015, the share of the GHG emissions was as follows: 65.1% CO_2, 22.7% CH_4 and 12.2% N_2O. The trend of the aggregated emissions and removals by gas is given in Table ES 2 and Figure ES 4.

Table ES 2 - Aggregated emissions and removals (Gg) by gas (1991 - 2015)

Year	Total GHG emissions (CO_2-eq)	Removals (CO_2) (CO_2-eq)	Net removals (CO_2-eq)	CO_2	CH_4 (CO_2-eq)	N_2O (CO_2-eq)
1991	19,849	-95,088	-75,239	9,885	6,608	3,356
1992	19,469	-95,643	-76,174	9,959	6,372	3,138
1993	19,049	-96,151	-77,102	10,056	6,026	2,967
1994	18,898	-96,659	-77,761	10,169	5,844	2,884
1995	18,762	-98,466	-79,705	10,177	5,735	2,850
1996	18,447	-100,291	-81,844	10,268	5,465	2,714
1997	18,450	-102,133	-83,683	10,318	5,421	2,711
1998	18,502	-104,175	-85,672	10,457	5,358	2,687
1999	18,560	-106,068	-87,508	10,591	5,301	2,668
2000	18,691	-108,117	-89,426	10,629	5,373	2,688
2001	19,164	-108,388	-89,224	11,021	5,399	2,744
2002	18,399	-112,687	-94,287	11,109	4,802	2,488
2003	18,848	-113,171	-94,323	11,438	4,878	2,532
2004	18,748	-114,970	-96,222	11,630	4,670	2,448
2005	19,141	-112,769	-93,628	11,799	4,837	2,506
2006	20,200	-109,173	-88,973	11,944	5,462	2,794
2007	20,730	-106,421	-85,690	12,063	5,720	2,947
2008	19,422	-115,035	-95,613	11,910	4,947	2,564
2009	21,554	-103,277	-81,723	11,999	6,366	3,189
2010	20,726	-107,450	-86,725	12,086	5,735	2,905
2011	22,705	-105,570	-82,866	12,922	6,480	3,302
2012	23,548	-104,576	-81,028	13,204	6,848	3,496

Year	Total GHG emissions (CO_2-eq)	Removals (CO_2) (CO_2-eq)	Net removals (CO_2-eq)	CO_2	CH_4 (CO_2-eq)	N_2O (CO_2-eq)
2013	19,835	-122,439	-102,604	13,076	4,398	2,362
2014	21,186	-119,525	-98,340	13,436	5,082	2,668
2015	21,078	-121,575	-100,497	13,730	4,780	2,567

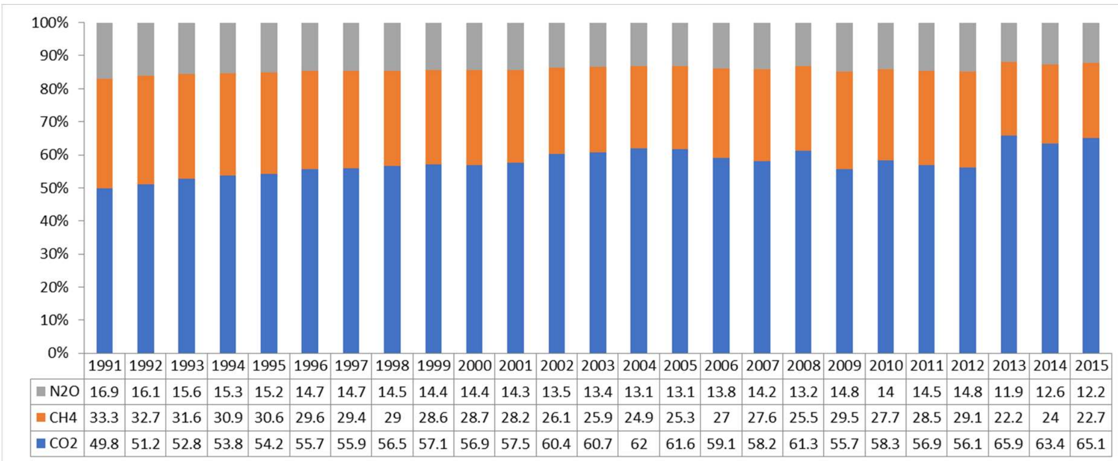

Figure ES 4 - Share of aggregated emissions (Gg CO_2-eq) by gas (1991 - 2015)

Emissions of indirect GHGs (CO, NO_x and NMVOC) and SO_2, have also been estimated and emissions of these gases for the period 1991 to 2015 are given in Table ES 3. Emissions of NO_x decreased from 50.5 Gg in the year 1991 to 38.4 Gg in 2015. CO emissions also regressed, from 2,547 Gg in 1994 to 939 Gg in 2015. Emissions of NMVOC increased from 16.0 Gg in 1991 to 24.7 Gg in 2015 whilst emissions of SO_2 varied between 1.9 Gg and 4.2 Gg during the same period.

Table ES 3 - Emissions (Gg) of indirect GHGs and SO_2 (1991 - 2015)

Year	NO_x	CO	NMVOC	SO_2
1991	50.5	2,547.3	16.0	2.0
1992	49.4	2,426.6	16.0	2.1
1993	48.7	2,313.0	15.7	2.4
1994	48.4	2,198.6	16.0	2.6
1995	45.0	2,083.2	16.1	2.1
1996	43.8	1,966.9	16.3	2.2
1997	41.4	1,849.6	16.8	1.9
1998	41.4	1,731.4	17.7	2.3
1999	41.1	1,612.3	18.4	2.5
2000	39.0	1,465.7	19.8	2.2
2001	40.6	1,479.0	19.8	2.4
2002	37.0	1,133.0	19.4	2.7
2003	38.8	1,140.7	20.2	3.0
2004	36.9	1,024.8	20.6	3.5
2005	41.1	1,267.3	20.4	3.7
2006	45.5	1,618.8	21.4	4.2
2007	49.3	1,904.4	21.5	4.0
2008	37.0	1,200.4	21.4	4.1
2009	54.9	2,263.2	21.8	3.7
2010	51.2	1,946.0	21.9	3.0

Year	NO_x	CO	NMVOC	SO_2
2011	52.7	2,076.8	22.9	3.0
2012	56.3	2,166.1	24.0	3.7
2013	30.7	657.2	22.6	2.5
2014	38.2	939.1	24.7	2.7
2015	38.4	939.1	24.7	2.7

ES 9. QA/QC

Namibia has its own national system for quality control (QC) of data being collected within the different institutions. All data are quality controlled at different stages of the process until the final quality assurance (QA) is made by the National Statistics Agency before archiving in national databases. The private sector also implements its own QC/QA within its data collection and archiving process. Thus, the initial phases of the control system remained beyond the GHG inventory team and the QA/QC process started as from the time the AD are received.

QC and QA procedures, as defined in the *2006 IPCC Guidelines (IPCC, 2006)* have been implemented during the preparation of the inventory. Whenever there were inconsistencies or possible transcription errors, the responsible institution was queried, the problem discussed and solved as far as possible. However, this process is not exempt of mistakes because outliers were frequently observed from the time series data for various activities. QC was implemented through:

- Routine and consistent checks to ensure data integrity, reliability and completeness;
- Routine and consistent checks to identify errors and omissions;
- Accuracy checks on data acquisition and calculations and the use of approved standardized procedures for emissions calculations; and
- Technical and scientific reviews of data used, methods adopted, and results obtained.

QA was undertaken by the independent international consultant who was not involved with the preparation of the inventory, the main objectives being to:

- 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.

Even if QA/QC procedures have been followed throughout the inventory process by the inventory compilers of the different IPCC sectors and the QA officer, a QA/QC plan has yet to be developed to fit within the domestic MRV system under development. Thus, systematic records as per the *2006 IPCC Guidelines* still has to be developed under a dedicated QA/QC coordinator. This resulted from the lack of permanent personnel on the establishment, insufficient capacity and since the inventory management system is still being developed and implemented in the country.

Namibia requested the UNFCCC and Global Support Programme to undertake a QA exercise on its inventory compilation process adopted for the BUR3. The main conclusions, listed below with actions taken, are:

- Use of N_2O for medical applications and ODS are now covered while incineration of medical waste is still being implemented;
- Institutional arrangements to ensure annual provision of AD for preparing the inventory are in the implementation phase;

- Develop and implement a QC management system remains a problem due to lack of permanent staff;
- Improve AD for the AFOLU sector through production of new maps to generate land use changes, national stock and EFs, possible use of Collect earth for confirming the assumptions and data used are all in abeyance due to unavailability of financial resources;
- Development of legal arrangements for securing collaboration of other institutions for AD is under study;
- Improved documentation and archiving are being addressed; and
- Capacity building in various areas of inventory compilation is under way.

ES 10. Completeness

An assessment of the completeness of the inventory was made for individual activity areas within each source category and the results are presented within the sections covering the individual sectors. The methodology adopted was according to the *IPCC 2006 Guidelines (IPCC 2007)* with the following notation keys used:

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

The level of completeness depicting the scope of the inventory is provided in the national and sectoral reporting tables within the respective sections further in this chapter.

ES 11. Uncertainty analysis

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 allocated for the two parameters and the combined uncertainty calculated. In most cases, the uncertainty values allocated to AD and EFs from within the range recommended by the IPCC Guidelines were applied.

Thus, lower values 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 is subject to expert knowledge. Regarding the EFs, the average value recommended in the IPCC Guidelines were adopted except for nationally determined EFs when the lower values in the range were used. 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 2006 Software. Uncertainties in total emissions based on the IPCC tool including emissions and removals from the Land sector is presented in Table ES 4. Uncertainty levels for the individual years of the period 1991 to 2015 varied from 26.7% to 29.1% while the trend assessment when adding one successive year on the base year 1991 for the years 1991 to 2015 ranged from 35.8% to 45.8%.

Table ES 4 - Overall uncertainty (%)

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Annual	28.2	28.0	27.8	27.7	27.6	27.3	27.2	27.1	27.0	27.0	27.1	26.9	26.8
Trend (base year 1991)	-	35.8	36.0	36.2	36.9	37.6	38.2	39.0	39.7	40.5	40.6	42.3	42.5

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Annual	26.7	26.9	27.4	27.8	26.9	28.2	27.7	28.7	29.1	26.8	27.3	27.2
Trend (base year 1994)	43.1	42.3	40.9	39.9	43.2	38.7	40.3	39.8	39.4	46.2	45.1	45.8

ES 12. Key Category Analysis

Key Category Analysis (KCA) gives the characteristics of the emission sources and sinks. According to the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (IPCC, 2000), key categories are those which contribute 95% of the total annual emissions, when ranked from the largest to the smallest emitter. Thus, it is a good practice to identify key categories, as it helps prioritize efforts and improve the overall quality of the national inventory, notwithstanding guiding of mitigation policies, strategies and actions.

The KCA with FOLU was performed using the tool available within the IPCC 2006 Software for both the level and trend assessments while the same exercise without FOLU was done using the EXCEL workbook. The summary of Key Categories based on the quantitative trend and level assessments to the 95% with FOLU is presented in Table ES 5.

Table ES 5 - Summary of Key Categories for level (2015) and trend (1991 - 2015) assessments

Number	IPCC category code	IPCC category	GHG	Identification criteria	Comment
1	3B1a	Forest land Remaining Forest land	CO_2	L1, T1	Quantitative
2	3B3b	Land Converted to Grassland	CO_2	L1, T1	Quantitative
3	3A1	Enteric fermentation	CH_4	L1, T1	Quantitative
4	1A3b	Road Transportation	CO_2	L1, T1	Quantitative
5	3B1b	Land Converted to Forest land	CO_2	T1	Quantitative
6	3C1	Emissions from Biomass Burning	CH_4	T1	Quantitative
7	3C4	Direct Emissions from Managed soils	N_2O	T1	Quantitative
8	3C1	Emissions from Biomass Burning	N_2O	T1	Quantitative
9	2A1	Cement Production	CO_2	T1	Quantitative
10	2C6	Zinc Production	CO_2	T1	Quantitative
11	1.A.4	Other Sectors - Liquid Fuels	CO_2	T1	Quantitative
12	2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	T1	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.

ES 13. Archiving

All raw data, collected for the inventory, have been stored in the IPCC 2006 software data base after being processed and formatted for making estimates of emissions and removals. All documentation on the data processing and formatting have been kept in soft copies in the excel sheets with the summaries reported in the NIR. These versions will be managed in electronic format in at least three copies, two stored at the Ministry of Environment and Tourism and a third copy at the National Statistics Agency.

ES 14. Constraints, gaps and needs

Namibia, as a NAI country, still faces serious challenges to report to the required standards to the Convention, including the inventory component. In order to reduce uncertainties and aim at producing an inventory in line with TACCC principles, Namibia invested in improving its national GHGIMS and Institutional arrangements. One major challenge for estimating emissions for the past years from 1991 to 1999 was gaps in AD. The latter were not readily available since the country was still setting up its national statistics department after independence. Thus, most of the AD for this period were sourced from international databases or extrapolated based on AD available for the period 2000 to 2015.

For this inventory, three more categories, namely N_2O for Medical Applications, RAC, and Harvested Wood Products (HWP) have been included. Some information has also been collected on the use of SF_6, and incineration of medical wastes, but unfortunately, they were not detailed enough to enable computation of emissions in these categories. The following major problems were encountered during the preparation of this national inventory of GHG:

- Almost all the AD, including those from the NSA 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 based on scientific and consumption parameters;
- Lack of solid waste characterization data, amount generated, and wastewater generated from the industrial sector were only partly available;
- National experts could not take over the full inventory compilation process because of insufficient time available when considering their other responsibilities.

ES 15. 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 made. These are:

- Adequate and proper data capture, QC, Validation, Storage and retrieval mechanism needed to facilitate the compilation of future inventories
- Capacity building and strengthening of the existing institutional framework within a GHGIMS to provide improved coordination for a smooth implementation of the GHG inventory cycle for sustainable production of inventories
- Development of EFs more representative of the national context
- Improved existing QA/QC system including a QA/QC plan in order to reduce uncertainty and improve inventory quality
- Find the necessary financial resources to establish a GHG inventory unit within DEA to be responsible for inventory compilation and coordination
- Institutionalize the archiving system; Pursue efforts for collecting the required AD for categories not covered in this exercise, namely the use of SF_6, and incineration of medical waste
- Conduct new forest inventories to confirm the stock and EFs developed with the new approach adopted for the Land sector
- Produce new maps for 1990 to 2015 to refine land use change data over 5 years periods to replace the poor-quality maps available now
- Refine data collection for determining country-specific (CS) weights for dairy cows, other cattle, sheep and goats
- Develop the digestible energy (DE) factor for livestock as country-specific data is better than the default IPCC value to address this key category fully at Tier 2

- Add the missing year 1990 to complete the full time series 1990 to the latest year for compliance in inventory compilation

These improvements will be addressed during the preparation of the NIR5 within the framework of the BUR4.

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1. Introduction

1.1. National circumstances

Namibia's development is guided by its long-term National Policy Framework, Vision 2030, which transcribes into National Development Plans for 5-year periods, and recently through the Harambee Prosperity Plan (HPP). The country is currently in its Fifth National Development Plan (NDP5) that outlines a development strategy that aims at improving the living conditions of every Namibian through sustainable development and a low carbon economy. The vision is to have a prosperous and industrialized Namibia, developed by its human resources, enjoying peace, harmony and political stability.

This section presents the national circumstances of Namibia, detailing the national development priorities, objectives and circumstances that serve as the basis for addressing issues relating to climate change.

1.2. Convention Obligations

Namibia ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1995 as a Non-Annex 1 Party, and as such, is obliged to report certain elements of information in accordance with Article 4, paragraph 1 of the Convention. These elements include:

(a) A national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases (GHG) 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 (COP);

(b) A general description of steps taken or envisaged by the Party to implement the Convention; and

(c) 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.

In order to meet its reporting obligations, Namibia has submitted three national communications (NCs), namely: the INC in 2002; the SNC in 2011; and the TNC in 2015. These reports were prepared with support from the Global Environmental Facility (GEF) through the United Nations Development Programme (UNDP) country office. The Cancun Agreements arrived at during COP 16 in 2011 stipulated that NC reports by non-Annex I Parties, including national GHG inventories, be enhanced to include information on mitigation actions and their effects as well as support received. It was also decided that developing countries, consistent with their capabilities and the level of support provided for reporting, should submit BURs. The latter, containing updates of national GHG inventories, inventory report and information on mitigation actions, needs and support received and Institutional Arrangements are produced every two years, with the first one due in December 2014 as decided in COP 17. Namibia also met this obligation and submitted its BUR1 during COP 20 in Lima in 2014 and further followed up with submitting its second and third BURs in 2016 and 2019 respectively, making Namibia one of the most compliant Non-Annex 1 Party to the Convention, in terms of reporting.

Reporting guidelines agreed during COP 8 for the preparation of NCs from Parties not included in Annex I to the Convention and contained in decision 17/CP.8 have been adopted for the preparation of this report.

The multi-sectoral National Climate Change Committee (NCCC), chaired by the Ministry of Environment and Tourism (MET), provided the overall oversight and advisory role for the implementation of the Fourth

National Communication (NC4) project. Like for previous NCs and BURs, NC4 was coordinated by the Climate Change Unit (CCU) of the Department of Environmental Affairs (DEA) of the MET, which is responsible for overseeing the coordination of climate change issues in Namibia in its role as national focal point of the Convention.

2. The Inventory Process

2.1. Overview of GHG inventories

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.

The INC and SNC of the Republic of Namibia to the UNFCCC included the National Inventory of greenhouse gases 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). These inventories have all been compiled using the sectoral bottom-up approach. The reference approach has also been used for the Energy sector, to enable comparison of the two methods. The gases estimated were carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), oxides of nitrogen (NO_x), sulphur dioxide (SO_2), non-methane volatile organic compounds (NMVOCs) and the precursor carbon monoxide (CO). A third Inventory has been compiled using a mix of Tiers 1 and 2 for the BUR1 and submitted to the UNFCCC in 2014. The fourth, fifth and sixth inventories have been submitted as stand-alone national inventory reports (NIR). The IPCC 2006 Guidelines and software were used for compiling these inventories. The preparation of the present inventory started in 2018 after completion of the one contained in the BUR3. One year was allocated to implement and complete the different steps of the inventory cycle as depicted in Figure 2.1.

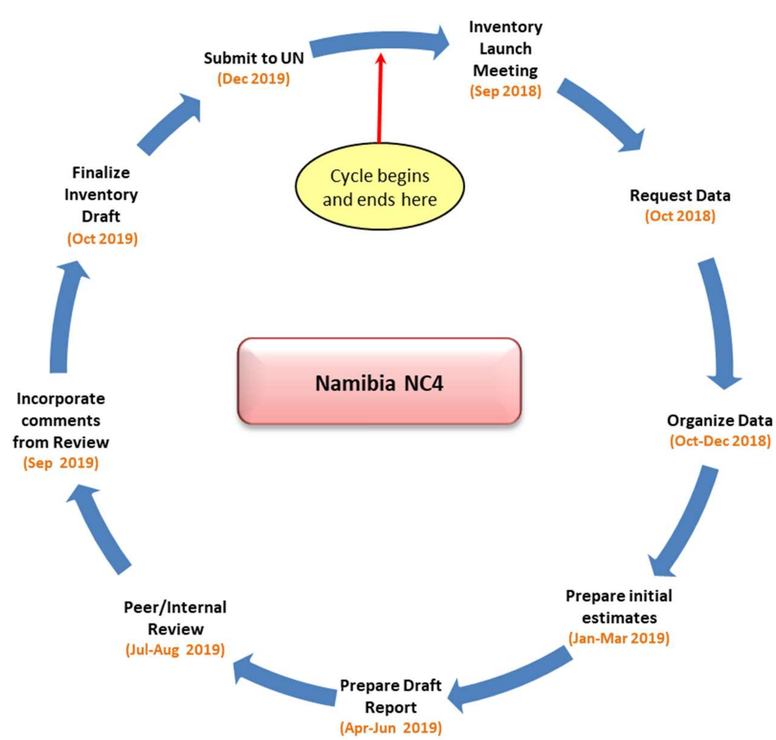

Figure 2.1 - The inventory cycle of Namibia's NC4

This seventh GHG inventory is presented as a chapter of the NC4 in lieu of a stand-alone national inventory report and provides data on GHG emissions by sources and removals by sinks for a full time series for the period 1991 to 2015, the years 1991 to 1993 and 2015 being additions to the previous one. Improvements over the previous inventory consisted in the inclusion of categories Medical Application of N_2O, Refrigeration and Air Conditioning (RAC) and Harvested Wood Products (HWP). Once again, a mix of Tiers 1 and 2 has been adopted.

2.2. Institutional arrangements and inventory preparation

Namibia consolidated the in-house production of its GHG inventory except for the support from a company's services for computation of emissions, QA/QC and report writing and an independent international consultant for performing the QA and capacity building to meet the enhanced transparency and higher standards of reporting due to lack of financial resources to maintain permanent staff for a full institutionalization of the process. The upfront segment of the process is a laborious exercise also as sufficient financial resources to support adequate human capacity remains a prominent limiting factor. Another factor is the numerous changes in the working groups following staff movements, promotions and resignations.

The CCU of MET monitors and coordinates the production of reports to the Convention, including the GHG inventories as National Focal Point of the Convention. The same framework adopted for the previous inventory (NIR3) compilation was followed. Collaboration with data providers, institutions and organizations to support derivation of national EFs and enable moving to Tier 2 were consolidated. Capacity building of the inventory working group members continued.

The responsibilities within the institutional arrangements did not change with:

- The CCU of MET for inventory coordination, compilation and submission;
- Ministry of Mines and Energy for the Energy sector;
- Ministry of Industrialization, Trade and SME Development for the IPPU sector;
- Ministry of Agriculture, Water Affairs and Forestry for the AFOLU sector;
- MET for the Waste sector;
- Namibia NSA for Archiving, including provision of quality-controlled AD;
- The CCU of MET for coordinating QA/QC;
- External consultant for capacity building and QA;
- The CCU of MET for coordinating Uncertainty Analysis; and
- The CCU of MET to act as GHG inventory specialist to track capacity building needs, the IPCC process and COP decisions for implementation.

The institutional arrangements for the compilation of the inventory and reporting for the different sectors are shown in Figure 2.2.

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

- Drawing up of work plan with timeline and deliverables;
- Allocation of tasks to sectoral experts;
- Collection, quality control and validation of AD;
- Selection of Tier level within each category and sub-category;
- Selection of 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;
- Uncertainty analysis;

- QA/QC of emissions and outputs;
- Assessment of completeness;
- Recalculations;
- Trend analysis;
- Identification of Gaps, constraints, needs and improvements;
- Report writing.
- Circulation of report to stakeholders for comments;
- Integration of stakeholder's comments;
- Validation of GHG inventory and report for inclusion in NC4; and
- Submission to UNFCCC as a component of the NC4

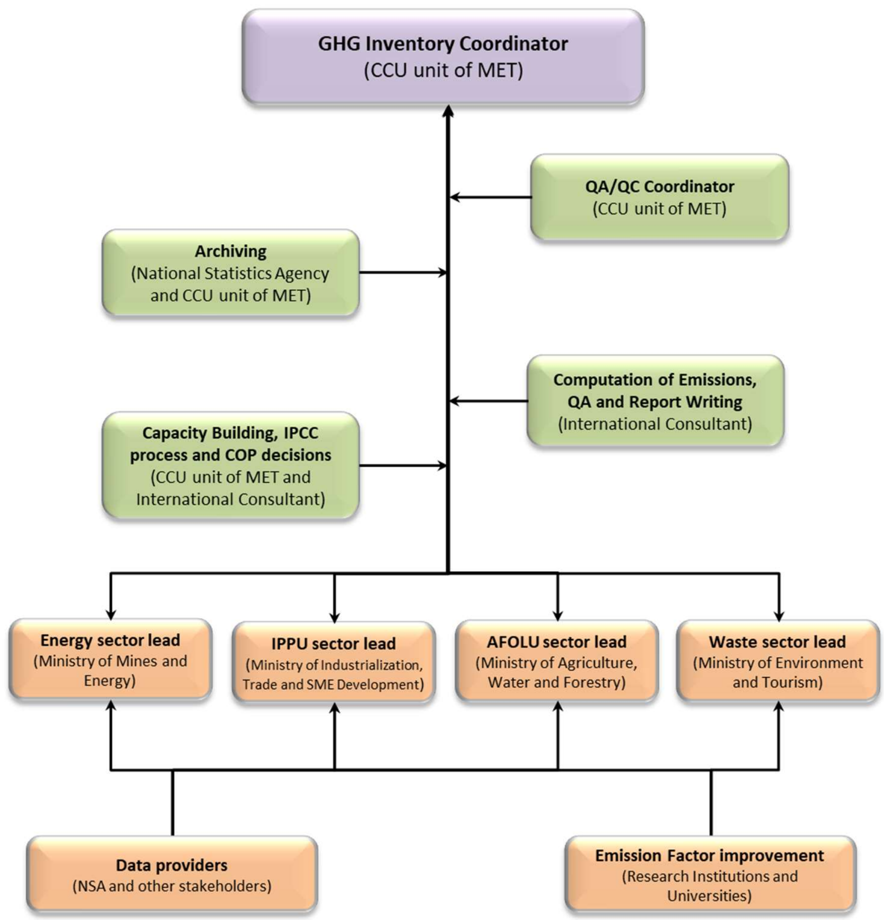

Figure 2.2 - Institutional arrangements for the GHG inventory preparation

2.3. Key Category Analysis

Key Category Analysis (KCA) gives the characteristics of the emission sources and sinks. According to the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (IPCC, 2000), key categories are those which contribute 95% of the total annual emissions, when ranked from the largest to the smallest emitter. Thus, it is a good practice to identify key categories, as it helps prioritize efforts and improve the overall quality of the national inventory, notwithstanding guiding of mitigation policies, strategies and actions.

The KCA with FOLU was performed using the tool available within the IPCC 2006 Software for both the level and trend assessments while the same exercise without FOLU was done using the EXCEL workbook.

The results, with and without FOLU, for the level assessment for the year 2015 are presented in Table 2.1 and the trend assessment in Table 2.2.

Table 2.1 - Key Category Analysis for the year 2015 with and without FOLU- Approach 1 - Level Assessment

A	B	C	D	E	F	G
IPCC Category code	IPCC Category	GHG	"2015 Ex,t (Gg CO_2-eq)"	"|Ex,t| (Gg CO_2-eq)"	Lx,t	Cumulative Total of Column F
With FOLU						
3.B.1.a	Forest land Remaining Forest land	CO_2	-120,525.8	120,525.8	0.844	0.844
3.B.3.b	Land Converted to Grassland	CO_2	9,755.9	9,755.9	0.068	0.913
3.A.1	Enteric Fermentation	CH_4	3,553.1	3,553.1	0.025	0.937
1.A.3.b	Road Transportation	CO_2	2,687.8	2,687.8	0.019	0.956
3.C.4	Direct N_2O Emissions from managed soils	N_2O	1,779.9	1,779.9	0.013	0.969
3.C.1	Emissions from biomass burning	CH_4	966.3	966.3	0.007	0.976
Without FOLU						
3.A.1	Enteric Fermentation	CH_4	3,553.1	3553.1	0.309	0.309
1.A.3.b	Road Transportation	CO_2	2,687.8	2687.8	0.234	0.542
3.C.4	Direct N2O Emissions from managed soils	N_2O	1,779.9	1779.9	0.155	0.697
3.C.1	Emissions from biomass burning	CH_4	966.3	966.3	0.084	0.780
3.C.1	Emissions from biomass burning	N_2O	421.2	421.2	0.037	0.817
1.A.4	Other Sectors - Liquid Fuels	CO_2	375.3	375.3	0.033	0.850
2.A.1	Cement production	CO_2	330.2	330.2	0.029	0.879
2.C.6	Zinc Production	CO_2	141.0	141.0	0.012	0.891
3.A.2	Manure Management	N_2O	137.1	137.1	0.012	0.903
3.C.6	Indirect N2O Emissions from manure management	N_2O	125.6	125.6	0.011	0.914
2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	113.2	113.2	0.010	0.924
1.A.5	Non-Specified - Liquid Fuels	CO_2	106.9	106.9	0.009	0.933
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	90.5	90.5	0.008	0.941
3.D.1	Harvested Wood Products	CO_2	-86.5	86.5	0.008	0.948
3.A.2	Manure Management	CH_4	84.7	84.7	0.007	0.955
4.A	Solid Waste Disposal	CH_4	84.2	84.2	0.007	0.963
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	65.1	65.1	0.006	0.969
1.A.3.c	Railways	CO_2	48.7	48.7	0.004	0.973

There are four key categories in the quantitative level assessment when including FOLU for the year 2015, three of these from the AFOLU sector, namely enteric fermentation, Forest land Remaining Forest land and Road Transportation. When considering the KCA without FOLU, there is a sharp increase from four to fifteen. This is because the FOLU categories were the highest sinks and emitters, contributing to 91.3 % at absolute level in the KCA. When these two categories are not considered without FOLU, the contribution came from 11 categories to equal the same emissions/sinks at absolute level. It is important to point out that 11 out of the 15 key categories when considering the analysis without FOLU contributed less than 2% individually. This raises the question of whether it is worth prioritising these categories for Tier 2 level estimation of emissions and also within the national mitigation strategy.

The results change quite drastically when considering the trend assessment covering the period 1991 to 2015 (Table 2.2). There are now twelve and eleven key categories when considering the assessment without FOLU, with four categories contributing less than 2% of national emissions under both situation with and without FOLU.

Table 2.2 - Key Category Analysis for the period 1991 - 2015 - Approach 1 - Trend Assessment

A	B	C	D	E	F	G	H
IPCC Category code	IPCC Category	GHG	1991 Year Estimate Ex0 (Gg CO_2-eq)	2015 Year Estimate Ext (Gg CO_2-eq)	Trend Assessment (Txt)	% Contribution to Trend	Cumulative Total of Column G
With FOLU							
3.B.1.a	Forest land Remaining Forest land	CO_2	-93,467.7	-120,525.8	0.035	0.234	0.234
3.B.3.b	Land Converted to Grassland	CO_2	8,671.9	9,755.9	0.035	0.231	0.465
1.A.3.b	Road Transportation	CO_2	570.1	2,687.8	0.020	0.134	0.599
3.A.1	Enteric Fermentation	CH_4	3,029.8	3,553.1	0.013	0.089	0.689
3.C.1	Emissions from Biomass Burning	CH_4	3,427.3	966.3	0.012	0.077	0.766
3.B.1.b	Land Converted to Forestland	CO_2	-1,619.9	-962.71	0.010	0.070	0.835
3.C.4	Direct N2O Emissions from Managed Soils	N_2O	1,510.9	1,779.9	0.006	0.045	0.880
3.C.1	Emissions from Biomass Burning	N_2O	1,501.9	412.2	0.005	0.034	0.914
2.A.1	Cement Production	CO_2	0	330.2	0.003	0.019	0.933
2.C.6	Zinc Production	CO_2	0	141.1	0.001	0.008	0.941
1.A.4	Other Sectors - Liquid Fuels	CO_2	375.9	375.3	0.001	0.007	0.949
2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	0	113.2	0.001	0.007	0.955
1.A.5	Non-Specified - Liquid Fuels	CO_2	9.13	106.9	0.001	0.006	0.961
3.D.1	Harvested Wood Products	CO_2	0	-86.5	0.001	0.005	0.966
3.C.6	Solid Waste Disposal	CH_4	10.9	84.2	0.001	0.004	0.970
Without FOLU							
3.C.1	Emissions from biomass burning	CH_4	3,427.3	966.3	0.338	0.334	0.338
1.A.3.b	Road Transportation	CO_2	570.1	2,687.8	0.277	0.277	0.615
3.C.1	Emissions from biomass burning	N_2O	1,501.9	421.2	0.148	0.148	0.763
3.A.1	Enteric Fermentation	CH_4	3,029.8	3,553.1	0.057	0.057	0.820
2.A.1	Cement production	CO_2	0	330.2	0.044	0.044	0.864
3.C.4	Direct N2O Emissions from managed soils	N_2O	1510.9	1779.9	0.030	0.030	0.894
2.C.6	Zinc Production	CO_2	0	141.0	0.019	0.019	0.912
2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	0	113.2	0.015	0.015	0.927
1.A.5	Non-Specified - Liquid Fuels	CO_2	9.1	106.9	0.013	0.015	0.940
3.D.1	Harvested Wood Products	CO_2	0	-86.5	0.011	0.011	0.951
4.A	Solid Waste Disposal	CH_4	10.9	84.2	0.010	0.009	0.960
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	29.4	65.1	0.005	0.006	0.966
1.A.3.b	Road Transportation	N_2O	8.5	41.6	0.004	0.004	0.970
3.A.2	Manure Management	N_2O	106.8	137.1	0.004	0.004	0.974

The summary of Key Categories based on the quantitative trend and level assessments to the 95% with FOLU is presented in Table 2.3.

Table 2.3 - Summary of Key Categories for level (2015) and trend (1991 to 2015) assessments

Number	IPCC category code	IPCC category	GHG	Identification criteria	Comment
1	3B1a	Forest land Remaining Forest land	CO_2	L1, T1	Quantitative
2	3B3b	Land Converted to Grassland	CO_2	L1, T1	Quantitative
3	3A1	Enteric fermentation	CH_4	L1, T1	Quantitative
4	1A3b	Road Transportation	CO_2	L1, T1	Quantitative
5	3B1b	Land Converted to Forest land	CO_2	T1	Quantitative
6	3C1	Emissions from Biomass Burning	CH_4	T1	Quantitative
7	3C4	Direct Emissions from Managed soils	N_2O	T1	Quantitative
8	3C1	Emissions from Biomass Burning	N_2O	T1	Quantitative
9	2A1	Cement Production	CO_2	T1	Quantitative
10	2C6	Zinc Production	CO_2	T1	Quantitative
11	1.A.4	Other Sectors - Liquid Fuels	CO_2	T1	Quantitative
12	2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	T1	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.

2.4. Methodological issues

Generally, the method adopted to compute emissions involved multiplying activity data (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.

As the IPCC 2006 Guidelines do not fully address compilations at the Tier 2 level, national EFs and stock factors as appropriate have been derived and adopted to compile estimates at the Tier 2 level partially for the Livestock and Land sectors. This is good practice and improved the accuracy of the emission estimates and reduced the uncertainty level.

Global Warming Potentials (GWP) as recommended by the IPCC have been used to convert GHGs other than CO_2 to the latter equivalent. Based on decision 17/CP.8, the values adopted were those from the IPCC Second Assessment Report for the three direct GHGs, namely carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) as well as for the gases used for Refrigeration and Air Conditioning (Table 2.4). Additional gases, known as (indirect gases), which affect global warming, namely oxides of nitrogen (NO_x), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (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)	21
Nitrous Oxide	(N_2O)	310
HFC - 32	(CH2F2)	650

Gas		Global Warming Potential
HFC - 125	(CH2CF3)	2800
HFC - 134a	(CF2FCF3)	1300
HFC - 143a	(CF3CH3)	3800

Default EFs were assessed for their appropriateness prior to their adoption, based on the situations under which they have been developed and the extent to which these were representative of national circumstances. Country-specific EFs and stock factors derived using national data and the IPCC equations as appropriate for the Livestock and Land sub-sectors were used instead of the default ones which did not reflect the national context.

