REPUBLIC OF NAMIBIA

NATIONAL GHG INVENTORY REPORT
NIR3
1994 - 2014

October 2018

PART 1

REPUBLIC OF NAMIBIA

NATIONAL GHG INVENTORY REPORT
NIR3
1994 - 2014

October 2018

PART 1

MET, Private bag 13306, Windhoek, Namibia
Phone: +264612842701

Foreword

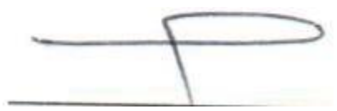
Hon. Pohamba Shifeta
Minister of Environment and Tourism

As the minister of the Ministry of Environment and Tourism, it is an honour and privilege for me to present Namibia's stand alone National GHG Inventory (NIR) for the period 1994 to 2014 in fulfilment of its obligations as a Non-Annex I (NAI) Party to the United Nations Framework Convention on Climate Change (UNFCCC) in accordance with the enhanced reporting requirements adopted at the 16^{th} and 17^{th} Conference of the Parties (COP).

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 in 2014 (BUR 1), the Third National Communication (TNC) in 2015 and the Second Biennial Update Report (BUR 2) in 2016. Furthermore, Namibia prepared and submitted its Intended Nationally Determined Contributions (INDC) in 2015.

Namibia is currently busy preparing its Fourth National Communication (NC4) which will be submitted in 2019. Namibia became 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. BUR 3 provides an update on Namibia's Greenhouse Gas (GHG) inventory, mitigation actions and their effects, including the associated domestic Monitoring, Reporting and Verification (MRV), and needs and support received, and institutional arrangements. BUR 3 will be submitted with a stand alone National GHG Inventory (NIR) making it the third NIR Namibia has submitted 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.



____

Hon. Pohamba Shifeta
Minister of Environment and Tourism

Acknowledgements

The Ministry of Environment and Tourism, on behalf of the Government of the Republic of Namibia, was entrusted with the responsibility for computing the National Inventory of Greenhouse Gases, within the framework of the preparation of the BUR3 to the UNFCCC, for the Republic to meet its obligations as a signatory Party to the Convention. This Ministry acknowledges the valuable financial support received from the Global Environment Facility through its implementing agency, the UNDP country office.

Namibia is grateful to all international institutions, namely IPCC, the United Nations Framework Convention on Climate Change (UNFCCC) secretariat and the Global Support Programme of the UN Environment and UNDP for providing very useful handbooks, guidelines and the QA exercise for the preparation of the Inventory and the GSP for reviewing the draft National Inventory Report and making useful comments for improving the final document towards enhancing the TCCCA standard.

Namibia also wishes to extend its appreciation for the contribution of the representatives of the institutions and private sector organizations, which collaborated in this work, as well as CLIMAGRIC LTD, that offered consultancy services for capacity building of the inventory team, the computation of the GHG Inventory and the preparation of this National Inventory Report.

Name	Institution	Sector
Mr. Petrus Muteyauli	Ministry of Environment and Tourism	National Focal Point
Mr. Reagan Chunga	Ministry of Environment and Tourism	Project Coordinator - NCs/BURs
Mr. Rasack Nayamuth	Climagric	Resource persons
Ms. Susan Tise	Ministry of Mines and Energy	
Mr. Edison Hiwanaame	NAMPOWER	
Mr. Abednego Ekandjo	Ministry of Mines and Energy	
Mr. Abraham Hangula	Namibia Energy Institute	Energy
Mr. Natangwe Nekuiyu		
Mr. Naville Geiriseb	Ministry of Works and Transport	
Ms. Charlene Binga		
Mr. Frans Nekuma		
Ms. Amalia Nangolo	Ministry of Industralization, Trade & SME Development	
Mr. Festus Oscar		IPPU
Mr. Konzmann Tobias	Ohorongo Cement	
Mr. Paulus Shikongo		
Ms. Sarafia Ashipala	Ministry of Agriculture, Water and Forestry	
Mr. Edward Muhoko		
Mr. Josephat Katuahupira		AFOLU
Mr. Tony Holbling	MEATCO	
Mr. Heinrich Lesch	Namibia Dairies	
Ms. Fransina Angula		
Ms. Saara Niitenge	Namibia Statistics Agency	Data Providers
Mr. Elijah Saushini		
Mr. Olavi Makutsi	City of Windhoek	
Mr. Stellio Tsauseb	City of Windhoek	Waste
Mr. Clive Lawrence	Swakopmund Municipality	

Table of contents

List of tables

List of figures

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	Forest Land
FOLU	Forestry and Other Land Use
FRA	Global Forest Resources Assessment 2010
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	Oxides of nitrogen
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	Tonnes
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 five inventories as components of its first, second and third national communications and its first and second Biennial Update Reports. More exhaustive information on the last inventory can be obtained by perusing the full NIR1 and NIR2 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 NIR3 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, each of these on a stand-alone basis, 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 NIR3 covers the period 1994 to 2014, 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.

ES 3. Institutional arrangements and GHG inventory system

Namibia outsourced its first two inventories and started to invest in producing its inventories in-house with the one published in the BUR 1. This capacity building exercise continued with the preparation of the other inventories to further improve, implement and consolidate the GHG inventory management system being developed. The process of preparation of GHG inventories, by the newly constituted team, remained a very laborious exercise as resources and human capacities continued to be limiting factors. Implementation of the different steps of the inventory cycle was staged over less than a year instead of a longer period to fit the availability of funds from the GEF for the compilation of this inventory. Due to this time constraint, it is obvious that there still exist shortcomings in this inventory, but the country is committed to strive to raise the quality of future GHG inventories through further strengthening of the GHG inventory system and human capacities.

The Climate Change Unit (CCU) of the Ministry of Environment and Tourism has the responsibility for overlooking the production of reports to the Convention, including the GHG inventories in its capacity as

National Focal Point of the Convention. The same framework as in the past was adopted for the present inventory and all stakeholders agreed to pursue with sharing the responsibilities for the compilation exercise between different departments of the key ministries as for the BUR2. The exercise of mapping of national institutions and organizations was renewed to identify any stakeholder that could contribute in one way or the other for the inventory compilation but is not included in the institutional arrangements. Thus, data providers and possible institutions and organizations to support derivation of emission factors (EFs) to suit national circumstances and enable adoption of Tier 2, were consolidated. It was also decided to maintain existing collaboration streams as they are working satisfactorily and there is no need for other official formal engagements. An international consultant was appointed to further capacity building, follow and guide the team until the production of the final output, which is the NIR3 and its summarization into the chapter for the BUR 3. Capacity building of all inventory team members continued on the different steps of the inventory cycle as well as on data management, running the 2006 IPCC software, analysing the outputs and reporting to the Convention. All members were once more engaged to ensure consistency of the inventory as the time series is being extended by another 8 years, 1994 to 1999, 2013 and 2014.

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	Global Warming

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

ES 5. Activity data

Country-specific 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 NIR3, under the section for the individual sectors or categories as applicable.

ES 6. Emission factors

Country emission factors 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 GHG sink over the period 1994 to 2014 as a result of the Land sector removals exceeding emissions. The net removal of CO_2 increased by 20,484 Gg from 77,770 Gg to 98,254 Gg in

2014, representing an increase of 26.3% over these 21 years. During the same period, the country recorded an increase of 12.1% in emissions, 2,291 Gg CO_2-eq from 18889 Gg CO_2-eq to 21,180 Gg CO_2-eq. The trend for the period 1994 to 2014 indicates that the total removals from the LAND category increased from 96,659 Gg CO_2-eq in 1994 to 119,434 (23.6%) Gg CO_2-eq in 2014 (Figure 1.1).

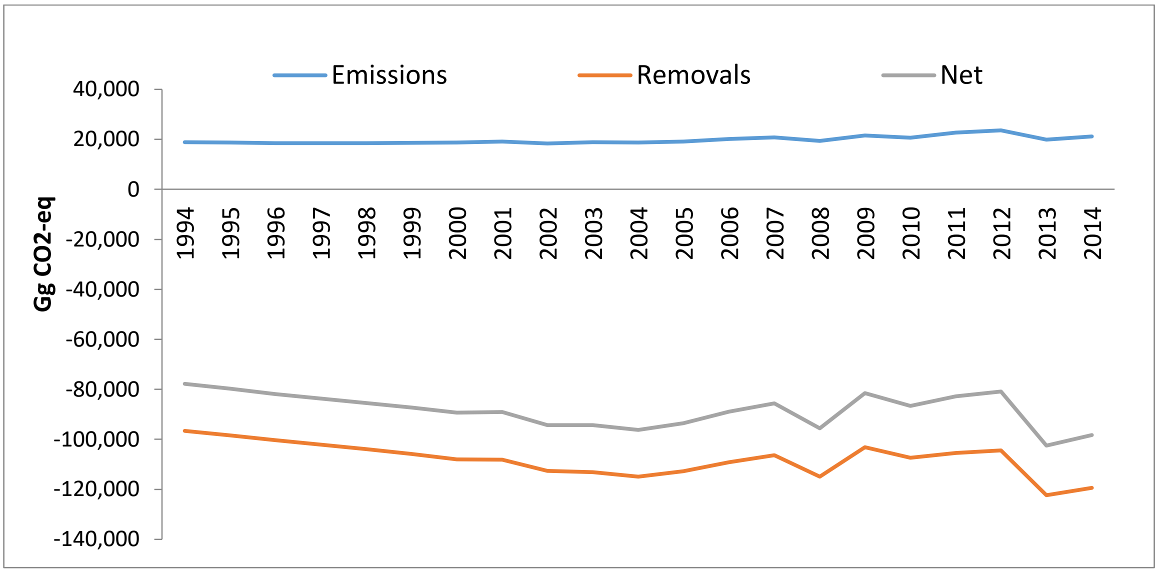


Figure ES 1.1 - National emissions, removals and net removals (Gg CO_2-eq) (1994 – 2014)

Per capita emissions of GHG decreased gradually from 11.9 tonnes CO_2-eq in 1994 to reach 9.9 tonnes in 2002; it then plateaued between 9.8 and 10.0 tonnes up to 2005 after which period it varied to reach 9.6 tonnes CO_2-eq in 2014 (Figure 1.2). The GDP emission index decreased almost steadily from 100 in the year 1994 to 46.6 in 2014 (Figure 1.3). This reflects the low emissions development strategy adopted by Namibia since more than a decade now.

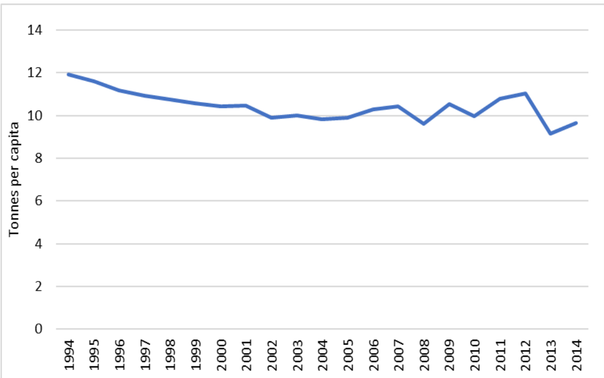


Figure ES 1.2 - Per capita GHG emissions (1994 - 2014)

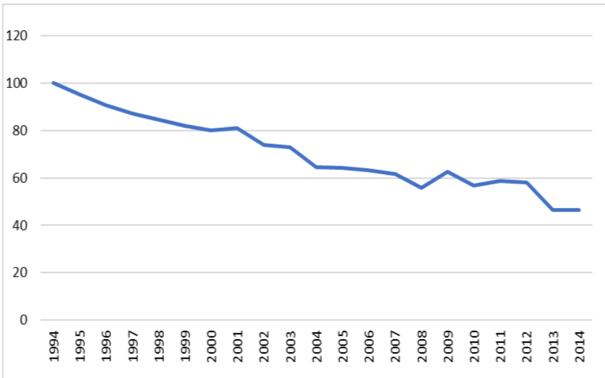


Figure ES 1.3 - GDP emissions index (1994 - 2014)

National and sectoral emissions are presented in Table 1.1 and Figure 1.4. Total national emissions increased by 12.1% over these 21 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, IPPU sector took over as the third emitter in lieu of the Waste sector as from the year 2003. Emissions from the AFOLU sector increased from 17,328 Gg CO_2-eq in 1994 to peak at 19,275 Gg CO_2-eq in 2012 and then regressed to 17,271 in 2014, representing a decrease of 0.3% from the 1994 level. The share of GHG emissions from the AFOLU sector out of total national emissions regressed from 91.7% in 1994 to 81.5% in 2014.

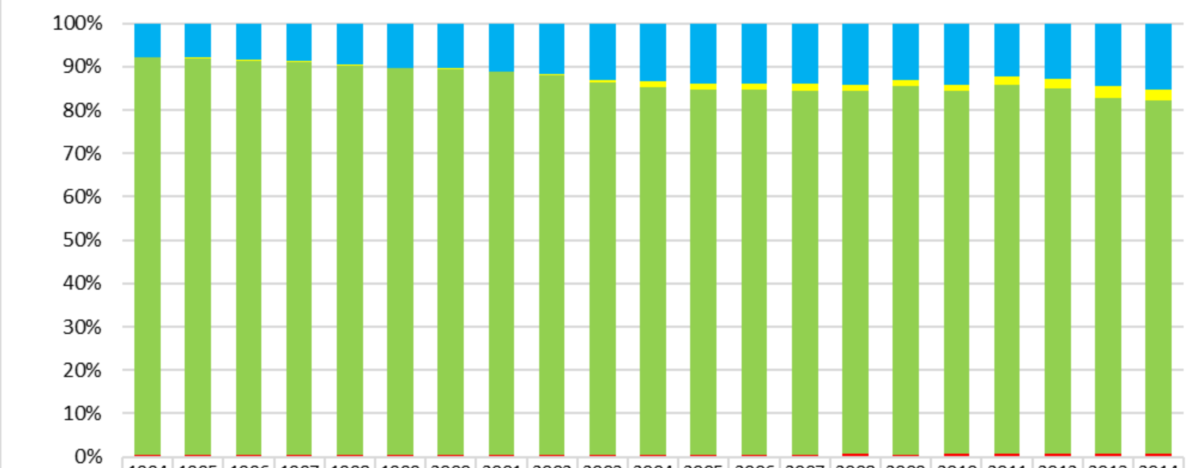
Energy emissions increased from 1,464 Gg CO_2-eq (7.8%) of national emissions in 1994 to 3,234 Gg CO_2-eq (15.3%) in 2014 as depicted in Table 1.1. During the period 1994 to 2014, the average annual increase of GHG emissions was by 6.0%%.

The contribution of the IPPU sector in total national emissions increased from 22 Gg CO_2-eq in 1994 to 522 Gg CO_2-eq in 2014 (Table 1.1). 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 1994 level of 75 Gg CO_2-eq to 153 Gg CO_2-eq in 2014 (Table 1.1), representing a 5.0% increase.

Table ES 1.1 - National GHG emissions (Gg, CO_2-eq) by sector (1994 - 2014)

Year	Total emissions	Energy	IPPU	AFOLU	Waste
1994	18,889	1,464	22	17,328	75
1995	18,752	1,473	23	17,183	72
1996	18,439	1,566	23	16,777	73
1997	18,442	1,617	24	16,726	76
1998	18,495	1,759	24	16,633	79
1999	18,553	1,893	25	16,551	83
2000	18,684	1,934	25	16,637	88
2001	19,157	2,116	25	16,927	90
2002	18,353	2,163	27	16,073	91
2003	18,842	2,454	110	16,176	101
2004	18,742	2,521	237	15,879	103
2005	19,135	2,671	260	16,094	110
2006	20,194	2,823	255	17,003	112
2007	20,725	2,907	293	17,415	109
2008	19,416	2,752	291	16,256	117
2009	21,549	2,832	303	18,289	125
2010	20,720	2,923	301	17,365	131
2011	22,699	2,796	438	19,326	138
2012	23,542	3,003	515	19,875	149
2013	19,829	2,861	528	16,291	149
2014	21,180	3,234	522	17,271	153



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Energy	7.8	7.9	8.5	8.8	9.5	10.2	10.3	11.0	11.8	13.0	13.5	14.0	14.0	14.0	14.2	13.1	14.1	12.3	12.8	14.4	15.3
IPPU	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.6	1.3	1.4	1.3	1.4	1.5	1.4	1.5	1.9	2.2	2.7	2.5
AFOLU	91.7	91.6	91.0	90.7	89.9	89.2	89.0	88.4	87.6	85.9	84.7	84.1	84.2	84.0	83.7	84.9	83.8	85.1	84.4	82.2	81.5
Waste	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.5	0.6	0.6	0.6	0.6	0.6	0.8	0.7

Figure ES 1.4. Share (%) of emissions by sector

Emissions by gas

The share of emissions by gas did not change during the period 1994 to 2014. 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 these of CH_4 and N_2O regressed over the time series. In 2014, the share of the GHG emissions was as follows: 63.44% CO_2, 23.98% CH_4 and 12.58% N_2O. The trend of the aggregated emissions and removals by gas is given in Table 1.2.

Table ES 1.2 - National GHG emissions and removals (Gg CO_2-eq) by gas (1994 - 2014)

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)
1994	18,889	-96,659	-77,770	10,169	5,837	2,884
1995	18,752	-98,466	-79,715	10,177	5,728	2,847
1996	18,439	-100,291	-81,852	10,268	5,458	2,713
1997	18,442	-102,133	-83,691	10,318	5,415	2,710
1998	18,495	-103,992	-85,497	10,457	5,352	2,685
1999	18,553	-105,869	-87,316	10,591	5,295	2,667
2000	18,684	-108,067	-89,383	10,629	5,367	2,687
2001	19,157	-108,212	-89,055	11,021	5,394	2,742
2002	18,353	-112,687	-94,333	11,070	4,797	2,487
2003	18,842	-113,128	-94,287	11,438	4,873	2,531
2004	18,742	-114,949	-96,208	11,630	4,665	2,447
2005	19,135	-112,723	-93,588	11,799	4,832	2,504
2006	20,194	-109,119	-88,925	11,944	5,458	2,793
2007	20,725	-106,355	-85,630	12,063	5,717	2,945
2008	19,416	-114,977	-95,561	11,910	4,944	2,563
2009	21,549	-103,127	-81,578	11,999	6,362	3,187
2010	20,720	-107,364	-86,644	12,086	5,732	2,903
2011	22,699	-105,448	-82,749	12,922	6,477	3,300
2012	23,542	-104,485	-80,943	13,204	6,845	3,494
2013	19,829	-122,363	-102,534	13,076	4,395	2,359

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)
2014	21,180	-119,434	-98,254	13,436	5,079	2,665

The share of emissions by gas is given in Figure 1.5. CO_2 increased from 54% of total aggregated national emissions in the year 1994 to 63% in 2014. The other two gases, CH_4 and N_2O, decreased from about 31% and 15% to some 24% and 13% respectively over this period of 21 years.

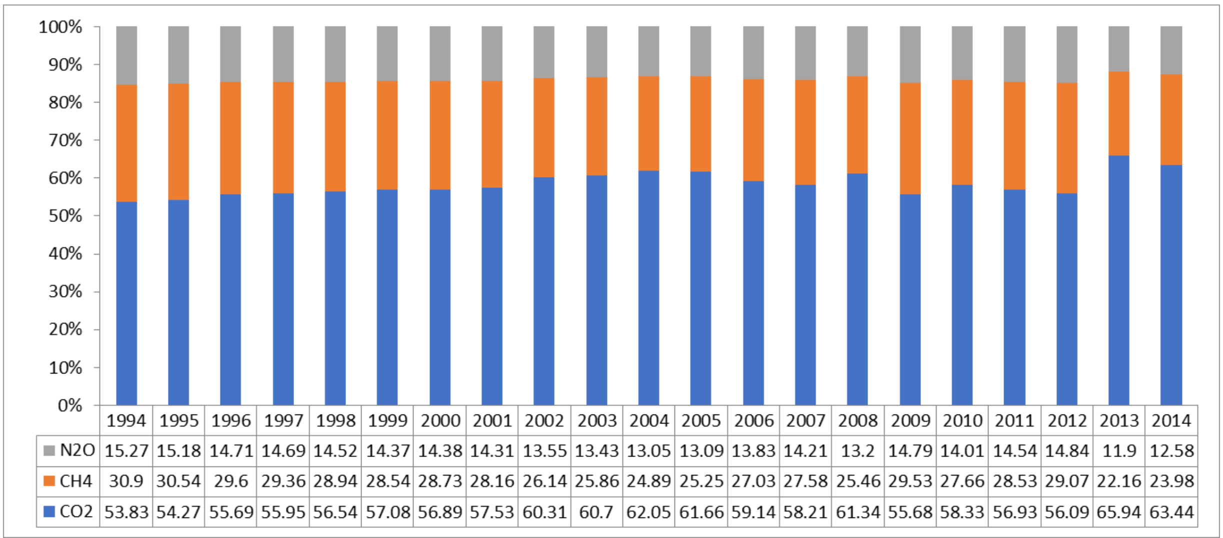


Figure ES 1.5 - Share of aggregated emissions (%) by gas (1994 - 2014)

Emissions of indirect GHGs (CO, NO_x and NMVOC) and SO_2, have also been estimated and reported in the inventory. Indirect GHGs have not been included in national total emissions. Emissions of these gases for the period 1994 to 2014 are given in Table 1.3. Emissions of NO_x decreased from 48.4 Gg in the year 1994 to 38.2 Gg in 2014. Carbon monoxide emissions also regressed from 2198 Gg in 1994 to 939 Gg in 2014. Emissions of NMVOC increased from 15.9 Gg in 1994 to 24.5 Gg in 2014 whilst emissions of SO_2 varied between 1.9 Gg and 4.2 Gg during the same period

Table ES 1.3 - Emissions (Gg) of GHG precursors and SO_2 (1994 - 2014)

Year	NO_x	CO	NMVOC	SO_2
1994	48.4	2,198.1	15.9	2.6
1995	45.0	2,082.6	16.0	2.1
1996	43.7	1,966.5	16.2	2.2
1997	41.4	1,849.1	16.7	1.9
1998	41.4	1,731.1	17.6	2.3
1999	41.1	1,611.9	18.4	2.5
2000	39.0	1,465.5	19.8	2.2
2001	40.6	1,478.7	19.7	2.4
2002	37.0	1,132.8	19.3	2.7
2003	38.8	1,140.6	20.1	3.0
2004	36.9	1,024.7	20.5	3.5
2005	41.1	1,267.2	20.4	3.7
2006	45.5	1,618.8	21.3	4.2
2007	49.3	1,904.4	21.4	4.0
2008	37.0	1,200.4	21.3	4.1
2009	54.9	2,263.2	21.7	3.7

Year	NO_x	CO	NMVOC	SO_2
2010	51.2	1,946.0	21.8	3.0
2011	52.7	2,076.8	13.0	3.0
2012	56.3	2,166.1	23.9	3.7
2013	30.7	657.3	22.6	2.5
2014	38.2	939.4	24.5	2.7

Summary result for the year 2014

The summary results from the software are presented in Annex 21 for the year 2014. The full sets for the whole time series 1994 to 2014 are available in Annexes 1 to 21 in Part 2 of this NIR3 report.

The following findings are based on the 2014 compilations:

(i) most CO_2 were emitted in the AFOLU sector with some 9700 Gg. Concurrently, this sector acted as a sink of about 120,000 Gg, to be a net sink of about 110,300 Gg for the year 2014. The Energy sector came next with emissions of 3142 Gg.

(ii) CH_4 also emanated mainly from the AFOLU sector followed by the Waste sector. Emissions were 242 Gg and 6 Gg for the year 2014 for these two sectors respectively. The Energy sector was responsible for 2 Gg of CH_4 emissions in 2014.

(iii) N_2O emissions, 8.4 Gg, were associated with the AFOLU sector primarily which contributed more than 97% of national emissions of this gas.

(iv) Among the indirect GHGs, the AFOLU sector was the highest emitter of CO at 91% of national emissions with 858 Gg, followed by Energy with 73 Gg and Waste with 8.5 Gg. Energy emitted 24.4 Gg of national NO_x emissions and AFOLU was responsible for 13.3 Gg. The Energy and AFOLU sectors contributed 9.2 Gg and 12.5 Gg of total NMVOCs emissions which stood at around 24.5 Gg.

(v) SO_2 emissions of 2.7 Gg emanated from the Energy sector and represented more than 99% of national emissions.

ES 9. QA/QC

Namibia has its own national system for quality control (QC) of data which are 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 compiler and the QA/QC process for the inventory 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, and the problem discussed and solved. 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.

Furthermore, the AD were compared with those available on international database such as those of FAO, the UN statistical database and the International Energy Agency. However, Namibia is yet to develop and implement a QC management system and this is one of the improvements contemplated in the future.

QA was undertaken by independent reviewers who were not involved with the compilation of the inventory, the main objectives being to:

- Confirm data quality and reliability from different sources wherever possible;
- 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.

Namibia requested the UNFCCC and Global Support Programme to undertake a QA exercise on its inventory compilation process. Unfortunately, the exercise was performed when the inventory report was not yet completed but on information available at that time. The main conclusions are:

- Attempt at collecting missing Ad for improving the completeness of the inventory, namely use of N_2O for medical applications, ODS and incineration of medical waste;
- Improve the Institutional arrangements to ensure annual provision of Ad for preparing the inventory;
- Develop and implement a QC management system;
- Improve AD for the AFOLU sector through production of new maps to generate land use changes, national stock and Emission factors, possible use of Collect earth for confirming the assumptions and data used;
- Develop legal arrangements for securing collaboration of other institutions for AD;
- Improve on documentation and archiving; and Capacity building in various areas of inventory compilation.

The implementing agency of the GEF, UNDP had the draft NIR3 report reviewed by the GSP. The comments were integrated in the final report as far as possible and those not attended to have been included in the NIIP for future action.

ES 10. Completeness

A source by source category analysis was conducted before the preparation of this inventory and it was updated by adding two more categories in the IPPU sector. Emissions from HFCs and PFCs have not been included due to lack of disaggregated data, the information on them being as blends without the content of the different components.

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 assigned for the two parameters and the combined uncertainty calculated. The uncertainty analysis has been performed using the tool available within the 2006 IPCC Software. The uncertainty in total emissions obtained using the IPCC tool is presented in Table 1.4 for the individual year of the inventory time series and the trend with the addition of one year at a time as from 1994 to 2014. Uncertainty levels (+/-) for the individual years of the period 1994 to 2014 varied from 26.0% to 29.1% while the trend assessment when adding one successive year on the base year 1994 for the years 1995 to 2014 ranged from 35.7% to 44.7%. The full set of results from the software is given in Annex 22 of Part 2 of this NIR3 report.

Table ES 1.4. Overall uncertainty (+/-%)

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Annual	26.0	27.6	27.4	27.3	27.1	27.0	27.0	27.2	26.7	26.8	26.7
Trend (base year 1994)	-	35.7	36.4	37.0	37.7	38.4	39.2	39.3	41.0	41.1	41.8

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	-
Annual	26.9	27.4	27.8	26.9	28.3	27.7	28.7	29.1	26.8	27.3	
Trend (base year 1994)	41.0	39.5	38.6	41.8	37.5	39.0	38.5	38.2	44.7	43.6	

ES 12. Key Category Analysis

The Key Category Analysis also was performed using the tool available within the IPCC 2006 Software for both level and trend assessment. There are four key categories in the quantitative level assessment for the year 2014, three of these from the AFOLU sector, of which enteric fermentation from Agriculture, the other two from FOLU being Forest land Remaining Forest land and the last one is Road Transportation from the Energy sector. The two next important emitters are also from the AFOLU sector when analysing up to the 97% level of contribution.

For the base year 1994, there were 4 key categories contributing to the 95% level and two additional ones when moving up to the 97% mark. All were from the AFOLU sector and within the LAND category except for Enteric Fermentation.

The results change quite drastically when considering the trend assessment covering the period 1994 to 2014. There are now ten key categories compared to the level assessment with four only. The four key categories under level assessment recur in the trend assessment also (Table 1.5).

The full set of results from the software is given in Annex 23 in Part 2 of this report.

Table ES 1.5. Summary of Key Categories for level (2014) and trend (1994 to 2014) 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 Grassland	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

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 developing country, has its constraints and gaps that need to be addressed to improve the quality of the inventory for reporting to the Convention. Major problems encountered were related to availability of AD, appropriateness of EFs, background information on technologies associated with production and national stock factors for the estimation exercise. Additionally, lack of resources - both technical and financial - coupled to insufficient capacity of national experts to take over the compilation of the full inventory remained a major issue of concern.

ES 15. National inventory improvement plan (NIIP)

Based on the constraints and gaps and other challenges encountered during the preparation of the inventory, a list of the priority improvements has been identified. The main issues are listed below.

- Adequate and proper data capture, QC, validation, storage and retrieval mechanism need to be improved to facilitate the compilation of future inventories;
- Capacity building and strengthening of the existing institutional framework to provide improved coordinated action for reliable data collection and accessibility is a priority undertaking in the future;
- Improve the existing QA/QC system in order to reduce uncertainty and improve inventory quality;
- Find the necessary resources to establish a GHG inventory unit within DEA to be responsible for inventory compilation and coordination;
- Conduct new forest inventories to supplement available data on the Land sector;
- Produce new maps for 1990 to 2015 to refine land use change data over 5 years periods as opposed to the decadal one available now which is proving inadequate;
- 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 years 1990 to 1993 to complete the full time series 1990 to at least 2015 in the next inventory compilation.
- Attempt at estimating emissions for categories not covered yet.

1. Introduction

1.1. National circumstances

The Republic of Namibia is situated in South-Western Africa between latitudes 17° and 29°S and longitudes 11° and 26°E. It extends over 825,608 km^2 of land which support a population of some 2.3 million in 2014. In 2014, about 47% of the population of the country inhabited urban areas. The country is known to be one with a relatively low population density at 2.6 persons per km^2.

Namibia's climate is very variable and is characterized by persistent droughts, unpredictable and variable rainfall patterns, variability in temperatures and scarcity of water. Natural resources are under increasing stress. Rainfall ranges from an average of 25 mm in the west to over 600 mm in the northeast. Apart from the coastal zone, there is a marked seasonal temperature regime, with the highest temperatures occurring just before the wet season in the wetter areas or during the wet season in the drier areas. The lowest temperatures occur during the dry season months of June to August. Mean monthly minimum temperatures do not, on average, fall below 0°C. High solar radiation, low humidity and high temperature lead to very high evaporation rates, which vary between 3800 mm per annum in the south to 2600 mm per annum in the north. Over most of the country, potential evaporation is at least five times greater than rainfall. Thus, only about 1% of rainfall ends up replenishing the groundwater aquifers. Lack of water is the key limitation factor to Namibia's development.

The services sector which accounted for 60% of Gross Domestic Product (GDP) in 2015 is the most important economic sector of Namibia. Agriculture, fisheries and forestry accounted for 9% and the manufacturing sector including mining and quarrying another 25%. The primary sector agriculture is one of the foundations of Namibia's economy, as it is a vital source of livelihood for most rural families in term of food generation with approximately 48% of Namibia's rural households depending on subsistence agriculture (NDP4).

Mining contributed about 12.3% to the country's GDP in 2015. The manufacturing sector, a priority sector under the NDP4, is estimated to have recorded a constant growth of 1.2% in 2011 and 2012 and contributed some 12.3% to national GDP in 2015. Namibia is highly dependent on imports to meet its energy requirements. The domestic economy is estimated to have expanded by 3.5% in 2015 (NSA, 2016).

1.2. Commitments under the Convention

The United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992 at the UN Conference on Environment and Sustainable Development in Rio de Janeiro, Brazil. The Convention came into force on 21 March 1994. The Republic of Namibia ratified the Convention on 16 May 1995 as a Non-Annex 1 Party and this decision came into effect on 14 August 1995.

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

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

a. A general description of steps taken or envisaged by the Party to implement the Convention; and

b. Any other information that the Party considers relevant to the achievement of the objective of the convention and suitable for inclusion in its communication, including, if feasible, material relevant for calculations of global emission trends

In order to meet its reporting obligations, Namibia has submitted three national communications (NCs); the initial national communication in 2002, the second national communication in 2011 and the third national communication in 2015. with support from the GEF through UNDP. The Republic of Namibia was the first developing country to submit its Biennial Update Report in 2014 and the second one in 2016. Thus, Namibia has to-date submitted five GHG inventories detailing its emissions and sinks as components of the national communications or stand-alone national inventory reports. Namibia has now prepared a third national inventory report fully detailing the compilation process in the best transparent manner possible. The summary will constitute the chapter on greenhouse gas inventory of the third Biennial Update Report (BUR3).

Additionally, Namibia has prepared and submitted its Intended Nationally Determined Contributions during COP 21 in Paris. The country signed and ratified the Paris Agreement on 22 April 2016 and 21 September 2016 respectively.

2. The inventory process

2.1. Overview of GHG inventories

The process of preparation of the present inventory started late 2017. One year was allocated to implement and complete the different steps of the inventory cycle as depicted in Figure 2.1. Funding under the climate change programme of the Global Environment Facility through its implementing agency, the United Nations Development Programme (UNDP), provided the financial support for the preparation of this sixth national GHG inventory reported in the third NIR.

The Initial and Second National Communications of the Republic of Namibia to the United Nations Framework Convention on Climate Change included the National Inventory of greenhouse gases. for base years 1994 and 2000. These inventories were compiled 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, Tier 1 level, and the GHG Inventory software. The reference approach has also been used for the Energy sector, to enable comparison of the two methods. The gases addressed were carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), 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 first Biennial Report and submitted to the UNFCCC in 2014. The fourth and fifth inventories have been submitted as stand-alone national inventory reports. The IPCC 2006 Guidelines and software were used for compiling these inventories.