Country-specific AD are readily available as a fairly good statistical system exists since 2003 whereby data pertaining to most of the socio-economic sectors are collected, verified and processed to produce official national statistics reports. Additional and/or missing data, and those required to meet the level of disaggregation for higher Tier levels, were sourced directly from both public and private sector operators. Data gaps were filled through personal contacts with the stakeholders and/or from results of surveys, scientific studies and by statistical modelling. These were considered reliable and sound since they were based on scientific findings and other observations. Estimates used included fuel use for navigation, domestic aviation, food consumption and forest areas by type. Most AD for the period 1991 to 2002 were generated based on related socio-economic factors or through extrapolations from the available time series AD.

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

Namibia has its own national system for quality control (QC) of data being collected within the different institutions. All data are quality controlled at different stages of the process until the final quality assurance (QA) is made by the National Statistics Agency before archiving in national databases. The private sector also implements its own QC/QA within its data collection and archiving process. Thus, the initial phases of the control system remained beyond the GHG inventory team and the QA/QC process started as from the time the AD are received.

QC and QA procedures, as defined in the *2006 IPCC Guidelines (IPCC, 2006)* have been implemented during the preparation of the inventory. Whenever there were inconsistencies or possible transcription errors, the responsible institution was queried, the problem discussed and solved as far as possible. However, this process is not exempt of mistakes because outliers were frequently observed from the time series data for various activities. QC was implemented through:

- Routine and consistent checks to ensure data integrity, reliability and completeness;
- Routine and consistent checks to identify errors and omissions;
- Accuracy checks on data acquisition and calculations and the use of approved standardized procedures for emissions calculations; and
- Technical and scientific reviews of data used, methods adopted, and results obtained.

QA was undertaken by the independent international consultant who was not involved with the preparation of the inventory, the main objectives being to:

- 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.

Even if QA/QC procedures have been followed throughout the inventory process by the inventory compilers of the different IPCC sectors and the QA officer, a QA/QC plan has yet to be developed to fit within the domestic MRV system under development. Thus, systematic records as per the *2006 IPCC Guidelines* still has to be developed under a dedicated QA/QC coordinator. This resulted from the lack of permanent personnel on the establishment, insufficient capacity and since the inventory management system is still being developed and implemented in the country.

Namibia requested the UNFCCC and Global Support Programme to undertake a QA exercise on its inventory compilation process adopted for the BUR3. The main conclusions, listed below with actions taken, are:

- Use of N_2O for medical applications and ODS are now covered while incineration of medical waste is still being implemented;
- Institutional arrangements to ensure annual provision of AD for preparing the inventory are in the implementation phase;
- Develop and implement a QC management system remains a problem due to lack of permanent staff;
- Improve AD for the AFOLU sector through production of new maps to generate land use changes, national stock and EFs, possible use of Collect earth for confirming the assumptions and data used are all in abeyance due to unavailability of financial resources;
- Development of legal arrangements for securing collaboration of other institutions for AD is under study;
- Improved documentation and archiving are being addressed; and
- Capacity building in various areas of inventory compilation is under way.

2.6. Uncertainty assessment

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 allocated for the two parameters and the combined uncertainty calculated. In most cases, the uncertainty values allocated to AD and EFs from within the range recommended by the IPCC Guidelines were applied. Thus, lower values 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 is subject to expert knowledge. Regarding the EFs, the average value recommended in the IPCC Guidelines were adopted except for nationally determined EFs when the lower values in the range were used. 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 2006 Software. Uncertainties in total emissions based on the IPCC tool including emissions and removals from the Land sector is presented in **Error! Reference source not found.** Uncertainty levels for the individual years of the period 1991 to 2015 varied from 26.7% to 29.1% while the trend assessment when adding one successive year on the base year 1991 for the years 1991 to 2015 ranged from 35.8% to 45.8%.

Table 2.5 - Overall uncertainty (%)

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Annual	28.2	28.0	27.8	27.7	27.6	27.3	27.2	27.1	27.0	27.0	27.1	26.9	26.8
Trend (base year 1991)	-	35.8	36.0	36.2	36.9	37.6	38.2	39.0	39.7	40.5	40.6	42.3	42.5

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Annual	26.7	26.9	27.4	27.8	26.9	28.2	27.7	28.7	29.1	26.8	27.3	27.2
Trend (base year 1994)	43.1	42.3	40.9	39.9	43.2	38.7	40.3	39.8	39.4	46.2	45.1	45.8

2.7. Assessment of completeness

An assessment of the completeness of the inventory was made for individual activity areas within each source category and the results are presented within the sections covering the individual sectors. The methodology adopted was according to the *IPCC 2006 Guidelines (IPCC 2007)* with the following notation keys used:

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

The level of completeness depicting the scope of the inventory is provided in the national and sectoral reporting tables within the respective sections further in this chapter.

2.8. Recalculations

There have been no recalculations performed during the computation of the present inventory. Recalculated emissions for the base years 1994, 2000 and 2010 are reproduced in Table 2.6 while for the remaining years of the time series, the recalculations can be captured in the sectoral presentations. Original estimates of 1994, 2000 and 2010 were made according to IPCC 1996 Revised GL, Tier 1, lower coverage of activity areas compared to present inventory and default EFs while recalculated values are compiled in line with 2006 IPCC GL, new improved data sets, a mix of Tiers 1 and 2, the latter for most key categories and an wider coverage.

Table 2.6 - Comparison of original and recalculated emissions, removals and net removals of past inventories presented in national communications

Year	1994		2000		2010	
	INC	NC4	SNC	NC4	TNC	NC4
Removals	-5,716	-96,659	-10,566	-108,117	-28,534	-107,450
Emissions	5,685	18,898	9,118	18,671	27,195	20,726
Net removals	-31	-77,761	-1,442	-89,426	-1,339	-86,725

2.9. Time series consistency

This inventory now covers the period 1991 to 2015 and AD within each of the source categories covered were abstracted from the same sources for all years. The same EFs have been used throughout the full 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.

2.10. Gaps, constraints and needs

Namibia, as a NAI country, still faces serious challenges to report to the required standards to the Convention, including the inventory component. In order to reduce uncertainties and aim at producing an inventory in line with TACCC principles, Namibia invested in improving its national GHGIMS and Institutional arrangements. One major challenge for estimating emissions for the past years from 1991 to 1999 was gaps in AD. The latter were not readily available since the country was still setting up its national statistics department after independence. Thus, most of the AD for this period were sourced from international databases or extrapolated based on AD available for the period 2000 to 2015.

For this inventory, three more categories, namely N_2O for Medical Applications, RAC, and Harvested Wood Products (HWP) have been included. Some information has also been collected on the use of SF_6, and incineration of medical wastes, but unfortunately, they were not detailed enough to enable computation of emissions in these categories. The following major problems were encountered during the preparation of this national inventory of GHG:

- Almost all the AD, including those from the NSA 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 based on scientific and consumption parameters;
- Lack of solid waste characterization data, amount generated, and wastewater generated from the industrial sector were only partly available;
- National experts could not take over the full inventory compilation process because of insufficient time available when considering their other responsibilities.

2.11. 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 made. These are: Adequate and proper data capture, QC, Validation, Storage and retrieval mechanism needed to facilitate the compilation of future inventories; Capacity building and strengthening of the existing institutional framework within a GHGIMS to provide improved coordination for a smooth implementation of the GHG inventory cycle for sustainable production of inventories; Development of EFs more representative of the national context; Improved existing QA/QC system including a QA/QC plan in order to reduce uncertainty and improve inventory quality; Find the necessary financial resources to establish a GHG inventory unit within DEA to be responsible for inventory compilation and coordination; Institutionalize the archiving system; Pursue efforts for collecting the required AD for categories not covered in this exercise, namely the use of SF_6, and incineration of medical waste; Conduct new forest inventories to confirm the stock and EFs developed with the new approach adopted for the Land sector; Produce new maps for 1990 to 2015 to refine land use change data over 5 years periods to replace the poor-quality maps available now; Refine data collection for determining country-specific (CS) weights for dairy cows, other cattle, sheep and goats; Develop the digestible energy (DE) factor for livestock as country-specific data is better than the default

IPCC value to address this key category fully at Tier 2; and Add the missing year 1990 to complete the full time series 1990 to the latest year for compliance in inventory compilation. These improvements will be addressed during the preparation of the NIR4 within the framework of the BUR4.

3. Trends in greenhouse gas emissions

3.1. The period 1991 to 2015

Namibia remained a net GHG sink over the period 1991 to 2015 as the Land category removals exceeded emissions from the other categories. The net removal of CO_2 increased by 25,258 Gg from 75,239 Gg to 100,497 Gg in 2015, representing an increase of 33.6% over these 25 years. During the same period, the country recorded an increase of 6.2% in emissions, from 19,849 Gg CO_2-eq to 21,554 Gg CO_2-eq. The trend for the period 1991 to 2015 indicates that the total removals from the LAND category increased from 95,088 Gg CO_2-eq in 1991 to 121,575 Gg CO_2-eq in 2015 (Table 3.1 and Figure 3.1).

Table 3.1 - GHG emissions (Gg CO_2-eq) characteristics (1991 - 2015)

Year	Total emissions	AFOLU removals	Net	Per capita emission (t)	GDP emissions index (Year 1991 = 100)
1991	19,849	95,088	75,239	13.3	100.0
1992	19,469	95,643	76,174	12.8	98.1
1993	19,049	96,151	77,102	12.3	96.0
1994	18,898	96,659	77,761	11.9	95.2
1995	18,762	98,466	79,705	11.6	90.8
1996	18,447	100,291	81,844	11.2	86.5
1997	18,450	102,133	83,683	10.9	83.0
1998	18,502	104,175	85,672	10.8	80.6
1999	18,560	106,068	87,508	10.6	78.2
2000	18,691	108,117	89,426	10.4	76.1
2001	19,164	108,388	89,224	10.5	77.1
2002	18,399	112,687	94,287	9.9	70.6
2003	18,848	113,171	94,323	10.0	69.4
2004	18,748	114,970	96,222	9.8	61.5
2005	19,141	112,769	93,628	9.9	61.3
2006	20,200	109,173	88,973	10.3	60.4
2007	20,730	106,421	85,690	10.4	58.8
2008	19,422	115,035	95,613	9.6	53.3
2009	21,554	103,277	81,723	10.5	59.8
2010	20,726	107,450	86,725	10.0	54.1
2011	22,705	105,570	82,866	10.8	56.0
2012	23,548	104,576	81,028	11.0	55.3
2013	19,835	122,439	102,604	9.2	44.1
2014	21,186	119,525	98,340	9.6	44.3
2015	21,078	121,575	100,497	9.5	44.1

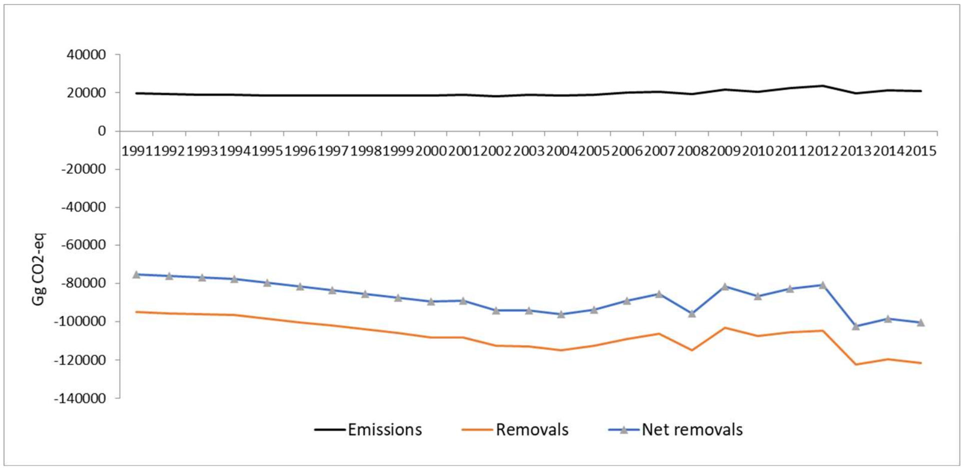

Figure 3.1 - Evolution of national emissions, national removals and the overall (net) situation (Gg CO_2-eq), (1991 - 2015)

Per capita emissions of GHG decreased gradually from 13.3 tonnes CO_2-eq in 1991 to reach 9.9 tonnes in 2002; it then plateaued between 9.8 and 10.0 tonnes up to 2005 after which period it seesawed to reach 9.5 tonnes CO_2-eq in 2015 (Figure 3.2). The GDP emission index decreased almost steadily from 100 in the year 1991 to 44 in 2015 (Figure 3.3).

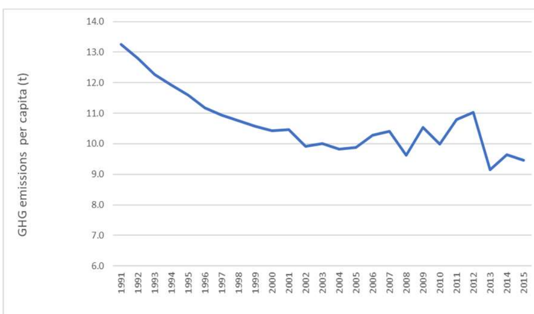

Figure 3.2 - Per capita GHG emissions (1991 - 2015)

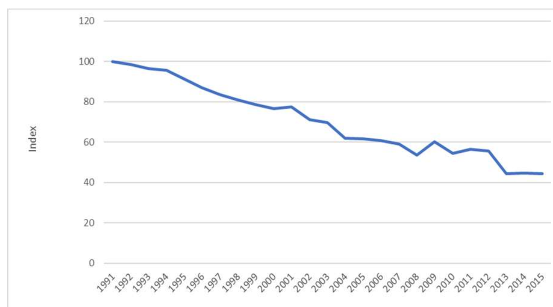

Figure 3.3 - GDP emissions index (1991 - 2015)

3.2. Trend of emissions by sector

Total national emissions increased by 6.2% over these 25 years. The AFOLU sector remained the leading emitter throughout this period followed by Energy, for all years under review. Following the setting up of new industries, the IPPU sector took over as the third emitter in lieu of the Waste sector as from the year 2003. Emissions from the AFOLU sector decreased from 18,574 Gg CO_2-eq in 1991 to 16,856 in 2015, representing a decrease of 9% from the 1991 level. The share of GHG emissions from the AFOLU sector out of total national emissions regressed from 93.5% in 1991 to 80.0% in 2015.

Energy emissions increased from 1,177 Gg CO_2-eq (6.0%) of national emissions in 1991 to 3,541 Gg CO_2-eq (16.8%) in 2015 as depicted in Table 3.2. During the period 1991 to 2015, the emissions increased by three times.

The contribution of the IPPU sector in total national emissions increased from 21 Gg CO_2-eq in 1991 to 518 Gg CO_2-eq in 2015 (Table 3.2**Error! Reference source not found.**). The very sharp increase in GHG emissions in the IPPU sector is due to the commencement of the production of Zinc in 2003 and cement in 2011.

Waste emissions on the other hand varied slightly over this period with the tendency being for a slight increase over time. Emissions from the waste sector increased from the 1991 level of 76 Gg CO_2-eq to 163 Gg CO_2-eq in 2015, representing a 115% increase.

In 2015, Energy contributed 16.8% of emissions, IPPU 2.5%, AFOLU 80.0% and Waste 0.8%.

Table 3.2 - National GHG emissions (Gg, CO_2-eq) by sector (1991 - 2015)

Year	Total emissions	Energy	IPPU	AFOLU	Waste
1991	19,849	1,177	21	18,574	76
1992	19,469	1,252	22	18,117	79
1993	19,049	1,350	23	17,595	81
1994	18,898	1,464	23	17,328	83
1995	18,762	1,473	24	17,183	81
1996	18,447	1,566	24	16,777	80
1997	18,450	1,617	25	16,726	82
1998	18,502	1,759	26	16,633	85
1999	18,560	1,893	26	16,551	89
2000	18,691	1,934	26	16,637	94
2001	19,164	2,116	26	16,927	95
2002	18,399	2,163	28	16,112	96
2003	18,848	2,454	112	16,176	106
2004	18,748	2,521	239	15,879	108
2005	19,141	2,671	262	16,094	114
2006	20,200	2,823	257	17,003	116
2007	20,730	2,907	295	17,415	113
2008	19,422	2,752	293	16,256	121
2009	21,554	2,832	305	18,289	129
2010	20,726	2,923	303	17,365	135
2011	22,705	2,796	440	19,326	142
2012	23,548	3,004	517	19,875	152
2013	19,835	2,862	530	16,291	152
2014	21,186	3,235	525	17,271	155
2015	21,078	3,541	518	16,856	163

3.3. Trend in emissions of direct GHGs

The share of emissions by gas did not change during the period 1991 to 2015. The main contributor to the national GHG emissions remained CO_2 followed by CH_4 and N_2O. However, the share of CO_2 increased while those of CH_4 and N_2O regressed over the time series. In 2015, the share of the GHG emissions was as follows: 65.1% CO_2, 22.7% CH_4 and 12.2% N_2O. The trend of the aggregated emissions and removals by gas is given in Table 3.3**Error! Reference source not found.** and Figure 3.4.

Table 3.3 - Aggregated emissions and removals (Gg) by gas (1991 - 2015)

Year	Total GHG emissions (CO_2-eq)	Removals (CO_2) (CO_2-eq)	Net removals (CO_2-eq)	CO_2	CH_4 (CO_2-eq)	N_2O (CO_2-eq)
1991	19,849	-95,088	-75,239	9,885	6,608	3,356
1992	19,469	-95,643	-76,174	9,959	6,372	3,138

Year	Total GHG emissions (CO_2-eq)	Removals (CO_2) (CO_2-eq)	Net removals (CO_2-eq)	CO_2	CH_4 (CO_2-eq)	N_2O (CO_2-eq)
1993	19,049	-96,151	-77,102	10,056	6,026	2,967
1994	18,898	-96,659	-77,761	10,169	5,844	2,884
1995	18,762	-98,466	-79,705	10,177	5,735	2,850
1996	18,447	-100,291	-81,844	10,268	5,465	2,714
1997	18,450	-102,133	-83,683	10,318	5,421	2,711
1998	18,502	-104,175	-85,672	10,457	5,358	2,687
1999	18,560	-106,068	-87,508	10,591	5,301	2,668
2000	18,691	-108,117	-89,426	10,629	5,373	2,688
2001	19,164	-108,388	-89,224	11,021	5,399	2,744
2002	18,399	-112,687	-94,287	11,109	4,802	2,488
2003	18,848	-113,171	-94,323	11,438	4,878	2,532
2004	18,748	-114,970	-96,222	11,630	4,670	2,448
2005	19,141	-112,769	-93,628	11,799	4,837	2,506
2006	20,200	-109,173	-88,973	11,944	5,462	2,794
2007	20,730	-106,421	-85,690	12,063	5,720	2,947
2008	19,422	-115,035	-95,613	11,910	4,947	2,564
2009	21,554	-103,277	-81,723	11,999	6,366	3,189
2010	20,726	-107,450	-86,725	12,086	5,735	2,905
2011	22,705	-105,570	-82,866	12,922	6,480	3,302
2012	23,548	-104,576	-81,028	13,204	6,848	3,496
2013	19,835	-122,439	-102,604	13,076	4,398	2,362
2014	21,186	-119,525	-98,340	13,436	5,082	2,668
2015	21,078	-121,575	-100,497	13,730	4,780	2,567

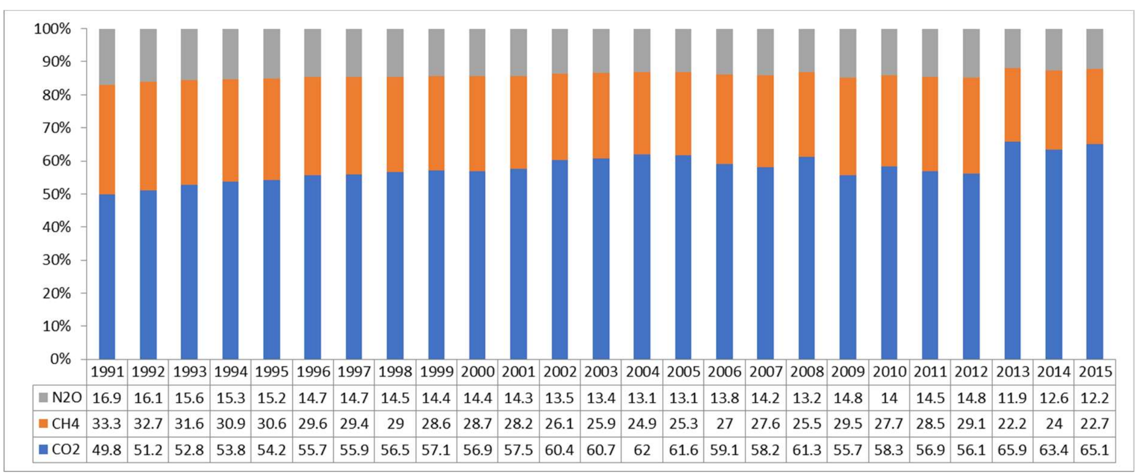

Figure 3.4 - Share of aggregated emissions (Gg CO_2-eq) by gas (1991 - 2015)

3.3.1. Carbon dioxide (CO_2)

The most significant anthropogenic GHG was CO_2. CO_2 emissions increased by 3,851 Gg from the 1991 level of 9,885 Gg (Table 3.4**Error! Reference source not found.**) to 13,736 Gg in 2015. In the same year, the sector that emitted the highest amount of CO_2 was AFOLU with 9,769 Gg followed by Energy with 3,443 Gg (Table 3.4).

Table 3.4 - CO_2 emissions (Gg) by source category (1991 - 2015)

Year	Total emissions	Total net removals	Energy	IPPU	AFOLU - emissions	AFOLU - removals	Waste
1991	9,885	-85,203	1,128	20	8,736	-95,088	0.9
1992	9,959	-85,684	1,201	21	8,736	-95,643	0.9
1093	10,056	-86,095	1,298	22	8,736	-96,151	0.9
1994	10,169	-86,490	1,410	22	8,736	-96,659	1.9
1995	10,177	-88,290	1,417	23	8,736	-98,466	1.0
1996	10,268	-90,023	1,508	23	8,736	-100,291	1.0
1997	10,318	-91,815	1,557	24	8,736	-102,133	1.1
1998	10,457	-93,717	1,696	24	8,736	-104,175	1.1
1999	10,591	-95,477	1,829	25	8,735	-106,068	1.2
2000	10,629	-97,487	1,868	25	8,736	-108,117	1.2
2001	11,021	-97,367	2,046	25	8,949	-108,388	1.3
2002	11,109	-101,578	2,093	27	8,949	-112,687	1.3
2003	11,438	-101,733	2,379	110	8,947	-113,171	1.4
2004	11,630	-103,341	2,444	237	8,947	-114,970	1.4
2005	11,799	-100,971	2,590	260	8,947	-112,769	1.5
2006	11,944	-97,229	2,740	255	8,947	-109,173	1.6
2007	12,063	-94,358	2,822	293	8,947	-106,421	1.7
2008	11,910	-103,125	2,671	291	8,946	-115,035	1.7
2009	11,999	-91,278	2,748	303	8,947	-103,277	1.8
2010	12,086	-95,365	2,837	301	8,947	-107,450	1.9
2011	12,922	-92,648	2,713	438	9,769	-105,570	2.1
2012	13,204	-91,372	2,918	515	9,769	-104,576	2.3
2013	13,076	-109,364	2,776	528	9,769	-122,439	2.3
2014	13,436	-106,089	3,142	522	9,769	-119,525	2.4
2015	13,730	-107,845	3,443	515	9,769	-121,575	2.4

3.3.2. Methane (CH_4)

Methane was the next contributor in national emissions after CO_2. It contributed 4,780 Gg CO_2-eq of the total emissions of 2015. Methane emissions decreased by 1828 Gg CO_2-eq from the 1991 level of 6,608 Gg CO_2-eq to 4,780 in 2015 (Table 3.5). AFOLU contributed between 96 to 99% of these emissions followed by the Waste sector.

Table 3.5 - CH_4 emissions (Gg) by source category (1991 - 2015)

Year	Total (Gg CO_2-eq)	Total	Energy	AFOLU - emissions	Waste
1991	6,608	315	1.4	311	2.5
1992	6,372	303	1.5	299	2.6
1993	6,026	287	1.5	283	2.7
1994	5,837	278	1.5	274	2.8
1995	5,728	273	1.5	269	2.7
1996	5,458	260	1.6	256	2.6
1997	5,415	258	1.6	254	2.7
1998	5,352	255	1.6	251	2.8
1999	5,295	252	1.7	248	3.0
2000	5,367	256	1.7	251	3.2
2001	5,394	257	1.7	252	3.3
2002	4,797	228	1.7	224	3.3
2003	4,873	232	1.8	227	3.8

Year	Total (Gg CO_2-eq)	Total	Energy	AFOLU - emissions	Waste
2004	4,665	222	1.8	217	3.8
2005	4,832	230	1.8	224	4.1
2006	5,458	260	1.9	254	4.2
2007	5,717	272	1.9	267	4.0
2008	4,944	235	1.8	229	4.4
2009	6,362	303	1.9	297	4.7
2010	5,732	273	1.9	266	5.0
2011	6,477	308	1.8	301	5.3
2012	6,845	326	1.9	318	5.8
2013	4,395	209	1.8	202	5.9
2014	5,079	242	1.9	234	6.1
2015	4,780	228	2.0	219	6.4

3.3.3. Nitrous Oxide (N_2O)

Nitrous oxide emissions stood at 2,567 Gg CO_2-eq in 2015. Emissions regressed by 692 Gg CO_2-eq from 3,259 Gg CO_2-eq in the year 1991 to 2,567 Gg CO_2-eq (Table 3.6) in 2015. The AFOLU sector was the highest emitter of N_2O with some 98%.

Table 3.6 - N_2O emissions (Gg) by source category (1991 - 2015)

Year	Total emissions (Gg CO_2-eq)	Total	Energy	IPPU	AFOLU - emissions	Waste
1991	3,259.5	10.51	0.06	0.003	10.38	0.07
1992	3,138.3	10.12	0.06	0.003	9.98	0.07
1993	2,966.7	9.57	0.07	0.003	9.43	0.07
1994	2,883.6	9.30	0.07	0.003	9.15	0.08
1995	2,847.2	9.18	0.08	0.003	9.04	0.07
1996	2,713.1	8.75	0.08	0.004	8.59	0.08
1997	2,709.7	8.74	0.09	0.004	8.58	0.08
1998	2,685.3	8.66	0.09	0.004	8.49	0.08
1999	2,666.8	8.60	0.10	0.004	8.43	0.08
2000	2,686.8	8.67	0.10	0.004	8.49	0.08
2001	2,742.2	8.85	0.11	0.005	8.66	0.08
2002	2,486.9	8.02	0.11	0.005	7.83	0.08
2003	2,530.7	8.16	0.12	0.005	7.96	0.08
2004	2,446.5	7.89	0.13	0.005	7.68	0.08
2005	2,504.1	8.08	0.13	0.005	7.86	0.09
2006	2,792.5	9.01	0.14	0.006	8.78	0.09
2007	2,944.8	9.50	0.15	0.006	9.26	0.09
2008	2,562.6	8.27	0.14	0.006	8.04	0.09
2009	3,187.1	10.28	0.14	0.006	10.05	0.09
2010	2,902.8	9.36	0.15	0.007	9.13	0.09
2011	3,300.3	10.65	0.14	0.007	10.41	0.09
2012	3,493.7	11.27	0.15	0.007	11.03	0.09
2013	2,359.1	7.61	0.15	0.007	7.37	0.09
2014	2,664.7	8.60	0.17	0.008	8.35	0.08
2015	2,567.4	8.28	0.18	0.008	8.01	0.08

3.4. Trends for indirect GHGS and SO_2

Emissions of indirect GHGs (CO, NO_x and NMVOC) and SO_2, have also been estimated and emissions of these gases for the period 1991 to 2015 are given in Table 3.7. Emissions of NO_x decreased from 50.5 Gg in the year 1991 to 38.4 Gg in 2015. CO emissions also regressed, from 2,547 Gg in 1994 to 939 Gg in 2015. Emissions of NMVOC increased from 16.0 Gg in 1991 to 24.7 Gg in 2015 whilst emissions of SO_2 varied between 1.9 Gg and 4.2 Gg during the same period.

Table 3.7 - Emissions (Gg) of indirect GHGs and SO_2 (1991 - 2015)

Year	NO_x	CO	NMVOC	SO_2
1991	50.5	2,547.3	16.0	2.0
1992	49.4	2,426.6	16.0	2.1
1993	48.7	2,313.0	15.7	2.4
1994	48.4	2,198.6	16.0	2.6
1995	45.0	2,083.2	16.1	2.1
1996	43.8	1,966.9	16.3	2.2
1997	41.4	1,849.6	16.8	1.9
1998	41.4	1,731.4	17.7	2.3
1999	41.1	1,612.3	18.4	2.5
2000	39.0	1,465.7	19.8	2.2
2001	40.6	1,479.0	19.8	2.4
2002	37.0	1,133.0	19.4	2.7
2003	38.8	1,140.7	20.2	3.0
2004	36.9	1,024.8	20.6	3.5
2005	41.1	1,267.3	20.4	3.7
2006	45.5	1,618.8	21.4	4.2
2007	49.3	1,904.4	21.5	4.0
2008	37.0	1,200.4	21.4	4.1
2009	54.9	2,263.2	21.8	3.7
2010	51.2	1,946.0	21.9	3.0
2011	52.7	2,076.8	22.9	3.0
2012	56.3	2,166.1	24.0	3.7
2013	30.7	657.2	22.6	2.5
2014	38.2	939.1	24.7	2.7
2015	38.4	939.1	24.7	2.7

3.4.1. Nitrogen oxides

Emissions of NO_x decreased by 24% over the inventory period from 50.5 Gg in the year 1991 to 38.4 Gg in 2015 (Table 3.8). The two main sources of NO_x emissions were the Energy and AFOLU sectors. The Energy sector witnessed an increase from 22% to 70% while the AFOLU sector contribution regressed from 78% to 29% of total national emissions from 1991 to 2015. Waste contributed the remainder.

Table 3.8 - NO_x emissions (Gg) by source category (1991 - 2015)

Year	Total emissions	Energy	AFOLU	Waste
1991	50.5	10.9	39.5	0.2
1992	49.4	11.7	37.5	0.2
1993	48.7	12.8	35.7	0.2

Year	Total emissions	Energy	AFOLU	Waste
1994	48.4	14.3	33.8	0.2
1995	45.0	12.8	32.0	0.2
1996	43.8	13.4	30.1	0.2
1997	41.4	13.0	28.2	0.2
1998	41.4	14.8	26.3	0.2
1999	41.1	16.5	24.4	0.2
2000	39.0	16.7	22.1	0.2
2001	40.6	18.2	22.2	0.3
2002	37.0	19.9	16.8	0.3
2003	38.8	21.7	16.8	0.3
2004	36.9	21.7	14.9	0.3
2005	41.1	22.1	18.7	0.3
2006	45.5	21.1	24.1	0.3
2007	49.3	20.4	28.5	0.3
2008	37.0	19.0	17.6	0.4
2009	54.9	20.5	34.1	0.4
2010	51.2	21.8	29.1	0.4
2011	52.7	21.1	31.2	0.4
2012	56.3	23.3	32.5	0.5
2013	30.7	21.2	9.1	0.5
2014	38.2	24.4	13.3	0.5
2015	38.4	26.9	11.0	0.5

3.4.2. Carbon monoxide

The major contributor of CO was the AFOLU sector with between 89% and 98% of national emission followed by the Energy sector with between 2% to 10% (Table 3.9). National CO emissions decreased from 2,547 Gg in the year 1991 to 788 Gg in 2015. The AFOLU sector contributed 705 Gg of total CO emissions compared to 74 Gg by the Energy sector and 8.6 Gg by the Waste sector in 2015.

Table 3.9 - CO emissions (Gg) by source category (1991 - 2015)

Year	Total emissions	Energy	%Energy	AFOLU	%AFOLU	Waste	%Waste
1991	2,547.3	38.7	1.5%	2,505.4	98.4%	3.1	0.1%
1992	2,426.6	40.0	1.6%	2,383.3	98.2%	3.2	0.1%
1993	2,313.0	41.4	1.8%	2,268.3	98.1%	3.3	0.1%
1994	2,198.6	42.9	1.9%	2,152.3	97.9%	3.5	0.2%
1995	2,083.2	44.4	2.1%	2,035.2	97.7%	3.6	0.2%
1996	1,966.9	46.0	2.3%	1,917.2	97.5%	3.7	0.2%
1997	1,849.6	47.6	2.6%	1,798.1	97.2%	3.9	0.2%
1998	1,731.4	49.4	2.9%	1,678.0	96.9%	4.0	0.2%
1999	1,612.3	51.2	3.2%	1,556.9	96.6%	4.2	0.3%
2000	1,465.7	53.0	3.6%	1,408.3	96.1%	4.3	0.3%
2001	1,479.0	55.7	3.8%	1,418.8	95.9%	4.5	0.3%
2002	1,133.0	55.7	4.9%	1,072.6	94.7%	4.7	0.4%
2003	1,140.7	60.1	5.3%	1,075.7	94.3%	5.0	0.4%
2004	1,024.8	62.9	6.1%	956.7	93.4%	5.2	0.5%
2005	1,267.3	65.1	5.1%	1,196.7	94.4%	5.4	0.4%
2006	1,618.8	67.4	4.2%	1,545.7	95.5%	5.7	0.4%
2007	1,904.4	69.1	3.6%	1,829.3	96.1%	6.0	0.3%

Year	Total emissions	Energy	%Energy	AFOLU	%AFOLU	Waste	%Waste
2008	1,200.4	64.6	5.4%	1,129.5	94.1%	6.3	0.5%
2009	2,263.2	66.9	3.0%	2,189.8	96.8%	6.6	0.3%
2010	1,946.0	71.0	3.7%	1,868.1	96.0%	6.9	0.4%
2011	2,076.8	66.3	3.2%	2,003.0	96.4%	7.5	0.4%
2012	2,166.1	66.6	3.1%	2,091.2	96.5%	8.2	0.4%
2013	657.2	66.4	10.1%	582.4	88.6%	8.4	1.3%
2014	939.1	72.6	7.7%	858.0	91.4%	8.5	0.9%
2015	787.7	74.2	9.4%	704.9	89.5%	8.6	1.1%

3.4.3. NMVOCs

In 2015, NMVOCs emissions stood at 24.7 Gg compared to 16.0 Gg in the year 1991. The two main emission sources were the Energy and AFOLU sectors (Table 3.10). NMVOC emissions increased throughout the inventory period for these two sectors with slight variations between years. Emissions from the Waste sector increased from 0.1 Gg to 0.6 Gg during the inventory period.

Table 3.10 - NMVOC emissions (Gg) by source category (1991 - 2015)

Year	Total emissions	Energy	IPPU	AFOLU	Waste
1991	16.0	5.4	0.5	10.0	0.1
1992	16.0	5.5	0.6	9.8	0.1
1993	15.7	5.7	0.6	9.2	0.1
1994	16.0	6.0	0.7	9.2	0.2
1995	16.1	6.1	0.7	9.1	0.2
1996	16.3	6.3	0.8	9.0	0.2
1997	16.8	6.5	0.9	9.3	0.2
1998	17.7	6.8	1.1	9.7	0.2
1999	18.4	7.0	1.2	10.0	0.2
2000	19.8	7.3	1.3	11.0	0.2
2001	19.8	7.1	1.5	10.9	0.2
2002	19.4	7.2	1.4	10.5	0.2
2003	20.2	7.7	1.6	10.6	0.3
2004	20.6	8.0	1.6	10.6	0.3
2005	20.4	8.3	1.7	10.1	0.3
2006	21.4	8.6	1.7	10.7	0.3
2007	21.5	8.8	1.8	10.5	0.3
2008	21.4	8.3	1.9	10.8	0.4
2009	21.8	8.6	2.1	10.7	0.4
2010	21.9	9.1	2.1	10.3	0.4
2011	22.9	8.6	2.2	11.7	0.5
2012	24.0	8.7	2.3	12.5	0.5
2013	22.6	8.4	2.3	11.3	0.5
2014	24.7	9.2	2.3	12.6	0.5
2015	24.7	9.5	2.4	12.2	0.6

3.4.4. SO_2

The energy sector remained nearly as the sole emitter of SO_2 (Table 3.11) during the full inventory period. Emissions fluctuated during the inventory period 1991 to 2015 from 1.9 Gg to 4.2 Gg. The Waste sector emitted an insignificant amount varying from 0.01 to 0.02 Gg during the inventory period.