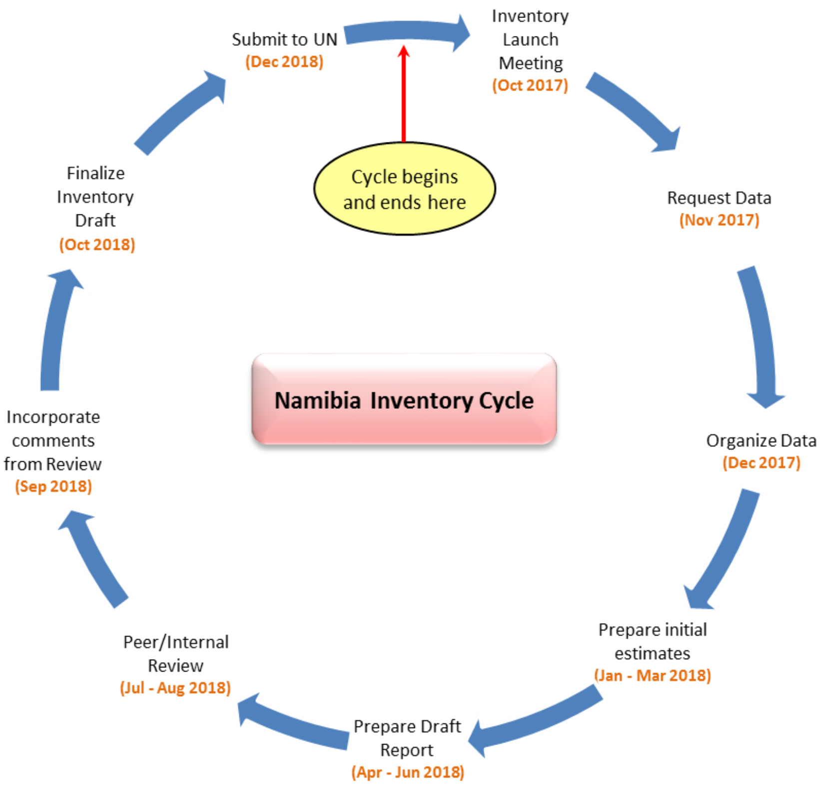


Figure 2.1 - The inventory cycle of Namibia's BUR3 GHG inventory

This sixth GHG inventory is presented in a stand-alone national inventory report as an accompanying document to the third Biennial Update Report. It provides data on GHG emissions by sources and removals by sinks for a full time series for the period 1994 to 2014. This inventory is exhaustive to the maximum, covering all source categories as far as possible, at the detailed level most appropriate for the country. Once again, a mix of Tiers 1 and 2 has been adopted.

2.2. Institutional arrangements and inventory preparation

From outsourcing its first and second inventories, Namibia started to institutionalise the compilation of its inventories with the one published in the BUR 1, with the support of an external consultant for capacity building, for enhanced transparency and meeting the higher requirements of reporting. This exercise continued with the inventories presented in the NIR2 to further improve, implement and consolidate the GHG inventory system being developed. The process of preparation of the present inventory and NIR3 by the GHG inventory team is still a very laborious exercise as resources and human capacities continued to be limiting factors. Furthermore, there has been numerous changes in the team following staff movements, promotions and resignations. Thus, there still exist shortcomings in this inventory but the country is committed to strive to further raise the quality of future GHG inventories through strengthening of the GHG inventory system.

The Climate Change Unit (CCU) of the Ministry of Environment and Tourism has the responsibility for overlooking the production of reports to the Convention, including the GHG inventories in its capacity as National Focal Point of the Convention. The same framework adopted for the previous inventory compilation was followed and all stakeholders agreed to pursue with sharing the responsibilities for the compilation exercise between different departments of the key ministries as for the NIR2. The exercise of mapping of national institutions and organizations was reviewed to identify additional stakeholders that would contribute in one way or the other for the inventory compilation. Thus, collaboration with data providers and potential institutions and organizations to support derivation of emission factors to suit national circumstances and enable moving to Tier 2 were consolidated. It was also decided to maintain the existing collaboration streams as it is working satisfactorily and there is no need for other official formal engagements such as MoUs. Capacity building of all inventory team members continued on the different steps of the inventory cycle as well as on data management, running the 2006 IPCC software and analysing the outputs. All members were further trained of the consistency component as a full series was lengthened by adding the period 1994 to 1999 to the 2000 to 2012 one as well as adding two recent years 2013 and 2014. Recalculations were performed for the previous years 2000 to 2012 with the advent of new activity datasets, emission and stock factors and other information prompting new approaches.

The responsibilities within the institutional arrangements did not change with:

- The CCU of Ministry of Environment and Tourism for inventory coordination, compilation and submission;
- Ministry of Mines and Energy for the Energy sector;
- Ministry of Industrialization, Trade and SME Development for the Industrial Production and Product Use sector;
- Ministry of Agriculture, Water Affairs and Forestry for Agriculture, Forest and Other Land Use sector;
- City Council of Windhoek for the Waste sector;
- Namibia National Statistics Agency for Archiving, including provision of quality-controlled activity data;
- The CCU of Ministry of Environment and Tourism for coordinating QA/QC;
- External consultant for capacity building and QA;

- The CCU of Ministry of Environment and Tourism for coordinating Uncertainty Analysis; and
- The CCU of Ministry of Environment and Tourism 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.

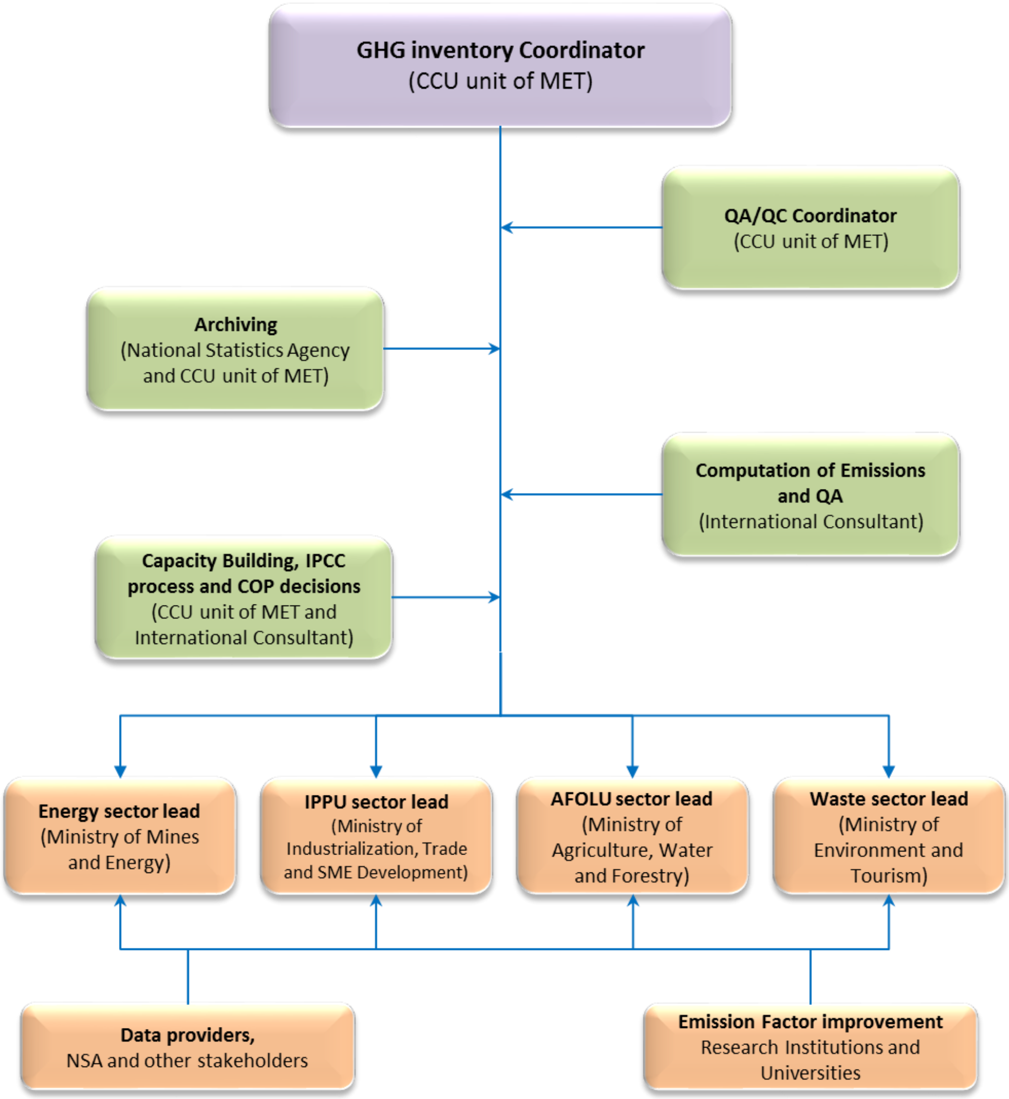


Figure 2.2 - Institutional arrangements for the GHG inventory preparation

The inventory preparation started in January 2018 due to delays in the availability of funds. A work plan with timeframe and responsibilities was drawn for the preparation of the inventory using a mix of Tiers 1 and 2. AD were collected for the years 1994 to 1999, 2013 and 2014 to update the existing series and meet the timing requirement for the BUR 3. The collected AD were processed and sectoral experts of the inventory team computed emissions and performed recalculations as necessary under the supervision of the external consultant. This exercise took place during a three-day workshop with the external consultant providing the support for identifying improvement areas relative to data availability and quality, appropriateness of EFs, gaps and constraints. Drawbacks and shortcomings were addressed to maintain smooth implementation of the inventory cycle. The 2006 IPCC Guidelines *for National Greenhouse Gas Inventories* (IPCC, 2007) were used with the most appropriate IPCC default EFs. Default EFs were likewise assessed and these were derived or amended in some cases to reflect national circumstances and conditions, the objective being to estimate emissions as accurately as possible. The results were reviewed during another three-day workshop which was attended by the full GHG inventory team. This exercise was very useful to enhance capacity of the national experts while serving for team building and also strengthening collaboration on cross-cutting issues. 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 activity data;
- Selection of Tier level within each category and sub-category;
- Selection of emission factors (EFs) and Derivation of local EFs wherever possible;
- Designing of appropriate MS Excel worksheets for detailed calculations;
- Computation of GHG emissions;
- Uncertainty analysis;
- Implementing QA/QC activities;
- Assessment of completeness;
- Recalculations;
- Trend analysis;
- Gaps, constraints, needs and improvements; and
- Report writing.

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. Alternatively, a key source is one that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of direct GHGs in terms of the absolute level of emissions, the trend in emissions, or both (IPCC, 2000). Thus, it is a good practice to identify key categories, as it helps prioritize efforts and improve the overall quality of the national inventory, notwithstanding guiding of mitigation policies, strategies and actions.

The Key Category Analysis was performed using the tool available within the IPCC 2006 Software for both level and trend assessment. The results for the level assessment for the year 2014 are presented in Table 2.1 (a) and 2.1 (b) and the trend assessment in Table 2.2.

Table 2.1 (a) - Key Category Analysis for the year 2014 - Approach 1 - Level Assessment

A	B	C	D	E	F	G
IPCC Category code	IPCC Category	GHG	"2012 Ex,t (Gg CO_2-eq)"	"|Ex,t| (Gg CO_2-eq)"	Lx,t	Cumulative Total of Column F
3.B.1.a	Forest land Remaining Forest land	CO_2	-118,470.9	118,470.9	0.843	0.843
3.B.3.b	Land Converted to Grassland	CO_2	9,755.9	9,755.9	0.069	0.912
3.A.1	Enteric Fermentation	CH_4	3,650.3	3,650.3	0.026	0.938
1.A.3.b	Road Transportation	CO_2	2,456.4	2,456.6	0.017	0.955
3.C.4	Direct N_2O Emissions from managed soils	N_2O	1795.1	1795.1	0.013	0.968
3.C.1	Emissions from biomass burning	CH_4	1176.2	1176.2	0.008	0.976

There are four key categories in the quantitative level assessment for the year 2014, three of these from the AFOLU sector, of which enteric fermentation from Agriculture, the other two from FOLU being Forest land Remaining Forest land and the last one is Road Transportation from the Energy sector. The two next important emitters are also from the AFOLU sector when analysing up to the 97% level of contribution.

For the base year 1994, there were 4 key categories contributing to the 95% level and two additional ones when moving up to the 97% mark. All were from the AFOLU sector and within the LAND category except for Enteric Fermentation.

Table 2.1 (b) - Key Category Analysis for the year 2014 - Approach 1 - Level Assessment

A	B	C	D	E	F	G
IPCC Category code	IPCC Category	GHG	"2012 Ex,t (Gg CO_2-eq)"	"|Ex,t| (Gg CO_2-eq)"	Lx,t	Cumulative Total of Column F
3.B.1.a	Forest land Remaining Forest land	CO_2	-95039.3	-95039.3	0.822	0.822
3.B.3.b	Land Converted to Grassland	CO_2	8671.9	8671.9	0.075	0.897
3.C.1	Emissions from biomass burning	CH_4	2944.9	2944.9	0.025	0.923
3.A.1	Enteric Fermentation	CH_4	2747.3	2747.3	0.024	0.947
3.B.1.b	Land Converted to Forest land	CO_2	-1619.9	-1619.9	0.014	0.961
3.C.4	Direct N2O Emissions from managed soils	N_2O	1359.4	1359.4	0.012	0.973

The results change quite drastically when considering the trend assessment covering the period 1994 to 2014. There are now ten key categories compared to the level assessment with four only.

Table 2.2 - Key Category Analysis for the period 1994 - 2014 - Approach 1 - Trend Assessment

A	B	C	D	E	F	G	H
IPCC Category code	IPCC Category	GHG	1994 Year Estimate Ex0 (Gg CO_2-eq)	2014Year Estimate Ext (Gg CO_2-eq)	Trend Assessment (Txt)	% Contribution to Trend	Cumulative Total of Column G
3.B.3.b	Land Converted to Grassland	CO_2	8,671.9	9,755.9	0.029	0.261	0.261
1.A.3.b	Road Transportation	CO_2	734.6	2,456.6	0.017	0.148	0.409
3.A.1	Enteric Fermentation	CH_4	2747.3	3,650.3	0.014	0.126	0.535
3.B.1.a	Forest land remaining Forest land	CO_2	-95,039.3	- 118,470.9	0.014	0.124	0.659
3.B.1.b	Land converted to Forest land	CO_2	-1,619.9	-962.7	0.009	0.084	0.743
3.C.1	Emissions from Biomass Burning	CH_4	2,944.9	1,176.2	0.009	0.076	0.819
3.C.4	Direct Emissions from Managed Soils	N_2O	1,359.4	1,795.1	0.007	0.061	0.880
3.C.1	Emissions from Biomass Burning	N_2O	1,289.7	512.8	0.004	0.034	0.914
2.A.1	Cement Production	CO_2	0	303.1	0.003	0.024	0.938
2.C.6	Zinc Production	CO_2	0	175.8	0.002	0.014	0.952
4.A	Solid Waste Disposal	CH_4	8.4	76.9	0.0006	0.005	0.957
3.A.2	Manure Management	N_2O	98.3	141.0	0.0006	0.005	0.962
3.C.6	Indirect N2O Emissions from manure management	N_2O	89.1	130.2	0.0006	0.005	0.967
1.A.5	Non-Specified - Liquid Fuels	CO_2	14.9	60.0	0.0004	0.004	0.971

The summary of Key Categories based on the quantitative level, for year 2014 and trend, period 1994 to 2014, assessments up to the 95% contribution mark is presented in Table 2.3. The number of Key categories increased from four under level assessment to ten with the four recurring in the trend assessment also. The full set of results from the software is provided in Annex 23 of Part 2 of the NIR3 report.

Table 2.3. Summary of Key Categories for level (2014) and trend (1994 to 2014) 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 Grassland	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

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

This section gives an overview of the methodological approach adopted for all sectors and sub-sectors covered in this inventory report. These procedures are extensively detailed in the respective section covering the individual IPCC Key Categories.

Generally, the method adopted to compute emissions involved multiplying activity data (AD) by the relevant appropriate emission factor (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 emission factors 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. Thus, the inventory has been compiled using a mix of Tiers 1 and 2. This is good practice and improved the accuracy of the emission estimates of most of the key categories 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) (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

Default EFs were assessed for their appropriateness prior to their adoption; namely on the basis of 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 than the Tier 1 level, were sourced directly from both public and private sector operators by the team members and coordinators. Data gaps were filled through personal contacts with the stakeholders by the national experts and/or from results of surveys, scientific studies and by statistical modelling. All the data and information collected during the inventory process have been stored in the software database.

In some cases, due to the restricted timeframe and lack of a declared National framework for data collection and archiving to meet the requirements for preparing GHG inventories, derived data and estimates were used to fill in the gaps. 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 1994 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 and 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 independent reviewers who were not involved with the preparation of the inventory, the main objectives being to:

- Confirm data quality and reliability from different sources wherever possible;
- 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 Measure, Report and Verify system under implementation. Thus, systematic records as per the *2006 IPCC Guidelines* still have to be developed under a QA/QC coordinator. This resulted from the lack of personnel, 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. Unfortunately, the exercise was performed when the inventory report was not yet completed but on information available at that time. The main conclusions are:

- Attempt at collecting missing AD for improving the completeness of the inventory, namely use of N_2O for medical applications, ODS and incineration of medical waste;
- Improve the Institutional arrangements to ensure annual provision of AD for preparing the inventory;
- Develop and implement a QC management system;
- Improve AD for the AFOLU sector through production of new maps to generate land use changes, national stock and Emission factors, possible use of Collect earth for confirming the assumptions and data used;
- Develop legal arrangements for securing collaboration of other institutions for AD;
- Improve on documentation and archiving; and
- Capacity building in various areas of inventory compilation.