Table 3.11 - SO_2 emissions (Gg) by source category (1991 - 2015)

Year	Total emissions	Energy	Waste
1991	2.0	2.0	0.01
1992	2.1	2.1	0.01
1993	2.4	2.4	0.01
1994	2.6	2.6	0.01
1995	2.1	2.1	0.01
1996	2.2	2.2	0.01
1997	1.9	1.9	0.01
1998	2.3	2.2	0.01
1999	2.5	2.5	0.01
2000	2.2	2.2	0.01
2001	2.4	2.4	0.01
2002	2.7	2.7	0.01
2003	3.0	3.0	0.01
2004	3.5	3.5	0.01
2005	3.7	3.7	0.01
2006	4.2	4.2	0.01
2007	4.0	4.0	0.01
2008	4.1	4.1	0.01
2009	3.7	3.7	0.01
2010	3.0	2.9	0.01
2011	3.0	3.0	0.01
2012	3.7	3.7	0.02
2013	2.5	2.5	0.02
2014	2.7	2.7	0.02
2015	2.9	2.8	0.02

Table 3.12 - Short Summary (Inventory Year 2015)

	Emissions (Gg)			Emissions CO2 Equivalents (Gg)					Emissions (Gg)			
Categories	Net CO2 (1)(2)	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors (3)	Other halogenated gases without CO2 equivalent conversion factors (4)	NOx	CO	NMVOCs	SO2
Total National Emissions and Removals	-107844.961	227.634	8.286	113.162	NE	NE	NE	NE	35.337	777.745	22.715	2.714
1 - Energy	3443.029	1.955	0.183	NA	NA	NA	NA	NA	24.382	72.867	9.217	2.714
1.A - Fuel Combustion Activities	3443.029	1.955	0.183	NA	NA	NA	NA	NA	24.382	72.867	9.217	2.714
1.B - Fugitive emissions from fuels	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
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	515.423	NO	0.012	113.162	NE	NE	NE	NE	NO	NO	1.035	NO
2.A - Mineral Industry	347.581	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B - Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C - Metal Industry	141.090	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D - Non-Energy Products from Fuels and Solvent Use	26.752	NO	NO	NA	NA	NA	NA	NA	NO	NO	0.000	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	113.162	NE	NA	NA	NA	NA	NA	NA	NA
2.G - Other Product Manufacture and Use	NO	NO	0.012	NO	NE	NE	NO	NE	NA	NA	NA	NA
2.H - Other	0.000	0.000	NO	NA	NA	NA	NA	NA	0.000	0.000	1.035	0.000
3 - Agriculture, Forestry, and Other Land Use	-111805.813	219.242	8.008	NA	NA	NA	NA	NA	10.954	704.878	12.464	NO
3.A - Livestock	NA	173.227	0.442	NA	NA	NA	NA	NA	NA	NA	12.464	NA
3.B - Land	-111719.812	0.000	0.000	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.C - Aggregate sources and non-CO2 emissions sources on land	0.470	46.014	7.566	NA	NA	NA	NA	NA	10.954	704.878	NA	NA
3.D - Other	-86.471	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
4 - Waste	2.400	6.437	0.083	NA	NA	NA	NA	NA	0.000	0.000	0.000	0.000
4.A - Solid Waste Disposal	NA	4.009	NO	NA	NA	NA	NA	NA	NO	NO	0.000	NA
4.B - Biological Treatment of Solid Waste	NA	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NA

Categories	Emissions (Gg)			Emissions CO2 Equivalents (Gg)				Emissions (Gg)				
	Net CO2 (1)(2)	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors (3)	Other halogenated gases without CO2 equivalent conversion factors (4)	NOx	CO	NMVOCs	SO2
4.C - Incineration and Open Burning of Waste	2.400	1.005	0.013	NA	NA	NA	NA	NA	0.000	0.000	0.000	0.000
4.D - Wastewater Treatment and Discharge	NA	1.423	0.069	NA	NA	NA	NA	NA	NO	NO	0.000	NA
4.E - Other (please specify)	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NA
5 - Other	NO	NO	NE	NO	NO	NO	NO	NO	NO	NO	NO	NO
5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3	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
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Memo Items (5)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
International Bunkers	263.112	0.015	0.007	NA	NA	NA	NA	NA	4.267	0.789	0.274	1.015
1.A.3.a.i - International Aviation (International Bunkers)	108.698	0.001	0.003	NA	NA	NA	NA	NA	0.441	0.038	0.017	0.035
1.A.3.d.i - International water-borne navigation (International bunkers)	154.414	0.014	0.004	NA	NA	NA	NA	NA	3.825	0.752	0.257	0.981
1.A.5.c - Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 3.13 - Long Summary (Inventory Year 2015)

Categories	Emissions (Gg)			Emissions CO2 Equivalents (Gg)				Emissions (Gg)				
	Net CO_2 (1)(2)	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors (3)	Other halogenated gases without CO2 equivalent conversion factors (4)	NOx	CO	NMVOCs	SO2
Total National Emissions and Removals	-107844.961	227.634	8.286	113.162	NE	NE	NE	NE	35.337	777.745	22.715	2.714
1 - Energy	3443.029	1.955	0.183	NA	NA	NA	NA	NA	24.382	72.867	9.217	2.714
1.A - Fuel Combustion Activities	3443.029	1.955	0.183	NA	NA	NA	NA	NA	24.382	72.867	9.217	2.714
1.A.1 - Energy Industries	20.602	0.000	0.000	NA	NA	NA	NA	NA	0.010	0.001	0.000	0.036
1.A.2 - Manufacturing Industries and Construction	178.308	0.034	0.005	NA	NA	NA	NA	NA	0.626	1.112	0.196	0.897
1.A.3 - Transport	2761.936	0.611	0.153	NA	NA	NA	NA	NA	16.328	51.215	5.408	0.025
1.A.4 - Other Sectors	375.278	1.303	0.019	NA	NA	NA	NA	NA	6.795	20.349	3.573	1.755
1.A.5 - Non-Specified	106.906	0.006	0.006	NA	NA	NA	NA	NA	0.623	0.190	0.040	0.000
1.B - Fugitive emissions from fuels	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
1.B.1 - Solid Fuels	NO	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NO
1.B.2 - Oil and Natural Gas	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NA
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 CO2	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	515.423	NO	0.012	113.162	NE	NE	NE	NE	NO	NO	1.035	NO
2.A - Mineral Industry	347.581	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.A.1 - Cement production	330.200	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.2 - Lime production	17.381	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	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Categories	Emissions (Gg)			Emissions CO2 Equivalents (Gg)				Emissions (Gg)				
	Net CO_2 (1)(2)	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors (3)	Other halogenated gases without CO2 equivalent conversion factors (4)	NOx	CO	NMVOCs	SO2
2.B.1 - Ammonia Production	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	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.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	141.090	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C.1 - Iron and Steel Production	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	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	141.090	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	26.752	NO	NO	NA	NA	NA	NA	NA	NO	NO	0.000	NO
2.D.1 - Lubricant Use	9.064	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.2 - Paraffin Wax Use	17.688	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	0.000	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

Categories	Emissions (Gg)			Emissions CO2 Equivalents (Gg)				Emissions (Gg)				
	Net CO_2 (1)(2)	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors (3)	Other halogenated gases without CO2 equivalent conversion factors (4)	NOx	CO	NMVOCs	SO2
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	113.162	NE	NA	NA	NA	NA	NA	NA	NA
2.F.1 - Refrigeration and Air Conditioning	NA	NA	NA	113.162	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	0.012	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 - SF6 and PFCs from Other Product Uses	NA	NA	NA	NA	NE	NE	NA	NE	NA	NA	NA	NA
2.G.3 - N2O from Product Uses	NA	NA	0.012	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	0.000	0.000	NO	NA	NA	NA	NA	NA	0.000	0.000	1.035	0.000
2.H.1 - Pulp and Paper Industry	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.H.2 - Food and Beverages Industry	0.000	0.000	NA	NA	NA	NA	NA	NA	0.000	0.000	1.035	0.000
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	-111805.813	219.242	8.008	NA	NA	NA	NA	NA	10.954	704.878	12.464	NO
3.A - Livestock	NA	173.227	0.442	NA	NA	NA	NA	NA	NA	NA	12.464	NA
3.A.1 - Enteric Fermentation	NA	169.194	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.A.2 - Manure Management	NA	4.034	0.442	NA	NA	NA	NA	NA	NA	NA	12.464	NA
3.B - Land	-111719.812	NA	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.B.1 - Forest land	-121488.522	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO

Categories	Emissions (Gg)			Emissions CO2 Equivalents (Gg)				Emissions (Gg)				
	Net CO_2 (1)(2)	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors (3)	Other halogenated gases without CO2 equivalent conversion factors (4)	NOx	CO	NMVOCs	SO2
3.B.2 - Cropland	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.B.3 - Grassland	9755.939	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	12.771	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.B.6 - Other Land	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.C - Aggregate sources and non-CO2 emissions sources on land	0.470	46.014	7.566	NA	NA	NA	NA	NA	10.954	704.878	NA	NA
3.C.1 - Emissions from biomass burning	NA	46.014	1.359	NA	NA	NA	NA	NA	10.954	704.878	NA	NA
3.C.2 - Liming	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C.3 - Urea application	0.470	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C.4 - Direct N2O Emissions from managed soils	NA	NA	5.742	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C.5 - Indirect N2O Emissions from managed soils	NA	NA	0.060	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C.6 - Indirect N2O Emissions from manure management	NA	NA	0.405	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C.7 - Rice cultivations	NA	NO	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	-86.471	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.D.1 - Harvested Wood Products	-86.471	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	2.400	6.437	0.083	NA	NA	NA	NA	NA	0.000	0.000	0.000	0.000
4.A - Solid Waste Disposal	NA	4.009	NO	NA	NA	NA	NA	NA	NO	NO	0.000	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	2.400	1.005	0.013	NA	NA	NA	NA	NA	0.000	0.000	0.000	0.000
4.D - Wastewater Treatment and Discharge	NA	1.423	0.069	NA	NA	NA	NA	NA	NO	NO	0.000	NA
4.E - Other (please specify)	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NA

Categories	Emissions (Gg)			Emissions CO2 Equivalents (Gg)					Emissions (Gg)			
	Net CO_2 (1)(2)	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors (3)	Other halogenated gases without CO2 equivalent conversion factors (4)	NOx	CO	NMVOCs	SO2
5 - Other	NO	NO	NE	NO	NO	NO	NO	NO	NO	NO	NO	NO
5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3	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
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Memo Items (5)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
International Bunkers	263.112	0.015	0.007	NA	NA	NA	NA	NA	4.267	0.789	0.274	1.015
1.A.3.a.i - International Aviation (International Bunkers)	108.698	0.001	0.003	NA	NA	NA	NA	NA	0.441	0.038	0.017	0.035
1.A.3.d.i - International water-borne navigation (International bunkers)	154.414	0.014	0.004	NA	NA	NA	NA	NA	3.825	0.752	0.257	0.981
1.A.5.c - Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

4. Energy

4.1. Description of Energy sector

Namibia is concerned only with activities occurring in the Fuel Combustion Category. Activities occurred under all sub-categories and GHG emissions have been estimated for all of them.

4.1.1. Fuel Combustion Activities (1.A)

Energy Industries (1.A.1)

The Energy Industries sub-category covers the production of electricity from a mix of liquid and solid fossil fuels. The contribution of fossil fuels is however minimal in the national energy balance since the country generates a high proportion of its electricity from hydro to supplement the imported power which stands at about 63% of Namibia's demand from the South African Power Pool (SAPP) compared to 65% in 2012. The fossil fuel generation plants are mainly used to supplement the imports and hydro production during peak demand time.

Manufacturing Industries and Construction (1.A.2)

Fossil fuel inputs are primarily used for generating process heat within the mining sector and in the production of cement. The two main mining companies also imported electricity directly from the neighbouring countries. The construction industry is highly diversified and detailed information was not available. There are some auto-production of electricity in this sub-category and efforts are being invested to collect data for estimating emissions from this process separately in the future.

Transport (1.A.3)

The transport sector includes domestic aviation, road transportation, railways and domestic water-borne navigation. Emissions for the three sub-categories domestic aviation, road transportation and railways have been computed in this inventory. Lack of data prevented estimation of emissions for domestic water-borne navigation which is of lesser importance compared to the other three modes of transport. Fuel supplied for international bunkering was also covered.

Other Sectors (1.A.4)

The sub-categories included under Other Sectors were the two main GHG contributors Residential and Fishing. AD for Commercial/Institutional, Stationary combustion and, Off-road vehicles and other machinery within the Agriculture and Forestry sectors were not available. It should however be pointed out that the fuels consumed in these sub-categories have been accounted for under other combustion activities within the national energy balance of the country. So, there is really no underestimation in the inventory.

Fishing is an important activity in Namibia with a fleet of some 160 fishing vessels (*Ministry of Works and Transport, Maritime Affairs, 2010*) operating out of a registered total of 208. Particular attention was paid to this sub-category to collect AD and make estimates of emissions.

Non-Specified (1.A.5)

Fossil fuel burned in this sector was considered confidential and the allocation from the energy balance not accounted for under other sectors was combusted under this sub-category.

Memo items

International bunkers included international aviation and navigation according to the IPCC Guidelines. Both activity areas were covered, and they consumed significant amounts of fossil fuel imported in the country. The emissions have been computed and reported in this inventory.

4.2. Methods

It is Good Practice to estimate emissions using both the Reference and Sectoral approaches. During this exercise, emission estimates were computed using both approaches. The top down Reference approach was carried out using import, export, production and stock change data that constituted the basis for producing the national energy balance. The bottom up Sectoral Approach generally involved the quantification of fuel consumption from end use data by the different source categories. Thereafter, the IPCC conversion and EFs were adopted to compile GHG emissions. The Sectoral approach covered all the IPCC source categories where AD were available.

The basic equations used to estimate GHG emissions are given below:

$$\textbf{Emissions}_{\textbf{GHG fuel}} = \textbf{Fuel Consumption}_{\textbf{fuel}} \times \textbf{Emission Factor}_{\textbf{GHG fuel}}$$

Where

Emissions $_{GHG, fuel}$	= emissions of a given GHG by type of fuel (kg GHG)
Fuel Consumption $_{fuel}$	= amount of fuel combusted (TJ)
Emission Factor $_{GHG, fuel}$	= default emission factor of a given GHG by type of fuel (kg gas/TJ). For CO_2, it includes the carbon oxidation factor, assumed to be 1.

4.3. Activity Data

AD for the reference approach was obtained from the database of the NSA on imports and exports of energy products. For the bottom up sectoral approach, AD were sourced from the end-users of fossil fuels. Data on biomass used were derived from data on consumption of different fuels by households collected in the censuses conducted by the NSA. The same approach was used to determine the amount of charcoal used. The data collection covered all solid, liquid and gaseous fossil fuels, fuelwood and charcoal. In cases where data were missing or to correct for outliers, the inventory compilers resorted to international databases including those from IEA, the United Nations database and the Food and Agriculture Organisation among others. These sources provided most of the AD required for the period 1991 to 2002 but to a lesser extent for the period 2003 to 2014 as the country was still in the process of organising its statistical organisation after gaining independence. Missing data for these years were thus obtained from the international databases or by extrapolation of the available time series. Where necessary, proxies such as population, GDP and production data were used to ascertain the generated data.

A summary of data sources of the country used for the inventory is given in Table 4.1.

Table 4.1 - Summary of data sources

Category	Fuel type	Data source
Energy industries	Fuel oil	Nampower
	Coal	Nampower

Category	Fuel type	Data source
Mining	Gasolene/Diesel	ECB Project "Energy Policy, Regulatory Framework and Energy Future of Namibia (2011-2013)".
	Coal	ECB Project "Energy Policy, Regulatory Framework and Energy Future of Namibia (2011-2013)".
	Waste oil	National statistics.
Other manufacturing	Gasoline/Diesel	Ministry of Industrialization, Trade and SME Development.
Domestic aviation	Aviation Gasoline	Airport profile data and national statistics
	Jet kerosene	Airport profile data and national statistics.
Road Transport	Gasoline/Diesel	Gasoline and diesel estimated for the different IPCC vehicles classes in the fleet, mileage run by each and fuel consumption indicators for respective years
	LPG	Import and export data from NSA
Railways	Diesel/residual	TransNamib
Residential	Kerosene	Import and export data from NSA.
	LPG	Import and export data from NSA.
	Wax candles	Ministry of Industrialization, Trade and SME Development and import and export data from NSA
	Wood fuel	Derived from NSA census data.
	Charcoal	Derived from NSA census data and import and export data from NSA.
Agriculture/ fishing	Gasoline	Import and export data from NSA.
	Diesel	National statistics on consumption and import and export from NSA.
International aviation bunkers	Jet kerosene	Airport profile data and national statistics.
International marine bunkers	Diesel	Ministry of Works and Transport, Maritime Affairs.
	Gasoline	National statistics.
	Residual fuel oil	SNC and National statistics.

AD were not always available and in the format required as well as at the level of disaggregation needed for all categories. This is because the country is still in the process of putting in place its GHGIMS. Gaps were filled using statistical methods such as trend analysis, interpolation and extrapolation as appropriate. In some cases, fuels had to be allocated or determined according to the activity area. One such example is the amount of fuel used in the fishing sector which is directly related to fishing vessel campaigns and fish catch. Fuel used for categories like Agriculture, Forestry and Institutional amongst others could neither be traced nor generated. Thus, fuels from these sectors were eventually allocated in different sectors based on amounts distributed and consumed. AD used for the Energy Sector is provided in Table 4.2.

4.4. Emission factors

Namibia does not have national EFs for the Energy sector. Thus, the IPCC default EFs were adopted to compute GHG emissions. The EFs are listed in Table 4.3.

4.5. Emission estimates

4.5.1. Reference approach

Comparison of the Sectoral approach (SA) with the Reference approach (RA)

The results differed across the years between the two approaches with higher emissions for the reference approach for all years as expected. The difference was on the high side for some years, namely 1995, 1996, 1997 and 2001 with some 27% and for 2008 with 24% (Table 4.4) The wide differences between the two approaches possibly occurred as import-export data on fuels were not available prior to 2003 when the statistics system was being set-up. Another impacting factor would be rolling stocks from one year to the next as this is difficult to track within the country's context. It is worth highlighting that the country is in the process of making annual energy balances that will help refine AD for this sector.

Table 4.2 - Activity data (tonnes) used for Energy Sector

Categories	Type of fuel	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Energy generation	HFO and LFO	212	212	212	212	212	212	212	212	212	53	119	131	628	130	1239	2610	2569	554	774	1123	1230	5616	2914	1508	254
	Bitum. coal	9441	10381	11322	12262	13203	14143	15084	16024	16965	2926	3609	18	7942	718	20384	63877	76599	95876	57453	13105	3735	32344	2575	275	8116
Mining	Gasoline	2454	2454	2454	2454	2454	2454	2454	2454	2454	2454	2454	2454	2454	2454	2454	2454	2454	2454	2454	2454	2454	2454	2454	2454	2454
	Gasoil/Diesel	6356	6995	7633	8271	8909	9548	10186	10824	11463	11778	11508	10994	11938	15007	14771	17309	23244	25310	22536	21145	19767	21149	15464	16201	16937
	Bitum. coal	29203	29518	29834	30150	30465	30781	31097	31413	31728	33479	39040	25800	38040	38040	32600	32840	28400	23960	31160	36160	49640	36148	36464	36780	37096
	Waste oil	427	427	427	427	427	427	427	427	427	483	224	618	1011	2050	3089	3483	5599	7440	7702	6948	7602	7615	7840	7686	7686
	Other petroleum pdts	16	16	16	16	16	16	16	20	0	1	0	43	19	26	205	148	194	154	101	1389	1418	890	933	215	418
	Petroleum coke	134	134	134	134	134	134	134	0	582	197	0	18	2	211	0	816	0	0	0	155	281	0	0	24	0
Other manufacturing	Gasoline	161.74	166.19	170.65	175	180	184	188	193	206	218	212	221	223	239	231	232	239	226	253	257	259	271	275	269	276
	Gasoil/Diesel	204.22	215.5	226.77	238	249	261	272	283	296	317	326	387	371	396	395	404	398	408	421	440	405	483	493	475	484
	Wood/wood waste	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27	30	27	27
Civil aviation	Aviation Gasoline	2595.7	2634.6	2673.5	2712	2751	2790	2829	2868	2907	3012	3043	3074	3105	3136	3167	3210	3210	3210	3210	3596	3413	3452	3491	3530	3568
	Jet kerosene	2429.6	2501.2	2572.8	2644	2716	2788	2859	2931	3002	3074	3105	3136	3168	3200	3232	3264	3297	3330	3363	3456	5652	4554	4554	4554	4554
Road transportation	Gasoline	136657	143849	151421	159390	169585	179780	189975	200169	210364	220559	239093	236045	268509	283498	300461	318194	331730	294461	308100	333283	290682	294559	301334	345808	357969
	Diesel	47265	55606	65419	76963	92407	107851	123295	138739	154183	169627	192004	196915	232291	249491	269389	286920	304652	286210	313149	348809	347386	374068	381972	437331	498178
	LPG	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	72	276	496	715	500	500	500	500	500
	Lubricant	2	2	3	3	3	3	3	3	4	4	4	4	5	5	6	7	7	7	7	7	8	7	7	8	8
Railways	Gasoil/Diesel	9862.5	10243	10623	11003	11383	11763	12143	12524	12904	12900	13607	14314	15021	15728	16435	16808	17207	16022	15710	6571	5948	6416	-	-	-
	Fuel oil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9857	8922	9624	14944	15570	15570
Residential	Other Kerosene	4608	4499	4391	4282	4173	4064	3956	3847	3738	3316	3283	3251	3219	3187	3155	3124	3093	2700	2357	2057	1796	1568	1369	1195	1043
	LPG	5000	5000	6000	6000	7000	7000	8000	7395	6987	5705	7798	9781	9059	6085	9999	9461	8923	8419	7915	7422	7348	6050	6406	8597	10787
	Parafin wax	24000.0	24000.0	24000.0	24000	24000	24000	24000	24000	24000	23532	21855	23661	24265	27354	24612	23256	23303	27700	28791	22023	24000	24000	24000	24000	24000.0
	Wood fuel	239012	241004	243008	245023	247050	249088	251139	253202	255278	257368	259471	259685	259883	260063	260225	260369	260496	260605	260696	260769	260823	259319	257895	256551	255351

Categories	Type of fuel	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	Charcoal	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
Fishing	Gasoline	1600	1770	1940	2110	2280	2450	2620	2790	2960	3300	3470	3640	3810	3980	4150	4320	4490	4660	4830	5000	5170	5340	3871	4023	4176
	Gasoil/Diesel	85014	90101	99547	112626	85741	85741	71935	87921	101000	98000	107000	128000	132000	121000	116000	90748	71932	65660	75460	78596	76636	93100	66836	81340	81400
Non-specified	Gasoline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	241	273	281	325	578
	Diesel	2866	3372	3967	4667	5603	6540	7476	8412	9349	10285	11576	11812	12967	13442	13512	13884	13879	11589	11987	12807	13742	15576	16010	18525	32995
International aviation	Jet kerosene	20767	21533	22300	23066	23833	24599	25366	26132	26899	27665	27945	28227	28512	28800	29088	29379	29673	29969	30269	31120	37826	34473	34473	34473	34473
International marine bunkers	Gasoil/Diesel	29781	29281	28781	28281	27781	27280	26780	26280	25780	25247	24672	24039	23407	22774	22142	21509	20876	20244	19611	18979	18921	18921	18921	18921	18921
	Gasoline	632	627	623	618	613	608	603	598	593	588	597	605	613	621	629	637	645	654	662	670	686	686	686	686	686
	Residual Fuel Oil	14795	14945	15096	15248	15402	15558	15715	15874	16034	16196	17399	18602	19805	21008	22211	23413	24616	25819	27022	28225	29428	29428	29428	29428	29428

Table 4.3 - List of emission factors (kg/TJ) used in the Energy sector

Fuel	Emission factor					
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Motor Gasoline	69,300	3.0	0.6	Vol. 2, table 2.3	Vol. 2, table 2.3	Vol. 2, table 2.3
	""	33.0	3.2	Vol. 2, table 3.2.1	Vol. 2, table 3.2.2	Vol. 2, table 3.2.2
	""	7.0	2.0	Vol. 2, table 3.5.2	Vol. 2, table 3.5.3	Vol. 2, table 3.5.3
	""	10.0	0.6	Vol. 2, table 2.5	Vol. 2, table 2.5	Vol. 2, table 2.5
Aviation gasoline	70,000	0.5	2.0	Vol. 2, table 3.6.4	Vol. 2, table 3.6.5	Vol. 2, table 3.6.5
Jet kerosene	71,500	0.5	2.0	Vol. 2, table 3.6.4	Vol. 2, table 3.6.5	Vol. 2, table 3.6.5
Other kerosene	71,900	10.0	0.6	Vol. 2, table 2.5	Vol. 2, table 2.5	Vol. 2, table 2.5
Gasoil/Diesel	74,100	3.0	0.6	Vol. 2, table 2.3	Vol. 2, table 2.3	Vol. 2, table 2.3
	""	3.9	3.9	Vol. 2, table 3.2.1	Vol. 2, table 3.2.2	Vol. 2, table 3.2.2
	""	4.15	28.6	Vol. 2, table 3.4.1	Vol. 2, table 3.4.1	Vol. 2, table 3.4.1
	""	7.0	2.0	Vol. 2, table 3.5.2	Vol. 2, table 3.5.3	Vol. 2, table 3.5.3
	""	10.0	0.6	Vol. 2, table 2.5	Vol. 2, table 2.5	Vol. 2, table 2.5
Residual fuel oil	77,400	3.0	0.6	Vol. 2, table 2.2	Vol. 2, table 2.2	Vol. 2, table 2.2
	""	7.0	2.0	Vol. 2, table 3.5.2	Vol. 2, table 3.5.3	Vol. 2, table 3.5.3
	""	4.15	28.6	Vol. 2, table 3.2.1	Vol. 2, table 3.4.1	Vol. 2, table 3.4.1
Liquefied petroleum gases	63,100	5.0	0.1	Vol. 2, table 2.5	Vol. 2, table 2.5	Vol. 2, table 2.5
Liquefied petroleum gases	63,100	62.0	0.2	Vol. 2, table 3.2.1	Vol. 2, table 3.2.2	Vol. 2, table 3.2.2
Petroleum coke	97,500	3.0	0.6	Vol. 2, table 2.3	Vol. 2, table 2.3	Vol. 2, table 2.3
Paraffin waxes	73,300	10.0	0.6	Vol. 2, table 2.5	Vol. 2, table 2.5	Vol. 2, table 2.5
Other petroleum products	73,300	3.0	0.6	Vol. 2, table 2.3	Vol. 2, table 2.3	Vol. 2, table 2.3
Other bituminous coal	94,600	1.0	1.5	Vol. 2, table 2.2	Vol. 2, table 2.2	Vol. 2, table 2.2
	""	10	1.5	Vol. 2, table 2.3	Vol. 2, table 3.4.1	Vol. 2, table 3.4.1
Natural gas liquids	64,200	10	0.6	Vol. 2, table 2.5	Vol. 2, table 2.5	Vol. 2, table 2.5
Waste oils	73,300	30.0	4.0	Vol. 2, table 2.3	Vol. 2, table 2.2	Vol. 2, table 2.2
Wood fuel	112,000	300.0	4.0	Vol. 2, table 2.5	Vol. 2, table 2.5	Vol. 2, table 2.5
Charcoal	112,000	200.0	1.0	Vol. 2, table 2.5	Vol. 2, table 2.5	Vol. 2, table 2.5

Table 4.4 - Comparison of the Reference and Sectoral Approaches (Gg CO_2) (1991 - 2015)

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Reference approach (Gg)	1247.7	1346.5	1383.6	1517.0	1806.4	1917.9	1964.5	2021.5	2035.6	2055.0	2606.9	2492.5	2680.4
Sectoral approach (Gg)	1128.0	1201.4	1297.7	1409.8	1417.5	1507.9	1557.2	1696.3	1829.0	1867.5	2045.9	2092.8	2378.9
Differences (%)	10.6	12.1	6.6	7.6	27.4	27.2	26.2	19.2	11.3	10.0	27.4	19.1	12.7

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Reference approach (Gg)	2837.9	2801.8	2916.2	3266.1	3297.9	3261.0	2912.1	2912.5	3408.6	3028.1	3189.1	3727.1
Sectoral approach (Gg)	2443.8	2590.3	2740.3	2821.7	2670.8	2748.3	2836.6	2713.1	2917.6	2775.9	3142.3	3443.0
Differences (%)	16.1	8.2	6.4	15.7	23.5	18.7	2.7	7.3	16.8	9.1	1.5	8.2

4.5.2. Sectoral approach

Total aggregated emissions for the three direct GHGs are provided in Table 4.5 while the share of emissions by category is depicted in Figure 4.1 for the five IPCC sub-categories falling under Fuel Combustion activities for the time series 1991 to 2015. Total emissions from Fuel Combustion Activities varied from 1,177.1 Gg CO_2-eq in 1991 to 3,540.0 Gg CO_2-eq in 2015. The emissions varied between the years under review as fuel combustion is related to economic activity and other factors.

Table 4.5 - Emissions for Fuel Combustion Activities (Gg CO_2-eq) (1991 - 2015)

Year	1 - Energy	1.A - Fuel Combustion Activities	1.A.1 - Energy Industries	1.A.2 - Manufacturing Industries and Construction	1.A.3 - Transport	1.A.4 - Other Sectors*	1.A.5 - Non-specified
1991	1177.1	1177.1	23.8	102.6	643.3	407.4	9.3
1992	1252.0	1252.0	26.1	105.4	696.3	424.1	10.9
1993	1350.1	1350.1	28.4	108.3	755.6	457.7	12.9
1994	1464.0	1464.0	30.8	111.2	806.9	500.0	15.1
1995	1473.4	1473.4	33.1	114.0	890.8	417.3	18.2
1996	1565.8	1565.8	35.4	116.9	974.6	417.8	21.2
1997	1617.1	1617.1	37.7	119.8	1058.4	376.9	24.2
1998	1758.5	1758.5	40.0	122.2	1142.3	426.8	27.3
1999	1893.5	1893.5	42.3	126.9	1226.1	467.9	30.3
2000	1933.7	1933.7	7.3	131.3	1308.8	453.0	33.3
2001	2115.5	2115.5	9.2	142.7	1442.3	483.8	37.5
2002	2163.0	2163.0	0.5	110.1	1451.4	562.8	38.3
2003	2454.2	2454.2	21.5	144.2	1670.9	575.7	42.0
2004	2521.4	2521.4	2.2	158.0	1776.5	541.1	43.6
2005	2670.7	2670.7	53.9	146.8	1897.1	529.2	43.8
2006	2823.4	2823.4	164.9	159.2	2011.2	443.1	45.0
2007	2906.9	2906.9	196.0	171.2	2113.0	381.8	45.0
2008	2751.8	2751.8	236.9	172.3	1932.5	372.5	37.6
2009	2831.6	2831.6	143.4	181.9	2062.4	405.1	38.9
2010	2923.3	2923.3	35.7	191.8	2261.1	393.2	41.5
2011	2796.3	2796.3	13.0	222.9	2122.8	392.2	45.3
2012	3003.3	3003.3	97.0	192.1	2222.3	440.7	51.4
2013	2861.0	2861.0	15.5	175.5	2265.0	352.3	52.8
2014	3234.2	3234.2	5.4	176.0	2586.6	405.1	61.1
2015	3540.0	3540.0	20.7	179.8	2931.0	408.6	108.8

*** Other sectors: include Residential and Fishing**

Transport contributed between 55 and 83% of total emissions over the period 1991 to 2015. The Other Sectors category was the second highest emitter after transport with 11.5%. Emissions from Manufacturing Industries and Construction varied between 102 and 180 but regressed from 8.7% to 5.1% of total aggregated emissions. Energy Industries emissions varied widely because local electricity generation serves only to supplement import deficits and emissions from that category which hit a maximum of 8.6% in 2008.

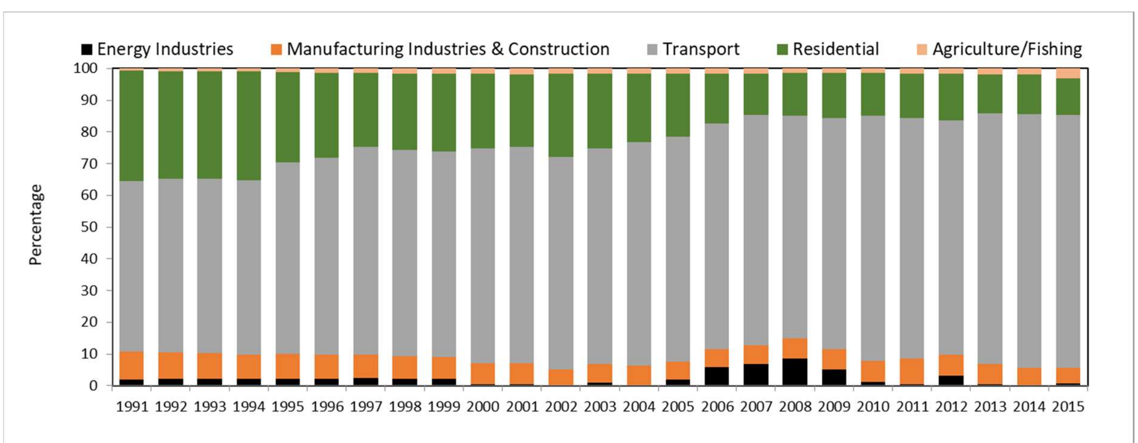

Figure 4.1 - Share of GHG emissions (Gg CO_2-eq) by Energy sub-category (1991 - 2015)

Out of the nine Energy sub-categories, Road transportation remained the major contributor of emissions (Table 4.6), expressed in terms of Gg CO_2-eq, followed by Fishing. The Residential sub-category that was emitting more than Mining in the 1990s, has remained more or less stable over the inventory period to be surpassed by Mining as from the year 2004. Emissions from the Road transportation sub-category increased from 583 Gg CO_2-eq in 1991 to reach 2742 Gg CO_2-eq in 2015.