2.6. Uncertainty assessment

Uncertainty estimation is an essential element of a complete greenhouse gas emissions and removals Inventory. The purpose of estimating the uncertainties attached to emission estimates is principally to provide information on the categories to be prioritized for maximum resources to be allocated to improve the quality of the inventory. Inventories prepared in accordance with *2006 IPCC guidelines (IPCC, 2007)* will typically contain a wide range of emission estimates, varying from carefully measured and demonstrably complete data on emissions to order-of-magnitude estimates of highly variable emissions such as N_2O fluxes from soils and waterways.

For this Inventory, a Tier 1 uncertainty analysis of the aggregated figures as required by the 2006 IPCC Guidelines, Vol. 1 (IPCC, 2007) was performed. Based on the quality of the data and whether the EFs used were defaults or nationally derived, uncertainty levels were allocated for the two parameters and the combined uncertainty calculated. In most instances, the uncertainty values allocated to AD and EFs from within the range recommended by the IPCC Guidelines. Thus. Lower uncertainties were allocated to AD obtained from measurements made and recorded, higher values for interpolated and extrapolated AD and the highest ones in the range when the AD 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 of the range were adopted. Whenever there was a need to revert to expert judgement, the protocol was to consult with more than one expert from the typical sector or industry to ascertain on the level of uncertainty to be adopted from within the range provided in the IPCC guidelines. In cases where IPCC has a particular recommended methodology, the uncertainty level was derived according to the procedure proposed in the IPCC Guideline 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 2.5. Uncertainty levels for the individual years of the period 1994 to 2014 varied from 26.0% to 29.1% while the trend assessment when adding one successive year on the base year 1994 for the years 1995 to 2014 ranged from 35.7% to 44.7%. The full set of results from the software is given in Annex 22 of Part 2 of this NIR3 report.

Table 2.5. Overall uncertainty (%)

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Annual	26.0	27.6	27.4	27.3	27.1	27.0	27.0	27.2	26.7	26.8	26.7
Trend (base year 1994)	-	35.7	36.4	37.0	37.7	38.4	39.2	39.3	41.0	41.1	41.8

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	-
Annual	26.9	27.4	27.8	26.9	28.3	27.7	28.7	29.1	26.8	27.3	
Trend (base year 1994)	41.0	39.5	38.6	41.8	37.5	39.0	38.5	38.2	44.7	43.6	

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
- EE Estimated Elsewhere

The level of completeness depicting the scope of the inventory is provided in Table 2.6. In cases where was no activity for all sub-categories within a category, only the category row was maintained for ease of presentation and understanding.

Table 2.6 - Completeness of the 1994 to 2014 inventories

Sector / Source category	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NO_x	CO	NMVOC	SO_2
1 - Energy										
1.A - Fuel Combustion Activities										
1.A.1 - Energy Industries	X	X	X	NA	NA	NA	X	X	X	X
1.A.2 - Manufacturing Industries and Construction	X	X	X	NA	NA	NA	X	X	X	X
1.A.3 - Transport	X	X	X	NA	NA	NA	X	X	X	X

Sector / Source category	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NO_x	CO	NMVOC	SO_2
1.A.4 - Other Sectors	X	X	X	NA	NA	NA	X	X	X	X
1.A.5 - Non-Specified	X	X	X	NA	NA	NA	X	X	X	X
1.B - Fugitive emissions from fuels	NO	NO	NO	NA	NA	NA	NO	NO	NO	NO
1.C - Carbon Dioxide Transport and Storage	NO	NO	NO	NA	NA	NA	NO	NO	NO	NO
2 - Industrial Processes and Product Use										
2.A - Mineral Industry										
2.A.1- Cement Production	X	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.2 - Lime production	X	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.3 - Glass Production	NO	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	NA	NA
2.A.5 - Other (please specify)	NO	NO	NO	NA	NA	NA	NO	NO	NO	NO
2.B - Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C - Metal Industry										
2.C.1 - Iron and Steel Production	NO	NO	NA	NA	NA	NA	NO	NO	NO	NO
2.C.2 - Ferroalloys Production	NO	NO	NA	NA	NA	NA	NO	NO	NO	NO
2.C.3 - Aluminium production	NO	NA	NA	NA	NO	NA	NO	NO	NO	NO
2.C.4 - Magnesium production	NO	NA	NA	NA	NA	NO	NO	NO	NO	NO
2.C.5 - Lead Production	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.C.6 - Zinc Production	X	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
2.D - Non-Energy Products from Fuels and Solvent Use										
2.D.1 - Lubricant Use	X	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.2 - Paraffin Wax Use	X	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.3 - Solvent Use	NA	NA	NA	NA	NA	NA	NA	NA	X	NA
2.E - Electronics Industry	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA
2.F - Product Uses as Substitutes for Ozone Depleting Substances										
2.F.1 - Refrigeration and Air Conditioning	NA	NA	NA	NE	NA	NA	NA	NA	NA	NA
2.F.2 - Foam Blowing Agents	NA	NA	NA	NO	NA	NA	NA	NA	NA	NA
2.F.3 - Fire Protection	NA	NA	NA	NE	NE	NA	NA	NA	NA	NA
2.F.4 - Aerosols	NA	NA	NA	NE	NA	NA	NA	NA	NA	NA
2.F.5 - Solvents	NA	NA	NA	NE	NE	NA	NA	NA	NA	NA
2.F.6 - Other Applications (please specify)	NA	NA	NA	NO	NO	NA	NA	NA	NA	NA
2.G - Other Product Manufacture and Use										
2.G.1 - Electrical Equipment	NA	NA	NA	NA	NE	NE	NA	NA	NA	NA
2.G.2 - SF_6 and PFCs from Other Product Uses	NA	NA	NA	NA	NE	NE	NA	NA	NA	NA
2.G.3 - N_2O from Product Uses	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA
2.G.4 - Other (Please specify)	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA
2.H - Other										
2.H.1 - Pulp and paper Industry	NO	NO	NA	NA	NA	NA	NO	NO	NO	NO
2.H.2 - Food and Beverages Industry	X	X	NA	NA	NA	NA	X	X	X	X
2.H.3 - Other (Please specify)	NO	NO	NO	NA	NA	NA	NO	NO	NO	NO
3 - Agriculture, Forestry, and Other Land Use										
3.A - Livestock										
3.A.1 - Enteric Fermentation	NA	X	NA	NA	NA	NA	NA	NA	NA	NA
3.A.2 - Manure Management	NA	X	X	NA	NA	NA	NA	NA	X	NA
3.B - Land										

Sector / Source category	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NO_x	CO	NMVOC	SO_2
3.B.1 - Forest land	X	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.B.2 - Cropland	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.B.3 - Grassland	X	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.B.4 - Wetlands	NO	NA	NO	NA	NA	NA	NO	NO	NO	NO
3.B.5 - Settlements	NE	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.B.6 - Other Land	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.C - Aggregate sources and non-CO_2 emissions sources on land										
3.C.1 - Emissions from biomass burning	NA	X	X	NA	NA	NA	X	X	NA	NA
3.C.2 - Liming	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C.3 - Urea application	X	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C.4 - Direct N_2O Emissions from managed soils	NA	NA	X	NA	NA	NA	NA	NA	NA	NA
3.C.5 - Indirect N_2O Emissions from managed soils	NA	NA	X	NA	NA	NA	NA	NA	NA	NA
3.C.6 - Indirect N_2O Emissions from manure management	NA	NA	X	NA	NA	NA	NA	NA	NA	NA
3.C.7 - Rice Cultivation	NA	NO	NA	NA	NA	NA	NA	NA	NA	NA
3.C.8 - Other (Please specify)	NA	NO	NO	NA	NA	NA	NA	NA	NA	NA
3.D - Other										
3.D.1 - Harvested Wood Products	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA
4 - Waste										
4.A - Solid Waste Disposal	NA	X	NO	NA	NA	NA	NO	NO	X	NA
4.B - Biological treatment of solid waste	NA	NO	NO	NA	NA	NA	NO	NO	NO	NA
4.C - Incineration and Open Burning of Waste	X	X	X	NA	NA	NA	X	X	X	X
4.D - Wastewater Treatment and Discharge	NA	X	X	NA	NA	NA	NO	NO	X	NA
4.E - Other (Please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5 - Other										
Memo Items (5)										
International Bunkers										
1.A.3.a.i - International Aviation (International Bunkers)	X	X	X	NA	NA	NA	X	X	X	X
1.A.3.d.i - International water-borne navigation (International bunkers)	X	X	X	NA	NA	NA	X	X	X	X
1.A.5.c - Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

X = Estimated, NA = Not Applicable, NO = Not Occurring, NE = Not Estimated, EE = Estimated Elsewhere

2.8. Recalculations

The initial inventories submitted for the years 2000 to 2012 in the NIR2 and summarized in the BUR 2 were recalculated to provide for a consistent series in this inventory report. Recalculations are normally carried out if AD and/or EFs are revised or if new updated methodologies are applied. The present National GHG Inventory Report, being an exhaustive one, also reports on recalculations made. The scope of the inventory of the NIR2 has been widened to include additional categories which were not covered within IPPU.

Recalculations have been performed for the past inventories for the full time series to maintain consistency following improvements in EFs in the guidelines, newly derived EFs to better suit national circumstances and improve the accuracy of the inventory and the change from the Revised 1996 IPCC Guidelines (*IPCC 1997*) to the IPCC 2006 Guidelines (*IPCC 2006*) for the year 1994, 2000 and 2010. Recalculations also concerned the categories where new AD sets were used such as for the LAND sector following problems encountered and reported in the BUR2 which is also provided under the AFOLU sector of this inventory in details.

Recalculated emission for the base years 1994, 2000 and 2010 presented in the NC1, NC2 and NC3 are compared with the recalculated emissions obtained in the present time series (Table 2.7). 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, Mix of Tiers 1 and 2, the latter for most key categories, much better coverage (only ODS, Incineration of medical wastes, Refrigeration and N_2O use for medical purposes not covered and national EFs and stock factors for most key categories.

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

Year	1994		2000		2010	
	INC	NIR3	SNC	NIR3	TNC	NIR3
Removals	-5,716	-96,659	-10,566	-108,067	-28,534	-107,364
Emissions	5,685	18,889	9,118	18,684	27,195	20,720
Net removals	-31	-77,770	-1,442	-89,383	-1,339	-86,644

2.9. Time series consistency

This inventory now covers the period 1994 to 2014 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 developing country, has its constraints and gaps that need to be addressed to produce better quality reports to the Convention. This is still a big challenge given that now the reporting standards have been raised and there is also a review of the inventory.

In order to reduce uncertainties and aim at producing an inventory in line with TACCC principles, Namibia invested in improving its national GHG inventory management system and Institutional arrangements. One major challenge for estimating emissions for the past years from 1994 to 1999 was gaps in AD. Additionally, the country aimed at adopting higher Tier levels whenever more disaggregated data for the various sectors could be collected and country-specific EFs derived as for Enteric Fermentation and the Land categories which are key categories for the country from previous inventory results. However, AD were not available for the period 1994 to 1998 when the country was still setting up its national statistics department after independence. Thus, most of the AD for this period were sourced from the international databases or extrapolated on the basis of AD for the time series 1999 to 2014. The National Inventory Improvement Plan and a review of the NIR2 enabled the identification of areas that could be improved in terms of data collection, as well as research to be undertaken for developing national EFs. The development of specific sectoral databases for GHG inventory purposes started when computing the present inventory.

For this inventory, one more category, namely solvent use has been covered. Some information was also collected on the use of SF_6, use of N_2O for medical purposes, incineration of medical wastes and Ozone Depleting Substances, but unfortunately, they were not detailed enough to enable computation of emissions in these categories. Further efforts will be invested to address these categories to make the inventory fully exhaustive in the future.

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

- Information required for the inventory were obtained from various sources as no institution has yet been endorsed with the responsibility for collection of specific AD needed for the estimation of emissions according to IPCC on an annual basis;
- Almost all of 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 on the basis of scientific and consumption parameters;
- Reliable biomass (bm) data such as timber, fuelwood, wood waste and charcoal consumed or produced were not available and had to be derived using statistical modelling;
- There were frequent inconsistencies when data were collected from different sources;
- Appropriate information on some activities such as beverage production and auto-production of heat and electricity were not always available as these were not released as considered confidential by the producers;
- Lack of solid waste characterization data, amount generated and wastewater generated from the industrial sector were only partly available and had to be derived on the basis of production and demographic data amongst others;
- Lack of EFs to better represent national circumstances and provide for more accurate estimates even if this has started to be addressed for some key categories;
- Emissions for a few categories have not been estimated due to lack of AD; and
- National experts are not yet ready to take over the full inventory compilation process which dictated the collaboration of an international consultant;
- National experts were provided with further capacity building and this will be pursued in the future until they are fully conversant with the whole process.

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 identified. These are listed below and will be addressed during the preparation of the next inventory for preparation of the NIR4 within the framework of the BUR4.

- Adequate and proper data capture, QC, validation, storage and retrieval mechanism need to be improved to facilitate the compilation of future inventories;
- Capacity building and strengthening of the existing institutional framework within a GHG inventory management system to provide improved coordinated action for a smooth implementation of the GHG inventory cycle for sustainable production of inventories;
- Development of emission factors (EFs) more representative of the national context;
- Improve the existing QA/QC system including a QA/QC plan in order to reduce uncertainty and improve inventory quality;
- Find the necessary 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, use of N_2O for medical purposes, incineration of medical waste and Ozone Depleting Substances;
- Conduct new forest inventories to confirm 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 which is proving inadequate;
- 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 years 1990 to 1993 to complete the full time series 1990 to at least 2015 in the next inventory compilation.
- Attempt at estimating emissions for categories not covered yet

3. Trends in greenhouse gas emissions

3.1. Overview

The trends of GHG emissions for the Republic of Namibia cover the period 1994 to 2014. Availability of more disaggregated data enabled the adoption of higher Tier methods, namely a combination of Tiers 1 and 2 for compiling this inventory. The period 1994 to 2014 included additional sub-categories that were not covered in the latest inventory presented in the BUR2.

3.2. The period 1994 to 2014

Namibia remained a net GHG sink over the period 1994 to 2014 as the Land category removals exceeded emissions from the other categories. The net removal of CO_2 increased by 20,484 Gg from 77,770 Gg to 98,254 Gg in 2014, representing an increase of 26.3% over these 21 years. During the same period, the country recorded an increase of 12.1% in emissions, 2,291 Gg CO_2-eq from 18,889 Gg CO_2-eq to 21,180 Gg CO_2-eq. The trend for the period 1994 to 2014 indicates that the total removals from the LAND category increased from 96,659 Gg CO_2-eq in 1994 to 119,434 (23.6%) Gg CO_2-eq in 2014 (Table 3.1 and Figure 3.1).

Table 3.1 - GHG emissions (Gg CO_2-eq) characteristics (1994 - 2014)

Year	Total emissions	AFOLU removals	Net	Per capita emission (t)	GDP emissions index (Year 1994 = 100)
1994	18,889	-96,659	-77,770	11.9	100.0
1995	18,752	-98,466	-79,715	11.6	95.4
1996	18,439	-100,291	-81,852	11.2	90.9
1997	18,442	-102,133	-83,691	10.9	87.2
1998	18,495	-103,992	-85,497	10.7	84.7
1999	18,553	-105,869	-87,316	10.6	82.1
2000	18,684	-108,067	-89,383	10.4	79.9
2001	19,157	-108,212	-89,055	10.5	81.0
2002	18,353	-112,687	-94,333	9.9	74.0
2003	18,842	-113,128	-94,287	10.0	72.9
2004	18,742	-114,949	-96,208	9.8	64.6
2005	19,135	-112,723	-93,588	9.9	64.4
2006	20,194	-109,119	-88,925	10.3	63.4
2007	20,725	-106,355	-85,630	10.4	61.7
2008	19,416	-114,977	-95,561	9.6	55.9
2009	21,549	-103,127	-81,578	10.5	62.8
2010	20,720	-107,364	-86,644	10.0	56.8
2011	22,699	-105,448	-82,749	10.8	58.9
2012	23,542	-104,485	-80,943	11.0	58.1
2013	19,829	-122,363	-102,534	9.2	46.4
2014	21,180	-119,434	-98,254	9.6	46.6

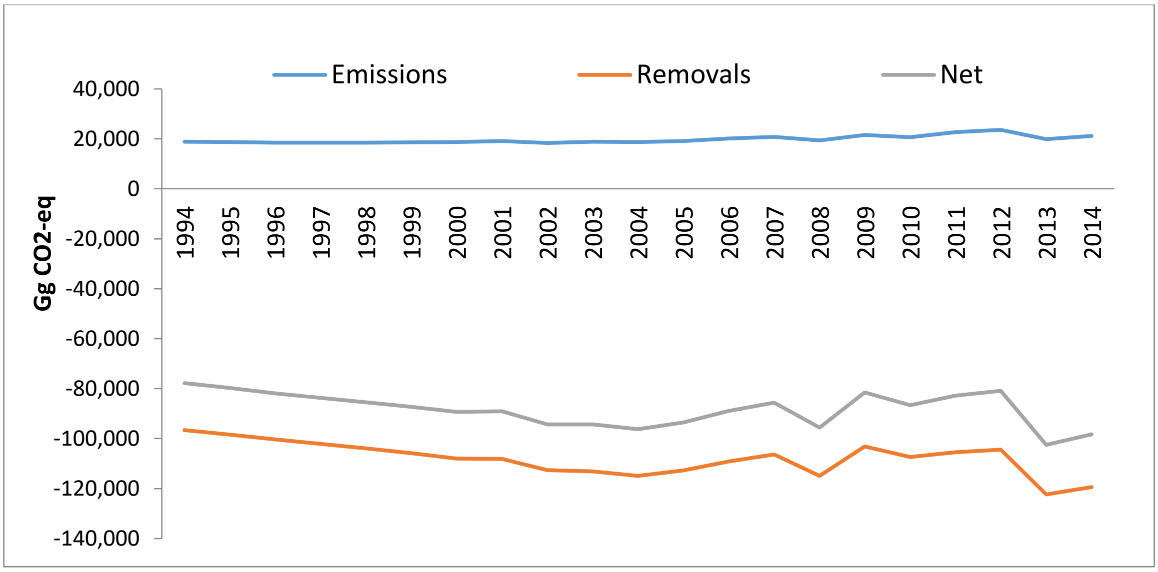


Figure 3.1 - Evolution of national emissions, national removals and the overall (net) situation (Gg CO_2-eq), (1994 - 2014)

Per capita emissions of GHG decreased gradually from 11.9 tonnes CO_2-eq in 1994 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 9.6 tonnes CO_2-eq in 2014 (Figure 3.2). The GDP emission index decreased almost steadily from 100 in the year 1994 to 46.6 in 2014 (Figure 3.3).

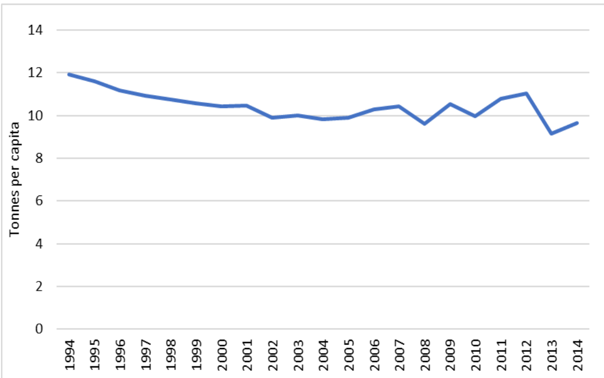


Figure 3.2 - Per capita GHG emissions (1994 - 2014)

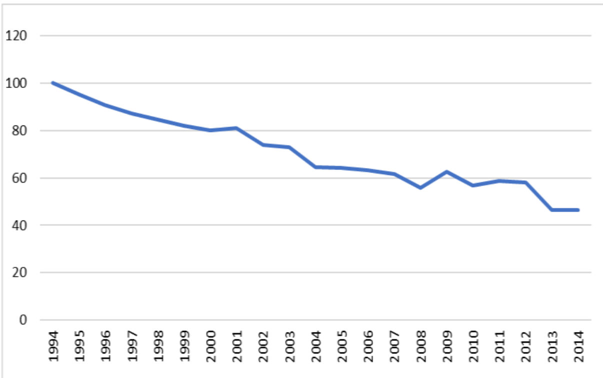


Figure 3.3 - GDP emissions index (1994 - 2014)

3.3. Trend of emissions by source category

Total national emissions increased by 12.1% over these 21 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, IPPU sector took over as the third emitter in lieu of the Waste sector as from the year 2003. Emissions from the AFOLU sector increased from 17,328 Gg CO_2-eq in 1994 to peak at 19,275 Gg CO_2-eq in 2012 and then regressed to 17,271 in 2014, representing a decrease of 0.3% from the 1994 level. The share of GHG emissions from the AFOLU sector out of total national emissions regressed from 91.7% in 1994 to 81.5% in 2014.

Energy emissions increased from 1,464 Gg CO_2-eq (7.8%) of national emissions in 1994 to 3,234 Gg CO_2-eq (15.3%) in 2014 as depicted in Table 3.2. During the period 1994 to 2014, the average annual increase of GHG emissions was by 6.0%.

The contribution of the IPPU sector in total national emissions increased from 22 Gg CO_2-eq in 1994 to 522 Gg CO_2-eq in 2014 (Table 3.2). 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 1994 level of 75 Gg CO_2-eq to 153 Gg CO_2-eq in 2014, representing a 5.0% increase.

Table 3.2 - National GHG emissions (Gg, CO_2-eq) by sector (1994 - 2014)

Year	Total emissions	Energy	IPPU	AFOLU	Waste
1994	18,889	1,464	22	17,328	75
1995	18,752	1,473	23	17,183	72
1996	18,439	1,566	23	16,777	73
1997	18,442	1,617	24	16,726	76
1998	18,495	1,759	24	16,633	79
1999	18,553	1,893	25	16,551	83
2000	18,684	1,934	25	16,637	88
2001	19,157	2,116	25	16,927	90
2002	18,353	2,163	27	16,073	91
2003	18,842	2,454	110	16,176	101
2004	18,742	2,521	237	15,879	103
2005	19,135	2,671	260	16,094	110
2006	20,194	2,823	255	17,003	112
2007	20,725	2,907	293	17,415	109
2008	19,416	2,752	291	16,256	117
2009	21,549	2,832	303	18,289	125
2010	20,720	2,923	301	17,365	131
2011	22,699	2,796	438	19,326	138
2012	23,542	3,003	515	19,875	149
2013	19,829	2,861	528	16,291	149
2014	21,180	3,234	522	17,271	153

3.4. Trend in emissions of direct GHGs

The share of emissions by gas did not change during the period 1994 to 2014. 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 these of CH_4 and N_2O regressed over the time series. In 2014, the share of the GHG emissions was as follows: 63.44% CO_2, 23.98% CH_4 and 12.58% N_2O. The trend of the aggregated emissions and removals by gas is given in Table 3.3 and Figure 3.4.

Table 3.3 - Aggregated emissions and removals (Gg) by gas (1994 - 2014)

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)
1994	18,889	-96,659	-77,770	10,169	5,837	2,884
1995	18,752	-98,466	-79,715	10,177	5,728	2,847
1996	18,439	-100,291	-81,852	10,268	5,458	2,713
1997	18,442	-102,133	-83,691	10,318	5,415	2,710
1998	18,495	-103,992	-85,497	10,457	5,352	2,685
1999	18,553	-105,869	-87,316	10,591	5,295	2,667
2000	18,684	-108,067	-89,383	10,629	5,367	2,687
2001	19,157	-108,212	-89,055	11,021	5,394	2,742
2002	18,353	-112,687	-94,333	11,070	4,797	2,487
2003	18,842	-113,128	-94,287	11,438	4,873	2,531
2004	18,742	-114,949	-96,208	11,630	4,665	2,447
2005	19,135	-112,723	-93,588	11,799	4,832	2,504
2006	20,194	-109,119	-88,925	11,944	5,458	2,793
2007	20,725	-106,355	-85,630	12,063	5,717	2,945
2008	19,416	-114,977	-95,561	11,910	4,944	2,563
2009	21,549	-103,127	-81,578	11,999	6,362	3,187
2010	20,720	-107,364	-86,644	12,086	5,732	2,903
2011	22,699	-105,448	-82,749	12,922	6,477	3,300
2012	23,542	-104,485	-80,943	13,204	6,845	3,494
2013	19,829	-122,363	-102,534	13,076	4,395	2,359
2014	21,180	-119,434	-98,254	13,436	5,079	2,665

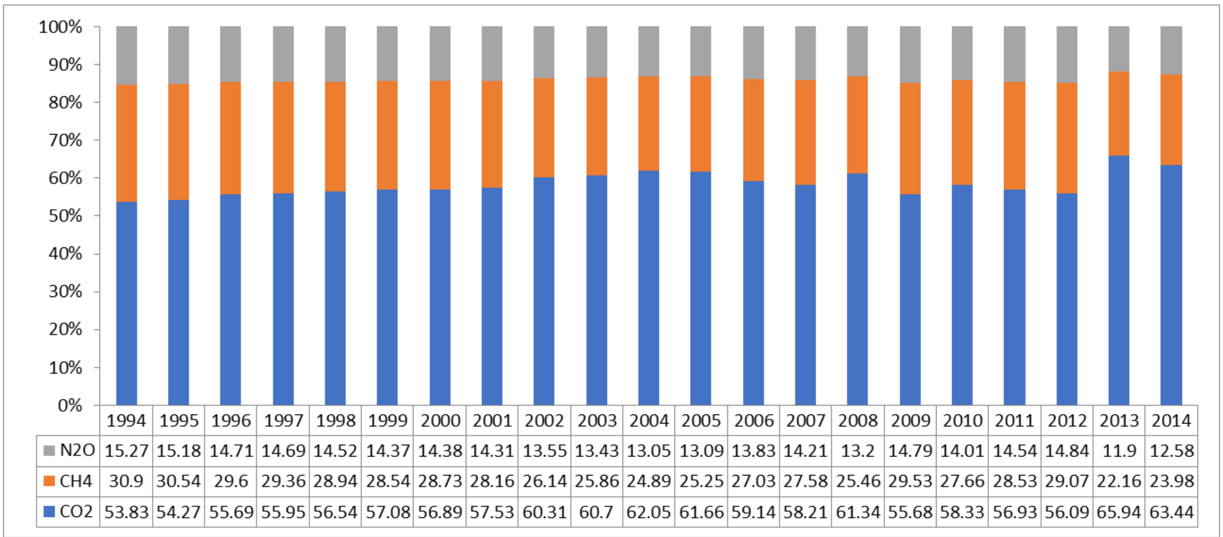


Figure 3.4 - Share of aggregated emissions (Gg CO_2-eq) by gas (1994 - 2014)

3.4.1. Carbon dioxide (CO_2)

The most significant anthropogenic GHG was CO_2. In 2014, it contributed the more than half of national emissions with 13,436 Gg (63.44%). CO_2 emissions increased by 3,268 Gg from the 1994 level of 10,169 Gg (Table 3.3) to 13,436 Gg in 2014. In the same year, the sector that emitted the highest amount of CO_2 was AFOLU with 9,769 Gg followed by Energy with 3,142 Gg (Table 3.4).

Table 3.4 - CO_2 emissions (Gg) by source category (1994 - 2014)

Year	Total emissions	Total net removals	Energy	IPPU	AFOLU - emissions	AFOLU - removals	Waste
1994	10,169	-86,491	1,410	22	8,736	-96,659	1.0
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	-93,535	1,696	24	8,736	-103,992	1.1
1999	10,591	-95,278	1,829	25	8,735	-105,869	1.2
2000	10,629	-97,437	1,868	25	8,736	-108,067	1.2
2001	11,021	-97,191	2,046	25	8,949	-108,212	1.3
2002	11,070	-101,617	2,093	27	8,949	-112,687	1.3
2003	11,438	-101,691	2,379	110	8,947	-113,128	1.4
2004	11,630	-103,320	2,444	237	8,947	-114,949	1.4
2005	11,799	-100,924	2,590	260	8,947	-112,723	1.5
2006	11,944	-97,175	2,740	255	8,947	-109,119	1.6
2007	12,063	-94,292	2,822	293	8,947	-106,355	1.7
2008	11,910	-103,067	2,671	291	8,946	-114,977	1.7
2009	11,999	-91,128	2,748	303	8,947	-103,127	1.8
2010	12,086	-95,279	2,837	301	8,947	-107,364	1.9
2011	12,922	-92,525	2,713	438	9,769	-105,448	2.1
2012	13,204	-91,281	2,918	515	9,769	-104,485	2.3
2013	13,076	-109,288	2,776	528	9,769	-122,363	2.3
2014	13,436	-105,998	3,142	522	9,769	-119,434	2.4

3.4.2. Methane (CH_4)

Methane was the next contributor in national emissions after CO_2. It contributed 5079 Gg CO_2-eq of the total emissions of 2014. Methane emissions decreased by 758 Gg CO_2-eq from the 1994 level of 5,837 Gg CO_2-eq to 5,079 in 2014 (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 (1994 - 2014)

Year	Total (Gg CO_2-eq)	Total	Energy	AFOLU - emissions	Waste
1994	5,837	278	1.5	274	2.4
1995	5,728	273	1.5	269	2.4
1996	5,458	260	1.6	256	2.3
1997	5,415	258	1.6	254	2.4
1998	5,352	255	1.6	251	2.5
1999	5,295	252	1.7	248	2.7
2000	5,367	256	1.7	251	3.0
2001	5,394	257	1.7	252	3.0

Year	Total (Gg CO_2-eq)	Total	Energy	AFOLU - emissions	Waste
2002	4,797	228	1.7	224	3.1
2003	4,873	232	1.8	227	3.5
2004	4,665	222	1.8	217	3.6
2005	4,832	230	1.8	224	3.9
2006	5,458	260	1.9	254	4.0
2007	5,717	272	1.9	267	3.8
2008	4,944	235	1.8	229	4.2
2009	6,362	303	1.9	297	4.6
2010	5,732	273	1.9	266	4.9
2011	6,477	308	1.8	301	5.2
2012	6,845	326	1.9	318	5.7
2013	4,395	209	1.8	202	5.7
2014	5,079	242	1.9	234	5.9

3.4.3. Nitrous Oxide (N_2O)

Nitrous oxide emissions stood at 2,665 Gg CO_2-eq in 2014. Emissions regressed by 219 Gg CO_2-eq from 2,884 Gg CO_2-eq in the year 1994 to 2,665 Gg CO_2-eq (Table 3.6) in 2014. The AFOLU sector was the highest emitter of N_2O with 97 to 98%.

Table 3.6 - N_2O emissions (Gg) by source category (1994 - 2014)

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

3.5. Trends for indirect GHGS and SO_2

Emissions of indirect GHGs (CO, NO_x and NMVOC) and SO_2, have also been estimated and reported in the inventory. Indirect GHGs have not been included in national total emissions. Emissions of these gases for the period 1994 to 2014 are given in Table 3.7.

Emissions of NO_x decreased from 48.4 Gg in the year 1994 to 38.2 Gg in 2014. Carbon monoxide emissions also regressed from 2,198 Gg in 1994 to 939 Gg in 2014. Emissions of NMVOC increased from 15.9 Gg in 1994 to 24.5 Gg in 2014 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 (1994 - 2014)

Year	NO_x	CO	NMVOC	SO_2
1994	48.4	2,198.1	15.9	2.6
1995	45.0	2,082.6	16.0	2.1
1996	43.7	1,966.5	16.2	2.2
1997	41.4	1,849.1	16.7	1.9
1998	41.4	1,731.1	17.6	2.3
1999	41.1	1,611.9	18.4	2.5
2000	39.0	1,465.5	19.8	2.2
2001	40.6	1,478.7	19.7	2.4
2002	37.0	1,132.8	19.3	2.7
2003	38.8	1,140.6	20.1	3.0
2004	36.9	1,024.7	20.5	3.5
2005	41.1	1,267.2	20.4	3.7
2006	45.5	1,618.8	21.3	4.2
2007	49.3	1,904.4	21.4	4.0
2008	37.0	1,200.4	21.3	4.1
2009	54.9	2,263.2	21.7	3.7
2010	51.2	1,946.0	21.8	3.0
2011	52.7	2,076.8	13.0	3.0
2012	56.3	2,166.1	23.9	3.7
2013	30.7	657.3	22.6	2.5
2014	38.2	939.4	24.5	2.7

3.5.1. NO_x

Emissions of NO_x decreased by 21% over the inventory period from 48.4 Gg in the year 1994 to 38.2 Gg in 2014 (Table 3.8). The two main sources of NO_x emissions were the Energy and AFOLU sectors. The Energy sector witnessed an increase from 30% to 64% while the AFOLU sector contribution regressed from 70% to 35% of total national emissions from 1994 to 2014. Waste contributed the remainder.

Table 3.8 - NO_x emissions (Gg) by source category (1994 - 2014)

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	43.7	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

3.5.2. CO

The major contributor of CO was the AFOLU sector with between 91% and 98% of national emission followed by the Energy sector with between 25 to 8% (Table 3.9). National CO emissions decreased from 2,198 Gg in the year 1994 to 939 Gg in 2014. The AFOLU sector contributed 858 Gg of total CO emissions compared to 73 Gg by the Energy sector and 8.5 Gg by the Waste sector in 2014.