Table 4.6 - GHG emissions (Gg CO_2-eq) by Energy sub-category (1991 - 2015)

Year	1 - Energy	1.A.1.a.i - Electricity Generation	1.A.2.i - Mining (excluding fuels) and Quarrying	1.A.2.m - Non-specified Industry	1.A.3.a - Civil Aviation	1.A.3.b - Road Transportation	1.A.3.c - Railways	1.A.4.b - Residential	1.A.4.c.iii - Fishing (mobile combustion)	1.A.5.b.iii - Mobile (Other)
1991	1177.1	23.8	101.4	1.2	15.9	583.0	35.2	130.1	277.3	9.3
1992	1252.0	26.1	104.2	1.2	16.2	632.6	36.6	130.0	294.1	10.9
1993	1350.1	28.4	107.1	1.3	16.5	688.2	37.9	132.9	324.9	12.9
1994	1464.0	30.8	109.9	1.3	16.9	750.7	39.3	132.8	367.3	15.1
1995	1473.4	33.1	112.7	1.4	17.2	832.9	40.7	135.6	281.7	18.2
1996	1565.8	35.4	115.5	1.4	17.6	915.0	42.0	135.5	282.2	21.2
1997	1617.1	37.7	118.3	1.4	17.9	997.1	43.4	138.4	238.5	24.2
1998	1758.5	40.0	120.7	1.5	18.3	1079.2	44.7	136.5	290.3	27.3
1999	1893.5	42.3	125.3	1.6	18.6	1161.4	46.1	135.2	332.7	30.3
2000	1933.7	7.3	129.6	1.7	19.2	1243.5	46.1	128.9	324.1	33.3
2001	2115.5	9.2	141.0	1.7	19.4	1374.3	48.6	130.3	353.5	37.5
2002	2163.0	0.5	108.2	1.9	19.6	1380.6	51.1	141.5	421.3	38.3
2003	2454.2	21.5	142.4	1.9	19.8	1597.4	53.6	141.1	434.6	42.0
2004	2521.4	2.2	156.0	2.0	20.0	1700.3	56.2	141.3	399.9	43.6
2005	2670.7	53.9	144.9	2.0	20.2	1818.2	58.7	144.8	384.4	43.8
2006	2823.4	164.9	157.2	2.0	20.4	1930.8	60.0	139.0	304.0	45.0
2007	2906.9	196.0	169.2	2.0	20.5	2031.0	61.5	137.5	244.3	45.0
2008	2751.8	236.9	170.3	2.0	20.6	1854.7	57.2	147.8	224.7	37.6
2009	2831.6	143.4	179.8	2.1	20.7	1985.6	56.1	148.4	256.6	38.9
2010	2923.3	35.7	189.6	2.2	22.2	2181.0	57.9	126.0	267.2	41.5
2011	2796.3	13.0	220.8	2.1	28.7	2041.8	52.4	130.8	261.5	45.3
2012	3003.3	97.0	189.7	2.4	25.3	2140.5	56.5	126.0	314.7	51.4
2013	2861.0	15.5	173.1	2.4	25.4	2187.4	52.1	126.3	226.0	52.8
2014	3234.2	5.4	173.7	2.3	25.5	2506.7	54.3	132.1	273.0	61.1
2015	3540.0	20.7	177.4	2.4	25.7	2742.2	54.3	138.0	270.5	108.8

The evolution of emissions of direct and indirect GHGs in the Energy sector is presented in Table 4.7. CO_2 contributed a major part of the emissions of the direct gases followed by CH_4 and N_2O throughout the full time series 1991 to 2015. The contribution of CO_2 increased over the same period from nearly 96% in 1991 to just over 98% in 2015 (Figure 4.2) of aggregated emissions of the direct GHGs of the Energy sector.

Among the indirect gases (Table 4.7), CO was the main gas emitted over the time series followed by NO_x and NMVOCs. Over the time series, the emissions increased very slightly for the three indirect GHGs, due to increased economic activity. Emissions of SO_2 varied between 1.9 Gg and 4.2 Gg.

Table 4.7 - Emissions (Gg) by gas for the Energy sector (1991 - 2015)

	Gg CO_2-eq			Gg			
Year	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
1991	1128.0	1.4	0.1	10.9	38.7	5.4	2.0
1992	1175.7	1.5	0.1	11.7	40.0	5.4	2.1
1993	1297.7	1.5	0.1	12.8	41.4	5.7	2.4
1994	1409.8	32.1	22.2	14.3	42.9	6.0	2.6
1995	1417.5	32.4	23.5	12.8	44.4	6.1	2.1
1996	1507.9	33.0	25.0	13.4	46.0	6.3	2.2
1997	1557.2	33.4	26.4	13.0	47.6	6.5	1.9
1998	1696.3	34.2	28.0	14.8	49.4	6.8	2.2
1999	1829.0	34.9	29.6	16.5	51.2	7.0	2.5
2000	1867.5	35.4	30.8	16.7	53.0	7.3	2.2
2001	2045.9	36.4	33.3	18.2	55.7	7.1	2.4
2002	2092.8	36.5	33.7	19.9	55.7	7.2	2.7
2003	2378.9	37.7	37.6	21.7	60.1	7.7	3.0
2004	2443.8	38.2	39.4	21.7	63.0	8.1	3.5
2005	2590.3	38.8	41.6	22.1	65.1	8.3	3.7
2006	2740.3	39.2	43.8	21.1	67.4	8.6	4.2
2007	2821.7	39.6	45.6	20.4	69.1	8.8	4.0
2008	2670.8	38.4	42.7	19.0	64.6	8.3	4.1
2009	2748.3	39.1	44.3	20.5	66.9	8.6	3.7
2010	2836.6	39.9	46.8	21.8	71.3	9.1	2.9
2011	2713.1	38.7	44.5	21.1	66.3	8.6	3.0
2012	2917.6	38.9	46.9	23.3	66.7	8.7	3.7
2013	2775.9	38.7	46.4	21.2	66.4	8.5	2.5
2014	3142.3	40.3	51.6	24.4	72.6	9.2	2.7
2015	3443.0	1.9	0.2	26.9	74.2	9.5	2.8

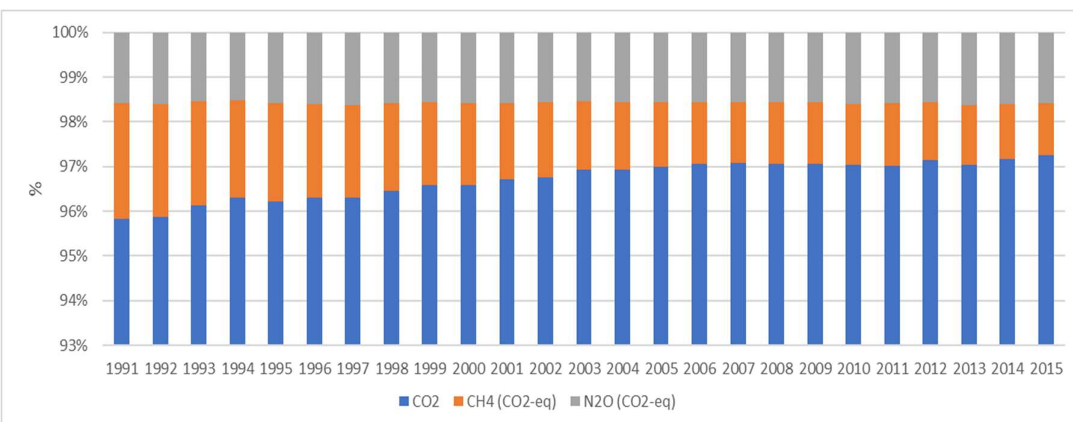

Figure 4.2 - Share emissions by gas (%) for the Energy sector (1991 - 2015)

4.5.3. Evolution of emissions by gas (Gg) in the Energy Sector (1991 - 2015)

Emissions of CO_2 in the Energy sector, Fuel Combustion Activities category, increased over the period 1991 to 2015, from 1,128 to 3,443 Gg. The annual increase was quite sharp up to 2007 but it stabilized thereafter until 2013 with the tendency for an increase in the last two years of the time series (Figure 4.3).

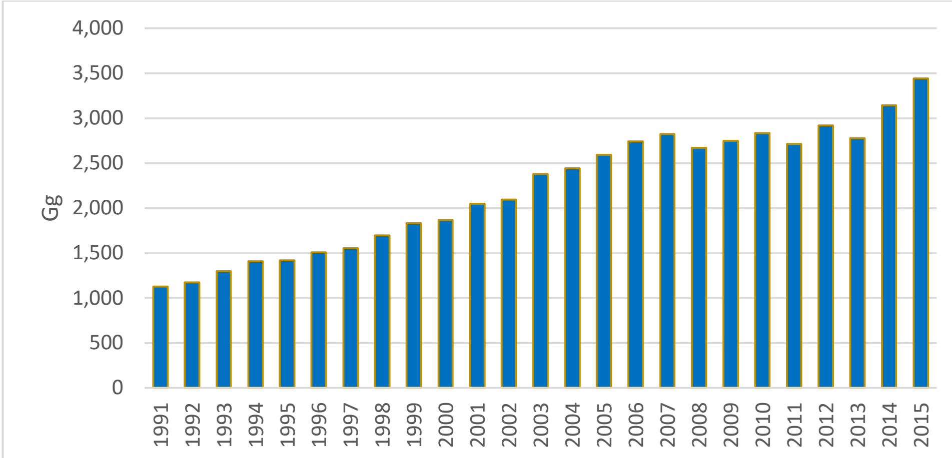

Figure 4.3 - Evolution of CO_2 emissions (Gg) in the Energy Sector (1991 - 2015)

Regarding CH_4, emissions varied between 1.5 Gg and 1.9 Gg during the period 1991 to 2015 (Figure 4.4). After increasing from 1.4 to 1.9 Gg during the period 1991 to 2007, emissions stabilised between 1.8 Gg and 1.9 Gg until 2015.

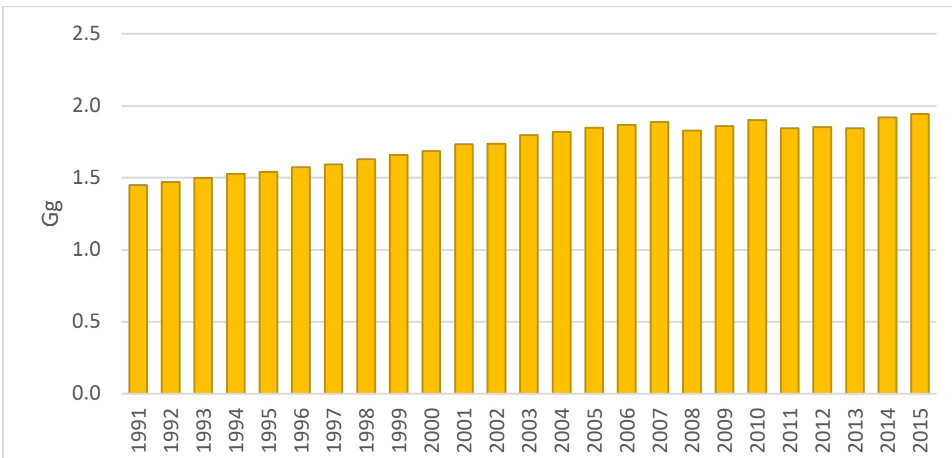

Figure 4.4 - Evolution of CH_4 emissions (Gg) in the Energy Sector (1991 - 2015)

Emissions of N_2O increased from 0.10 to 0.2 Gg (Figure 4.5) over the period 1991 to 2015.

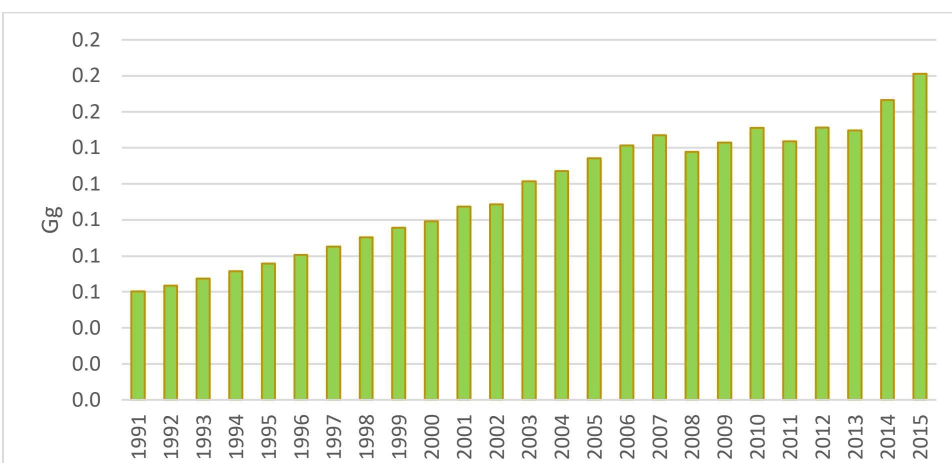

Figure 4.5 - Evolution of N_2O emissions (Gg) in the Energy Sector (1991 - 2015)

Emissions of NO_x varied from 10.9 Gg to 26.9 Gg during the period 1991 to 2015 (Figure 4.6).

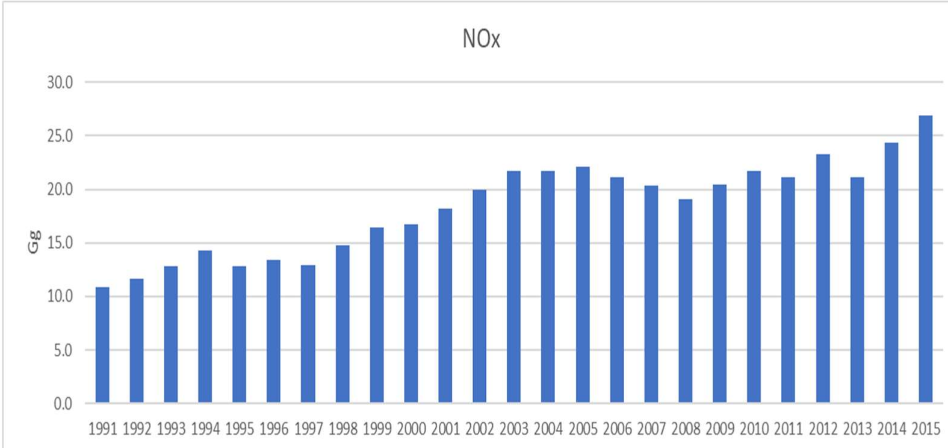

Figure 4.6 - Evolution of NO_x emissions (Gg) in the Energy Sector (1991 - 2015)

Emissions of CO varied between 38.7 Gg to 74.2 Gg from 1991 to 2015, the trend being an overall increase over the inventory period (Figure 4.7).

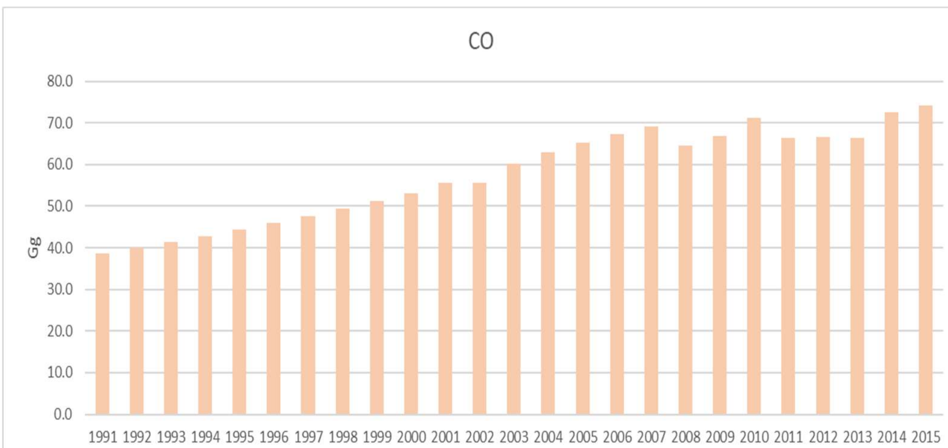

Figure 4.7 - Evolution of CO emissions (Gg) in the Energy Sector (1991 - 2015)

NMVOCs emissions varied between 5.4 and 9.5 Gg over the inventory period 1991 to 2015 (Figure 4.8).

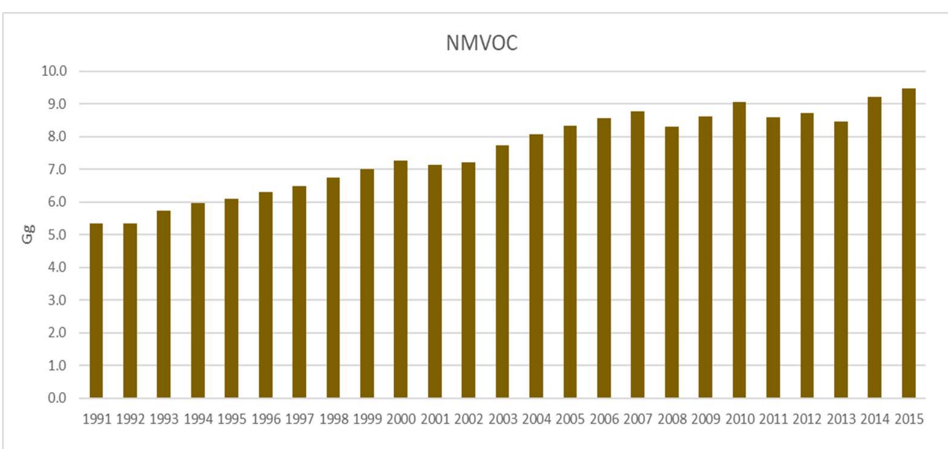

Figure 4.8 - Evolution of NMVOCs emissions (Gg) in the Energy Sector (1991 - 2015)

SO_2 emissions fluctuated between 1.9 Gg and 4.2 Gg during the inventory period 1991 to 2015 with the peak in 2006 (Figure 4.9).

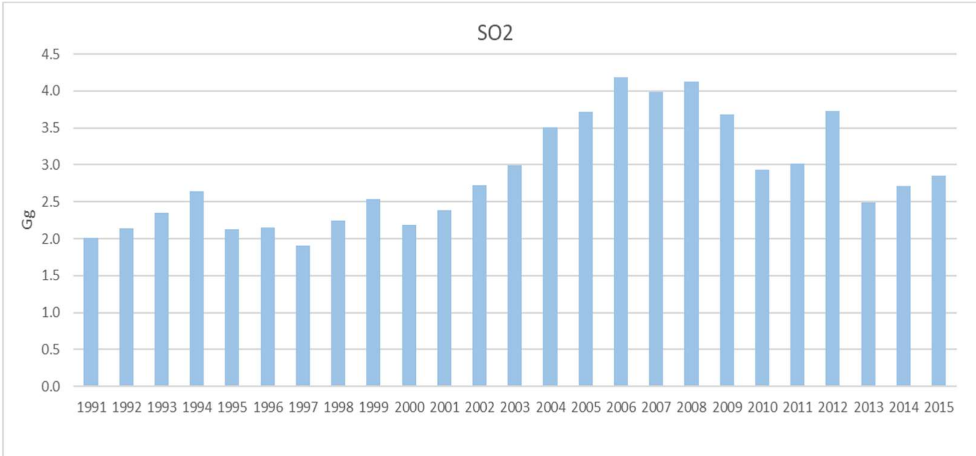

Figure 4.9 - Evolution of SO_2 emissions (Gg) in the Energy Sector (1991 - 2015)

4.5.4. Emissions by gas by category for the period 1991 to 2015

CO_2 emissions

Emissions (Gg) of CO_2 for the years 1991 to 2015 are summarized in Table 4.8. Total CO_2 emissions emanating from fuel combustion activities increased from 1,128 Gg in 1991 to 3,443 in 2015. For the Transport category, CO_2 emissions increased from 617 Gg in 1991 to 2,762 Gg in 2015, whilst for Energy Industries, it varied between 0.5 Gg to 235.7 Gg. Emissions from the Other sectors sub-category fluctuated between 319 Gg and 541 Gg. The Non-specified sub-category emissions increased from 9 to 107 Gg over the period under review.

Table 4.8 - CO_2 emissions (Gg) in Energy sector (1991 - 2015)

Year	Total	Energy Industries	Manufacturing Industries and Construction	Transport	Other Sectors	Non-Specified
1991	1128.0	23.7	101.9	617.3	375.9	9.1
1992	1201.4	26.0	104.8	667.5	392.3	10.7
1993	1297.7	28.3	107.6	723.6	425.6	12.6
1994	1409.8	30.6	110.5	786.4	467.4	14.9
1995	1417.5	32.9	113.4	868.4	385.0	17.9
1996	1507.9	35.2	116.2	950.5	385.1	20.8
1997	1557.2	37.5	119.1	1032.6	344.3	23.8
1998	1696.3	39.8	121.5	1114.6	393.6	26.8
1999	1829.0	42.1	126.2	1196.7	434.2	29.8
2000	1867.5	7.3	130.5	1277.7	419.2	32.8
2001	2045.9	9.2	141.8	1408.4	449.6	36.9
2002	2092.8	0.5	109.4	1417.1	528.2	37.6
2003	2378.9	21.3	143.3	1632.0	541.0	41.3
2004	2443.8	2.2	157.0	1735.2	506.6	42.8
2005	2590.3	53.6	145.8	1853.2	494.7	43.1
2006	2740.3	164.1	158.1	1964.9	409.0	44.2
2007	2821.7	195.0	170.0	2064.5	348.0	44.2
2008	2670.8	235.7	171.0	1888.3	338.8	36.9

Year	Total	Energy Industries	Manufacturing Industries and Construction	Transport	Other Sectors	Non-Specified
2009	2748.3	142.6	180.5	2015.8	371.1	38.2
2010	2836.6	35.5	190.4	2210.6	359.3	40.8
2011	2713.1	13.0	221.2	2076.0	358.4	44.5
2012	2917.6	96.5	190.6	2173.3	406.8	50.5
2013	2775.9	15.4	174.1	2215.6	319.0	51.9
2014	3142.3	5.4	174.6	2530.6	371.7	60.0
2015	3443.0	20.6	178.3	2761.9	375.3	106.9

CH_4 emissions

A total of 1.96 Gg of CH_4 was emitted from the Energy sector, Fuel Combustion Activities category in 2014 from 1.57 Gg in 1991. The main contributing sub-categories over the full period 1991 to 2015 were Other Sectors and Transport. The former emitted at 1.30 Gg and Transport 0.61 Gg (Table 4.9) in 2015. In 2015, CH_4 emissions from the Energy Industries sub-category was 0.00024 Gg and Manufacturing Industries and Construction emitted 0.034 Gg.

Table 4.9 - CH_4 emissions (Gg) in Energy sector (1991 - 2015)

Year	Total	Energy Industries	Manufacturing Industries and Construction	Transport	Other Sectors	Non-Specified
1991	1.45	0.00027	9.3E-03	0.21	1.23	4.8E-04
1992	1.47	0.00029	9.4E-03	0.22	1.24	5.7E-04
1993	1.50	0.00032	9.6E-03	0.23	1.25	6.7E-04
1994	1.53	3.4E-04	9.8E-03	0.25	1.27	7.8E-04
1995	1.54	3.7E-04	9.9E-03	0.27	1.27	9.4E-04
1996	1.57	3.9E-04	1.0E-02	0.28	1.28	1.1E-03
1997	1.59	4.1E-04	1.0E-02	0.30	1.28	1.3E-03
1998	1.63	4.4E-04	1.0E-02	0.32	1.30	1.4E-03
1999	1.66	4.6E-04	1.1E-02	0.34	1.31	1.6E-03
2000	1.69	8.2E-05	1.1E-02	0.35	1.32	1.7E-03
2001	1.73	1.1E-04	1.2E-02	0.38	1.33	1.9E-03
2002	1.74	1.6E-05	9.2E-03	0.38	1.34	2.0E-03
2003	1.80	2.8E-04	1.3E-02	0.43	1.35	2.2E-03
2004	1.82	3.4E-05	1.5E-02	0.46	1.34	2.3E-03
2005	1.85	6.8E-04	1.4E-02	0.49	1.34	2.3E-03
2006	1.87	2.0E-03	1.5E-02	0.52	1.33	2.3E-03
2007	1.89	2.3E-03	1.8E-02	0.54	1.32	2.3E-03
2008	1.83	2.5E-03	1.9E-02	0.48	1.32	1.9E-03
2009	1.86	1.6E-03	2.1E-02	0.51	1.33	2.0E-03
2010	1.90	4.7E-04	2.1E-02	0.55	1.33	2.1E-03
2011	1.84	2.5E-04	2.5E-02	0.49	1.33	2.7E-03
2012	1.85	1.5E-03	2.2E-02	0.50	1.33	3.0E-03
2013	1.84	4.2E-04	2.1E-02	0.51	1.31	3.1E-03
2014	1.92	1.9E-04	2.1E-02	0.58	1.31	3.6E-03
2015	1.96	2.4E-04	3.4E-02	0.61	1.30	6.3E-03

N_2O emissions

Total emissions from the Fuel Combustion Activities category increased from 0.06 Gg in 1991 to 0.18 Gg in 2015 (Table 4.10). For all years, the highest emission was from the Transport sub-category followed by Other Sectors and Manufacturing Industries and Construction. They accounted 0.15 Gg, 0.019 Gg and 0.005 Gg respectively in 2015. In the same year, the Energy Industries sub-category emitted 0.000047 Gg of N_2O with Non-Specified sub-category contributing 0.0032 Gg.

Table 4.10 - N_2O emissions (Gg) in Energy sector (1991 - 2015)

Year	Total	Energy Industries	Manufacturing Industries and Construction	Transport	Other Sectors	Non-Specified
1991	0.06	3.7E-04	0.001	0.04	0.018	3.7E-04
1992	0.06	4.1E-04	0.002	0.04	0.018	4.1E-04
1993	0.07	4.4E-04	0.002	0.05	0.019	4.4E-04
1994	0.07	4.8E-04	0.002	0.05	0.019	7.8E-04
1995	0.08	5.2E-04	0.002	0.05	0.019	9.4E-04
1996	0.08	5.5E-04	0.002	0.06	0.019	1.1E-03
1997	0.09	5.9E-04	0.002	0.06	0.019	1.3E-03
1998	0.09	6.3E-04	0.002	0.07	0.019	1.4E-03
1999	0.10	6.6E-04	0.002	0.07	0.020	1.6E-03
2000	0.10	1.1E-04	0.002	0.08	0.020	1.7E-03
2001	0.11	1.4E-04	0.002	0.08	0.020	1.9E-03
2002	0.11	3.9E-06	0.001	0.08	0.021	2.0E-03
2003	0.12	3.2E-04	0.002	0.10	0.021	2.2E-03
2004	0.13	3.1E-05	0.002	0.10	0.021	2.3E-03
2005	0.13	8.2E-04	0.002	0.11	0.020	2.3E-03
2006	0.14	2.5E-03	0.002	0.11	0.020	2.3E-03
2007	0.15	3.0E-03	0.003	0.12	0.019	2.3E-03
2008	0.14	3.7E-03	0.003	0.11	0.019	1.9E-03
2009	0.14	2.2E-03	0.003	0.12	0.019	2.0E-03
2010	0.15	5.3E-04	0.003	0.13	0.019	2.1E-03
2011	0.14	1.7E-04	0.004	0.12	0.019	2.3E-03
2012	0.15	1.4E-03	0.003	0.12	0.020	2.7E-03
2013	0.15	1.7E-04	0.003	0.12	0.019	2.7E-03
2014	0.17	4.7E-05	0.003	0.14	0.019	3.2E-03
2015	0.18	3.2E-04	0.005	0.15	0.019	5E-03

NO_x emissions

Emissions of NO_x from the combustion of fuels increased from 10.9 Gg in 1991 to 27.0 Gg in 2015. The main contributor was the Transport and Other Sectors sub-categories, followed by Manufacturing Industries and Construction, and Non-Specified sub-categories (Table 4.11). Transport emissions increased from 3.4 Gg in 1991 to 18.4 in 2015. Emissions from the Other Sectors sub-category varied between 5.6 Gg and 10.8 Gg during the period 1991 to 2015 while Energy Industries emissions fluctuated between less than 0.1 Gg to 0.52 Gg. Non-Specified sub-category emissions increased from 0.10 in 1991 to 1.11 Gg in 2015.

Table 4.11 - NO_x emissions (Gg) in Energy sector (1991 - 2015)

Year	Total	Energy Industries	Manufacturing Industries and Construction	Transport	Other Sectors	Non-Specified
1991	10.9	0.05	0.34	3.4	7.0	0.10
1992	11.7	0.06	0.36	3.7	7.4	0.11
1993	12.8	0.06	0.37	4.1	8.2	0.13
1994	14.3	0.07	0.39	4.5	9.2	0.16
1995	12.8	0.07	0.40	5.1	7.1	0.19
1996	13.4	0.08	0.42	5.6	7.1	0.22
1997	13.0	0.08	0.43	6.2	6.0	0.25
1998	14.8	0.09	0.45	6.7	7.3	0.28
1999	16.5	0.09	0.47	7.3	8.3	0.31
2000	16.7	0.02	0.48	7.8	8.1	0.34
2001	18.2	0.02	0.32	8.6	8.8	0.39
2002	19.9	0.00	0.32	8.8	10.5	0.39
2003	21.7	0.05	0.34	10.1	10.8	0.43
2004	21.7	0.00	0.58	10.8	9.9	0.45
2005	22.1	0.12	0.56	11.5	9.5	0.45
2006	21.1	0.36	0.63	12.1	7.5	0.46
2007	20.4	0.43	0.73	12.7	6.1	0.46
2008	19.0	0.52	0.77	11.8	5.6	0.39
2009	20.5	0.31	0.74	12.7	6.3	0.40
2010	21.8	0.08	0.76	13.9	6.6	0.43
2011	21.1	0.03	0.79	13.4	6.4	0.46
2012	23.3	0.21	0.75	14.1	7.7	0.52
2013	21.2	0.03	0.62	14.3	5.6	0.54
2014	24.4	0.01	0.63	16.3	6.8	0.62
2015	27.0	0.05	0.65	18.4	6.7	1.11

CO emissions

The Energy sector, Fuel Combustion Activities category CO emissions of 38.7 Gg in 1991 increased to 74.2 Gg in 2015. The emissions originated mainly from the Transport and Other Sectors sub-categories with 52.6 Gg and 20.1 Gg respectively in 2015 (Table 4.12). CO emissions from Manufacturing Industries and Construction increased from 0.10 Gg in 1991 to 1.13 Gg in 2015 while Non-Specified sub-category emissions evolved from 0.02 Gg in 1991 to 0.34 Gg in 2015. Emissions from Energy Industries were minimal.

Table 4.12 - CO emissions (Gg) in Energy sector (1991 - 2015)

Year	Total	Energy Industries	Manufacturing Industries and Construction	Transport	Other Sectors	Non-Specified
1991	38.73	2.2E-03	0.10	20.9	17.7	0.02
1992	40.01	2.5E-03	0.11	21.9	18.0	0.03
1993	41.39	2.7E-03	0.11	23.0	18.3	0.03
1994	42.4	2.9E-03	0.11	24.1	18.1	0.04
1995	43.8	3.1E-03	0.12	25.6	18.0	0.04
1996	45.6	3.3E-03	0.12	27.0	18.4	0.05
1997	47.1	3.5E-03	0.12	28.5	18.5	0.06
1998	49.1	3.7E-03	0.12	29.9	19.0	0.06
1999	50.9	3.9E-03	0.13	31.4	19.3	0.07

Year	Total	Energy Industries	Manufacturing Industries and Construction	Transport	Other Sectors	Non-Specified
2000	52.8	7.0E-04	0.13	32.9	19.7	0.08
2001	55.5	9.0E-04	0.05	35.4	19.9	0.09
2002	55.4	1.0E-04	0.06	35.1	20.2	0.09
2003	60.0	2.2E-03	0.07	39.3	20.5	0.10
2004	62.8	2.0E-04	0.97	41.3	20.5	0.10
2005	65.0	5.3E-03	0.91	43.4	20.6	0.10
2006	67.4	1.6E-02	0.93	45.8	20.6	0.11
2007	69.1	1.9E-02	0.89	47.6	20.6	0.11
2008	64.6	2.2E-02	0.84	43.1	20.6	0.09
2009	66.9	1.3E-02	1.01	45.0	20.8	0.09
2010	71.0	3.6E-03	1.10	48.9	20.9	0.10
2011	66.3	1.6E-03	1.43	43.7	21.0	0.14
2012	66.6	1.1E-02	1.11	44.2	21.1	0.16
2013	66.5	2.4E-03	1.10	45.2	20.1	0.16
2014	72.9	1.0E-03	1.11	51.2	20.3	0.19
2015	74.2	2.0E-03	1.13	52.6	20.1	0.34

NMVOC emissions

Total NMVOC emissions increased from 5.3 Gg in 1991 to 9.5 Gg in 2015. NMVOCs originated mainly from the Transport and Other Sectors sub-categories and they accounted for 5.6 Gg and 3.6 Gg of emissions of the Energy sector respectively in 2015 (Table 4.13). The other three sub-categories contributed marginally, about 0.27 Gg combined, to total NMVOC emissions.

Table 4.13 - NMVOCs emissions (Gg) in Energy sector (1991 - 2015)

Year	Total	Energy Industries	Manufacturing Industries and Construction	Transport	Other Sectors	Non-Specified
1991	5.3	2.6E-04	0.40	2.0	3.0	0.01
1992	5.5	2.9E-04	0.41	2.1	3.1	0.01
1993	5.7	3.1E-04	0.41	2.2	3.1	0.01
1994	5.9	3.0E-04	0.42	2.3	3.1	0.01
1995	6.0	4.0E-04	0.42	2.5	3.1	0.01
1996	6.3	4.0E-04	0.43	2.6	3.2	0.01
1997	6.4	4.0E-04	0.43	2.8	3.2	0.01
1998	6.7	4.0E-04	0.44	3.0	3.3	0.02
1999	7.0	5.0E-04	0.44	3.1	3.4	0.02
2000	7.2	1.0E-04	0.47	3.3	3.5	0.02
2001	7.1	1.0E-04	0.02	3.6	3.5	0.02
2002	7.2	0.0E+00	0.02	3.5	3.6	0.02
2003	7.7	3.0E-04	0.03	4.0	3.7	0.02
2004	8.0	0.0E+00	0.11	4.2	3.7	0.03
2005	8.3	6.0E-04	0.13	4.5	3.7	0.03
2006	8.6	1.9E-03	0.14	4.7	3.7	0.03
2007	8.8	2.2E-03	0.16	5.0	3.6	0.03
2008	8.3	2.5E-03	0.18	4.5	3.6	0.02
2009	8.6	1.6E-03	0.20	4.7	3.7	0.02

Year	Total	Energy Industries	Manufacturing Industries and Construction	Transport	Other Sectors	Non-Specified
2010	9.1	4.0E-04	0.20	5.1	3.7	0.02
2011	8.6	2.0E-04	0.23	4.6	3.8	0.03
2012	8.7	1.4E-03	0.20	4.6	3.8	0.03
2013	8.5	3.0E-04	0.20	4.7	3.5	0.03
2014	9.2	1.0E-04	0.20	5.4	3.6	0.04
2015	9.5	2.3E-04	0.20	5.6	3.6	0.07

SO_2 emissions

Total SO_2 emissions in the Energy sector varied between 1.9 Gg and 4.2 Gg for the time series 1991 to 2015. Emissions of SO_2 across the time period were more important in the Other Sectors sub-category followed by the Manufacturing Industries and Construction sub-category (Table 4.14). Emissions in the former sub-category varied between 1.5 Gg and 2.8 Gg while in the Manufacturing and Construction sub-category, the emissions increased from 0.02 Gg in 1991 to 0.90 Gg in 2015 after a peak of 1.21 Gg in 2011.