Table 3.9 - CO emissions (Gg) by source category (1994 - 2014)

Year	Total emissions	Energy	%Energy	AFOLU	%AFOLU	Waste	%Waste
1994	2,198.1	42.4	0.02	2,152.3	0.98	3.5	0.00
1995	2,082.6	43.8	0.02	2,035.2	0.98	3.6	0.00
1996	1,966.5	45.6	0.02	1,917.2	0.97	3.7	0.00
1997	1,849.1	47.1	0.03	1,798.1	0.97	3.9	0.00
1998	1,731.1	49.1	0.03	1,678.0	0.97	4.0	0.00
1999	1,611.9	50.9	0.03	1,556.9	0.97	4.2	0.00
2000	1,465.5	52.8	0.04	1,408.3	0.96	4.3	0.00
2001	1,478.7	55.5	0.04	1,418.8	0.96	4.5	0.00
2002	1,132.8	55.4	0.05	1,072.6	0.95	4.7	0.00
2003	1,140.6	60.0	0.05	1,075.7	0.94	5.0	0.00
2004	1,024.7	62.8	0.06	956.7	0.93	5.2	0.01
2005	1,267.2	65.0	0.05	1,196.7	0.94	5.4	0.00

Year	Total emissions	Energy	%Energy	AFOLU	%AFOLU	Waste	%Waste
2006	1,618.8	67.4	0.04	1,545.7	0.95	5.7	0.00
2007	1,904.4	69.1	0.04	1,829.3	0.96	6.0	0.00
2008	1,200.4	64.6	0.05	1,129.5	0.94	6.3	0.01
2009	2,263.2	66.9	0.03	2,189.8	0.97	6.6	0.00
2010	1,946.0	71.0	0.04	1,868.1	0.96	6.9	0.00
2011	2,076.8	66.3	0.03	2,003.0	0.96	7.5	0.00
2012	2,166.1	66.6	0.03	2,091.2	0.97	8.2	0.00
2013	657.3	66.5	0.10	582.4	0.89	8.4	0.01
2014	939.4	72.9	0.08	858.0	0.91	8.5	0.01

3.5.3. NMVOCs

In 2014, NMVOCs emissions stood at 24.5 Gg compared to 15.9 Gg in the year 1994. 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 0.2 Gg to 0.5 Gg during the inventory period.

Table 3.10 - NMVOC emissions (Gg) by source category (1994 - 2014)

Year	Total emissions	Energy	IPPU	AFOLU	Waste
1994	15.9	5.9	0.7	9.2	0.2
1995	16.0	6.0	0.7	9.1	0.2
1996	16.2	6.3	0.8	9.0	0.2
1997	16.7	6.4	0.9	9.3	0.2
1998	17.6	6.7	1.1	9.7	0.2
1999	18.4	7.0	1.2	10.0	0.2
2000	19.8	7.2	1.3	11.0	0.2
2001	19.7	7.1	1.5	10.9	0.2
2002	19.3	7.2	1.4	10.5	0.2
2003	20.1	7.7	1.6	10.5	0.3
2004	20.5	8.0	1.6	10.6	0.3
2005	20.4	8.3	1.7	10.1	0.3
2006	21.3	8.6	1.7	10.6	0.3
2007	21.4	8.8	1.8	10.5	0.3
2008	21.3	8.3	1.9	10.7	0.4
2009	21.7	8.6	2.1	10.7	0.4
2010	21.8	9.1	2.1	10.3	0.4
2011	13.0	8.6	2.2	1.7	0.5
2012	23.9	8.7	2.3	12.4	0.5
2013	22.6	8.5	2.3	11.2	0.5
2014	24.5	9.2	2.3	12.5	0.5

3.5.4. 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 1994 to 2014 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 (1994 - 2014)

Year	Total emissions	Energy	Waste
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

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)

4.1.1.1. 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) Zambia and Zimbabwe compared to 65% in 2012.

Namibia's currently total installed electricity generation capacity is about 500 MW for a peak demand of some 597 MW normally. The biggest generation plant is the Ruacana Hydro Power station which generates about 332 MW of electricity, Van Eck Coal power station generates about 120 MW and the Paratus and Anixas diesel power stations at the coast with 24 MW and 22.5 MW respectively (Konrad *et al*., 2013). The fossil fuel generation plants are mainly used to supplement the imports and hydro production during peak demand time. Solar and wind potential exists but are tapped only marginally up to now. The strategy is geared towards penetration of renewable energy sources and a better idea of the status can be obtained in the mitigation chapter of this report where actions are more extensively described.

4.1.1.2. 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.

4.1.1.3. 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 areas of transport. Fuel supplied for international bunkering was also covered.

4.1.1.4. 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.

The fuel mix used within the residential sector by households for cooking varied over the inventory period following urbanisation and increase in purchasing power resulting in households shifting from wood and charcoal to other energy sources. In 2014, the mix was about 50% using wood/charcoal, electricity (33%) and the remainder mainly LPG. Paraffin and waxes (50%) and electricity (43%) were the main sources of energy used for lighting. About 50% of households consumed wood/charcoal for heating purposes and 30% had recourse to electricity.

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.

4.1.1.5. 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 for estimating GHG emissions.

4.1.1.6. 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 sector source categories. Thereafter, the IPCC conversion and emission factors were adopted to compile GHG emissions. The Sectoral approach covered all the IPCC source categories where AD were available. AD could not be traced for a few minor sub-categories such as Agriculture, Forestry, Commercial and Institutional but this does not really affect the quality of the inventory as the fossil fuels consumed in these sub-categories have been allocated and burned in other categories.

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

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

Where

Emissions $_{\text{GHG, fuel}}$	=	emissions of a given GHG by type of fuel (kg GHG)
Fuel Consumption $_{\text{fuel}}$	=	amount of fuel combusted (TJ)
Emission Factor $_{\text{GHG, fuel}}$	=	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 working out the reference approach was obtained from the energy 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 International Energy Agency, the United Nations and Food and Agriculture Organisation among others. These sources provided most of the AD required for the period 1994 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 of these years were thus obtained from the international databases or from 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 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
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.

Category	Fuel type	Data source
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 the sectors. This is due to the fact that the country is still in the process of putting in place its GHG inventory management system. 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. Fuel used for sectors 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 emission factors for the Energy sector. Thus, the IPCC default emission factors were adopted to compute greenhouse gas 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)

CO_2 emissions were estimated anew under the RA as updated data sets on energy became available. The results differed between the years but 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 after independence of the country. Another impacting would be rolling stocks from one year to the next as this is difficult to track within the country’s context. As well, it could be that fuels are purchased outside the borders and then burned on the territory or vice versa. 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	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Energy generation	HFO and LFO	212	212	212	212	212	212	53	119	131	628	130	1,239	2,610	2,569	554	774	1,123	1,230	5,616	2,914	1,508
	Bitum. coal	12,262	13,203	14,143	15,084	16,024	16,965	2,926	3,609	18	7,942	718	20,384	63,877	76,599	95,876	57,453	13,105	3,735	32,344	2,575	275
Mining	Gasoline	2,454	2,454	2,454	2,454	2,454	2,454	2,454	2,454	2,454	2,454	2,454	2,454	2,454	2,454	2,454	2,454	2,454	2,454	2,454	2,454	2,454
	Gasoil/Diesel	8,271	8,909	9,548	10,186	10,824	11,463	11,778	11,508	10,994	11,938	15,007	14,771	17,309	23,244	25,310	22,536	21,145	19,767	21,149	15,464	16,201
	Bitum. coal	30,150	30,465	30,781	31,097	31,413	31,728	33,479	39,040	25,800	38,040	38,040	32,600	32,840	28,400	23,960	31,160	36,160	49,640	36,148	36,464	36,780
	Waste oil	427	427	427	427	427	427	483	224	618	1,011	2,050	3,089	3,483	5,599	7,440	7,702	6,948	7,602	7,615	7,840	7,686
	Other petroleum pdts	16	16	16	16	20	0	1	0	43	19	26	205	148	194	154	101	1,389	1,418	890	933	215
	Petroleum coke	134	134	134	134	0	582	197	0	18	2	211	0	816	0	0	0	155	281	0	0	24
Other manufacturing	Gasoline	175	180	184	188	193	206	218	212	221	223	239	231	232	239	226	253	257	259	271	275	269
	Gasoil/Diesel	238	249	261	272	283	296	317	326	387	371	396	395	404	398	408	421	440	405	483	493	475
	Wood/wood waste	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27	21	28
Civil aviation	Aviation Gasoline	2,712	2,751	2,790	2,829	2,868	2,907	3,012	3,043	3,074	3,105	3,136	3,167	3,210	3,210	3,210	3,210	3,596	3,413	3,452	3,491	3,530
	Jet kerosene	2,644	2,716	2,788	2,859	2,931	3,002	3,074	3,105	3,136	3,168	3,200	3,232	3,264	3,297	3,330	3,363	3,456	5,652	4,554	4,554	4,554
Road transportation	Gasoline	159,390	169,585	179,780	189,975	200,169	210,364	220,559	239,093	236,045	268,509	283,498	300,461	318,194	331,730	294,461	308,100	333,283	290,682	294,559	301,334	345,808
	Diesel	76,963	92,407	107,851	123,295	138,739	154,183	169,627	192,004	196,915	232,291	249,491	269,389	286,920	304,652	286,210	313,149	348,809	347,386	374,068	381,972	437,331
	LPG	-	-	-	-	-	-	-	-	-	-	-	-	-	72	276	496	715	500	500	500	500
Railways	Gasoil/Diesel	11,003	11,383	11,763	12,143	12,524	12,904	12,900	13,607	14,314	15,021	15,728	16,435	16,808	17,207	16,022	15,710	6,571	5,948	6,416	-	-
	Fuel oil			-	-	-	-	-	-	-	-	-	-	-	-	-	-	9,857	8,922	9,624	14,944	15,570
Residential	Other Kerosene	4,282	4,173	4,064	3,956	3,847	3,738	3,316	3,283	3,251	3,219	3,187	3,155	3,124	3,093	2,700	2,357	2,057	1,796	1,568	1,369	1,195
	LPG	6,000	7,000	7,000	8,000	7,395	6,987	5,705	7,798	9,781	9,059	6,085	9,999	9,461	8,923	8,419	7,915	7,422	7,348	6,050	6,406	8,597
	Parafin wax	24,000	24,000	24,000	24,000	24,000	24,000	23,532	21,855	23,661	24,265	27,354	24,612	23,256	23,303	27,700	28,791	22,023	24,000	24,000	24,000	24,000
	Wood fuel	245,023	247,050	249,088	251,139	253,202	255,278	257,368	259,471	259,685	259,883	260,063	260,225	260,369	260,496	260,605	260,696	260,769	260,823	259,319	257,895	256,551
	Charcoal	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Fishing	Gasoline	2,110	2,280	2,450	2,620	2,790	2,960	3,300	3,470	3,640	3,810	3,980	4,150	4,320	4,490	4,660	4,830	5,000	5,170	5,340	3,871	4,023
	Gasoil/Diesel	112,626	85,741	85,741	71,935	87,921	101,000	98,000	107,000	128,000	132,000	121,000	116,000	90,748	71,932	65,660	75,460	78,596	76,636	93,100	66,836	81,340
Non-specified	Gasoline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	241	273	281	325
	Diesel	4,667	5,603	6,540	7,476	8,412	9,349	10,285	11,576	11,812	12,967	13,442	13,512	13,884	13,879	11,589	11,987	12,807	13,742	15,576	16,010	18,525
International aviation	Jet kerosene	23,066	23,833	24,599	25,366	26,132	26,899	27,665	27,945	28,227	28,512	28,800	29,088	29,379	29,673	29,969	30,269	31,120	37,826	34,473	34,473	34,473
International marine bunkers	Gasoil/Diesel	28,281	27,781	27,280	26,780	26,280	25,780	25,247	24,672	24,039	23,407	22,774	22,142	21,509	20,876	20,244	19,611	18,979	18,921	18,921	18,921	18,921
	Gasoline	618	613	608	603	598	593	588	597	605	613	621	629	637	645	654	662	670	686	686	686	686
	Residual Fuel Oil	15,248	15,402	15,558	15,715	15,874	16,034	16,196	17,399	18,602	19,805	21,008	22,211	23,413	24,616	25,819	27,022	28,225	29,428	29,428	29,428	29,428

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) (1994 - 2014)

Approach	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Reference approach (Gg)	1,517	1,806	1,918	1,965	2,022	2,036	2,055	2,607	2,492	2,680	2,838	2,802	2,916	3,266	3,298	3,261	2,912	2,912	3,409	3,028	3,189
Sectoral approach (Gg)	1,410	1,417	1,508	1,557	1,696	1,829	1,868	2,046	2,093	2,379	2,444	2,590	2,740	2,822	2,671	2,748	2,837	2,713	2,918	2,776	3,142
Difference (%)	7.6	27.4	27.2	26.2	19.2	11.3	10.0	27.4	19.1	12.7	16.1	8.2	6.4	15.7	23.5	18.7	2.7	7.3	16.8	9.1	1.5

4.5.2. Sectoral approach

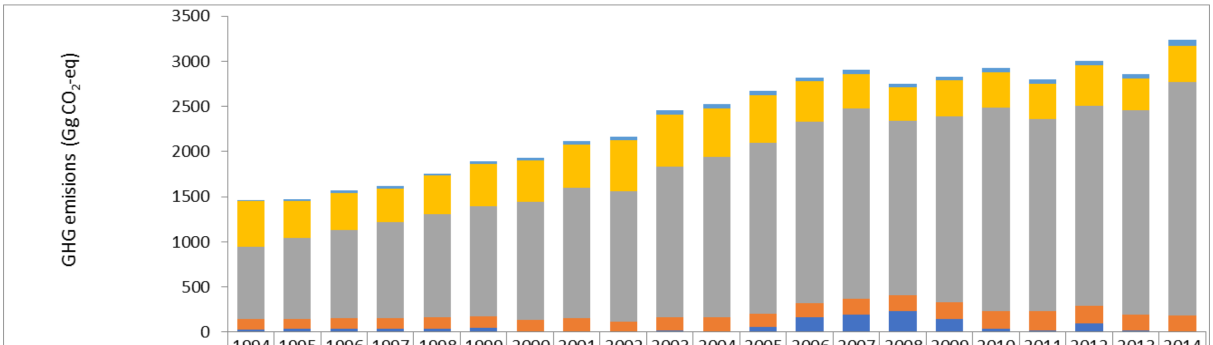
Only one category is concerned with emissions in the Energy sector, namely Fuel Combustion activities. Total aggregated emissions for the three direct GHGs are provided in Table 4.5 while the share of emissions by category is depicted in Figure 4.1 for the five IPCC source sub-categories falling under Fuel Combustion activities for the time series 1994 to 2014. Total emissions from Fuel Combustion Activities varied from 1,464 Gg CO_2-eq in 1994 to 3,234 Gg CO_2-eq in 2014. The emissions varied between the years under review as fuel combustion is related to economic activity and other factors. However, the trend is for an increase in consumption of fossil fuels from 1994 to 2014.

Table 4.5 - Emissions for Fuel Combustion Activities (Gg CO_2-eq) (1994 - 2014)

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
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

Other sectors: include Residential and Fishing

Transport contributed the major share of these emissions, between 55 and 80% over the period 1994 to 2014. Emissions from transport increased by 221% over these 21 years. Emissions from Other Sectors category remained the second highest emitter after transport. Emissions fluctuated between 352 Gg CO_2-eq and 576 Gg CO_2-eq, representing between 12% and 34% of total aggregated emissions. Emissions from Manufacturing Industries and Construction varied between 11 and 222 for a share of 5.8% and 8.0 of total aggregated emissions. Energy Industries emissions varied widely because local electricity generation serves only to supplement import deficits and emissions from that category hit a maximum of 8.6% in 2008.



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Non-specified	15.13	18.16	21.2	24.24	27.27	30.31	33.34	37.53	38.29	42.04	43.58	43.8	45.01	44.99	37.57	38.86	41.52	45.31	51.35	52.78	61.08
Other sectors	500	417.3	417.8	376.9	426.8	467.9	453	483.8	562.8	575.7	541.1	529.2	443.1	381.8	372.5	405.1	393.2	392.2	440.7	352.3	405.1
Transport	806.9	890.8	974.6	1058	1142	1226	1309	1442	1451	1671	1776	1897	2011	2113	1933	2062	2261	2123	2222	2265	2587
Manuf. Ind. & Const.	111.2	114	116.9	119.8	122.2	126.9	131.3	142.7	110.1	144.2	158	146.8	159.2	171.2	172.3	181.9	191.8	222.9	192.1	175.5	176
Energy Industries	30.75	33.05	35.36	37.67	39.98	42.28	7.343	9.226	0.456	21.45	2.17	53.89	164.9	196	236.9	143.4	35.67	12.97	96.97	15.46	5.404

Figure 4.1 - Share of GHG emissions (Gg CO_2-eq) by Energy sub-category (1994 - 2014)

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 lately. Emissions from the Road transportation sub-category increased from 751 Gg CO_2-eq in 1994 to reach 2507 Gg CO_2-eq in 2014.