Table 4.14 - SO_2 emissions (Gg) in Energy sector (1991 - 2015)

Year	Total	Energy Industries	Manufacturing Industries and Construction	Transport	Other Sectors	Non-Specified
1991	2.0	0.20	0.02	0.01	1.8	1.0E-04
1992	2.1	0.22	0.02	0.01	1.9	1.0E-04
1993	2.4	0.24	0.02	0.01	2.1	1.0E-04
1994	2.6	0.26	0.02	0.01	2.3	1.0E-04
1995	2.1	0.28	0.02	0.01	1.8	1.0E-04
1996	2.2	0.30	0.03	0.01	1.8	1.0E-04
1997	1.9	0.32	0.03	0.01	1.5	1.0E-04
1998	2.2	0.34	0.03	0.02	1.9	1.0E-04
1999	2.5	0.36	0.03	0.02	2.1	1.0E-04
2000	2.2	0.06	0.03	0.02	2.1	2.0E-04
2001	2.4	0.08	0.03	0.02	2.3	2.0E-04
2002	2.7	0.00	0.03	0.02	2.7	2.0E-04
2003	3.0	0.18	0.03	0.02	2.8	2.0E-04
2004	3.5	0.02	0.92	0.02	2.5	2.0E-04
2005	3.7	0.46	0.80	0.02	2.5	2.0E-04
2006	4.2	1.40	0.81	0.02	1.9	2.0E-04
2007	4.0	1.67	0.72	0.02	1.6	2.0E-04
2008	4.1	2.04	0.62	0.02	1.5	2.0E-04
2009	3.7	1.23	0.78	0.02	1.7	2.0E-04
2010	2.9	0.30	0.89	0.02	1.7	2.0E-04
2011	3.0	0.10	1.21	0.02	1.7	2.0E-04
2012	3.7	0.80	0.89	0.02	2.0	3.0E-04
2013	2.5	0.11	0.89	0.02	1.5	3.0E-04
2014	2.7	0.04	0.90	0.03	1.8	3.0E-04
2015	2.9	0.18	0.90	0.03	1.7	5.5E-04

4.5.5. Memo Items

International Bunkering

Both international aviation and navigation were covered in this inventory for the full time series. As expected, emissions increased over the time period 1991 to 2015 due to enhanced levels of activities in both seaports and airports.

Total emissions from international bunkers are given in Table 4.15. It increased by 26% from 210.6 Gg CO_2-eq in the year 1994 to 265.6 Gg CO_2-eq in 2015. CO_2 was the major contributor with slightly more than 99% of total bunkering emissions for all years. The other direct GHGs CH_4 and N_2O contributed the remainder.

Table 4.15 - Total emissions (Gg CO_2-eq) and by gas (Gg) from international bunkers (1991 - 2015)

Year	Total CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1991	210.6	208.58	0.014	0.006	3.73	0.590	0.20	0.601
1992	211.9	209.85	0.014	0.006	3.73	0.590	0.20	0.601
1993	213.2	211.13	0.014	0.006	3.73	0.590	0.20	0.601
1994	214.5	212.4	0.014	0.006	3.73	0.590	0.203	0.601
1995	215.8	213.7	0.013	0.006	3.71	0.583	0.201	0.592
1996	217.1	215.0	0.013	0.006	3.70	0.578	0.199	0.582
1997	218.4	216.3	0.013	0.006	3.68	0.572	0.197	0.573
1998	219.7	217.6	0.013	0.006	3.66	0.566	0.195	0.564
1999	221.0	218.9	0.013	0.006	3.65	0.561	0.193	0.554
2000	222.3	220.1	0.013	0.006	3.63	0.555	0.191	0.544
2001	225.1	223.0	0.013	0.006	2.30	0.556	0.191	0.533
2002	227.8	225.6	0.013	0.006	2.25	0.556	0.191	0.521
2003	230.5	228.3	0.013	0.006	2.21	0.557	0.191	0.509
2004	233.2	231.0	0.014	0.006	3.83	0.712	0.248	0.917
2005	235.9	233.7	0.014	0.006	3.88	0.721	0.251	0.929
2006	238.6	236.3	0.014	0.006	3.93	0.731	0.254	0.941
2007	241.3	239.0	0.014	0.006	3.98	0.740	0.257	0.953
2008	244.1	241.7	0.014	0.007	4.03	0.749	0.260	0.964
2009	246.8	244.5	0.014	0.007	4.08	0.758	0.263	0.976
2010	251.3	248.9	0.015	0.007	4.13	0.768	0.267	0.989
2011	276.3	273.7	0.015	0.007	4.31	0.793	0.276	1.019
2012	265.6	263.1	0.015	0.007	4.27	0.789	0.274	1.015
2013	265.6	263.1	0.015	0.007	4.27	0.789	0.274	1.015
2014	265.6	263.1	0.015	0.007	4.27	0.789	0.274	1.015
2015	265.6	263.1	0.015	0.007	4.27	0.789	0.274	1.015

Total emissions from international aviation increased from 66.1 Gg CO_2-eq to 109.7 Gg CO_2-eq (Table 4.16), representing an increase of 24% in 2015 over the 1991 emissions. Once more, CO_2 constituted more than 99% of the aggregated emissions of the direct gases.

Table 4.16 - Total emissions (Gg CO_2-eq) and by gas (Gg) from international aviation (1991 - 2015)

Year	Total CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1991	66.1	65.5	0.000	0.002	0.295	0.025	0.012	0.023
1992	68.5	67.9	0.000	0.002	0.295	0.025	0.012	0.023

Year	Total CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1993	70.9	70.3	0.000	0.002	0.295	0.025	0.012	0.023
1994	73.4	72.7	0.001	0.002	0.295	0.025	0.012	0.023
1995	75.8	75.1	0.001	0.002	0.305	0.026	0.012	0.024
1996	78.2	77.6	0.001	0.002	0.315	0.027	0.012	0.025
1997	80.7	80.0	0.001	0.002	0.325	0.028	0.013	0.025
1998	83.1	82.4	0.001	0.002	0.335	0.029	0.013	0.026
1999	85.6	84.8	0.001	0.002	0.344	0.030	0.013	0.027
2000	88.0	87.2	0.001	0.002	0.354	0.030	0.014	0.028
2001	88.9	88.1	0.001	0.002	0.358	0.031	0.014	0.028
2002	89.8	89.0	0.001	0.002	0.361	0.031	0.014	0.028
2003	90.7	89.9	0.001	0.003	0.365	0.031	0.014	0.029
2004	91.6	90.8	0.001	0.003	0.369	0.032	0.014	0.029
2005	92.5	91.7	0.001	0.003	0.372	0.032	0.015	0.029
2006	93.5	92.6	0.001	0.003	0.376	0.032	0.015	0.029
2007	94.4	93.6	0.001	0.003	0.380	0.033	0.015	0.030
2008	95.3	94.5	0.001	0.003	0.384	0.033	0.015	0.030
2009	96.3	95.4	0.001	0.003	0.387	0.033	0.015	0.030
2010	99.0	98.1	0.001	0.003	0.398	0.034	0.016	0.031
2011	120.3	119.3	0.001	0.003	0.484	0.042	0.019	0.038
2012	109.7	108.7	0.001	0.003	0.441	0.038	0.017	0.035
2013	109.7	108.7	0.001	0.003	0.441	0.038	0.017	0.035
2014	109.7	108.7	0.001	0.003	0.441	0.038	0.017	0.035
2015	109.7	108.7	0.001	0.003	0.441	0.038	0.017	0.035

International water-borne navigation was responsible for more emissions compared to aviation bunkering. CO_2 exceeded by far the emissions of CH_4 and N_2O combined with more than 99% throughout the time series. Total aggregated emissions of the direct gases increased by 11% from 144.6 Gg CO_2-eq in 1991 to 156.0 Gg CO_2-eq in 2015 (Table 4.17).

Table 4.17 - Total emissions (Gg CO2-eq) and by gas (Gg) from international water-borne navigation (1991 - 2015)

Year	Total CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1991	144.6	143.1	0.013	0.004	3.435	0.564	0.191	0.578
1992	143.4	142.0	0.013	0.004	3.435	0.564	0.191	0.578
1993	142.3	140.8	0.013	0.004	3.435	0.564	0.191	0.578
1994	141.1	139.7	0.013	0.004	3.435	0.564	0.191	0.578
1995	140.0	138.6	0.013	0.004	3.408	0.557	0.189	0.568
1996	138.8	137.4	0.013	0.004	3.381	0.551	0.187	0.558
1997	137.7	136.3	0.013	0.004	3.354	0.544	0.184	0.548
1998	136.6	135.2	0.013	0.004	3.327	0.538	0.182	0.538
1999	135.5	134.1	0.012	0.004	3.301	0.531	0.180	0.528
2000	134.2	132.9	0.012	0.004	3.272	0.524	0.177	0.517
2001	136.2	134.9	0.013	0.004	1.942	0.525	0.177	0.505
2002	138.0	136.6	0.013	0.004	1.893	0.525	0.177	0.493
2003	139.8	138.4	0.013	0.004	1.843	0.525	0.177	0.480
2004	141.6	140.2	0.013	0.004	3.460	0.681	0.233	0.888
2005	143.4	141.9	0.013	0.004	3.505	0.689	0.236	0.900

Year	Total CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
2006	145.2	143.7	0.013	0.004	3.551	0.698	0.239	0.911
2007	146.9	145.5	0.013	0.004	3.597	0.707	0.242	0.923
2008	148.7	147.2	0.014	0.004	3.643	0.716	0.245	0.934
2009	150.5	149.0	0.014	0.004	3.689	0.725	0.248	0.946
2010	152.3	150.8	0.014	0.004	3.734	0.734	0.251	0.958
2011	156.0	154.4	0.014	0.004	3.825	0.752	0.257	0.981
2012	156.0	154.4	0.014	0.004	3.825	0.752	0.257	0.981
2013	156.0	154.4	0.014	0.004	3.825	0.752	0.257	0.981
2014	156.0	154.4	0.014	0.004	3.825	0.752	0.257	0.981
2015	156.0	154.4	0.014	0.004	3.825	0.752	0.257	0.981

4.5.6. Information items

CO_2 from Biomass Combustion for Energy Production

The evolution of CO_2 emissions (Gg) from biomass burning for energy production is given in Table 4.18. Emissions increased by 17 % from 450.6 Gg in 1991 to 526.4 in 2015.

Table 4.18 - Emissions (Gg CO_2-eq) by gas from Biomass Combustion for Energy Production (1991 - 2015)

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
CO_2	450.6	454.1	457.6	461.1	464.7	468.2	471.8	475.4	479.1	482.7	486.4	486.8	487.1

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CO_2	487.4	487.7	488	488.2	488.4	488.5	488.7	488.8	486.2	483.7	481.3	526.4

Table 4.19 - Sectoral Table: Energy (Inventory Year: 2015)

	Emissions (Gg)						
Categories	CO2	CH4	N2O	NOx	CO	NMVOCs	SO2
1 - Energy	3443.029	1.955	0.183	24.382	72.867	9.217	2.714
1.A - Fuel Combustion Activities	3443.029	1.955	0.183	24.382	72.867	9.217	2.714
1.A.1 - Energy Industries	20.602	0.000	0.000	0.010	0.001	0.000	0.036
1.A.1.a - Main Activity Electricity and Heat Production	20.602	0.000	0.000	0.010	0.001	0.000	0.036
1.A.1.a.i - Electricity Generation	20.602	0.000	0.000	0.010	0.001	0.000	0.036
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	NO	NO	NO	NO	NO	NO	NO
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries	NO	NO	NO	NO	NO	NO	NO
1.A.1.c.i - Manufacture of Solid Fuels	NO	NO	NO	NO	NO	NO	NO
1.A.1.c.ii - Other Energy Industries	NO	NO	NO	NO	NO	NO	NO
1.A.2 - Manufacturing Industries and Construction	178.308	0.034	0.005	0.626	1.112	0.196	0.897
1.A.2.a - Iron and Steel	NO	NO	NO	NO	NO	NO	NO
1.A.2.b - Non-Ferrous Metals	NO	NO	NO	NO	NO	NO	NO
1.A.2.c - Chemicals	NO	NO	NO	NO	NO	NO	NO
1.A.2.d - Pulp, Paper and Print	NO	NO	NO	NO	NO	NO	NO
1.A.2.e - Food Processing, Beverages and Tobacco	EE	EE	EE	EE	EE	EE	EE
1.A.2.f - Non-Metallic Minerals	EE	EE	EE	EE	EE	EE	EE
1.A.2.g - Transport Equipment	NO	NO	NO	NO	NO	NO	NO

Categories	Emissions (Gg)						
	CO2	CH4	N2O	NOx	CO	NMVOCs	SO2
1.A.2.h - Machinery	NO	NO	NO	NO	NO	NO	NO
1.A.2.i - Mining (excluding fuels) and Quarrying	175.919	0.021	0.003	0.610	1.109	0.195	0.896
1.A.2.j - Wood and wood products	NO	NO	NO	NO	NO	NO	NO
1.A.2.k - Construction	EE	EE	EE	EE	EE	EE	EE
1.A.2.l - Textile and Leather	EE	EE	EE	EE	EE	EE	EE
1.A.2.m - Non-specified Industry	2.389	0.013	0.002	0.017	0.002	0.001	0.002
1.A.3 - Transport	2761.936	0.611	0.153	16.328	51.215	5.408	0.025
1.A.3.a - Civil Aviation	25.426	0.000	0.001	0.061	4.245	0.068	0.008
1.A.3.a.i - International Aviation (International Bunkers) (1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.A.3.a.ii - Domestic Aviation	25.426	0.000	0.001	0.061	4.245	0.068	0.008
1.A.3.b - Road Transportation	2687.824	0.608	0.134	15.451	46.804	5.267	0.017
1.A.3.b.i - Cars	567.305	0.229	0.027	1.582	11.838	1.415	0.006
1.A.3.b.i.1 - Passenger cars with 3-way catalysts	182.552	0.074	0.009	0.511	3.817	0.457	0.002
1.A.3.b.i.2 - Passenger cars without 3-way catalysts	384.753	0.155	0.018	1.070	8.021	0.958	0.004
1.A.3.b.ii - Light-duty trucks	1059.942	0.323	0.052	4.768	32.521	3.229	0.009
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts	794.957	0.242	0.039	3.576	24.390	2.422	0.007
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts	264.986	0.081	0.013	1.192	8.130	0.807	0.002
1.A.3.b.iii - Heavy-duty trucks and buses	1058.151	0.056	0.056	9.097	2.066	0.523	0.002
1.A.3.b.iv - Motorcycles	2.426	0.001	0.000	0.005	0.379	0.100	0.000
1.A.3.b.v - Evaporative emissions from vehicles	NO	NO	NO	NO	NO	NO	NO
1.A.3.b.vi - Urea-based catalysts	NO	NO	NO	NO	NO	NO	NO
1.A.3.c - Railways	48.687	0.003	0.018	0.816	0.167	0.073	0.000
1.A.3.d - Water-borne Navigation	EE	EE	EE	EE	EE	EE	EE
1.A.3.d.i - International water-borne navigation (International bunkers) (1)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.A.3.d.ii - Domestic Water-borne Navigation	EE	EE	EE	EE	EE	EE	EE
1.A.3.e - Other Transportation	EE	EE	EE	EE	EE	EE	EE
1.A.3.e.i - Pipeline Transport	NO	NO	NO	NO	NO	NO	NO
1.A.3.e.ii - Off-road	EE	EE	EE	EE	EE	EE	EE
1.A.4 - Other Sectors	375.278	1.303	0.019	6.795	20.349	3.573	1.755
1.A.4.a - Commercial/Institutional	EE	EE	EE	EE	EE	EE	EE
1.A.4.b - Residential	106.199	1.267	0.017	0.372	17.438	2.615	0.048
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	269.079	0.036	0.002	6.423	2.911	0.958	1.707
1.A.4.c.i - Stationary	EE	EE	EE	EE	EE	EE	EE
1.A.4.c.ii - Off-road Vehicles and Other Machinery	EE	EE	EE	EE	EE	EE	EE
1.A.4.c.iii - Fishing (mobile combustion)	269.079	0.036	0.002	6.423	2.911	0.958	1.707
1.A.5 - Non-Specified	106.906	0.006	0.006	0.623	0.190	0.040	0.000
1.A.5.a - Stationary	EE	EE	EE	EE	EE	EE	EE
1.A.5.b - Mobile	106.906	0.006	0.006	0.623	0.190	0.040	0.000
1.A.5.b.i - Mobile (aviation component)	EE	EE	EE	EE	EE	EE	EE
1.A.5.b.ii - Mobile (water-borne component)	EE	EE	EE	EE	EE	EE	EE
1.A.5.b.iii - Mobile (Other)	106.906	0.006	0.006	0.623	0.190	0.040	0.000
1.A.5.c - Multilateral Operations (1)(2)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.B - Fugitive emissions from fuels	NO	NO	NO	NO	NO	NO	NO
1.B.1 - Solid Fuels	NO	NO	NO	NO	NO	NO	NO
1.B.1.a - Coal mining and handling	NO	NO	NA	NO	NO	NO	NO

Categories	Emissions (Gg)						
	CO2	CH4	N2O	NOx	CO	NMVOCs	SO2
1.B.1.a.i - Underground mines	NO	NO	NA	NO	NO	NO	NO
1.B.1.a.i.1 - Mining	NO	NO	NA	NO	NO	NO	NO
1.B.1.a.i.2 - Post-mining seam gas emissions	NO	NO	NA	NO	NO	NO	NO
1.B.1.a.i.3 - Abandoned underground mines	NO	NO	NA	NO	NO	NO	NO
1.B.1.a.i.4 - Flaring of drained methane or conversion of methane to CO2	NO	NO	NA	NO	NO	NO	NO
1.B.1.a.ii - Surface mines	NO	NO	NA	NO	NO	NO	NO
1.B.1.a.ii.1 - Mining	NO	NO	NA	NO	NO	NO	NO
1.B.1.a.ii.2 - Post-mining seam gas emissions	NO	NO	NA	NO	NO	NO	NO
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	NO	NO	NO	NO	NO	NO	NO
1.B.2.a - Oil	NO	NO	NO	NO	NO	NO	NO
1.B.2.a.i - Venting	NO	NO	NA	NO	NO	NO	NO
1.B.2.a.ii - Flaring	NO	NO	NO	NO	NO	NO	NO
1.B.2.a.iii - All Other	NO	NO	NO	NO	NO	NO	NO
1.B.2.a.iii.1 - Exploration	NO	NO	NO	NO	NO	NO	NO
1.B.2.a.iii.2 - Production and Upgrading	NO	NO	NO	NO	NO	NO	NO
1.B.2.a.iii.3 - Transport	NO	NO	NO	NO	NO	NO	NO
1.B.2.a.iii.4 - Refining	NO	NO	NA	NO	NO	NO	NO
1.B.2.a.iii.5 - Distribution of oil products	NO	NO	NA	NO	NO	NO	NO
1.B.2.a.iii.6 - Other	NO	NO	NO	NO	NO	NO	NO
1.B.2.b - Natural Gas	NO	NO	NO	NO	NO	NO	NO
1.B.2.b.i - Venting	NO	NO	NA	NO	NO	NO	NO
1.B.2.b.ii - Flaring	NO	NO	NO	NO	NO	NO	NO
1.B.2.b.iii - All Other	NO	NO	NO	NO	NO	NO	NO
1.B.2.b.iii.1 - Exploration	NO	NO	NA	NO	NO	NO	NO
1.B.2.b.iii.2 - Production	NO	NO	NA	NO	NO	NO	NO
1.B.2.b.iii.3 - Processing	NO	NO	NA	NO	NO	NO	NO
1.B.2.b.iii.4 - Transmission and Storage	NO	NO	NA	NO	NO	NO	NO
1.B.2.b.iii.5 - Distribution	NO	NO	NA	NO	NO	NO	NO
1.B.2.b.iii.6 - Other	NO	NO	NO	NO	NO	NO	NO
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 CO2	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

	Emissions (Gg)						
Categories	CO2	CH4	N2O	NOx	CO	NMVOCs	SO2
Memo Items (3)							
International Bunkers	263.112	0.015	0.007	4.267	0.789	0.274	1.015
1.A.3.a.i - International Aviation (International Bunkers) (1)	108.698	0.001	0.003	0.441	0.038	0.017	0.035

	Emissions (Gg)						
Categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1.A.3.d.i - International water-borne navigation (International bunkers) (1)	154.414	0.014	0.004	3.825	0.752	0.257	0.981
1.A.5.c - Multilateral Operations (1)(2)				0.000	0.000	0.000	0.000
Information Items							
CO_2 from Biomass Combustion for Energy Production	526.363						

5. Industrial Processes and Product Use (IPPU)

5.1. Description of IPPU sector

Emissions were estimated for activities occurring in six out of the eight categories falling under the IPPU sector and these sub-categories are listed in Table 5.1.

Table 5.1 - Categories and sub-categories for which emissions are reported

Sectoral Categories	Sub-Categories from which emissions are reported
2.A Mineral Industry	2.A.1 - Cement production 2.A.2 - Lime production
2.C Metal Industry	2.C.6 - Zinc Production
2.D Non-Energy Products from Fuels and Solvent	2.D.3 - Solvent Use (7) 2.D.3.a - Wood preservation 2.D.3.b - Paint application 2.D.3.c - Asphalt and bitumen
2.F Product Uses as Substitutes for Ozone Depleting Substances	2.F.1 - Refrigeration and Air Conditioning
2.G Other Product Manufacture and Use	2.G.3 - N_2O from Product Use (Medical Applications 2.G.3.a)
2.H Other	2.H.2 - Food and Beverages Industry 2.H.2.a - Beer manufacturing 2.H.2.a - Breadmaking

A few more activity areas still have to be included given that disaggregated AD were not available to compute the estimates, despite special efforts being devoted to collect these AD when this inventory was prepared. A survey is under way for estimating SF_6 from electrical equipment. These sources are.

- **Product used as substitutes for ozone depleting substances**
  - Fire protection
  - Aerosols
  - Solvents
- **Other products manufacture and use**
  - Disposal of electric equipment
  - SF_6 in military applications
  - N_2O used as propellant for pressure and aerosol products.
- **Food and beverage industry**
  - Fishmeal production

5.2. Methods

The method adopted is according to the 2006 IPCC Guidelines, at the Tier 1 level, due to unavailability of disaggregated information on the technologies used in the production processes for moving to higher Tiers. As well, these emitting sources are not key categories in most cases. Only emissions of CO_2, and NMVOCs were estimated, the former through computations made using the 2006 IPCC software and the latter using Excel for programming the equations recommended in the EMEP/EEA guidelines.

5.3. Activity Data

AD for the IPPU sector were obtained mainly from the NSA and complemented with those collected from the industrialists. Outputs from the production units and the annual report of the Chamber of Mines were used to supplement the import and export AD from the NSA for the metal industry. All AD from the different sources were compared and quality controlled to identify the most reliable sets which were then keyed in the software for generating emissions. AD for lubricants and paraffin wax use were derived from the mass balance of import and export data. AD used for the time series are provided in Table 5.2**Error! Reference source not found.**.

Table 5.2 - Activity data for the IPPU sector (1991 - 2015)

Year	2.A.1-Cement production (t)	2.A.2-Lime production (t)	2.C.6-Zinc production (t)	2.D.1-Lubricant use (t)	2.D.2-Paraffin Wax Use (t)	2.D.3.a-Wood preservation (creosote) (t)	2.D.3.b-Paint application (Non-aqueous paint) (t)	2.D.3.c-Asphalt and bitumen (t)	2.F.1 - Refrigeration and Air Conditioning	2.G.1 - medical Applications of N_2O	2.H.2.a-Beer manufacturing (t)	2.D.H.2.a-Bread making (wheat) (t)
1991	NO	2,903	NO	854	30,000	16	2089	485	0	2.789	8,566	32,860
1992	NO	3,652	NO	854	30,000	16	2278	485	0	2.956	6,843	41,886
1993	NO	4,402	NO	854	30,000	16	2467	485	0.15	3.130	6,986	43,913
1994	NO	5,152	NO	854	30,000	16	2,657	485	0.28	3.309	9,904	45,939
1995	NO	5,901	NO	854	30,000	16	3,169	485	5.88	3.494	9,908	55,865
1996	NO	6,651	NO	854	30,000	16	3,287	485	11.03	3.686	9,908	60,950
1997	NO	7,401	NO	854	30,000	16	3,405	485	15.79	3.884	42,141	45,646
1998	NO	8,151	NO	854	30,000	16	2,904	742	20.24	4.088	113,177	60,953
1999	NO	8,900	NO	854	30,000	16	5,169	92	24.43	4.300	156,568	75,648
2000	NO	9,161	NO	965	29,415	16	3,452	263	28.41	4.518	202,498	64,218
2001	NO	10,735	NO	448	27,319	16	3,729	1,175	32.23	4.744	258,058	65,271
2002	NO	11,200	35	294	29,577	16	5,481	1,047	35.71	4.945	185,268	83,019
2003	NO	12,400	47,436	2,022	30,332	16	2,224	2,672	40.26	5.150	264,395	80,685
2004	NO	12,600	119,205	543	34,193	16	3,415	4,297	47.44	5.360	248,612	88,614
2005	NO	13,050	132,813	6,179	30,765	16	3,524	5,921	89.35	5.575	264,516	85,699
2006	NO	13,500	129,897	6,966	29,070	16	5,108	7,546	91.00	5.795	282,645	73,770
2007	NO	14,500	150,080	11,197	29,128	16	5,542	9,171	92.64	6.020	291,301	74,914
2008	NO	15,400	145,396	14,880	34,625	16	4,885	10,796	85.84	6.250	328,516	67,798
2009	NO	17,600	150,400	15,404	35,989	16	5,723	12,421	85.68	6.486	393,881	70,136
2010	NO	19,800	151,688	13,896	27,529	16	5,883	14,045	84.60	6.723	367,496	74,892
2011	284,000	18,996	144,755	15,205	30,000	16	8,397	15,670	89.69	6.973	385,193	79,918
2012	428,000	19,890	145,342	15,231	30,000	16	5,427	17,295	91.15	7.223	410,695	85,445
2013	520,000	20,785	124,924	15,681	30,000	16	5,379	18,920	94.65	7.490	427,188	89,471
2014	583,000	21,679	102,188	15,372	30,000	16	6,809	20,545	100.68	7.757	397,039	91,879
2015	635,000	22,573	82,029	15,372	30,000	16	6,820	22,169	113.16	8.030	428,890	93,936

5.3.1. Cement Production (2.A.1)

During the period under review there was only one cement production plant in operation in Namibia, namely, the Ohorongo Cement Plant (Ohorongo (Pty) Ltd), which according to the company's website (www.ohrongo-cement.com) has a production capacity of over 1 million tonnes of cement per year. AD for this sub-category is based on clinker utilisation provided by the manufacturer. Cement production started in 2010 and, from that year to 2014, cement production increased steadily, as indicated by clinker utilisation which increased from 284,000 tonnes/year at the beginning of the period to reach 635,000 tonnes by 2015 (Table 5.2).

5.3.2. Lime Production (2.A.2)

The amount of lime produced in Namibia steadily increased from 1991 when it stood at 2,903 tonnes to reach 22,573 tonnes in 2015. AD for the period 2000 to 2010 was obtained from the Ministry of Industrialisation, Trade and SME. The 2000 to 2005 trend was used to extrapolate data for the period 1991 to 1999 while the 2000 to 2010 trend was used to extrapolate data for the period 2011 to 2015 (Table 5.2).

5.3.3. Zinc Production (2.C.6)

For the purpose of this inventory, only production of metallic zinc is considered. Data obtained from the Chamber of Mines indicate that though activities were launched in 2002, it was only in 2003 that commercial production started and by 2004 had reached 119,205 tonnes. Production still grew, albeit at a slower rate, during the following years to reach 151,688 tonnes in 2010. However, thereafter production decreased significantly over the years to stand at 82,029 tonnes in 2015 (Table 5.2).

5.3.4. Lubricant Use (2.D.1)

AD gaps for Lubricant Use were filled through generation based on AD collected for the period 2000 to 2013 from Trade Statistics and the Ministry of Industrialisation, Trade and SME. The average lubricant use for 2000 and 2001 was used as a constant for the period 1991 to 1999. Regarding 2014 and since trade data for that year was not reliable, the average usage during the period 2011 to 2013 was adopted. The time series thus obtained shows: (i) lubricant use was stable during the 1991 to 1999 period with an annual use of 854 tonnes, (ii) from 2004 to 2009 lubricant use jumped from 294 tonnes to 15,404 tonnes and (iii) thereafter, with the exception of a drop to 13,896 tonnes in 2010, usage stabilised at around 15,400 tonnes per year (Table 5.2).

5.3.5. Paraffin Wax Use (2.D.2)

For the period 2000 to 2010, AD for Paraffin Wax Use were generated by adjusting figures obtained from the Ministry of Industrialisation, Trade and SME with data from Trade Statistics. For the periods 1991 to 1999 and that of 2011 to 2015, an estimate of 30,000 tonnes per year was used (Table 5.2).

5.3.6. Wood Preservation (2.D.3.a)

The utilisation of creosote by the railway network was considered and the assumption made that over the period under review utilisation was constant given that the railway network did not expand. Thus, AD for creosote was estimated at 16 tonnes per year based on average trade data (Table 5.2).

5.3.7. Paint application (2.D.3.b)

Since no production data were available from manufacturers of solvent-based paints and lacquers, the mass balance from import and export data was adopted as AD for this activity. Extrapolation of data available for the period 1998 to 2014 was adopted to generate data for the period 1991 to 1997. A linear trend was then generated for the whole period to correct the marked highs and lows of the original trade data (Table 5.2).

5.3.8. Asphalt and bitumen (2.D.3.c)

Asphalt and bitumen import and export data available for the period 1998 to 2014 presented marked variations between the years. AD for the period 1991 to 1997 was computed as the average amount of product used during the period 1998 to 2003, export data being retained for the period 1998 to 2003 and linear trending of import and export data for the period 2003 to 2014 was used to generate data for completing the time series. Asphalt and bitumen use during the period 1998 to 2003 was mainly for maintenance purposes while the steady increase from 2004 onwards was attributed to development of the road network (Table 5.2).

5.3.9. Refrigeration and Air Conditioning (2.F.1)

Description of the Refrigeration and Air Conditioning (RAC) sub-category

Emissions from fluorinated gases used as substitutes for Ozone Depleting Substances (ODS) occur from product use, namely PFCs and HFCs. These gases are used in the production of foam blowing agents, aerosols, fire suppression and other applications. These gases have been introduced on the market in RAC to replace ODS following the entry into force of the Montreal Protocol in 1987.

Emissions of PFCs and HFCs occur during the production of these gases, their use and when equipment containing them are retired. These specialized production units are mostly found in the northern hemisphere. Their use in RAC equipment is the major source of emissions occurring in Namibia. These gases are present in equipment requiring air temperature control such as refrigerators, chillers, air conditioners, cars and other vehicles among others. Leakages from the gas system occur during the lifetime of the equipment. Gases can also escape during recharge of the cooling system and at the end of the lifetime of the equipment when it is retired.

Thus, the continuous influx of new equipment on the market contribute to what is called a bank and small amounts are lost through leakages continuously from that bank. Major emissions occur when the equipment is retired without recovery of the residual charge.

Method

The Tier 1 method with mass balance, approach B as per Table 7.2, recommended in the IPCC 2006 Guidelines V3_7_Ch7_ODS_Subtitutes, was adopted for estimating emissions from this sub-category.

Activity data

It has not been possible for Namibia to report on this subcategory before as data was scanty. Available trade statistics are not disaggregated enough to allow tracking of the different gases by type and number of equipment imported. A study was completed by GIZ in 2016 whereby resources were available to further inquire at customs levels and undertake surveys with importers and users of these gases in the industry.

Information and AD from that study was partially used to produce a time series for this sub-category. Available information from the report that was used for estimating emissions was:

- Refrigeration and stationary air conditioning
    - New equipment sales from 2010 to 2015 for each type;
    - Existing equipment in each year from 2010 to 2015 by equipment type;
    - Charge of refrigerant gas in new equipment;
    - Refrigerant gas used in each equipment type;

- Mobile air conditioning; and
- Refrigerant gas used in vehicles in Namibia.

The information from 2010 to 2015 from the GIZ study was used to generate data for missing years in the timeseries for commercial refrigeration and stationary air conditioning, based on population growth of urban regions of Namibia. The growth is estimated to be 3.88 % annually during the period 1990 to 2000 and 4.11 % for the period 2001 to 2010.

Data obtained from the institution responsible for road transport in Namibia and used for estimating emissions for this category in the Energy sector was used to calculate the annual number of new vehicles entering the market. The AD generated on charge per vehicle by the number is presented in Table 5.3. R410a gas used in stationary air conditioning consists of R32 and R125 on a 1:1 basis while R507, a 1:1 mix of R125 and R143 as well as R134a solely are used in commercial refrigeration.

Table 5.3 - Amount of refrigerant (kg) in new equipment on an annual basis

	Stationary air conditioning		Mobile air conditioning	Domestic refrigeration	Commercial refrigeration		
Year	R32	R125	R 134A	R600a	R125	R134a	R143
1993	-	-	-	9.336	-	774	-
1994	-	-	-	9,698	-	804	-
1995	6,153	6,153	6,907	10,074	4,324	835	4,324
1996	6,391	6,391	7,175	10,465	4,492	867	4,492
1997	6,639	6,639	7,453	10,871	4,666	901	4,666
1998	6,897	6,897	7,742	11,293	4,847	936	4,847
1999	7,165	7,165	8,042	11,731	5,035	972	5,035
2000	7,443	7,443	8,354	12,186	5,230	1,010	5,230
2001	7,749	7,749	8,698	12,687	5,445	1,051	5,445
2002	8,067	8,067	7,938	13,209	5,669	1,095	5,669
2003	8,399	8,398	10,382	13,751	5,902	1,140	5,902
2004	8,744	8,744	10,350	14,317	6,145	1,186	6,145
2005	9,103	9,103	11,081	14,905	6,397	1,235	6,397
2006	9,477	9,477	11,766	15,518	6,660	1,286	6,660
2007	9,867	9,867	12,179	16,155	6,934	1,339	6,934
2008	10,272	10,272	9,214	16,819	7,219	1,394	7,219
2009	10,694	10,694	11,553	17,511	7,516	1,451	7,516
2010	6,489	6,489	12,895	13,911	7,043	895	7,043
2011	17,440	17,440	13,942	27,942	8,957	2,242	8,957
2012	9,471	9,471	13,949	12,838	7,473	1,396	7,473
2013	17,086	17,086	14,069	12,241	8,081	1,955	8,081
2014	22,448	22,448	17,705	14,612	9,831	2,729	9,831
2015	21,010	21,010	18,029	14,986	9,318	2,385	9,318

It is assumed that all the gases came on the market in new equipment as from 1995 except R134a in domestic and commercial refrigeration as from 1993. Unfortunately, it has not been possible to include import and export data in the calculations as disaggregated data by gas was unavailable. This constitutes an underestimate of the emissions as gas used to recharge an equipment when leakage occurred will eventually be lost in leakages of following years in the lifetime of the equipment.

Emission factors

The different gases used as ODS substitutes have different GWP. EFs and details on the gases are given in Table 5.4. The parameters for the constitution of the bank and subsequent emissions from the bank is also given in the same table. Furthermore, R 600 A (Iso-butane) is not regulated under the Convention and has thus not been reported on.

Table 5.4 - Emission factors used for estimating emissions from RAC

	Stationary air conditioning		Mobile air conditioning	Commercial refrigeration		
	R32	R125	R 134A	R134a	R125	R143
Year of introduction	1995		1995	1993	1995	
Growth rate (%)	7		6	9	10	
Lifetime (years)	9		20	10	10	
Emission factor (%)	5		15	15	15	

Results

Table 5.5 summarizes emissions for the timeseries 1993 to 2015. Emissions from this sub-category is on an increasing trend, from 0.15 Gg CO_2 eq in 1993 to 113.16 Gg CO_2 eq in 2015.

Table 5.5 - Emissions (Gg CO_2 eq) from RAC (1993 - 2015)

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Emissions	0.15	0.28	5.88	11.03	15.79	20.24	24.43	28.41	32.23	35.71	40.26	47.44

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Emissions	89.35	91.00	92.64	85.84	85.68	84.60	89.69	91.15	94.65	100.68	113.16

5.3.10. N_2O from Product Use (2.G.3) - (Medical Applications 2.G.3.a)

Description of the Medical application sub-category

N_2O is used as an anaesthesia gas during surgical operations. It can also be used for pain relief and in veterinary applications. The gas is assumed to be breathed in by patients and released back to the atmosphere chemically unchanged.

Method

A Tier 1 level was used to estimate the emissions from this sub-category.

Activity data

National statistics are not disaggregated enough to obtain the amount of gas imported/exported and hence used. A timeseries was constructed based on the following assumptions.

- Number of operations per 100,000 inhabitants for years 1990 and 2010 (WHO website)
- 90 grams of N_2O used per operation (personal communication from a practicing anaesthetist)

Table 5.6 gives the AD used.

Table 5.6 - Amount of N_2O used in medical applications on an annual basis (1991 - 2015)

Year	Population	Number of surgical operations per 100,000 persons	Total number of operations	Amount of N_2O (t) used
1991	1,489,782	2,080	30,987	2.79
1992	1,520,770	2,160	32,849	2.96
1993	1,552,402	2,240	34,774	3.13
1994	1,584,692	2,320	36,765	3.31
1995	1,617,653	2,400	38,824	3.49
1996	1,651,300	2,480	40,952	3.69
1997	1,685,647	2,560	43,153	3.88
1998	1,720,709	2,640	45,427	4.09
1999	1,756,500	2,720	47,777	4.30
2000	1,793,035	2,800	50,205	4.52
2001	1,830,330	2,880	52,714	4.74
2002	1,856,138	2,960	54,942	4.94
2003	1,882,309	3,040	57,222	5.15
2004	1,908,850	3,120	59,556	5.36
2005	1,935,765	3,200	61,944	5.58
2006	1,963,059	3,280	64,388	5.79
2007	1,990,738	3,360	66,889	6.02
2008	2,018,807	3,440	69,447	6.25
2009	2,047,273	3,520	72,064	6.49
2010	2,076,139	3,600	74,741	6.73
2011	2,105,413	3,680	77,479	6.97
2012	2,136,036	3,760	80,315	7.23
2013	2,167,105	3,840	83,217	7.49
2014	2,198,625	3,920	86,186	7.76
2015	2,230,604	4,000	89,224	8.03

Emission factors

Since all the gas used is expected to be sent to the atmosphere, an EF of 1 applies to this sub-category.

Results

Table 5.7 summarizes the emissions for the timeseries 1991 to 2015. Lowest emissions occurred in 1991 at 0.83 Gg CO_2 eq and highest emissions was recorded in 2015 at 2.45 Gg CO_2 eq. This is in direct relationship with the increasing number of operations resulting from increase in population and improvement in the healthcare system.

Table 5.7 - Emissions (Gg CO_2 eq) from N_2O in medical applications (1991 - 2015)

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Emissions	0.83	0.89	0.94	1.00	1.05	1.11	1.17	1.24	1.30	1.37	1.44	1.50	1.56

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Emission	1.63	1.69	1.76	1.83	1.90	1.97	2.05	2.12	2.20	2.28	2.36	2.45

5.3.11. Beer manufacturing (2.H.2.a)

Past efforts to obtain data from the beer manufacturer has been unsuccessful. Thus, production of beer was calculated by summing the amount of beer consumed locally with the amount exported. In turn, the amount of beer consumed was derived from data on the amount of alcohol consumed in the form of beer based on FAO data after adjustment for Namibia.

The AD so obtained show that beer production has steadily increased at an average rate of over 20,000 tonnes per year over the period of 21 years under review, to reach almost 429,000 tonnes in 2015.

5.3.12. Bread Making (2.H.2.a)

Data from various sources were studied prior to the generation of AD for Bread Making activity. Since trade statistics were found unreliable, AD was computed as the average of FAO and the Agricultural Statistical Bulletin on wheat consumption. An extraction rate of 80% of the wheat was adopted to produce flour and the latter converted to bread at the rate of 610 g of flour per kg of bread.

5.4. Emission factors

In the absence of information on technology used, all EFs used were IPCC defaults, with those giving the highest emissions adopted as per Good Practice. When the choice was linked to the country's development level, the factor associated with developing countries was chosen. The EFs used for the different source categories are listed in Table 5.8.

Table 5.8 - Sources of EFs for the IPPU sector

Category	IPPC 2006 Guideline	Table and page No.
Cement	V3_2_Ch2 Mineral Industry	Chapter 2.2.1.2 Page 2.11
Lime	V3_2_Ch2 Mineral Industry	Table 2.4 Page 2.22
Zinc	V3_4_CH_4 Metal Industry	Table 4.24 Page 4.80
Lubricant	V3_5_Ch5 Non-Energy Products	Table 5.2 Page 5.9
Paraffin wax	V3_5_Ch5 Non-Energy Products	Chapter 5.3.2.2 Page 5.12
Refrigeration and Air Conditioning	V3_7_Ch7 ODS substitutes	Table 7.9 Page 7.52
Medical Applications (N_2O)	V3_8_Ch8 Other Products	Page 8.36 Section 8.4.2.2
Wood preservation	EMEP CORINAIR - SNAP 060406	Table 3.5 Page 15
Paint application	EMEP CORINAIR - SNAP 0601063 and 060104	Table 3.3 Page 17
Asphalt and bitumen	EMEP CORINAIR - SNAP 040611	Table 3.1 Page 8
Beer manufacturing	EMEP CORINAIR - SNAP 060407	Table 3-1 Page 7
Bread making	EMEP CORINAIR - SNAP 060405	Table 3-1 Page 7

5.5. Emission estimates

5.5.1. Aggregated emissions by gas for inventory year 2015

Direct gases and HFCs

Two direct gases CO_2 and N_2O and HFCs, were emitted from the IPPU Sector. The emissions amounted to 631.03 Gg CO_2-eq (Table 5.4). The highest emitter in 2015 was the Cement industry with 330.20 Gg CO_2-eq followed by Zinc production with 141.09 Gg CO_2-eq. The remaining sub-categories are less important emitters as depicted in Figure 5.1. The second gas in importance, the HFCs, from RAC was at 113.16 Gg CO_2-eq while N_2O, was emitted from medical uses and stood at 2.45 Gg in 2015.

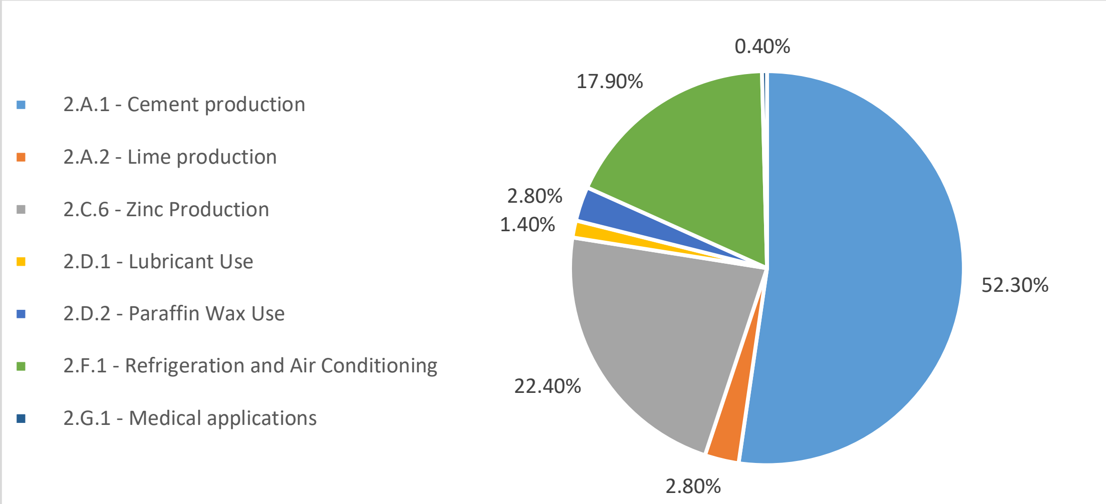

Figure 5.1 - Percentage distribution of emissions for IPPU Sector (2015)

Indirect gases

The only indirect gases that were emitted in the IPPU sector in 2015 were NMVOCs and 2.43 Gg were emitted (Table 5.9).

Table 5.9 - Emissions from IPPU Sector categories for inventory year 2015

Categories	NMVOCs (Gg)
2 - Industrial Processes and Product Use	2.43
2.A.1 - Cement production	NA
2.A.2 - Lime production	NA
2.C.6 - Zinc Production	NA
2.D.1 - Lubricant Use	NA
2.D.2 - Paraffin Wax Use	NA
2.D.3 - Solvent Use	1.33
2.H.2 - Food and Beverages Industry	1.10

5.5.2. Emission trends of direct GHGs by category for the period 1991 to 2015

Direct gases

CO_2 emissions from IPPU Sector during the period 1991 to 2015 are given in Table 5.10. The total emissions of 631.03 Gg CO_2-eq was mainly due to Cement Production and to a lesser extent Zinc Production and RAC activities which represented 52.3%, 22.4% and 17.9% respectively. The remaining emissions originated from Paraffin Wax Use (2.8%), Lime Production (2.8%) and Lubricant Use (1.4%).

Table 5.10 - Emissions trends of Direct gases (Gg CO_2 -eq) by category of IPPU Sector for period 1991 to 2015

Year	2.A.1 - Cement production	2.A.2 - Lime production	2.C.6 - Zinc Production	2.D.1 - Lubricant Use	2.D.2 - Paraffin Wax Use	2.F.1 - Refrigeration and Air Conditioning	2.G.1 - Medical Applications of N_2O	IPPU Sector
1991	0	2.24	0	0.50	17.69	0	0.83	21.26
1992	0	2.81	0	0.50	17.69	0	0.89	21.89
1992	0	3.39	0	0.50	17.69	0.15	0.94	22.67

Year	2.A.1 - Cement production	2.A.2 - Lime production	2.C.6 - Zinc Production	2.D.1 - Lubricant Use	2.D.2 - Paraffin Wax Use	2.F.1 - Refrigeration and Air Conditioning	2.G.1 - Medical Applications of N_2O	IPPU Sector
1994	0	3.97	0	0.50	17.69	0.28	1.00	23.44
1995	0	4.54	0	0.50	17.69	5.88	1.05	29.66
1996	0	5.12	0	0.50	17.69	11.03	1.11	35.45
1997	0	5.70	0	0.50	17.69	15.79	1.17	40.85
1998	0	6.28	0	0.50	17.69	20.24	1.24	45.95
1999	0	6.85	0	0.50	17.69	24.43	1.30	50.77
2000	0	7.05	0	0.57	17.34	28.41	1.37	54.74
2001	0	8.27	0	0.26	16.11	32.23	1.44	58.31
2002	0	8.62	0.06	0.73	17.44	35.71	1.50	64.06
2003	0	9.55	81.59	1.19	17.88	40.26	1.57	152.04
2004	0	9.70	205.03	2.42	20.16	47.44	1.63	286.38
2005	0	10.05	228.44	3.64	18.14	89.35	1.70	351.32
2006	0	10.40	223.42	4.11	17.14	91.00	1.76	347.83
2007	0	11.17	258.14	6.60	17.17	92.64	1.83	387.55
2008	0	11.86	250.08	8.77	20.41	85.84	1.90	378.86
2009	0	13.55	258.69	9.08	21.22	85.68	1.97	390.19
2010	0	15.25	260.90	8.19	16.23	84.60	2.05	387.22
2011	147.68	14.63	248.98	8.96	17.69	89.69	2.12	529.75
2012	222.56	15.32	249.99	8.98	17.69	91.15	2.20	607.89
2013	270.4	16.00	214.87	9.25	17.69	94.65	2.28	625.14
2014	303.16	16.69	175.76	9.06	17.69	100.68	2.36	625.40
2015	330.20	17.38	141.09	9.06	17.69	113.16	2.45	631.03

5.5.3. Emission trends of Indirect GHGs by sub-category for inventory period 1991 to 2015

Indirect gases

NMVOCs emissions came from two sub-categories Solvent Use and Food and Beverages covering five activities, namely Wood Preservation, Paint Application, Asphalt and Bitumen use, Beer Manufacturing and Bread Making (Table 5.11). In 2015, a total amount of 2.43 Gg of NMVOCs were emitted by the IPPU sector, most of which originating from the use of solvents with 54.6% of emissions (1.33 Gg) and Food and Beverages with 45.6% of emissions at 1.10 Gg. Total emissions of NMVOCs increased from 0.52 in 1991 to 2.43 Gg in 2015.

Table 5.11 - NMVOCs emission trends for IPPU sector categories (1991 - 2015)

Year	2.D.3 - Solvent	2.H.2 - Food and Beverages Industry	Total IPPU Sector
1991	0.42	0.10	0.52
1992	0.46	0.12	0.58
1993	0.50	0.13	0.62
1994	0.53	0.14	0.67
1995	0.57	0.17	0.74
1996	0.61	0.18	0.79
1997	0.65	0.2	0.85
1998	0.68	0.39	1.07

Year	2.D.3 - Solvent	2.H.2 - Food and Beverages Industry	Total IPPU Sector
1999	0.72	0.51	1.23
2000	0.76	0.57	1.33
2001	0.80	0.69	1.49
2002	0.84	0.59	1.42
2003	0.87	0.74	1.61
2004	0.91	0.73	1.64
2005	0.95	0.75	1.70
2006	0.99	0.76	1.75
2007	1.03	0.78	1.80
2008	1.06	0.83	1.90
2009	1.10	0.97	2.07
2010	1.14	0.93	2.07
2011	1.18	0.98	2.16
2012	1.22	1.05	2.26
2013	1.25	1.09	2.34
2014	1.29	1.04	2.33
2015	1.33	1.10	2.43

Table 5.12 - Sectoral Table: IPPU (Inventory Year: 2015)

Categories	(Gg)			CO2 Equivalents(Gg)				(Gg)				
	CO2	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors (1)	Other halogenated gases without CO2 equivalent conversion factors (2)	NOx	CO	NMVOCs	SO2
2 - Industrial Processes and Product Use	515.423	0.000	0.008	113.162	0.000	0.000	0.000	0.000	0.000	0.000	1.035	0.000
2.A - Mineral Industry	347.581	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.A.1 - Cement production	330.200	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.2 - Lime production	17.381	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.3 - Glass Production	0.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.4 - Other Process Uses of Carbonates	0.000	0.000	0.000	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.A.4.a - Ceramics	NO	NO	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	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B.1 - Ammonia Production	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	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

Categories	(Gg)			CO2 Equivalents(Gg)					(Gg)			
	CO2	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors (1)	Other halogenated gases without CO2 equivalent conversion factors (2)	NOx	CO	NMVOCs	SO2
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 Vinyl Chloride Monomer	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
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	141.090	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C.1 - Iron and Steel Production	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	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	141.090	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)	26.752	NO	NO	NA	NA	NA	NA	NA	NO	NO	0.000	NO
2.D.1 - Lubricant Use	9.064	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.2 - Paraffin Wax Use	17.688	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	0.000	NA
2.D.4 - Other (please specify) (3), (8)	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO

Categories	(Gg)			CO2 Equivalents(Gg)				(Gg)				
	CO2	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors (1)	Other halogenated gases without CO2 equivalent conversion factors (2)	NOx	CO	NMVOCs	SO2
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
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	NA	NA	NA	NA	NA	NA	NA	NA
2.F.1.a - Refrigeration and Stationary Air Conditioning	NA	NA	NA	NE	NA	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	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) (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	0.000	NA	NE	0.000	0.000	0.000	0.000
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

Categories	(Gg)			CO2 Equivalents(Gg)				(Gg)				
	CO2	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors (1)	Other halogenated gases without CO2 equivalent conversion factors (2)	NOx	CO	NMVOCs	SO2
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	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.G.3.c - Other (Please specify) (3)	NA	NA	NO	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	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.035	0.000
2.H.1 - Pulp and Paper Industry	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.H.2 - Food and Beverages Industry	0.000	0.000	NA	NA	NA	NA	NA	NA	0.000	0.000	1.035	0.000
2.H.3 - Other (please specify) (3)	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO

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

6.1. Description of AFOLU sector

The AFOLU sector includes activities responsible for GHG emissions and removals linked to Agriculture (crops and livestock), changes in land use within and between the six IPCC land use classes, soil organic matter dynamics, fertilizer use and management of land. Emissions and removals were estimated for activity areas falling under all four IPCC categories of this sector.

6.1.1. Emission estimates for the AFOLU sector

The AFOLU sector remained a sink throughout the time series. Net removals increased from 76,610 Gg CO_2-eq in the year 1991 to 104,719 in the year 2015. There was an 18% increase in emissions from the livestock category. Emissions from aggregate sources and non-CO_2 emissions from land varied from 2,957 Gg CO_2-eq to 6,538 Gg CO_2-eq. The variation in this sub-category was directly linked to the land area (biomass) burned. The land sub-category removal of 86,352 Gg CO_2 in 1991 reached 111,720 Gg in 2015 (Table 6.1).

Table 6.1 - Aggregated emissions (CO_2-eq) from the AFOLU sector (1991 - 2015)

Year	3 - Agriculture, Forestry, and Other Land Use	3.A - Livestock	3.B - Land	3.C - Aggregate sources and non-CO_2 emissions sources on land	3.D Harvested Wood Products
1991	-76,610	3,204	-86,352	6,538	0
1992	-77,526	3,133	-86,907	6,249	0
1993	-78,555	2,935	-87,415	5,925	0
1994	-79,331	2,908	-87,924	5,685	0
1995	-81,283	2,946	-89,731	5,502	0
1996	-83,514	2,846	-91,556	5,196	0
1997	-85,407	2,964	-93,398	5,026	0
1998	-87,542	3,070	-95,257	4,828	-183
1999	-89,517	3,179	-97,133	4,636	-199
2000	-91,480	3,460	-99,332	4,442	-50
2001	-91,461	3,470	-99,266	4,511	-176
2002	-96,574	3,338	-103,740	3,789	39
2003	-96,995	3,393	-104,182	3,837	-43
2004	-99,091	3,350	-106,003	3,583	-21
2005	-96,675	3,180	-103,776	3,968	-47
2006	-92,170	3,340	-100,173	4,717	-54
2007	-89,006	3,289	-97,409	5,179	-66
2008	-98,779	3,388	-106,030	3,921	-58
2009	-84,987	3,346	-94,181	5,997	-150
2010	-90,085	3,154	-98,418	5,265	-86
2011	-86,244	3,718	-95,679	5,840	-122
2012	-84,701	3,961	-94,716	6,145	-91
2013	-106,148	3,566	-112,586	2,957	-85
2014	-102,255	3,879	-109,657	3,623	-100
2015	-104,719	3,775	-111,720	3,312	-86

Table 6.2 shows the evolution in emissions of the direct and indirect GHGs. CO_2 emissions increased steadily from 8,736 Gg in 1991 to reach 9,769 Gg in 2015. However, CO_2 removals far exceeded emissions over the whole period with an increasing trend. Removals increased from 95,088 Gg in 1991 to 121,575 Gg in 2015. The other two direct gases CH_4 and N_2O varied over the inventory period on account of the annual variation in the area burnt in forestland and grassland, outcome of wildfires over the country. CH_4 emissions ranged from 217 Gg to 318 Gg while N_2O emissions varied between 7.4 Gg and 11.0 Gg.

Emissions of the indirect gases and NMVOCs also varied over the inventory period for the same reason as for CH_4 and N_2O. NO_x emissions varied between 9.1 and 39.5 Gg, CO between 582 and 2505 Gg and NMVOCs between 9.0 and 12.6 Gg. Emissions of CH_4, N_2O, NO_x and CO regressed during the inventory period since the area burnt in forestland and grassland significantly decreased as a result of better management.

Table 6.2 - Emissions (Gg) by gas for AFOLU (1991 - 2015)

Year	CO_2 - Emissions	CO_2 - Removals	CO_2 - Net removals	CH_4	N_2O	NO_x	CO	NMVOCs
1991	8,735.6	-95,087.6	-86,352.0	310.7	10.4	39.5	2,505.4	10.0
1992	8,735.6	-95,643.2	-86,907.6	299.4	10.0	37.5	2,383.3	9.8
1993	8,735.6	-96,150.6	-87,415.0	282.8	9.4	35.7	2,268.3	9.2
1994	8,735.6	-96,659.2	-87,923.6	274.0	9.2	33.8	2,152.3	9.2
1995	8,735.6	-98,466.5	-89,730.9	268.8	9.0	32.0	2,035.2	9.1
1996	8,735.6	-100,291.1	-91,555.5	256.1	8.6	30.1	1,917.2	9.0
1997	8,735.6	-102,133.0	-93,397.4	253.8	8.6	28.2	1,798.1	9.3
1998	8,735.5	-104,174.8	-95,439.2	250.7	8.5	26.3	1,678.0	9.7
1999	8,735.5	-106,067.6	-97,332.1	247.8	8.4	24.4	1,556.9	10.0
2000	8,735.8	-108,116.8	-99,381.0	251.0	8.5	22.1	1,408.3	11.0
2001	8,949.5	-108,388.4	-99,438.9	252.1	8.7	22.2	1,418.8	10.9
2002	8,987.9	-112,686.5	-103,698.7	223.6	7.8	16.8	1,072.6	10.5
2003	8,947.3	-113,171.1	-104,223.8	226.7	8.0	16.8	1,075.7	10.6
2004	8,947.0	-114,970.2	-106,023.1	216.7	7.7	14.9	956.7	10.6
2005	8,946.6	-112,769.4	-103,822.8	224.4	7.9	18.7	1,196.7	10.1
2006	8,946.6	-109,172.8	-100,226.2	254.0	8.8	24.1	1,545.7	10.7
2007	8,946.7	-106,420.8	-97,474.1	266.5	9.3	28.5	1,829.3	10.5
2008	8,946.5	-115,034.7	-106,088.2	229.4	8.0	17.6	1,129.5	10.8
2009	8,946.6	-103,276.9	-94,330.3	296.5	10.1	34.1	2,189.8	10.7
2010	8,946.5	-107,450.1	-98,503.6	266.2	9.1	29.1	1,868.1	10.3
2011	9,769.1	-105,570.1	-95,801.0	301.4	10.4	31.2	2,003.0	11.7
2012	9,769.2	-104,575.8	-94,806.6	318.4	11.0	32.5	2,091.2	12.5
2013	9,769.0	-122,439.3	-112,670.2	201.7	7.4	9.1	582.4	11.3
2014	9,769.0	-119,525.4	-109,756.5	234.0	8.3	13.3	858.0	12.6
2015	9,769.2	-121,575.0	-111,805.8	219.2	8.0	11.0	704.9	12.2

The evolution of aggregated emissions, excluding removals, of the three direct GHGs is presented in Figure 6.1. Total emissions fluctuated between 15,879 Gg CO_2-eq and 19,875 Gg CO_2-eq during the period 1991 to 2015, with the peak occurring in 2012. Emissions of the three direct GHGs varied during the inventory period. The major contributor to emissions remained CO_2, contributing on average 53% of total emissions for this period in this sector followed by CH_4 with an average of 31% and N_2O the remaining 16%.

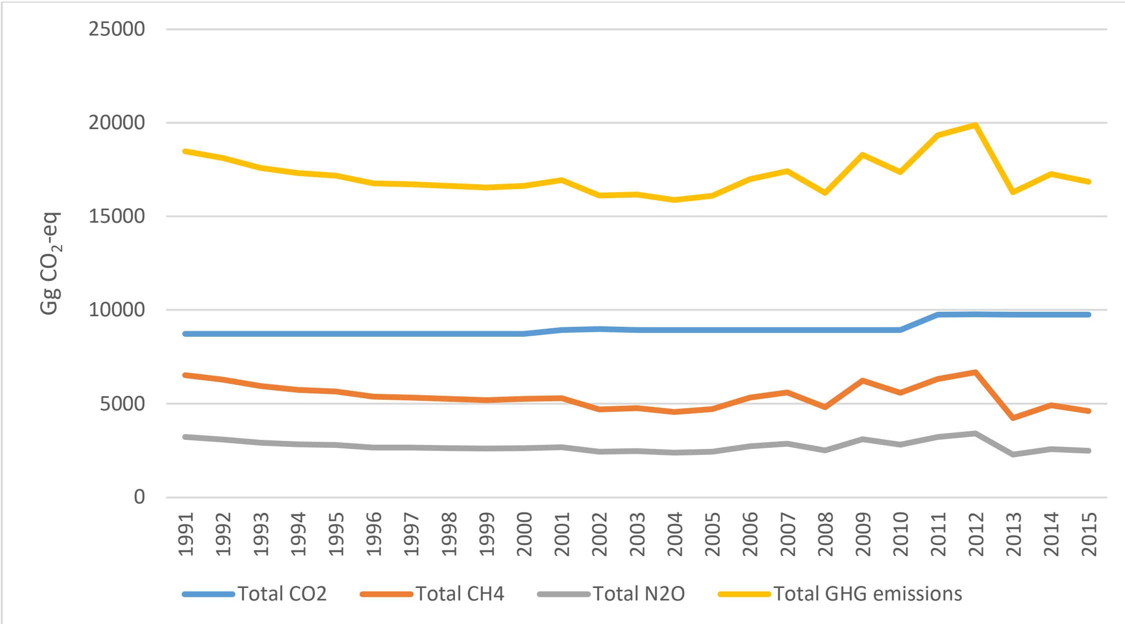

Figure 6.1 - Evolution of aggregated emissions (CO_2-eq) in the AFOLU sector (1991 - 2015)

6.2. Livestock

Namibia has an important livestock rearing activity, attributes of its dry climate and extensive grazing areas available. The major livestock is cattle, including dairy cows followed by the smaller ruminants, goats and sheep. The management conditions differ between the commercial and communal systems of livestock rearing despite both being done on an extensive basis. An increased production in the poultry sub-category occurred during 2014 with the setting up of commercial intensive farms.

6.3. Methods

Tier 2 level has been adopted for cattle and dairy cows for enteric fermentation while Tier 1 was used for manure management. A Tier 1 approach was adopted for all other animals. Available country-specific data on live weight, pregnancy and other parameters were collected and used. Missing data were generated as described in the EF section later in this chapter.

6.3.1. Activity Data

Source

The FAO database was used to complete information from the NSA and annual surveys done by the Ministry of Agriculture. Priority was given to country data over the international database.

Quality control / Quality Assurance

The livestock population is tracked meticulously to maintain a healthy sanitary status and avoid disease spread. All new-borns and animals culled or exported are followed through a tagging system managed by the national veterinary services of the MAWF. Thus, local data were privileged and considered of good quality and the few missing data points were generated using statistical modelling techniques, interpolation or trend analysis.

Removal of outliers

There were two outliers that were replaced using interpolation or trend analysis. Furthermore, in the case of camels, the figures prior to 1999 from the FAO database were not used even though the local statistics were not available as the information obtained was that these animals were introduced in the country in the year 2000 for tourist activity.

Animal population

The population of the different livestock types used as AD for estimating emissions is provided in Table 6.3 for the years 1991 to 2015.

In order to move to Tier 2 estimates, it is essential to segregate the population into sub-divisions according to age, sex, and gender. The cattle population recorded for both the commercial and communal sectors was further sub-divided into mature bulls, mature females, mature male castrates, young intact males and young females following a split of respectively 36%, 4%, 16%, 20% and 24% respectively based on a study done on farming practices (NNFU, 2006) in Namibia. The sub-division into the different classes was available for communal animals only. The same split was adopted for the commercial sector as this is the normal situation for cattle rearing.

Table 6.3 - Number of animals (1991 - 2015) by species

Year	Dairy cows	Cattle	Sheep	Goats	Horses	Mules and asses	Swine	Poultry	Camels
1991	1,500	2,211,624	3,295,447	1,991,581	51,000	68,000	16,904	502,667	-
1992	1,500	2,206,373	2,863,401	1,750,238	54,540	70,000	14,790	497,092	-
1993	1,500	2,073,540	2,651,823	1,579,856	57,391	85,000	20,065	491,518	-
1994	1,500	2,035,790	2,619,520	1,639,210	58,801	145,607	17,843	464,451	-
1995	1,500	2,031,353	2,409,699	1,616,090	53,217	145,607	19,979	487,031	-
1996	1,500	1,989,947	2,198,436	1,786,150	53,217	145,607	18,923	458,158	-
1997	1,500	2,055,416	2,429,328	1,821,009	53,217	145,607	16,884	522,618	-
1998	1,500	2,192,359	2,086,434	1,710,190	53,217	145,607	14,706	403,937	-
1999	1,500	2,278,569	2,169,651	1,689,770	53,217	145,607	18,731	450,513	-
2000	1,500	2,504,930	2,446,146	1,849,569	61,885	167,548	23,148	476,331	54
2001	1,500	2,508,570	2,369,809	1,769,055	52,502	169,314	21,854	502,356	71
2002	1,500	2,329,553	2,764,253	2,110,092	47,220	134,305	47,805	883,950	88
2003	1,500	2,336,094	2,955,454	2,086,812	47,542	119,828	46,932	894,027	124
2004	1,500	2,349,700	2,619,363	1,997,172	62,726	142,353	52,624	957,966	113
2005	1,500	2,219,330	2,663,795	2,043,479	47,429	140,291	55,931	998,278	63
2006	1,500	2,383,960	2,660,252	2,061,403	46,209	159,948	51,972	923,555	73
2007	1,500	2,353,498	2,652,658	1,926,429	43,863	156,328	51,863	916,991	63
2008	1,500	2,453,097	2,228,059	1,893,387	42,267	165,126	49,187	864,988	43
2009	1,500	2,465,989	1,803,460	1,792,390	38,201	173,923	48,223	843,277	23
2010	1,500	2,389,891	1,378,861	1,690,467	49,852	141,588	63,498	777,480	43
2011	1,500	2,762,240	2,209,593	1,736,565	45,529	105,062	43,865	684,236	69
2012	1,500	2,904,451	2,677,913	1,933,103	46,643	114,591	69,430	940,765	47
2013	2,000	2,634,418	2,188,758	1,693,145	40,265	124,120	69,070	659,033	51
2014	2,000	2,882,489	2,044,156	1,892,439	55,241	159,029	68,710	3,436,430	55
2015	2,000	2,808,117	1,973,393	1,868,535	47,151	148,859	62,945	2,429,529	37

The average live weights of the non-dairy cattle classes were obtained from data of the slaughterhouses of MeatCo and auction of livestock. Information on development and typical animal mass of the dominant local breeds Brahman and Nguni were used. Daily weight gain was derived from the live weight and age of the different animal groups at slaughtering or auction time. The data was compared and aligned with information obtained from breeding studies done on the 2 main species with various others (S.J. Schoeman, 1996). The live weight for dairy cows has been assumed to be 525 kg based on available information on the race, pending confirmation of the current liveweight of the population from the dairy farms.

For Tier 2 estimates, it is necessary to also assign a typical mature weight for each animal group and these values for commercial and communal cattle classes were again derived from the weight of animals slaughtered or sold at auctions. Table 6.4 depicts the typical mature weight adopted for the different classes.

Table 6.4 - Typical animal mass

Animal type		Typical mass or mature weight (Kg)
Dairy cow		525
Commercial cattle	Mature males	506
	Mature female	480
	Mature male castrate	506
	Young growing male	251
	Young growing female	251
Communal cattle	Mature males	435
	Mature female	323
	Mature male castrate	403
	Young intact male	146
	Young growing female	146
Other animals	Sheep	34.9
	Goats	30
	Horses	238
	Mules and asses	130
	Swine	28
	Poultry	1.8
	Camels	217

6.3.2. Emission factors

Management practices adopted for livestock have an important bearing on the level of emissions. Both enteric fermentation and manure management EFs are dependent on such practices, namely the feeding situation, daily work performed, lactation period and frequency of pregnancy and the management of the excreta. Since emissions of enteric fermentation fell in the key categories in previous inventories, a Tier 2 approach has been maintained for this category. For the other animal groups, the default EFs (2006 IPCC GL, Table 10-10, p. 1.28, developing countries) have been used to compute enteric fermentation and manure management CH_4 emissions.

Country specific EFs were derived for enteric fermentation using country data and information in the equations provided for this exercise in the 2006 IPCC GL for the cattle sub-classes. The datasets described above were used to calculate the maximum methane production capacity for the cattle sub-classes. MCF default EFs used for the different animal classes are provided in Table 6.5.

Table 6.5 - MCF values used for computing enteric fermentation emissions

Animal type		MCF (Kg CH_4/head/yr)
Dairy cow		92
Commercial cattle	Mature males	69
	Mature female	70
	Mature male castrate	72
	Young growing male	59
	Young growing female	66
Communal cattle	Mature males	59
	Mature female	46
	Mature male castrate	55
	Young intact male	36
	Young growing female	40
Other animals	Sheep	5
	Goats	5
	Horses	18
	Mules and asses	10
	Swine	1
	Camels	46

Table 6.6 summarizes the manure management systems for the various animal categories. This is based on information available from the censuses and surveys conducted by the MAWF and NSA, while manure management systems (MMS) for cattle are based on expert judgment and on information from the farming systems guide (NNFU, 2006). Experts comprised officers of the MAWF, commercial livestock herders and communal farmers. As manure management is not a key category for all animal classes, the default EFs from the guidelines were adopted.

The temperature assigned for this sub-category for Namibia in previous inventories was 26°C and this was amended to 20°C as it was a mistake. In fact, Namibia falls under a temperate climate according to the IPCC Guideline except for a negligible area classified as Tropical Dry. Thus, temperature cannot be 26°C. This is confirmed from processing of data available on the site http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_historical_climate&ThisCCode=NAM for the period 1901 to 2015.

Table 6.6 - MMS adopted for the different animal species

Type of animal	Manure management system
Dairy cows	Solid storage
Commercial cattle (All)	100% Pasture-Range-Paddock (PRP)
Communal cattle (All)	50% PRP/ 49% Solid Storage / 1% Burnt for fuel
Sheep	100% PRP
Goats	PRP 100%
Horses	100% PRP
Mules and asses	100% PRP
Swine	Daily spread 60% and liquid slurry 40%
Poultry	Poultry manure with litter 60% and poultry manure without litter 40%
Camels	100% PRP

Pregnancy has been accounted for dairy, commercial and communal cows. The lactation period of dairy cows is zero day as the calves are severed just after birth. Lactation by commercial and communal cows have not been integrated in the derivation of the MCFs due to inadequacy of available information.

The digestible energy is taken from the 2006 IPCC GL, Chapter 10, annex Table 10A2 for animals in large grazing areas except for dairy cows for which the factor of 75% for feedlot cattle was adopted.

The average daily work for commercial and communal cattle has been assumed as 6 hours/day for the whole year, based on expert judgment of members of the Namibian GHG inventory team for mature male castrates only, as the other animal groups do not perform any work.

6.3.3. Results - Emission estimates

The emission estimates from enteric fermentation and manure management are presented in Table 6.7. Enteric fermentation contributed around 94% of total emissions of CH_4 from the livestock sector throughout the time series. Emissions increased from 3,204 Gg CO_2-eq in 1991 to 3,775 Gg CO_2-eq in 2015. The main contributor to the substantial increase as from 2013 is due to further development of the dairy industry with an increase in the number of dairy cows from 1500 to 2000 and a gradual increase in the population of other cattle from about 2.1 M to 2.8 M during the same period. Emissions from manure management increased from 174 Gg CO_2-eq to 222 Gg CO_2-eq in 2015 as the manure management practice did not change much over the inventory period.