Table 4.6 - GHG emissions (Gg CO_2-eq) by Energy sub-category (1994 - 2014)

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)
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

The evolution of emissions of direct and indirect GHGs in the Energy sector is presented in Table 4.7. Throughout the period 1994 to 2014, CO_2 contributed the major part of the emissions of the direct gases followed by CH_4 and N_2O. The contribution of CO_2 turned around 97% (Figure 4.2) of emissions 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 (1994 - 2014)

Year	Gg CO_2-eq			Gg			
	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2

Year	Gg CO_2-eq			Gg			
	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
1994	1409.8	32.1	22.2	14.3	42.4	5.9	2.6
1995	1417.5	32.4	23.5	12.8	43.8	6.0	2.1
1996	1507.9	33.0	25.0	13.4	45.6	6.3	2.2
1997	1557.2	33.4	26.4	13.0	47.1	6.4	1.9
1998	1696.3	34.2	28.0	14.8	49.1	6.7	2.2
1999	1829.0	34.9	29.6	16.5	50.9	7.0	2.5
2000	1867.5	35.4	30.8	16.7	52.8	7.2	2.2
2001	2045.9	36.4	33.3	18.2	55.5	7.1	2.4
2002	2092.8	36.5	33.7	19.9	55.4	7.2	2.7
2003	2378.9	37.7	37.6	21.7	60.0	7.7	3.0
2004	2443.8	38.2	39.4	21.7	62.8	8.0	3.5
2005	2590.3	38.8	41.6	22.1	65.0	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	71.0	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	66.6	8.7	3.7
2013	2775.9	38.7	46.4	21.2	66.5	8.5	2.5
2014	3142.3	40.3	51.6	24.4	72.9	9.2	2.7

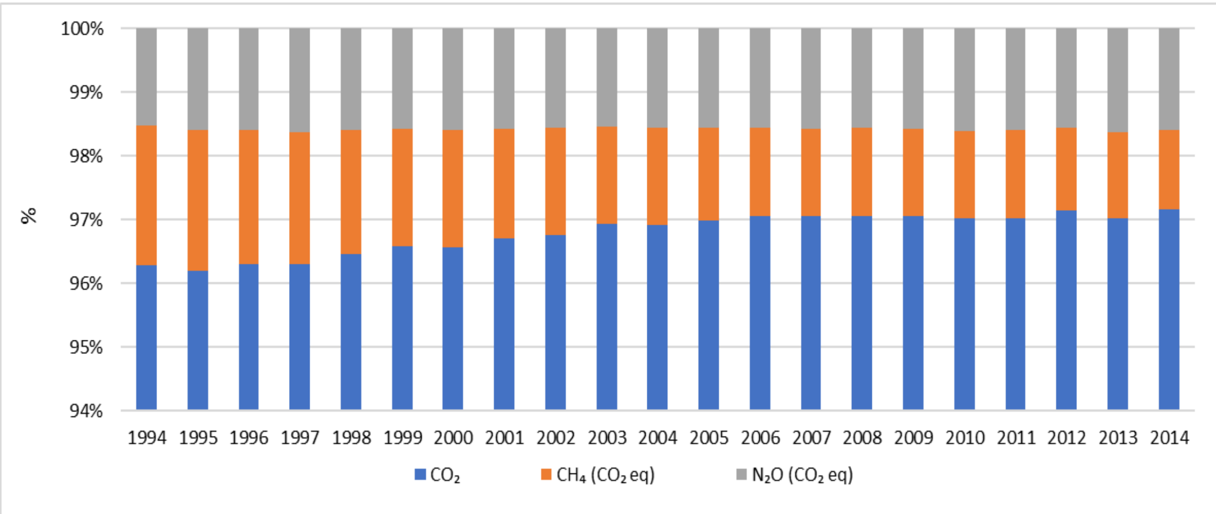


Figure 4.2 - Share emissions by gas (%) for the Energy sector (1994 - 2014)

4.5.3. Evolution of emissions by gas (Gg) in the Energy Sector (1994 - 2014)

Emissions of CO_2 in the Energy sector, Fuel Combustion Activities category showed an increase over the period 1994 to 2014, from 1,410 to 3,142 Gg. The annual increase which was quite sharp up to 2007 and plateaued thereafter until 2014.

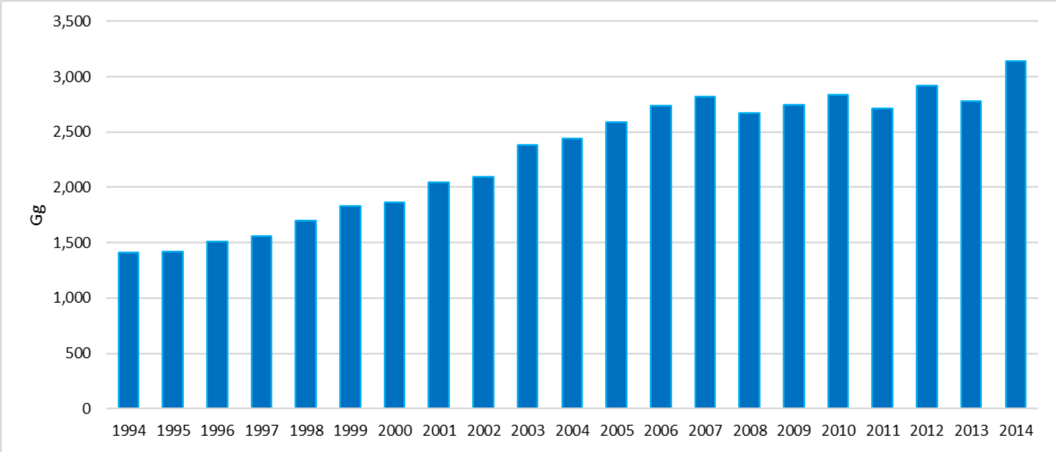


Figure 4.3 - Evolution of CO_2 emissions (Gg) in the Energy Sector (1994 - 2014)

With regard to CH_4, emissions varied between 1.5 Gg and 1.9 Gg during the period 1994 to 2014 (Figure 4.4). After increasing to 1.9 Gg during the period 1994 to 2007, emissions stabilised between 1.8 Gg and 1.9 Gg until 2014.

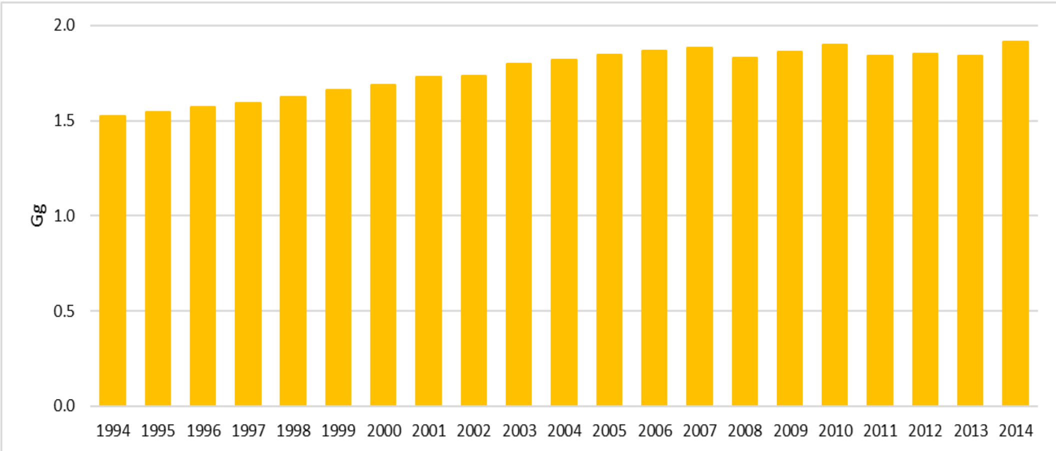


Figure 4.4 - Evolution of CH_4 emissions (Gg) in the Energy Sector (1994 - 2014)

Emissions of N_2O increased from 0.10 to 0.2 Gg (Figure 4.5) over the period 1994 to 2014.

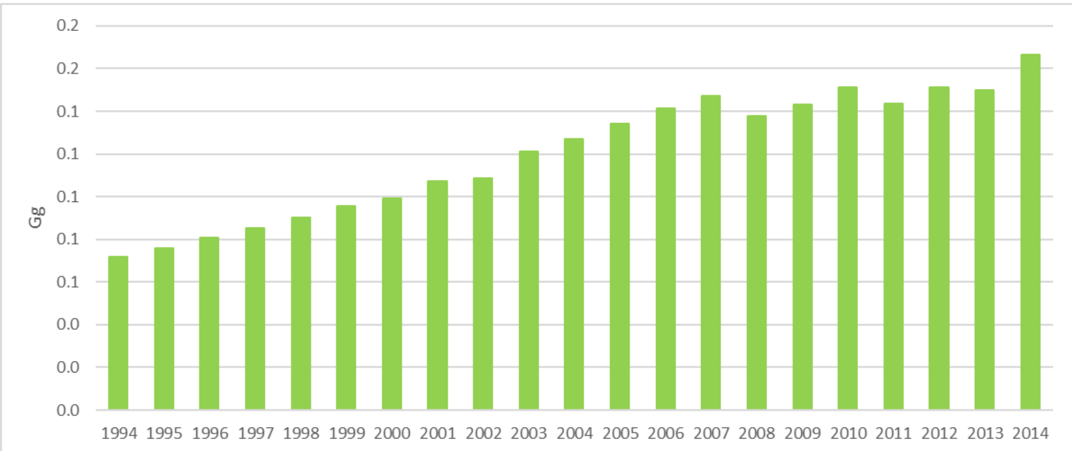


Figure 4.5 - Evolution of N_2O emissions (Gg) in the Energy Sector (1994 - 2014)

Emissions of NO_x varied from 14.3 Gg to 24.4 Gg during the period 1994 to 2014 (Figure 4.6).

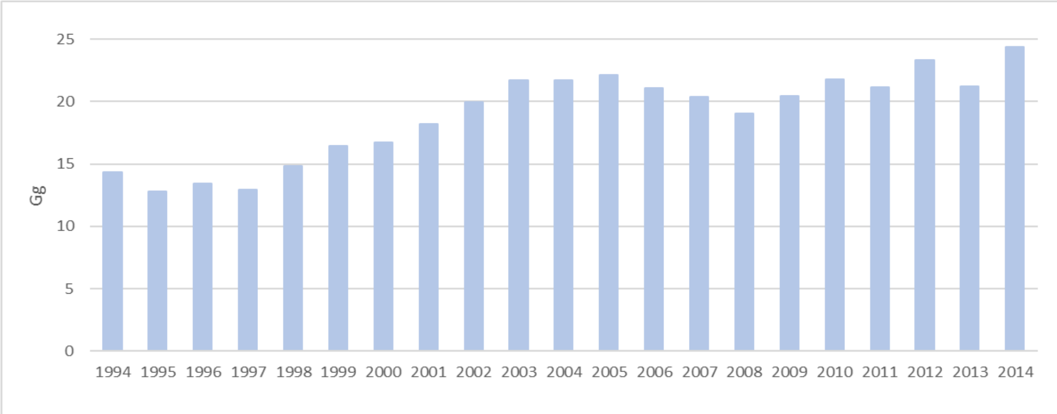


Figure 4.6 - Evolution of NO_x emissions (Gg) in the Energy Sector (1994 - 2014)

Emissions of CO started at 42.4 Gg in 1994 to reach 69.1 Gg in 2007. Thereafter it fluctuated up to 2014 to peak in that year at 72.9 Gg.

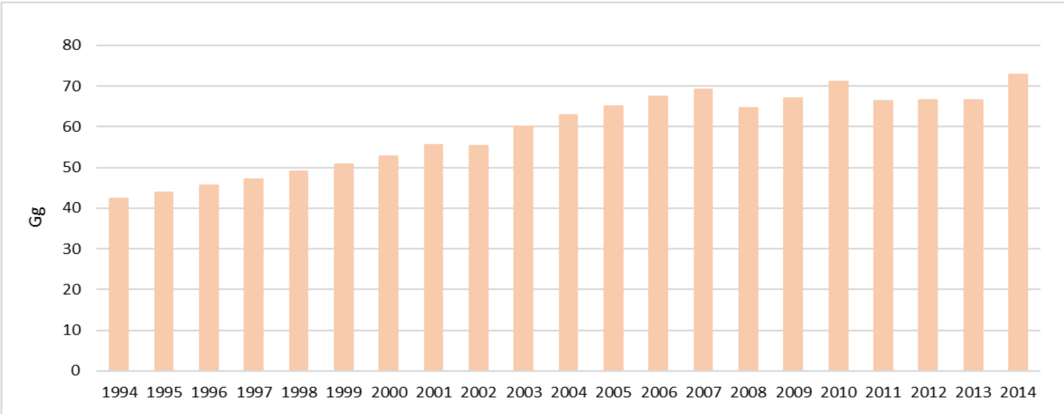


Figure 4.7 - Evolution of CO emissions (Gg) in the Energy Sector (1994 - 2014)

NMVOCs emissions increased by nearly 57% over the inventory period 1994 to 2014, starting at 5.9 Gg to reach 9.2 Gg (Figure 4.8).

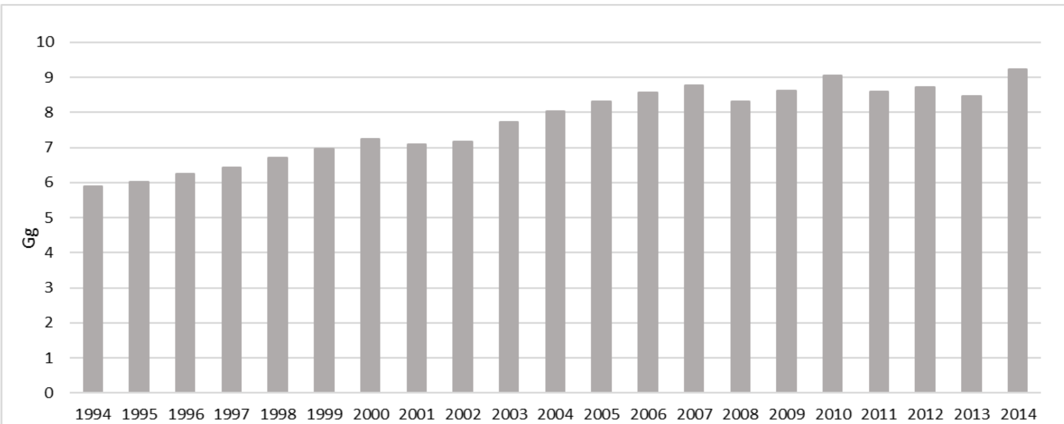


Figure 4.8 - Evolution of NMVOCs emissions (Gg) in the Energy Sector (1994 - 2014)

SO_2 emissions increased from 2.6 Gg in 1994 to reach a peak of 4.2 Gg in 2006, a 62% increase. However, emissions fluctuated thereafter and decreased to 2.7 Gg in 2014 (Figure 4.9).

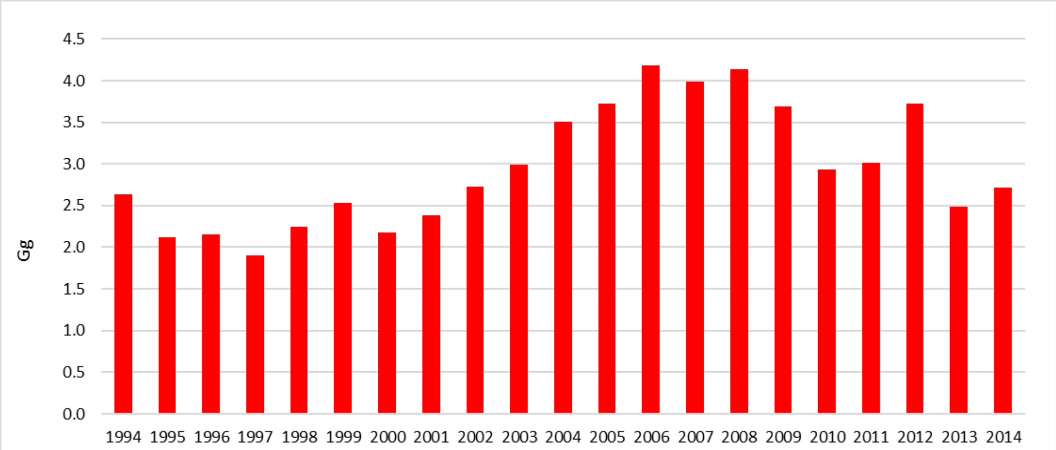


Figure 4.9 - Evolution of SO_2 emissions (Gg) in the Energy Sector (1994 - 2014)

Table 4.8 presents the emissions for the different categories and sub-categories of the Energy sector

4.5.4. Emissions by gas by category for the period 1994 to 2014

4.5.4.1. CO_2 emissions

Emissions (Gg) of CO_2 for the years 1994 to 2014 are summarized in Table 4.8. Total CO_2 emissions emanating from fuel combustion activities increased from 1,410 Gg in 1994 to 3,142 in 2014. For the Transport category, CO_2 emissions increased from 786 Gg in 1994 to 2,531 Gg in 2014, whilst for Energy Industries, it varied between 0.5 Gg to 235.7 Gg as the main activity electricity production only supplements imports from neighbouring countries. Emissions from the Other sectors sub-category fluctuated between 319 Gg and 541 Gg. The Non-specified sub-category emissions increased from 15 to 60 Gg over the period under review.