Table 6.7 - Emissions (Gg CO_2-eq) from enteric fermentation and manure management of livestock (1991 - 2015)

Year	Enteric Fermentation	Manure management
1991	3,029.8	174.3
1992	2,960.7	171.9
1993	2,772.8	161.9
1994	2,747.3	160.6
1995	2,793.9	152.0
1996	2,687.2	159.0
1997	2,800.9	163.1
1998	2,898.1	171.6
1999	2,998.4	181.0
2000	3,263.8	195.8
2001	3,272.7	197.5
2002	3,150.0	187.6
2003	3,210.3	182.2
2004	3,163.0	187.4
2005	2,997.6	182.0
2006	3,138.6	201.3
2007	3,091.8	197.5
2008	3,191.4	196.6
2009	3,150.7	195.2
2010	2,957.7	195.8
2011	3,502.3	215.4
2012	3,731.8	229.6
2013	3,358.1	207.6
2014	3,650.3	229.1
2015	3,553.1	221.8

The evolution of emissions of the three gases CH_4, N_2O and NMVOCs emitted by the Livestock category is given in Table 6.8. There is an increase in emissions for all three 3 gases from 1991 to 2015. The increase over the period 1991 to 2015 was of the order of 26 Gg (17.4%) for CH_4, 0.10 Gg for (28.4%) for N_2O and 2.2 Gg (22.0%) for NMVOC respectively.

Table 6.8 - Emissions (Gg) by gas for Livestock (1991-2015)

Year	CH_4	N_2O	NMVOCs
1991	147.5	0.344	10.0
1992	144.1	0.344	9.8
1993	135.0	0.323	9.2
1994	133.8	0.317	9.2
1995	136.2	0.276	9.1
1996	131.1	0.300	9.0
1997	136.7	0.304	9.3
1998	141.3	0.329	9.7
1999	146.3	0.348	10.0
2000	159.1	0.380	11.0
2001	159.6	0.384	10.9
2002	153.7	0.355	10.5
2003	156.6	0.337	10.6
2004	154.3	0.353	10.6
2005	146.3	0.346	10.1
2006	153.2	0.396	10.7
2007	150.9	0.388	10.5
2008	155.7	0.385	10.8
2009	153.6	0.387	10.7
2010	144.2	0.401	10.3
2011	170.7	0.432	11.7
2012	181.9	0.456	12.5
2013	163.7	0.414	11.3
2014	178.0	0.455	12.6
2015	173.2	0.442	12.2

6.4. Land

All lands within the Namibian territory have been classified under the six IPCC land categories and have been treated in this inventory as managed land. Activities within the six IPCC land classes and between the classes were taken into consideration. Land use changes have been derived from the land cover maps generated from satellite imagery, more fully described below under land representation and changes.

The six land categories are:

- 3.B.1 Forestland
- 3.B.2 Cropland
- 3.B.3 Grassland
- 3.B.4 Wetlands
- 3.B.5 Settlements
- 3.B.6 Other land

6.4.1. Description

Forestland

Forests were divided in two sub-categories and the definitions adopted for the integration of all information from FRA (Global Forest Resources Assessment), RCMRD (Regional Centre for Mapping Resource for Development) maps and other reports are provided below:

- Forestland (FL): tree height of 5 m and a canopy cover of more than 20%; and
- Other Wooded Land (OWL): There are three different land sub-classes in this sub-category:
    - Woodlands: tree height of 5 m with a canopy cover between 10% and 20%.
    - Shrubland: trees and saplings are present as these have been invaded long ago and trees have grown to a height whereby some areas can now be reclassified as woodland or forest.
    - Savannah: grassland where bush invasion is occurring with an increase in woody biomass.

Cropland

Land used for annual cropping has been considered. Main crops are maize, wheat and millet and sorghum produced under both commercial and communal systems. Land under perennial crops are negligible in Namibia.

Grassland

Grassland is now redefined as a pure stand without the presence of woody biomass as in the NIR3. The grassland is estimated to be situated between the bush encroachment wetter North and East regions of the country and the desert found on the South Western part.

Wetlands

Water bodies, rivers and other marshy areas are considered as Wetlands. The area of this land class has been kept fixed as no development has been done on Wetlands during the inventory period.

Settlements

Land with infrastructures such as roads, buildings, houses and other mad-made structures have been included under Settlements. Urbanization and development of the road network are the major contributors to change in this land class.

Other Land

All other land present in Namibia and not falling in any of the above categories are included under this category. Desert, rock outcrops and bare land are the main constituents of Other Land. There was no change in this land class during the time series.

6.4.1.1. Methods

Estimation of emissions by source and removals by sink for the Land sector has been done using Approach 2 with a mix of Tier 1 and Tier 2 levels. The latter has been applied for the categories falling under Land as some of these were key sources in the last inventory. Most of the stock factors were derived based on data from past forest inventories and other available in-country information and resources.

6.4.2. Activity Data

Land representation and changes

A new rationale for compiling the GHG inventory in the Land category was used. Deforestation was a fact during the past century when tree felling was an economic activity for timber production. Furthermore, other human activities such as fuelwood collection, construction of dwellings, fencing, crafts and arts have contributed to the state of degradation of the Forestland.

Several reports and studies show that Namibia has witnessed a constant woody biomass accumulation in its Forestland and OWL from natural regeneration and more rapidly from the phenomenon of encroachment by both indigenous and alien species. Invasion by indigenous and exotic species have been observed since a century and have accelerated in the past 3 decades to become a serious problem, especially when the encroachment has been on the grasslands. It has reached a point that some areas are completely colonised with these encroacher species while others are affected to a lesser degree, but the result is that the carrying capacity of the rangelands of the country has decreased to a point which represents a serious threat to the sustainability of the livestock industry. In fact, there is a programme for rehabilitating of the rangelands which is presently ongoing.

Thus, deforestation as reported in the FRA of FAO is considered not representative of the national circumstances. In fact, FAO worked on information from different sources to generate land cover and land use for the year 2000 and adopted a rate of deforestation with linear extrapolation for the years 2005, 2010, 2015 and back to 1990. In the FRA reports, reclassification of various land cover types with vegetation does not allow the capture of movement in land use changes happening as per national circumstances. Table 6.9 shows the reclassification done by FAO. It is not clear from the FRA reports on which basis FAO arrived at the three classes of land, Forests, OWL and especially OL. These three classes do not fit the IPCC land representation and reporting requirements. However, this classification has been partly used as explained later to support the generation of land use changes.

Table 6.9 - Reclassification of various land classes into 3 main classes done in FRA for year 2000

Land cover description	Calibrated area in ha	Calibrated area reclassified under new class		
		Forests	OWL	OL
Shrubland	43,460,321	-	-	43,460,321
Forest	99,496	99,496	-	-
Grassland	7,220,148	-	-	7,220,148
Riverine woodland	346,870	208,122	104,061	34,687
Salt pans	538,262	-	-	538,262
Shrubland-Woodland mosaic	14,211,507	-	4,689,797	9,521,710
Sparse grassland and Shrubland	3,576,921	-	-	3,576,921
Woodland	12,875,475	7,725,285	3,862,643	1,287,548
Total	82,329,000	8,032,903	8,656,501	65,639,596

Data from maps produced by the RCMRD were used for generating land use changes for previous inventories. A summary of the original data is shown in Table 6.10. Explanations of the problems encountered with the original data was provided in the previous NIRs, accessible from the UNFCCC website. The change in land cover from the time series were not sustainable and differed a lot from those adopted in the FRA reports. The major problem areas were:

- Unsustainable deforestation rates that would result in the Forestland and Woodland classes disappearing in the medium term.
- Non-realistic land use changes recorded such as Settlements being converted to Forestland.
- Inclusion of vast areas with significant stocks of woody biomass under Grassland.
- The area of Other Land double that of previous studies and official country reports.

Namibia is an arid country and the use of satellite imagery to track land cover and land use change can be very misleading if not done with care. For example, an image of land with woody biomass can be interpreted as being grassland/shrubland if that image has been taken during the dry season as opposed to the rainy season as the canopy cover will be very different. Additionally, ground truthing of the maps were done on a restricted basis due to lack of resources.

Table 6.10 - Summary of original RCMRD Land Use/Cover derived from satellite imagery

Land cover type	Year 2000 (ha)	Year 2010 (ha)
Cropland	625,001	501,879
Forestland	2,942,075	1,969,215
Woodland	924,510	271,436
Grassland	7,393,363	3,984,627
Savannah grassland	36,911,447	37,229,582
Shrubland	7,397,053	15,400,213
Other land	25,612,829	22,302,300
Settlements	29,896	38,863
Wetland	724,608	862,667

Due to these inconsistencies, it was felt necessary to review the situation, consider all available information and work out improved land use changes. The description of each land class among the various documents (FRA, RCMRD, Atlas of Namibia, etc.) had inherent differences and overlaps in their coverage. The information was merged with the objective of meeting the requirements of the IPCC land categories. The merger also had to integrate information available with respect to bush encroachment and its related de-bushing activities.

Forestland areas for 2000 and 2010 were adopted from FRA. The area of Settlements with its changes were taken from the RCMRD maps. The different areas between Woodland, Shrubland and Savannah grassland was a mix of information from RCMRD and FRA. Cropland and Wetland areas were taken from RCMRD maps. The extent of Other Land was the remainder after distracting the other classes from the area of the territory. This was in line with the area classified as Other Land in Atlas of Namibia (Mendelsohn, et al., 2002).

Changes

Forestland

Deforestation is estimated to be under control since the independence of Namibia. Various laws and regulations have helped to preserve the remaining Forestland of the country. A rise in the standard of living and urbanization has decreased the pressure for wood resources from forests. A gain of 10,000 ha yearly from OWL has been included on account of bush encroachment since the 1960s and led to the bush being so thick and more than 5 metres warranting a change in the classification.

De-bushing methods include the use of chemicals and other mechanical means to get rid of the encroacher species that are affecting farms, particularly with respect to carrying capacity of livestock. It is reported that 80,000 hectares were de-bushed annually during the 1990s (Routhauge A., 2014). The use of chemicals for bush control is being discouraged by the authorities. This rate increased to 90,000 hectares during the first decade of the 21st century and 100,000 hectares as from 2011 (De Klerk J.N., 2004). Added to that, an NGO, the Cheetah Foundation has implemented a project on the rehabilitation of the natural habitat of the cheetah, a threatened species because of bush encroachment. This activity produced some 8,000 tonnes of bush-block annually (Feller S, et al. 2006) from the encroached species. They are sold or exported, and the proceeds used to support the Foundation financially.

Encroachment has nearly peaked as the Grassland are in the drier environment with rainfall inadequate to support growth of bushes and trees eventually. The aim now is to keep the right balance for economic activities to be sustainable, preserving the ecosystems and biodiversity through the control of encroachment by harvesting bush encroached species for use as woody biomass feedstocks.

Since independence, the Government of Namibia has promulgated many forests as protected areas, conservancies and community forests with an enhanced management level. This type of management is preserving the remaining forests and woodlands of the country. The rate of growth of major species are so slow that a tree takes around 50 years to reach 15 cm diameter at breast height (dbh) and between 70 to 100 years to reach 30 cm dbh (Mendelson and Obeid, 2004) depending on species and climate. This implies that natural regeneration of these areas will take a long time. However, it is a good sign that all forest inventories data indicate a high number of seedlings, saplings, and young growing healthy trees. It is estimated that the clearing and felling of trees when forests were intensively exploited for timber has resulted in vast extents of the territory without a cover which had taken centuries to develop and the phenomenon of bush encroachment is the recolonization of those spaces by species better adapted to the changed climate. An extract of the report by Mendelson and Obeid is given in the NIR3 (Figure 6.3, Page 74). It is to be noted that Caprivi has been renamed Zambezi now.

Cropland

A steady decrease in Cropland is estimated, as subsistence farming is gradually diminishing. This is due to migration of the rural population to urban areas, a higher purchasing power for a more varied food basket, improved yields from better crop husbandry practices and the combination of climate change including a higher climate variability.

Grassland

Bush encroachment has led to a rapid decrease in previously classified Grassland (Shrubland and Savanna) area. These are now under the class OWL as per the presence of enough woody species.

Wetlands

The area of Wetlands is estimated to be constant during the whole time series. The area from the 2000 RCMRD map was used as constant.

Settlements

An increase in the Settlement class has been included in the NIR3. Development of infrastructure to accommodate a growing urban population plus the building of infrastructures have contributed to this increase. The land change was from cropland and OWL during the period 1994 to 2010. As from 2011, only OWL was converted to Settlements at a lower rate than previously observed.

Other Land

The class Other Land was estimated from the information in the Atlas of Namibia as the part where desert and sand were present. This area of about 11.5 M hectares lies along the coast from the north towards the south western part of Namibia. It was assumed that there was no change and no activity leading to emissions or removals in this land category.

QC

A study by Barnes, et al, 2005 on the assessment of woody biomass stocks from forest resources arrived at 257 million m^3. The estimates made for the same year for the present inventory based on the area of Forestland and the woodland component of OWL is 290 million m^3. This is comforting and indicates that the approach adopted, and the assumptions and derivations made from available information are reliable.

Cropland area was overestimated in the two previous land cover land use maps compared to real harvested area surveyed annually. It was estimated that subsistence farmers were rotating their land so that area cultivated and harvested was lower than the area under crops estimated from the maps. The movement of the population from rural to urban areas is deemed to have slowed the process of land clearing and the movement in the Cropland area is expected to be very low in this decade.

Time series AD on Land Use Changes

Three time periods have been adopted for this inventory for determining land use changes between the 6 IPCC classes: 1991 to 2000, 2001 to 2010 and 2011 to 2015. Initial areas for each period and annual change used in land matrices are given in Table 6.11 to Table 6.13.

Table 6.11 - Total land use adjusted area and annual change used in land matrix (1991 - 2000)

Land Type category	Area (ha)			
	Year 1991	Year 2000	Annual gain	Annual loss
Forestland	8.689,537	8,032,903	-	72,959
OWL	51,168,431	54,291,441	427,496	80,495
Cropland	925,000	625,001	-	37,500
Grassland	9,531,147	7,393,363	80,000	317,532
Wetlands	724,608	724,608	-	-
Settlements	20,990	29,896	990	-
Other land	11,463,570	11,463,570	-	-
Total	**82,560,782**	**82,560,782**	**508,486**	**508,486**

The major change during 1991 to 2000 is the loss of Grassland to OWL with bush encroachment. De-bushing activities to the tune of 80,000 ha annually were mitigating that effect. Forestland lost an average of 73,000 ha annually.

Table 6.12 - Total land use adjusted area and annual change used in land matrix (2001 - 2010)

Land Type category	Area (ha)			
	Year 2001	Year 2010	Annual gain	Annual loss
Forestland	7,968,622	7,390,095	10,000	74,281
OWL	54,610,659	57,483,623	411,670	92,452
Cropland	606,698	441,974	-	18,303
Grassland	7,155,832	5,018,049	82,000	319,531
Wetlands	724,608	724,608	-	-

Land Type category	Area (ha)			
	Year 2001	Year 2010	Annual gain	Annual loss
Settlements	30,793	38,863	897	-
Other land	11,463,570	11,463,570	-	-
Total	**82,560,782**	**82,560,782**	**504,567**	**504,567**

The conversion of Grassland to OWL peaked during the period 2001 to 2010 at nearly 320,000 ha encroached every year. A conversion of OWL to Forestland at the rate of 10,000 ha per year is now included as bush encroached land meets the Forestland definition.

Table 6.13 - Total land use adjusted area and annual change used in land matrix (2011 - 2015)

Land Type category	Area (ha)			
	Year 2011	Year 2015	Annual gain	Annual loss
Forestland	7,328,707	7.083,155	10,000	71,388
OWL	57,672,871	58,429,861	289,361	100,114
Cropland	432,777	395,987	-	9,197
Grassland	4,899,273	4,542,946	90,000	208,776
Wetlands	724,608	724,608	-	-
Settlements	38,977	39,318	114	-
Other land	11,463,570	11,463,570	-	-
Total	**82,560,782**	**82,560,782**	**389,475**	**389,475**

During 2011 to 2015, the rate of loss of Cropland and Grassland decreased. The rate of increase of Settlements also slowed down.

It is a fact that this approach which has been adopted in the BUR3 and in this NC4 may not be fully representative of the national situation, but it is considered better than the one adopted in the NIRs 1 and 2. The intent of the country is to develop a new set of land cover land use maps over a few time steps of the inventory period to overcome the inaccuracies in the representation of land.

Soil type

Another hurdle is the sub-division of land into 4 different soil types. The HAC and LAC soil types were the most abundant and kept from the NIR2. While segregation brings accuracy in the estimates, this is not easy to accommodate in the IPCC 2006 software when the Tier 2 level is implemented. Thus, a weighted average of the soil factors, using the areas adopted by RCMRD, was calculated and used for the whole of Namibia. A summary of the various soil types and the weightage used for deriving user-defined factors is given in Table 6.14.

Table 6.14 - % Distribution of different soil types in Namibia

	Soil type			
	HAC	LAC	SAN	WET
Area (ha)	50,128,385	90,367	32,340,961	1,069
% of total area	60.7%	0.1%	39.2%	0.0%

Climate

In the NIRs 1 and 2, two climate types were allocated by RCMRD in association with the different soil types. During the review and development of the new approach for the NIR3 and repeated for the NC4, the climate assigned to Namibia which was wrong has been corrected. After confirmation from IPCC map

(2006 IPCC GL, Volume 4, page 3.38, Figure 3.A.5.1), the climate of Namibia is now set as Temperate dry for the whole country since the small area associated with the Tropical dry climate type is situated in the Other Land class where there is no activity.

A Tier 2 approach has been maintained but slight changes brought as follows:

(i) A much lower use of local wood resources which is highly supported by the results of the recent censuses.
(ii) The lower reliance on local wood resources is attributed to a rise in urbanization rate accompanied by a fall in woody material used for dwellings coupled with use of alternative materials for dwellings, imports of wood from neighbouring South Africa, lower use of wood as fuel for cooking, heating and lighting, and reduced commercial harvest of wood.
(iii) Thus, compared to FRA data, slower rates have been adopted over the 20 years of this time series (see matrices provided separately).
(iv) Bush encroachment has resulted in vast areas of land previously misclassed as Shrubland / Savanna / Grassland and reclassified as Forest or dense Woodland now.
(v) Bush encroachment rate and bush clearing have been taken into consideration in the land use changes.
(vi) Additionally, by combining Shrubland, Savanna and Open Woodland under a common class Other Wooded Land, computation of emissions and removals in the software has been simplified.
(vii) It is essential to account for the biomass of the bushes properly including their role in wood removals. Emission and stock factors (Growing stock, annual growth rates, etc) have been derived for the country based on the latest information available (see worksheets thereon).
(viii) Most wood removals accounted for in this new OWL as is presently the case for known uses of woody biomass stocks.
(ix) An increase in Settlement land category is included in the change as population and urbanization is constantly increasing. This is estimated to be accompanied by a loss in Cropland area whereby subsistence farming is regressing, and villages are also growing.

6.4.3. Generated data and emission factors

Biomass stock factors

The standing biomass stock for Forestland was obtained by averaging the data from Forest inventory reports performed in preserved forests, community forests and conservancies in areas receiving adequate rainfall to maintain trees. Regarding Other Wooded Land, the standing biomass stocks of land defined as Woodlands, Shrubland and Savannahs in forest inventories were pooled to provide a weighted average on an area basis for OWL. The areas used pertained to the 1990 areas allocated to these different land cover classes. The information from the different national forest inventory (NFI) reports and the land cover classes considered for deriving the user-defined stock factor for Forestland and OWL have been provided in the NIR3 (Table 6.15, Page 78). The data obtained from the NFIs were further aggregated on a weight basis to generate country specific biomass stocks. Table 6.15 shows the different biomass factors derived for the Forestland, OWL and Grassland categories.

Table 6.15 - Biomass stock factors for FOLU.

Land classes	Woody biomass (t/ha)	Deadwood (m3)	Above ground Biomass (t dm/ha)	Age to reach this class (yrs)	Annual growth (t dm/yr)	Grass layer (t dm/ha)
Forestland	22.63	2.76	38.47	100.0	0.385	0.23

Land classes	Woody biomass (t/ha)	Deadwood (m3)	Above ground Biomass (t dm/ha)	Age to reach this class (yrs)	Annual growth (t dm/yr)	Grass layer (t dm/ha)
OWL	12.13	1.48	36.38	45.6	0.797	0.69
Grassland						1.15

Wood removals

Removal of fuelwood was indexed on its use rate by urban and rural population respectively. Removal of timber and poles was based on number of traditional dwellings and the amount of woody resources needed to build and maintain these units.

Charcoal produced was estimated from trade statistics and converted to woody biomass and included in the fuelwood estimates.

The amount of woody biomass removed is shown in Table 6.16.

Table 6.16 - Wood removals (t) from various activities (1991 - 2015)

Year	Charcoal production	Fuelwood exported	Fuelwood collected	Poles removal	Bushblock production	Industrial consumption	Total
1991	300,000	500	191,210	164,737	*	*	656,447
1992	300,000	500	192,804	162,224	*	*	655,528
1993	300,000	500	194,406	165,727	*	*	660,633
1994	300,000	500	196,018	169,068	*	*	665,586
1995	300,000	500	197,640	172,245	*	*	670,385
1996	300,000	500	199,270	175,259	*	*	675,029
1997	300,000	500	200,911	178,111	*	*	679,522
1998	300,000	555	202,562	180,799	*	*	683,915
1999	300,000	621	204,223	183,323	*	*	688,167
2000	300,000	152	205,894	185,685	*	*	691,731
2001	300,000	122	207,577	187,946	8,000	*	703,644
2002	300,000	130	207,748	190,055	8,000	*	705,934
2003	300,000	68	207,906	193,325	8,000	*	709,299
2004	301,044	2,469	208,050	200,640	8,000	*	720,203
2005	294,031	4,486	208,180	194,950	8,000	*	709,647
2006	320,779	7,120	208,296	201,706	8,000	*	745,900
2007	374,117	7,553	208,397	197,702	8,000	*	795,768
2008	523,727	11,651	208,484	198,838	8,000	*	950,700
2009	693,161	14,251	208,557	199,816	8,000	*	1,123,785
2010	621,187	14,467	208,615	200,112	8,000	*	1,052,381
2011	465,524	14,571	208,659	204,371	8,000	*	901,125
2012	471,321	15,116	207,455	201,247	8,000	27,000	930,138
2013	549,841	14,997	206,316	201,552	8,000	30,000	1,010,706
2014	541,410	15,909	205,241	201,631	8,000	27,000	999,191
2015	645,763	19,277	204,230	201,547	8,000	27,000	1,105,817

*** Not Occurring**

Woody biomass removals were assigned as follows:

(a) Charcoal from OWL as de-bushing activities are the major contributor of wood for charcoal production.

(b) All fuelwood from OWL.

(c) Poles removal was accounted for as 50% from Forestland and 50% from OWL during the period 1994 to 2000, 40% from Forestland and 60% from OWL during the period 2001 to 2010 and 30% and 70% as from 2011 to 2015. This mix is based on 1% population migrating from rural to urban areas and relieving the use of poles for dwellings and the shift to other building materials as well as imports of wood for construction purposes.

Area disturbed

Information from MAWF was available for years 2000 to 2014 for total area burnt. Trending technique was used to generate the areas burnt for 1994 to 1999. This area was apportioned according to area under Forestland, OWL and Grassland classes on a weight basis. It was estimated that 1% of the biomass stock was lost during disturbance occurring in Forestland, 5% in OWL and 30% of the grass layer of Grasslands. The annual area burnt, and its breakdown is given in Table 6.17.

Table 6.17 - Distribution of annual area disturbed by fire (1991 - 2015)

Year	Total	Area (ha) disturbed by fire		
		Forestland	OWL	Grassland
1991	8,918,116	1,118,855	6,633,724	1,165,537
1992	8,476,412	1,050,244	6,322,761	1,103,406
1993	8,034,708	986,492	6,030,524	1,017,692
1994	7,593,004	923,742	5,734,154	935,108
1995	7,151,300	861,991	5,433,660	855,649
1996	6,709,596	801,238	5,129,046	779,311
1997	6,267,892	741,482	4,820,321	706,089
1998	5,826,188	682,720	4,507,490	635,978
1999	5,384,484	624,952	4,190,560	568,972
2000	4,851,640	557,698	3,798,187	495,755
2001	4,868,950	555,058	3,833,225	480,667
2002	3,667,000	414,528	2,903,128	349,343
2003	3,663,350	410,613	2,916,389	336,348
2004	3,245,920	360,722	2,598,376	286,822
2005	4,044,970	445,658	3,255,834	343,478
2006	5,205,020	568,498	4,212,481	424,042
2007	6,136,760	664,407	4,993,548	478,805
2008	3,775,280	405,137	3,088,588	281,556
2009	7,291,860	775,560	5,997,580	518,720
2010	6,197,680	653,278	5,124,840	419,562
2011	6,642,550	693,422	5,500,960	448,168
2012	6,922,060	716,395	5,750,525	455,140
2013	1,924,180	197,417	1,603,547	123,216
2014	2,829,330	287,749	2,365,260	176,322
2015	2,319,940	233,864	1,945,479	140,597

Emissions and Removals estimates

Estimates of emissions and removals for the Land sector is depicted in Table 6.18. Namibia remained a sink during the whole time series. Removals resulting from biomass accumulation outpaced the emissions. Bush encroachment and its thickening is responsible for the removals and maintenance of the sink capacity. The removals in Forestland increased from -95,087.6 Gg CO_2 in 1991 to reach a peak of -

122,354.6 Gg CO_2 in 2013 and regress slightly to -121,488.5 Gg CO_2 in 2015. Emissions from Grassland increased from 8,671.9 Gg CO_2 to reach 9,755.9 Gg in 2015. Emissions from land converted to settlements decreased from 63.3 Gg CO_2 to 12.8 Gg CO_2 in line with converted area. Net removals varied from a minimum of -86,352.3 Gg CO_2 in 1991 to peak at -112,585.9 Gg CO_2 in 2013 and decrease to -111,719.8 Gg CO_2 in 2015.

Table 6.18 - Emissions (CO_2) for the LAND sector (1991 - 2015)

Year	3.B.1 - Forest land	3.B.3 - Grassland	3.B.5 - Settlements	Net Removals
1991	-95,087.6	8671.9	63.3	-86,352.3
1992	-95,643.2	8671.9	63.3	-86,908.0
1993	-96,150.6	8671.9	63.3	87,415.4
1994	-96,659.2	8671.9	63.3	-87,923.9
1995	-98,466.5	8671.9	63.3	-89,731.2
1996	-100,291.1	8671.9	63.3	-91,555.8
1997	-102,133.0	8671.9	63.3	-93,397.8
1998	-103,992.2	8671.9	63.3	-95,256.9
1999	-105,868.6	8671.9	63.3	-97,133.4
2000	-108,066.7	8671.9	63.3	-99,331.5
2001	-108,212.1	8888.7	57.7	-99,265.7
2002	-112,686.5	8888.7	57.7	-103,740.1
2003	-113,128.4	8888.7	57.7	-104,181.9
2004	-114,949.2	8888.7	57.7	-106,002.8
2005	-112,722.8	8888.7	57.7	-103,776.3
2006	-109,118.9	8888.7	57.7	-100,172.5
2007	-106,355.0	8888.7	57.7	-97,408.5
2008	-114,976.9	8888.7	57.7	-106,030.4
2009	-103,127.0	8888.7	57.7	-94,180.5
2010	-107,364.4	8888.7	57.7	-98,417.9
2011	-105,447.8	9755.9	12.8	-95,679.0
2012	-104,484.9	9755.9	12.8	-94,716.2
2013	-122,354.6	9755.9	12.8	-112,585.9
2014	-119,425.6	9755.9	12.8	-109,656.9
2015	-121,488.5	9755.9	12.8	-111,719.8

6.5. Aggregated sources and non-CO_2 emission sources on land

6.5.1. Description *of* category

Aggregated sources and non-CO_2 emission sources on land in Namibia originated from four of the IPCC categories and all four with activities occurring were covered in this inventory. The categories are

- 3.C.1 Biomass burning;
- 3.C.4 Direct emissions from managed soils;
- 3.C.5 Indirect emissions from managed soils; and
- 3.C.6 Indirect emissions from manure management.

6.5.2. Methods

Methods are according to the IPCC 2006 Guidelines and the 2006 IPCC Software has been used to compute emissions for these categories.

6.5.3. Activity data

The AD are those adopted for computing direct emissions for the Land and Livestock categories, which are used by default in the software to aggregate emissions from different sources. Here, reference is made to the manure generated by livestock and area disturbed with their biomass stocks.

AD for fertilizers and urea are from the mass balance of imports and exports data from the NSA. The statistics did not refer to the exact N content as required for input in the software but rather by fertilizer type. A description of the fertilizers imported and used in the country along with their N content is provided in Table 6.20. While the N content of certain straight fertilizers is known, the molecular formula was used in some cases to estimate the N contents of blends/mixtures. The percentages N content adopted have been provided in the NIR3 (Table 6.20, Page 82). No import and export data were available for the period 1991 to 1997 and the average of N used in the years 1998 to 2000 was adopted as AD for these years.

The total amount of N obtained from the fertilizers used and keyed in the software for estimating emissions is provided in Table 6.19. The very high amount of synthetic N fertilizer used for the period 2011 to 2014 was due to a donation from a friendly country.

Table 6.19 - Amount of N (kg) used from fertilizer application (1991 - 2015)

Type of fertilizer	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Urea N	212,650	212,650	212,650	212,650	212,650	212,650	168,158	142,158	327,634	1,888,517	1,291,430	542,740	368,488
Synthetic fertilizer N	711,152	711,152	711,152	711,152	711,152	711,152	711,152	761,278	579,424	792,753	789,181	1,405,803	1,044,076

Type of fertilizer	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Urea N	212,650	126,153	90,414	173,177	32,491	103,965	50,217	269,867	319,444	212,319	176,470	294,984
Synthetic fertilizer N	4,081,591	4,511,194	5,795,314	6,791,457	4,703,351	7,482,384	10,949,854	12,111,961	12,532,870	9,688,535	5,013,240	11,823,803

6.5.4. Emission factors

Biomass burning is known to occur in the country on account of wildfires. Default EFs were used for all gases in Forestland, OWL and Grassland burning. Biomass burning is a key category in some years on account of the vast areas burned rather than the EFs. Thus, it is not contemplated to attempt at deriving national ones. However, the amount of standing biomass in the different land classes will be further refined when new forest inventories will be performed. Default EFs were used for estimating emissions from urea application as well as for estimates of indirect emissions from managed soils and manure management.

6.5.5. Emission estimates

The emissions for aggregate sources and non-CO_2 emissions on land are given in Table 6.20. Emissions varied between 3,312 Gg CO_2-eq and 6,538 Gg CO_2-eq for the period 1991 to 2015. This high variability in estimates is attributed to the varying areas disturbed by wildfires between years and this is very difficult to control.

Table 6.20 - Aggregated emissions (Gg CO_2-eq) for aggregate sources and non-CO_2 emissions on Land (1991 - 2015)

1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
6,538	6,249	5,925	5,685	5,502	5,196	5,026	4,828	4,636	4,442	4,510	3,789	3,837

2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
3,583	3,968	4,717	5,179	3,921	5,997	5,265	5,840	6,145	2,957	3,622	3,312

The emissions for the direct and indirect GHGs are given in Table 6.21. The major gas emitted among the direct ones in this category remained CH_4 throughout the period followed by N_2O. CO_2 emissions were minimal for all years. For the indirect gases, CO emissions was substantial, varying between 704.9 to 2504.4 Gg.

Table 6.21 - Emissions (Gg) by gas for aggregate sources and non-CO_2 emissions on Land (1991 - 2015)

Gas	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
CO_2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.5	3.0	2.1	0.9
CH_4	163.2	155.3	147.8	140.2	132.6	124.9	117.2	109.4	101.5	91.8	92.5	70.0	70.2
N_2O	10.0	9.6	9.1	8.8	8.8	8.3	8.3	8.2	8.1	8.1	8.3	7.5	7.6
NO_x	39.5	37.5	35.7	33.8	32.0	30.1	28.2	26.3	24.4	22.1	22.2	16.8	16.8
CO	2505.4	2383.3	2268.3	2152.3	2035.2	1917.2	1798.1	1678.0	1556.9	1408.3	1418.8	1072.6	1075.7

Gas	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CO_2	0.6	0.2	0.1	0.3	0.1	0.2	0.1	0.4	0.5	0.3	0.3	0.5
CH_4	62.4	78.1	100.8	115.6	73.7	142.9	121.9	130.7	136.5	38.0	56.0	46.0
N_2O	7.3	7.5	8.4	8.9	7.7	9.7	8.7	10.0	10.6	7.0	7.9	7.6
NO_x	14.9	18.7	24.1	28.5	17.6	34.1	29.1	31.2	32.5	9.1	13.3	11.0
CO	956.7	1196.7	1545.7	1829.3	1129.5	2189.8	1868.1	2003.0	2091.2	582.4	858.0	704.9

6.6. Harvested Wood Products (HWP)

6.6.1. Description of the HWP category

Emissions from cut trees do not necessarily occur in the same year but depends on the fate of the harvested wood, unless it is burned in the same year. Hence, the category HWP to account for the sink created by the harvested wood used as a commodity for housing, furniture and other uses. This category was not covered in previous inventories of Namibia primarily because of lack of available data and other information required to allow for emissions to be estimated with a certain level of accuracy. Now that the background work has been completed, the category HWP is now covered as one of the listed improvement areas. Only the period 1998 to 2015 is covered presently until AD is sourced for the remaining years 1991 to 1997.

6.6.2. Method

The Tier 1 method recommended in the IPCC 2006 Guidelines was adopted for estimating emissions or removals from this category. The stock change approach was used, based on the AD that were available.

6.6.3. Activity data

Available trade statistics on wood and other wood products for the period 1998 to 2015 were preferred to the datasets available in the FAO database as most of the latter were estimates. Wood and its products were regrouped to align them with the different groups used in the computation of emissions as per the 2006 software requirements. The trade data were supplemented with those available in the FAO database, which covers the period 2000 to 2015, only to fill any existing gap and as a method of quality control of the national data available. Additionally, AD on wood removals from forests used in the Land category was used as production data to complement the trade and FAO statistics which covered the import and export part. Data for fuelwood was generated as from the year 1961 based on use rate and population.

Based on information collected from the authorities dealing with waste and the environment, it was assumed that there were no production of wood pulp and recycling of paper in the country. Outliers in the AD for the time series were corrected using statistical techniques, namely trending or averaging based on analysis of the available data.

Trade statistics were obtained from NSA for the period 1998 to 2015. Different groups of HS codes were analysed and regrouped according to the various AD components required to populate the table in the software. The information which was in weight was then converted to the units required by the software. Data for fuelwood was generated as from the year 1961 based on use rate and population.

The AD was then compared to information from FAO which existed for the years 2000 to 2015. The FAO statistics were analysed, and the information regrouped under each header required for the HWP software data entry. There were differences probably resulting from the classification of the HS codes in the various elements and the estimates made in the FAO statistics and it was decided to keep the national statistics as AD. It is assumed that there were no production of wood pulp/recycled paper in Namibia. Outliers were corrected using trending technique or average based on expert judgement.

6.6.4. Timeseries Activity data

AD from HWP category are presented in Table 6.22. All components required by the software were allocated.

Table 6.22 - Activity data for HWP from trade statistics

Year	Roundwood (m3)			Sawnwood (m3)*		Wood-based panels (m3)*		Paper + Paperboard (t)*		Wood Pulp (1875)+ recycled paper (t)*		Industrial roundwood (m3)*		Chips and particles (m3)		Wood charcoal (t)			Wood residues (m3)	
	Production	Import	Export	Import	Export	Import	Export	Import	Export	Import	Export	Import	Export	Import	Export	Production	Import	Export	Import	Export
1998	504,448	355	1,148	32,031	4,257	10,454	73	92,743	5,886	181	3,578	21,038	1,283	136	298	60,000	670	9,572	359	78
1999	510,383	405	1,292	30,077	1,957	13,445	129	128,648	6,266	118	3,357	17,406	469	414	1,301	60,000	733	177,684	176	1
2000	515,522	483	700	29,458	3,391	13,145	79	54,987	7,096	65	2,933	15,628	618	165	757	60,000	1,961	9,782	102	7
2001	520,941	400	574	36,559	2,534	14,282	161	131,958	5,492	156	4,537	21,396	1,554	167	1,570	60,000	2,330	26,039	280	509
2002	524,637	159	345	20,753	4,418	5,854	662	27,304	2,666	103	4,582	22,249	1,599	244	863	60,000	131	20,683	109	0
2003	530,183	482	580	41,336	10,089	10,820	606	50,273	3,957	149	7,703	19,789	2,658	429	295	60,000	520	35,425	36	79
2004	544,919	418	3,944	31,344	11,437	12,303	3,000	47,864	4,568	72	8,709	24,122	3,781	97	19	60,209	756	50,965	284	96
2005	537,582	925	7,334	42,628	9,039	13,400	4,818	46,430	4,910	27	8,076	32,198	4,144	64	137	58,806	711	49,517	31	60
2006	551,592	108	10,280	35,278	7,878	18,185	1,277	49,735	3,456	24	7,463	30,272	5,789	88	714	64,156	137	54,293	21	3
2007	545,453	192	10,982	37,474	8,854	18,408	164	54,905	2,477	117	8,982	31,129	11,155	614	1,131	74,823	13	64,837	14	0
2008	551,533	130	16,775	37,280	12,394	20,811	824	57,008	4,587	339	9,708	29,075	10,804	579	512	104,745	19	94,764	27	1
2009	555,834	203	20,561	83,510	14,596	22,998	935	67,604	6,193	107	11,729	41,529	10,305	7	425	138,632	21	128,654	38	0
2010	556,602	64	20,731	45,610	8,517	20,033	266	67,345	3,383	950	11,913	42,203	5,734	66	253	124,237	48	114,286	90	25
2011	563,848	89	20,906	45,038	6,488	61,361	345	64,449	3,525	322	13,138	43,812	3,909	114	64	93,105	68	83,172	39	44
2012	557,982	95	21,690	53,831	7,481	21,233	404	72,753	10,492	95	14,120	49,912	6,184	378	242	94,264	646	84,910	597	160
2013	557,233	414	21,838	52,549	8,265	25,288	185	74,338	14,468	284	13,596	60,693	6,024	1,130	38	109,968	524	100,492	621	113
2014	557,201	477	23,204	60,639	9,608	20,914	254	83,944	16,986	65	14,578	61,312	8,017	1,085	99	108,282	11,244	109,527	234	128
2015	559,418	444	27,982	57,906	12,868	27,006	261	88,851	24,695	69	16,023	75,092	5,031	914	207	129,153	144	119,297	1,451	99

* Production columns are not shown for items where the data is zero

6.6.5. Emission factors

Default EFs from the IPCC 2006 Guidelines (V4_12_Ch12-HWP Table 12.2 Page 12.17) were used for estimating emissions and removals.

6.6.6. Results

Only one gas, CO_2 is emitted or removed in the HWP category. Emissions and removals from the HWP category are given in Table 6.23. The HWP category constituted a sink throughout the time period 1998 to 2015 except for the year 2002 when it emitted 39.4 Gg of CO_2. The removals varied between 21.0 and 199.0 Gg, which occurred in 1999.

Table 6.23 - Emissions (Gg) from Harvested Wood Products (1998 - 2015)

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006
Emission/Removals	-182.6	-199.0	-50.1	-176.3	39.4	-42.7	-21.0	-46.7	-53.9

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015
Emission/Removals	-65.8	-57.8	-149.9	-85.7	-122.4	-91.0	-84.7	-99.9	-86.5

Table 6.24 - Sectoral Table: AFOLU (Inventory Year: 2015)

Categories	Net CO2 emissions / removals	Emissions (Gg)				
		CH4	N2O	NOx	CO	NMVOCs
3 - Agriculture, Forestry, and Other Land Use	-111805.813	219.242	8.008	10.954	704.878	12.464
3.A - Livestock	NA	173.227	0.442	NA	NA	12.464
3.A.1 - Enteric Fermentation	NA	169.194	NA	NA	NA	NA
3.A.1.a - Cattle	NA	147.582	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	147.399	NA	NA	NA	NA
3.A.1.b - Buffalo	NA	NO	NA	NA	NA	NA
3.A.1.c - Sheep	NA	9.867	NA	NA	NA	NA
3.A.1.d - Goats	NA	9.343	NA	NA	NA	NA
3.A.1.e - Camels	NA	0.002	NA	NA	NA	NA
3.A.1.f - Horses	NA	0.849	NA	NA	NA	NA
3.A.1.g - Mules and Asses	NA	1.489	NA	NA	NA	NA
3.A.1.h - Swine	NA	0.063	NA	NA	NA	NA
3.A.1.j - Other (please specify)	NA	NO	NA	NA	NA	NA
3.A.2 - Manure Management (1)	NA	4.034	0.442	NA	NA	12.464
3.A.2.a - Cattle	NA	2.810	0.437	NA	NA	10.399
3.A.2.a.i - Dairy cows	NA	0.002	0.002	NA	NA	0.016
3.A.2.a.ii - Other cattle	NA	2.808	0.435	NA	NA	10.383
3.A.2.b - Buffalo	NA	NO	NA	NA	NA	0.000
3.A.2.c - Sheep	NA	0.395	NA	NA	NA	0.346
3.A.2.d - Goats	NA	0.411	NA	NA	NA	1.026
3.A.2.e - Camels	NA	0.000	NA	NA	NA	0.000
3.A.2.f - Horses	NA	0.103	NA	NA	NA	0.236
3.A.2.g - Mules and Asses	NA	0.179	NA	NA	NA	0.234
3.A.2.h - Swine	NA	0.063	0.003	NA	NA	0.038
3.A.2.i - Poultry	NA	0.073	0.002	NA	NA	0.186
3.A.2.j - Other (please specify)	NA	NA	NA	NA	NA	NA
3.B - Land	-111719.812	NA	NO	NO	NO	NO

Categories	Net CO2 emissions / removals	Emissions (Gg)				
		CH4	N2O	NOx	CO	NMVOCs
3.B.1 - Forest land	-121488.522	NA	NO	NO	NO	NO
3.B.1.a - Forest land Remaining Forest land	-120525.811	NA	NA	NO	NO	NO
3.B.1.b - Land Converted to Forest land	-962.711	NA	NA	NO	NO	NO
3.B.1.b.i - Cropland converted to Forest Land	-62.193	NA	NA	NO	NO	NO
3.B.1.b.ii - Grassland converted to Forest Land	-900.518	NA	NA	NO	NO	NO
3.B.1.b.iii - Wetlands converted to Forest Land	NO	NA	NA	NO	NO	NO
3.B.1.b.iv - Settlements converted to Forest Land	NO	NA	NA	NO	NO	NO
3.B.1.b.v - Other Land converted to Forest Land	NO	NA	NA	NO	NO	NO
3.B.2 - Cropland	NO	NA	NA	NO	NO	NO
3.B.2.a - Cropland Remaining Cropland	NO	NA	NA	NO	NO	NO
3.B.2.b - Land Converted to Cropland	NO	NA	NA	NO	NO	NO
3.B.2.b.i - Forest Land converted to Cropland	NO	NA	NA	NO	NO	NO
3.B.2.b.ii - Grassland converted to Cropland	NO	NA	NA	NO	NO	NO
3.B.2.b.iii - Wetlands converted to Cropland	NO	NA	NA	NO	NO	NO
3.B.2.b.iv - Settlements converted to Cropland	NO	NA	NA	NO	NO	NO
3.B.2.b.v - Other Land converted to Cropland	NO	NA	NA	NO	NO	NO
3.B.3 - Grassland	9755.939	NA	NA	NO	NO	NO
3.B.3.a - Grassland Remaining Grassland	NO	NA	NA	NO	NO	NO
3.B.3.b - Land Converted to Grassland	9755.939	NA	NA	NO	NO	NO
3.B.3.b.i - Forest Land converted to Grassland	9755.939	NA	NA	NO	NO	NO
3.B.3.b.ii - Cropland converted to Grassland	NO	NA	NA	NO	NO	NO
3.B.3.b.iii - Wetlands converted to Grassland	NO	NA	NA	NO	NO	NO
3.B.3.b.iv - Settlements converted to Grassland	NO	NA	NA	NO	NO	NO
3.B.3.b.v - Other Land converted to Grassland	NO	NA	NA	NO	NO	NO
3.B.4 - Wetlands	NO	NO	NO	NO	NO	NO
3.B.4.a - Wetlands Remaining Wetlands	NO	NO	NO	NO	NO	NO
3.B.4.a.i - Peatlands remaining peatlands	NO	NO	NO	NO	NO	NO
3.B.4.a.ii - Flooded land remaining flooded land	NA	NO	NO	NO	NO	NO
3.B.4.b - Land Converted to Wetlands	0.000	NO	NO	NO	NO	NO
3.B.4.b.i - Land converted for peat extraction	NA	NO	NO	NO	NO	NO
3.B.4.b.ii - Land converted to flooded land	NO	NO	NO	NO	NO	NO
3.B.4.b.iii - Land converted to other wetlands	NA	NO	NO	NO	NO	NO
3.B.5 - Settlements	12.771	NA	NA	NO	NO	NO
3.B.5.a - Settlements Remaining Settlements	NO	NA	NA	NO	NO	NO
3.B.5.b - Land Converted to Settlements	12.771	NA	NA	NO	NO	NO

Categories	Net CO2 emissions / removals	Emissions (Gg)				
		CH4	N2O	NOx	CO	NMVOCs
3.B.5.b.i - Forest Land converted to Settlements	12.771	NA	NA	NO	NO	NO
3.B.5.b.ii - Cropland converted to Settlements	0.000	NA	NA	NO	NO	NO
3.B.5.b.iii - Grassland converted to Settlements	NO	NA	NA	NO	NO	NO
3.B.5.b.iv - Wetlands converted to Settlements	NO	NA	NA	NO	NO	NO
3.B.5.b.v - Other Land converted to Settlements	NO	NA	NA	NO	NO	NO
3.B.6 - Other Land	NO	NO	NO	NO	NO	NO
3.B.6.a - Other land Remaining Other land	NO	NO	NO	NO	NO	NO
3.B.6.b - Land Converted to Other land	NO	NO	NO	NO	NO	NO
3.B.6.b.i - Forest Land converted to Other Land	NO	NO	NO	NO	NO	NO
3.B.6.b.ii - Cropland converted to Other Land	NO	NO	NO	NO	NO	NO
3.B.6.b.iii - Grassland converted to Other Land	NO	NO	NO	NO	NO	NO
3.B.6.b.iv - Wetlands converted to Other Land	NO	NO	NO	NO	NO	NO
3.B.6.b.v - Settlements converted to Other Land	NO	NO	NO	NO	NO	NO
3.C - Aggregate sources and non-CO2 emissions sources on land (2)	0.470	46.014	7.566	10.954	704.878	NO
3.C.1 - Emissions from biomass burning	0.000	46.014	1.359	10.954	704.878	NO
3.C.1.a - Biomass burning in forest lands	NA	45.927	1.351	10.806	702.415	NO
3.C.1.b - Biomass burning in croplands	NA	NO	NO	NO	NO	NO
3.C.1.c - Biomass burning in grasslands	NA	0.087	0.008	0.148	2.463	NO
3.C.1.d - Biomass burning in all other land	NA	NO	NO	NO	NO	NO
3.C.2 - Liming	NO	NA	NA	NA	NA	NA
3.C.3 - Urea application	0.470	NA	NA	NA	NA	NA
3.C.4 - Direct N2O Emissions from managed soils (3)	NA	NA	5.742	NA	NA	NA
3.C.5 - Indirect N2O Emissions from managed soils	NA	NA	0.060	NA	NA	NA
3.C.6 - Indirect N2O Emissions from manure management	NA	NA	0.405	NA	NA	NA
3.C.7 - Rice cultivations	NA	NO	NA	NA	NA	NA
3.C.8 - Other (please specify)	NE	NO	NO	NA	NA	NA
3.D - Other	-86.471	NO	NO	NO	NO	NO
3.D.1 - Harvested Wood Products	-86.471	NA	NA	NA	NA	NA
3.D.2 - Other (please specify)	NO	NO	NO	NO	NO	NO

7. Waste

7.1. Description of the Waste Sector

In Namibia, solid waste is generated by domestic, industrial, commercial and agricultural activities whereas wastewater is generated mostly through domestic, industrial and commercial activities. As in other countries, waste generation is directly related to population growth, industrialization rate and urbanization trend, the latter being an important impacting factor. GHG emission in the waste sector is also affected by the type of disposal mechanisms as well as the level of management exercised.

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

- 4.A.3 - Uncategorised Waste Disposal Sites;
- 4.C.2 - Open Burning of Waste;
- 4.D.1 - Domestic Wastewater Treatment and Discharge; and
- 4.D.2 - Industrial Wastewater Treatment and Discharge.

7.1.1. Uncategorised Waste Disposal Sites

Waste collection is mostly practised in urban areas. There are three landfill sites in the country, one at Kupferberg in the Khomas region for the disposal of general and hazardous waste generated within the City of Windhoek area of jurisdiction, and two in the region of Erongo which receive waste from Swakopmund and Walvis Bay. Waste from other towns and municipalities of the country is disposed of in open dump sites. Since there is no data on division of managed / unmanaged waste disposal systems, the classification used in this report for Solid Waste Disposal will be 'Uncategorised Waste Disposal Sites' (4.A.3).

It is estimated that in 2015, the waste and garbage of about 41% of Namibian households was sent to waste disposal sites, about 36% being collected on a regular basis and 5% being collected irregularly. There is a sharp contrast between urban and rural areas since, while the waste of 73% of urban households was collected on a regular (65%) or irregular (8%) basis, only about 7% of the rural households has the same service (5% on a regular basis and 2% irregularly).

On average, waste collection (regular and irregular basis) remained fairly constant during the 2001 to the 2011 period, moving from about 42.2% of households having access to the service in 2001 to 42.4% in 2011. However, it should be noted, that during the same period, regular collection increased from 30.9% to 37.2% of households while irregular collection decreased from 11.5% to reach only 5.2% of households. From 2011 to 2015, the percentage of household serviced gradually decreased to reach about 41%, both regular and irregular collection decreasing slightly to 36% and 5% of households respectively.

7.1.2. Open Burning of Waste

It is estimated that at national level in 2015, the waste and garbage of some 32% of Namibian households were open burnt, a sharp contrast being observed between urban and rural areas, about 10% of urban households being concerned with open burning, while some 61% of their rural counterparts were concerned by the same method of solid waste management.

Trend analysis reveals that the percentage households whose waste was open burnt increased from 18.0% in 2001 to 37.8% in 2011 and thereafter decreased to about 34% in 2015. Data also show that open burning of waste is a far more frequent practice in rural areas as compared to urban ones.

7.1.3. Domestic Wastewater Treatment and Discharge

The estimated percentage distribution of household by type of main toilet facility for the year 2015 is given in Table 7.2. At the country level, a notable fact is that around 47 % of the population did not have any toilet facility. All regions confounded, about 41% of the households had either a private or shared flush system, of which around 60% were connected to a sewer system and 3% to a septic tank. The remaining households used ventilated pits (about 8%), latrines without ventilation system (about 4%), or had recourse to buckets (about 1%).

7.1.4. Industrial Wastewater Treatment and Discharge

Industrial wastewater of relevance to GHG emissions originates mainly from such activities as fish processing, slaughterhouses, meat conditioning, tanneries and breweries. Because of unavailable data, only the meat sector and fish processing are covered in this inventory. It should be noted that these two activities account for a major part of industrial wastewater in the country.

7.2. Methods

GHG emissions originating from the Waste Sector were estimated following a Tier 1 methodological approach as per the IPCC 2006 Guidelines for National Greenhouse Gas Inventories and computed using the IPCC 2006 software.

7.3. Activity Data

7.3.1. Solid waste

Data from municipal councils coupled with population census statistics were first used to estimate solid waste generation for "high-income" urban and "low-income" urban regions for 2010. The need for this categorization has been prompted by the sustained and significant population migration from rural to urban regions with the emergence of fast expanding suburbs to the main cities where the dwellers' lifestyle is of the urban type with a relatively lower purchasing power.

Estimates of solid waste generation for rural regions for 2010 were subsequently worked out by discounting solid wastes which are typically generated by urban dwellers from the landfills data available. These solid waste generation potentials were also compared with those in the 2006 IPCC Guidelines (Volume 5: Waste, Page 2.5, Table 2.1).

Using the 2001, 2006 and 2011 Population and Housing Census Reports (interpolated or extrapolated for non-census years) and other data source such as the FAO; adjusting for socio-economic factors and extrapolating waste generation from Windhoek data, estimates for solid waste generation were made for the period 1995 to 2015.

The process of calculating solid waste generation was not straightforward because of the lack of data. Furthermore, no official data was available on waste categorization which would have enabled more accurate estimations of GHG emissions. Thus, all the waste from Urban regions were considered as sent to solid waste disposal sites while 80 % of the waste from the rural regions were open burned.

The amount of sludge generated per capita for 2010 was estimated using that year's data for Windhoek City Council. Using this factor and urban population, the amount of sludge generated for the period 1990 to 2014 was then estimated for the other urban areas. AD for the period 1991 to 2015 is given in Table 7.1.

Table 7.1 - Activity data for MSW in Waste sector (1991 - 2015)

	Municipal Solid Waste (MSW) (t)			Sent to MSW (Gg)	
Year	Urban high	Urban low	Rural	Sludge	Industrial waste
1991	-	40.41	68.93	0.72	22.42
1992	-	43.04	71.63	0.74	23.43
1993	-	45.82	74.42	0.77	24.49
1994	-	48.77	77.32	0.80	25.60
1995	-	51.89	80.33	0.83	26.76
1996	-	55.20	83.45	0.87	27.97
1997	-	58.71	86.68	0.90	29.24
1998	-	62.42	90.04	0.93	30.56
1999	-	66.35	93.52	0.97	31.94
2000	-	70.50	97.14	1.00	33.39
2001	40.28	39.22	100.88	1.57	34.90
2002	44.04	43.16	105.82	1.65	36.48
2003	48.07	47.48	110.97	1.72	38.13
2004	52.40	52.23	116.34	1.80	39.86
2005	57.04	57.43	121.94	1.88	41.66
2006	62.01	63.13	127.79	1.96	43.55
2007	67.33	69.37	133.87	2.04	45.52
2008	73.04	76.20	140.21	2.13	47.58
2009	79.14	83.68	146.81	2.22	49.73
2010	85.67	91.85	153.67	2.31	51.98
2011	92.66	100.78	160.81	2.40	54.33
2012	97.45	107.19	184.32	2.50	58.27
2013	102.40	113.89	187.14	2.60	59.05
2014	107.51	120.91	189.89	2.70	59.82
2015	112.77	128.25	192.53	2.80	60.57

7.3.2. Wastewater

The actual amount of domestic wastewater generated was not available at country level. However, the different types and usage levels of treatment or discharge as per the NPHC 2001, 2006 and 2011 census reports were used as well as the respective IPCC 2006 Guidelines (Vol 5.3 Ch 3 Table 3.1) default MCFs. The use the different waste systems have been harmonized into three main types: Centralized aerobic, septic tank and latrines. The timeseries of the evolution of the three types of sewage systems and the use rate is given in Table 7.2.

Table 7.2 - Timeseries for use rate of different sewage systems in Namibia

Year	Urban high			Urban low			Rural		
	Centralized aerobic	Latrine	Septic Tank	Centralized aerobic	Latrine	Septic Tank	Centralized aerobic	Latrine	Septic
1991	0.738	0.041	0	0909	0.105	0022	0.107	0.092	0.011
1992	0.740	0.040	0	0.895	0.104	0.023	0.106	0.092	0.011
1993	0.741	0.040	0	0.880	0.103	0.024	0.105	0.093	0.012
1994	0.743	0.039	0.002	0.866	0.102	0.025	0.104	0.094	0.013

Year	Urban high			Urban low			Rural		
	Centralized aerobic	Latrine	Septic Tank	Centralized aerobic	Latrine	Septic Tank	Centralized aerobic	Latrine	Septic
1995	0.744	0.039	0.003	0.851	0.101	0.025	0.104	0.095	0.014
1996	0.746	0.038	0.005	0.836	0.100	0.026	0.103	0.096	0.015
1997	0.748	0.037	0.007	0.822	0.099	0.027	0.102	0.097	0.016
1998	0.749	0.037	0.008	0.807	0.098	0.027	0.101	0.098	0.016
1999	0.751	0.036	0.010	0.793	0.097	0.028	0.101	0.099	0.017
2000	0.752	0.036	0.011	0.791	0.097	0.029	0.102	0.099	0.017
2001	0.754	0.035	0.013	0.741	0.095	0.028	0.096	0.102	0.020
2002	0.756	0.034	0.015	0.756	0.095	0.030	0.099	0.101	0.019
2003	0.757	0.034	0.016	0.738	0.094	0.031	0.098	0.102	0.020
2004	0.759	0.033	0.018	0.720	0.093	0.031	0.097	0.103	0.021
2005	0.760	0.033	0.019	0.702	0.092	0.032	0.096	0.105	0.022
2006	0.762	0.032	0.021	0.749	0.092	0.036	0.104	0.102	0.020
2007	0.764	0.031	0.023	0.667	0.090	0.033	0.093	0.107	0.024
2008	0.765	0.031	0.024	0.649	0.089	0.033	0.092	0.108	0.025
2009	0.767	0.030	0.026	0.631	0.088	0.034	0.091	0.109	0.026
2010	0.768	0.030	0.027	0.613	0.087	0.034	0.090	0.110	0.027
2011	0.770	0.029	0.029	0.563	0.085	0.033	0.084	0.113	0.030
2012	0.772	0.028	0.031	0.543	0.084	0.033	0.082	0.115	0.033
2013	0.774	0.027	0.033	0.516	0.083	0.033	0.080	0.116	0.034
2014	0.775	0.027	0.034	0.488	0.082	0.033	0.077	0.118	0.036
2015	0.777	0.026	0.036	0.0460	0.080	0.033	0.074	0.120	0.038

Coupled with the use rate, the fraction of population living in the 3 different zones,namely, urban high, urban low and rural was also generated in a timeseries as input in the software. The evolution of the different population fraction used is given in Table 7.3.

Table 7.3 - Fraction of population living in the different areas

Year	Fraction population		
	Urban high	Urban low	Rural
1991	0.127	0.153	0.723
1992	0.130	0.153	0.720
1993	0.133	0.155	0.715
1994	0.136	0.159	0.705
1995	0.139	0.161	0.700
1996	0.142	0.163	0.695
1997	0.145	0.165	0.690
1998	0.148	0.167	0.685
1999	0.151	0.169	0.680
2000	0.154	0.166	0.680
2001	0.157	0.173	0.670
2002	0.161	0.179	0.660
2003	0.165	0.185	0.650
2004	0.169	0.191	0.640
2005	0.173	0.197	0.630
2006	0.177	0.203	0.620
2007	0.180	0.210	0.610
2008	0.184	0.216	0.600

Year	Fraction population		
	Urban high	Urban low	Rural
2009	0.187	0.223	0.590
2010	0.190	0.230	0.580
2011	0.193	0.237	0.570
2012	0.196	0.244	0.560
2013	0.200	0.250	0.550
2014	0.203	0.257	0.540
2015	0.206	0.264	0.530

The protein content in the diet of the population is also needed as an AD for calculation of emissions from domestic wastewater. FAO data for years 1999 to 2014 is available. Trending technique was applied to generate the data for years 1994 to 1997. Table 7.4 summarizes the data for protein intake by the population.

Table 7.4 - Annual per capita protein intake in Namibia

Year	Protein intake (kg per capita / year)
1991	26.353
1992	26.061
1993	25.477
1994	25.477
1995	25.185
1996	24.893
1997	24.601
1998	24.309
1999	24.090
2000	23.725
2001	23.360
2002	22.995
2003	22.995
2004	22.995
2005	22.995
2006	23.360
2007	22.995
2008	22.265
2009	21.900
2010	21.535
2011	21.170
2012	20.659
2013	20.221
2014	19.783
2015	19.345

Exploitable data on industrial waste water production were available only for the meat (beef and sheep) (source: Meatco factories, Agric Stats 2009, AGRA) and fish (Pilchards and Mackerel processing) (source: Ministry of Fisheries, Annual report 2005, Source for 2006 to 2010 - Preliminary census 2011 data) industries. The total meat industry product and the amount of wastewater as provided by local authorities were used in conjunction with the respective IPCC 2006 Guidelines (Vol 5.3 Ch 3 Table 3.1) defaults for calculation of emissions. AD for industrial wastewater is given in Table 7.5.

Table 7.5 - Activity data for industrial wastewater (1991 - 2015)

Year	Fish processing (t)	Meat and Poultry (t)
1991	502,000	46,310
1992	508,000	46,617
1993	490,600	50,061
1994	475,000	46,868
1995	409,000	43,051
1996	321,000	43,813
1997	338,000	28,311
1998	323,000	36,629
1999	330,000	43,575
2000	362,805	44,822
2001	326,008	42,135
2002	263,343	47,869
2003	383,002	46,104
2004	339,010	46,147
2005	352,828	53,176
2006	312,294	46,395
2007	225,182	46,219
2008	205,751	47,537
2009	235,188	50,751
2010	240,518	48,622
2011	230,440	44,001
2012	313,193	43,394
2013	230,270	43,080
2014	208,634	44,093
2015	255,485	46,698

7.4. Emission factors

In the absence of country specific EFs, the default values provided within the IPCC 2006 software and IPCC 2006 Guidelines (Vol_5_Ch6_Wastewater Table 6.8 and Table 6.9) were used for estimating GHG emissions.

7.5. Emission estimates

7.5.1. Aggregated emissions by gas for inventory year 2015

In 2015, a total of 163.20 Gg CO_2-eq. were emitted from sector Waste. The most important contributor to emissions was CH_4 with 135.17 Gg CO_2-eq, representing 82.8 % emissions, followed by N_2O with 25.62 Gg CO_2-eq (15.7 % emissions) and CO_2 with 2.40 Gg CO_2-eq (1.5 % emissions) (Figure 7.1).

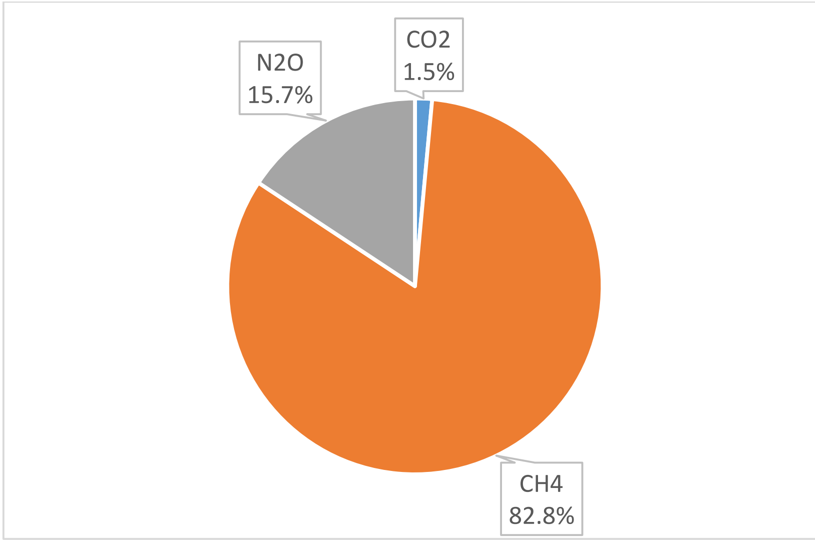

Figure 7.1 - Percentage distribution of emissions for waste Sector (2015)

7.5.2. Other emissions by gas for inventory year 2015

In 2015 sector Waste also emitted 0.57 Gg of NMVOCs, 0.49 Gg NO_x, 0.08 Gg N_2O and 0.02 Gg SO_2 (Figure 7.2).

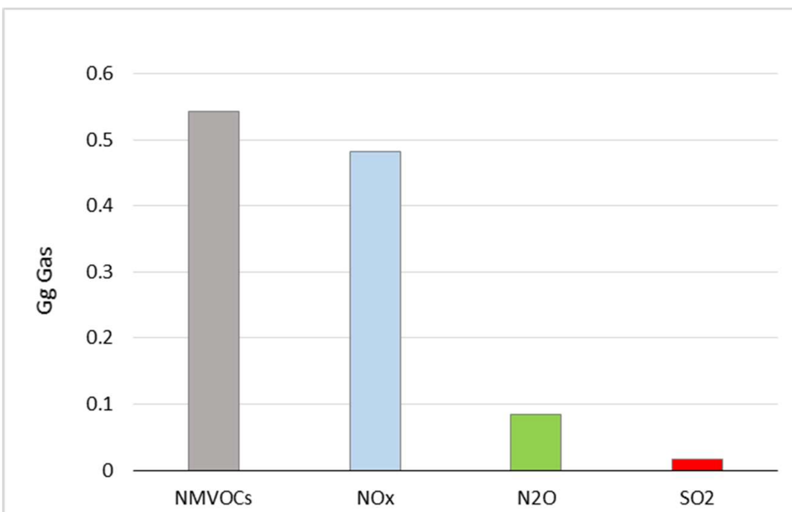

Figure 7.2 - Emissions of N_2O, NO_x, NMVOCs and SO_2 from waste Sector (2015)

7.5.3. Emission trend by gas for the period 1991 to 2015

Analysis of aggregated emission trend by gas (Figure 7.3) shows the following:

(i) CH_4 was the main contributor to emissions from sector waste, with 135.17 Gg CO_2-eq. in 2015, representing 82.8% of total emissions from the sector.

(ii) N_2O was the second contributor to emissions with 25.62 Gg CO_2-eq. in 2015, representing 15.7% of total emissions from the sector.

(iii) CO_2 contributed to a much lesser extent, with 2.40 Gg in 2015, representing 1.5% of total emissions from the sector.

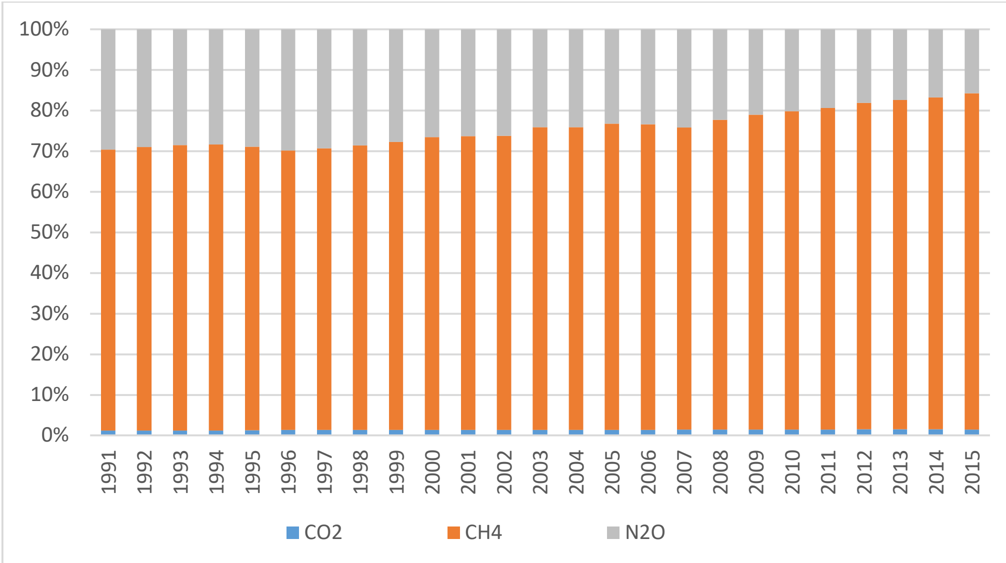

Figure 7.3 - Percentage distribution of emissions for waste Sector (1991 - 2015)

7.5.4. Emissions by waste category for inventory year 2015

Out of the total emissions of 163.20 Gg CO_2-eq. recorded in 2015, Solid Waste Disposal was the most important contributor with 84.18 Gg CO_2-eq. (51.6% of total), followed by Domestic Wastewater Treatment and Discharge with 34.40 Gg CO_2-eq (21.1%), Open Burning of Waste, with 27.62 Gg (16.9%) and Industrial Wastewater Treatment and Discharge, with 17.0 Gg CO_2-eq (10.4%) (Table 7.6).

During the same inventory year, sector waste also emitted 0.49 Gg NO_x, 8.64 Gg CO, 0.57 Gg NMVOC and 0.02 Gg SO_2 (Table 7.6).

Table 7.6 - Emissions from Waste sector for inventory year 2015

Categories	Emissions (Gg CO_2 eq)				Emissions (Gg)			
	CO_2	CH_4	N_2O	Total CO_2 eq	NO_x	CO	NMVOCs	SO_2
4 - Waste	2.40	135.174	25.62	163.20	0.49	8.64	0.57	0.02
4.A - Solid Waste Disposal	-	84.18	-	84.18	-	-	0.38	-
4.A.2 - Unmanaged Waste Disposal Sites	-	76.86	-	76.86	-	-	0.38	-
4.C - Incineration and Open Burning of Waste	2.40	20.74	4.10	27.61	0.49	8.64	0.19	0.02
4.C.2 - Open Burning of Waste	2.40	20.74	4.10	27.61	0.49	8.64	0.19	0.02
4.D - Wastewater Treatment and Discharge	-	26.75	21.52	51.40	-	-	1.00E-06	-
4.D.1 - Domestic Wastewater Treatment and Discharge		12.36	21.52	34.40	-	-	8.00E-07	-
4.D.2 - Industrial Wastewater treatment and Discharge	-	14.38	-	17.00	-	-	2.00E-07	-

Table 7.7 - Sectoral Table: Waste (Inventory Year: 2015)

Categories	Gg						
	CO_2	CH4	N2O	NOx	CO	NMVOCs	SO2
4 - Waste	2.400	6.437	0.083	0.000	0.000	0.000	0.000
4.A - Solid Waste Disposal	0.000	4.009	0.000	0.000	0.000	0.000	0.000
4.A.1 - Managed Waste Disposal Sites	NA	0.000	NA	NO	NO	NO	NA
4.A.2 - Unmanaged Waste Disposal Sites	NA	0.000	NA	NO	NO	NO	NA
4.A.3 - Uncategorised Waste Disposal Sites	NA	0.000	NA	NO	NO	0.000	NA
4.B - Biological Treatment of Solid Waste	NA	NO	NO	NO	NO	NO	NA
4.C - Incineration and Open Burning of Waste	2.400	1.005	0.013	0.000	0.000	0.000	0.000
4.C.1 - Waste Incineration	NE	NE	NE	NE	NE	NE	NE
4.C.2 - Open Burning of Waste	2.400	1.005	0.013	0.000	0.000	0.000	0.000
4.D - Wastewater Treatment and Discharge	NA	1.423	0.069	NO	NO	0.000	0.000
4.D.1 - Domestic Wastewaster Treatment and Discharge	NA	0.613	0.069	NO	NO	0.000	NA
4.D.2 - Industrial Wastewater Treatment and Discharge	NA	0.809	NA	NO	NO	0.000	NA
4.E - Other (please specify)	NO	NO	NO	NO	NO	NO	NO

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