Table 4.8 - CO_2 emissions (Gg) (1994 - 2014)

Year	Total	Energy Industries	Manufacturing Industries and Construction	Transport	Other Sectors	Non-Specified
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

Year	Total	Energy Industries	Manufacturing Industries and Construction	Transport	Other Sectors	Non-Specified
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
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

4.5.4.2. CH_4 emissions

A total of 1.92 Gg of methane (CH_4) was emitted from the Energy sector, Fuel Combustion Activities category in 2014 from 1.53 Gg in 1994. The main contributing sub-categories over all years of this period 1994 to 2014 were Other Sectors and Transport. The former emitted at 1.31 Gg and Transport with 0.58 Gg (Table 4.9) in 2014. In 2014, CH_4 emissions from the Energy Industries sub-category was 0.00019 Gg and Manufacturing Industries and Construction emitted 0.021 Gg.

Table 4.9 - CH_4 emissions (Gg) (1994 - 2014)

Year	Total	Energy Industries	Manufacturing Industries and Construction	Transport	Other Sectors	Non-Specified
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

4.5.4.3. N_2O emissions

Total emissions from the Fuel Combustion Activities category increased from 0.07 Gg in 1994 to 0.17 Gg in 2014 (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 0.14 Gg, 0.019 Gg and 0.003 Gg respectively in 2014. 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) (2000 - 2012)

Year	Total	Energy Industries	Manufacturing Industries and Construction	Transport	Other Sectors	Non-Specified
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

4.5.4.4. NO_x emissions

Emissions of NO_x from the combustion of fuels increased from 14.3 Gg in 1994 to 24.4 Gg in 2014. 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 4.5 Gg in 1994 to 16.3 in 2014. Emissions from the Other Sectors sub-category varied between 5.6 Gg and 10.8 Gg during the period 194 to 2014 while Energy Industries emissions fluctuated between less than 0.1 Gg to 0.52 Gg. Non Specified sub-category emissions increased from 0.16 in 1994 0.62 Gg in 2014.

Table 4.11 - NO_x emissions (Gg) (1994 - 2014)

Year	Total	Energy Industries	Manufacturing Industries and Construction	Transport	Other Sectors	Non-Specified

Year	Total	Energy Industries	Manufacturing Industries and Construction	Transport	Other Sectors	Non-Specified
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

4.5.4.5. CO emissions

The Energy sector Fuel Combustion Activities category witnessed CO emissions of 42.4 Gg in 1994 which increased to 72.9 Gg in 2014. The emissions originated mainly from the Transport and Other Sectors sub-categories with 51.2 Gg and 20.3 Gg respectively in 2014 (Table 4.12). CO emissions for the Manufacturing Industries and Construction increased from 0.11 Gg in 1994 to 1.11 Gg in 2014 while Non-Specified sub-category emissions evolved from 0.04 Gg in 1994 to 0.19 Gg in 2014. Emissions from Energy Industries were minimal.

Table 4.12 - CO emissions (Gg) (2000 - 2012)

Year	Total	Energy Industries	Manufacturing Industries and Construction	Transport	Other Sectors	Non-Specified
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
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

Year	Total	Energy Industries	Manufacturing Industries and Construction	Transport	Other Sectors	Non-Specified
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

4.5.4.6. NMVOC emissions

Total NMVOC emissions increased from 5.9 Gg in 1994 to 9.2 Gg in 2014. NMVOCs originated mainly from the Transport and Other Sectors sub-categories and they accounted for 5.4 Gg and 3.6 Gg of emissions of the Energy sector respectively in 2014 (Table 4.13). The other three sub-categories contributed marginally to a total NMVOC emissions with about 0.25 Gg combined.

Table 4.13 - NMVOCs emissions (Gg) (2000 - 2012)

Year	Total	Energy Industries	Manufacturing Industries and Construction	Transport	Other Sectors	Non-Specified
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
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

4.5.4.7. SO_2 emissions

Total SO_2 emissions in the Energy sector varied between 1.9 Gg and 4.2 Gg for the time series 1994 to 2014. 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 1994 to 0.90 Gg in 2014 after a peak of 1.21 Gg in 2011.

Table 4.14 - SO_2 emissions (Gg) (2000 - 2014)

Year	Total	Energy Industries	Manufacturing Industries and Construction	Transport	Other Sectors	Non-Specified
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

4.5.4.8. Emissions (Gg) by gas from Energy Generation

Within the Energy Generation sub-category, GHG emissions, varied between 0.5 Gg CO_2-eq and 236.9 Gg CO_2-eq (Table 4.15). The largest share of emissions came from CO_2 for all years of the period 1994 to 2014.

Table 4.15 - Emissions (Gg) by gas from energy generation

Year	CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1994	30.8	30.6	3.4E-04	4.8E-04	0.07	2.9E-03	3.0E-04	0.26
1995	33.1	32.9	3.7E-04	5.2E-04	0.07	3.1E-03	4.0E-04	0.28
1996	35.4	35.2	3.9E-04	5.5E-04	0.08	3.3E-03	4.0E-04	0.30
1997	37.7	37.5	4.1E-04	5.9E-04	0.08	3.5E-03	4.0E-04	0.32

Year	CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1998	40.0	39.8	4.4E-04	6.3E-04	0.09	3.7E-03	4.0E-04	0.34
1999	42.3	42.1	4.6E-04	6.6E-04	0.09	3.9E-03	5.0E-04	0.36
2000	7.3	7.3	8.2E-05	1.1E-04	0.02	7.0E-04	1.0E-04	0.06
2001	9.2	9.2	1.1E-04	1.4E-04	0.02	9.0E-04	1.0E-04	0.08
2002	0.5	0.5	1.6E-05	3.9E-06	0.00	1.0E-04	0.0E+00	0.00
2003	21.5	21.3	2.8E-04	3.2E-04	0.05	2.2E-03	3.0E-04	0.18
2004	2.2	2.2	3.4E-05	3.1E-05	0.00	2.0E-04	0.0E+00	0.02
2005	53.9	53.6	6.8E-04	8.2E-04	0.12	5.3E-03	6.0E-04	0.46
2006	164.9	164.1	2.0E-03	2.5E-03	0.36	1.6E-02	1.9E-03	1.40
2007	196.0	195.0	2.3E-03	3.0E-03	0.43	1.9E-02	2.2E-03	1.67
2008	236.9	235.7	2.5E-03	3.7E-03	0.52	2.2E-02	2.5E-03	2.04
2009	143.4	142.6	1.6E-03	2.2E-03	0.31	1.3E-02	1.6E-03	1.23
2010	35.7	35.5	4.7E-04	5.3E-04	0.08	3.6E-03	4.0E-04	0.30
2011	13.0	13.0	2.5E-04	1.7E-04	0.03	1.6E-03	2.0E-04	0.10
2012	97.0	96.5	1.5E-03	1.4E-03	0.21	1.1E-02	1.4E-03	0.80
2013	15.5	15.4	4.2E-04	1.7E-04	0.03	2.4E-03	3.0E-04	0.11
2014	5.4	5.4	1.9E-04	4.7E-05	0.01	1.0E-03	1.0E-04	0.04

4.5.4.9. Emissions (Gg) by gas from Mining and Quarrying

Within the Mining and Quarrying sub-category, GHG emissions, expressed as Gg CO_2-eq, increased from 109.9 Gg in 1994 to peak at 220.8 Gg in 2011 (Table 4.16), and then regressed to 173.7 Gg in 2014, together with some fluctuations between years. More than 99% of the emissions stemmed from CO_2.

Table 4.16 - Emissions (Gg) by gas from the Mining and Quarrying sub-category

Year	CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1994	109.9	109.2	9.7E-03	1.5E-03	0.38	0.1	0.42	0.02
1995	112.7	112.0	9.9E-03	1.5E-03	0.39	0.1	0.42	0.02
1996	115.5	114.8	1.0E-02	1.6E-03	0.41	0.1	0.43	0.02
1997	118.3	117.6	1.0E-02	1.6E-03	0.42	0.1	0.43	0.03
1998	120.7	120.0	1.0E-02	1.6E-03	0.44	0.1	0.44	0.03
1999	125.3	124.6	1.1E-02	1.7E-03	0.46	0.1	0.44	0.03
2000	129.6	128.8	1.1E-02	1.7E-03	0.47	0.1	0.46	0.03
2001	141.0	140.1	1.2E-02	1.9E-03	0.31	0.0	0.02	0.03
2002	108.2	107.5	9.2E-03	1.4E-03	0.30	0.1	0.02	0.03
2003	142.4	141.5	1.3E-02	2.0E-03	0.32	0.1	0.03	0.03
2004	156.0	155.0	1.5E-02	2.3E-03	0.56	1.0	0.11	0.92
2005	144.9	143.9	1.4E-02	2.2E-03	0.54	0.9	0.13	0.79
2006	157.2	156.1	1.5E-02	2.4E-03	0.61	0.9	0.14	0.81
2007	169.2	168.0	1.7E-02	2.7E-03	0.72	0.9	0.16	0.71
2008	170.3	169.0	1.9E-02	2.8E-03	0.75	0.8	0.18	0.62
2009	179.8	178.4	2.1E-02	3.1E-03	0.72	1.0	0.20	0.78
2010	189.6	188.2	2.1E-02	3.2E-03	0.74	1.1	0.20	0.89
2011	220.8	219.1	2.5E-02	3.8E-03	0.77	1.4	0.23	1.20

Year	CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
2012	189.7	188.2	2.2E-02	3.3E-03	0.73	1.1	0.20	0.89
2013	173.1	171.7	2.1E-02	3.2E-03	0.61	1.1	0.19	0.89
2014	173.7	172.3	2.1E-02	3.1E-03	0.61	1.1	0.20	0.90

4.5.4.10. Emissions (Gg) by gas from Non-Specified Industry

GHG emissions in the Non-specified Industry sub-category (Table 4.17) increased from 1.3 Gg CO_2-eq in 1994 to 2.3 in 2014 after reaching 2.4 Gg CO_2-eq in 2012 and 2013, with nearly all emissions (99.7%) being CO_2.

Table 4.17 - Emissions (Gg) by gas from the Non-Specified Industry sub-category

Year	CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1994	1.3	1.3	5.4E-05	1.1E-05	9.2E-03	1.2E-03	5.0E-04	8.0E-04
1995	1.4	1.3	5.6E-05	1.1E-05	9.6E-03	1.2E-03	5.0E-04	9.0E-04
1996	1.4	1.4	5.8E-05	1.2E-05	9.9E-03	1.3E-03	5.0E-04	9.0E-04
1997	1.4	1.4	6.0E-05	1.2E-05	1.0E-02	1.3E-03	5.0E-04	9.0E-04
1998	1.5	1.5	6.2E-05	1.2E-05	1.1E-02	1.4E-03	5.0E-04	1.0E-03
1999	1.6	1.6	6.6E-05	1.3E-05	1.1E-02	1.4E-03	5.0E-04	1.0E-03
2000	1.7	1.7	7.0E-05	1.4E-05	1.2E-02	1.5E-03	6.0E-04	1.1E-03
2001	1.7	1.7	7.0E-05	1.4E-05	1.2E-02	1.5E-03	6.0E-04	1.1E-03
2002	1.9	1.9	7.9E-05	1.6E-05	1.4E-02	1.7E-03	7.0E-04	1.2E-03
2003	1.9	1.9	7.7E-05	1.5E-05	1.3E-02	1.7E-03	6.0E-04	1.2E-03
2004	2.0	2.0	8.3E-05	1.7E-05	1.4E-02	1.8E-03	7.0E-04	1.3E-03
2005	2.0	2.0	8.2E-05	1.6E-05	1.4E-02	1.8E-03	7.0E-04	1.3E-03
2006	2.0	2.0	8.3E-05	1.7E-05	1.4E-02	1.8E-03	7.0E-04	1.3E-03
2007	2.0	2.0	8.3E-05	1.7E-05	1.4E-02	1.8E-03	7.0E-04	1.3E-03
2008	2.0	2.0	8.3E-05	1.7E-05	1.4E-02	1.8E-03	7.0E-04	1.3E-03
2009	2.1	2.1	8.8E-05	1.8E-05	1.5E-02	1.9E-03	7.0E-04	1.4E-03
2010	2.2	2.2	9.1E-05	1.8E-05	1.6E-02	2.0E-03	8.0E-04	1.4E-03
2011	2.1	2.1	8.7E-05	1.7E-05	1.5E-02	1.9E-03	7.0E-04	1.4E-03
2012	2.4	2.4	1.1E-04	2.1E-05	1.7E-02	2.4E-03	9.0E-04	1.5E-03
2013	2.4	2.4	1.1E-04	2.2E-05	1.7E-02	2.4E-03	9.0E-04	1.6E-03
2014	2.3	2.3	1.1E-04	2.1E-05	1.7E-02	2.4E-03	9.0E-04	1.5E-03

4.5.4.11. Emissions (Gg) by gas from Civil Aviation

Total emissions increased from 16.9 Gg CO_2-eq in 1994 to 28.7 Gg CO_2-eq in 2011 to fall to 25.5 Gg CO_2-eq in 2014. The main gas emitted in the Civil Aviation sub-category was CO_2, contributing more than 99% for all years under review (Table 4.18). CO was the main indirect GHG emitted and emissions increased from 3.3 Gg in 1994 to 4.2 Gg in 2014.

Table 4.18 - Emissions (Gg) by gas from the Civil Aviation sub-category

Year	CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1994	16.9	16.8	1.2E-04	4.7E-04	3.8E-02	3.3	5.2E-02	5.4E-03
1995	17.2	17.1	1.2E-04	4.8E-04	3.9E-02	3.3	5.3E-02	5.5E-03
1996	17.6	17.4	1.2E-04	4.9E-04	4.0E-02	3.4	5.3E-02	5.6E-03

Year	CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1997	17.9	17.8	1.3E-04	5.0E-04	4.1E-02	3.4	5.4E-02	5.7E-03
1998	18.3	18.1	1.3E-04	5.1E-04	4.2E-02	3.4	5.5E-02	5.8E-03
1999	18.6	18.5	1.3E-04	5.2E-04	4.3E-02	3.5	5.6E-02	5.9E-03
2000	19.2	19.0	1.3E-04	5.4E-04	4.4E-02	3.6	5.8E-02	6.1E-03
2001	19.4	19.2	1.4E-04	5.4E-04	4.4E-02	3.7	5.8E-02	6.1E-03
2002	19.6	19.4	1.4E-04	5.5E-04	4.5E-02	3.7	5.9E-02	6.2E-03
2003	19.8	19.6	1.4E-04	5.5E-04	4.5E-02	3.7	5.9E-02	6.3E-03
2004	20.0	19.8	1.4E-04	5.6E-04	4.6E-02	3.8	6.0E-02	6.3E-03
2005	20.2	20.0	1.4E-04	5.7E-04	4.6E-02	3.8	6.1E-02	6.4E-03
2006	20.4	20.2	1.4E-04	5.7E-04	4.7E-02	3.9	6.1E-02	6.5E-03
2007	20.5	20.4	1.4E-04	5.8E-04	4.7E-02	3.9	6.1E-02	6.5E-03
2008	20.6	20.5	1.4E-04	5.8E-04	4.7E-02	3.9	6.1E-02	6.5E-03
2009	20.7	20.6	1.5E-04	5.8E-04	4.8E-02	3.9	6.1E-02	6.6E-03
2010	22.2	22.0	1.6E-04	6.2E-04	5.0E-02	4.3	6.9E-02	7.1E-03
2011	28.7	28.4	2.0E-04	8.0E-04	7.2E-02	4.1	6.5E-02	9.1E-03
2012	25.3	25.1	1.8E-04	7.1E-04	6.1E-02	4.2	6.6E-02	8.0E-03
2013	25.4	25.2	1.8E-04	7.1E-04	6.1E-02	4.2	6.7E-02	8.0E-03
2014	25.5	25.3	1.8E-04	7.1E-04	6.1E-02	4.2	6.8E-02	8.1E-03

4.5.4.12. Emissions (Gg) by gas from Road Transportation

The Road Transportation sub-category emitted 750.7 Gg CO_2-eq in 1994, increasing to 2,506.7 Gg CO_2-eq in 2014. CO_2 was the main direct GHG emitted. Emissions of NO_x increased from 3.9 Gg in 1994 to reach 15.5 Gg in 2014. CO and NMVOCs emissions increased over the time period, from 20.7 Gg to 46.8 Gg for CO and from 2.2 Gg to 5.3 Gg for NMVOCs for the years 1994 to 2014 respectively (Table 4.19).

Table 4.19 - Emissions (Gg) by gas from the Road Transportation sub-category

Year	CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1994	750.7	734.6	0.25	0.04	3.9	20.7	2.2	6.9E-03
1995	832.9	815.1	0.26	0.04	4.4	22.1	2.4	7.5E-03
1996	915.0	895.6	0.28	0.04	5.0	23.5	2.5	8.0E-03
1997	997.1	976.1	0.30	0.05	5.5	24.9	2.7	8.6E-03
1998	1079.2	1056.6	0.32	0.05	6.0	26.3	2.8	9.1E-03
1999	1161.4	1137.1	0.33	0.06	6.5	27.7	3.0	9.7E-03
2000	1243.5	1217.6	0.35	0.06	7.1	29.1	3.2	1.0E-02
2001	1374.3	1345.8	0.38	0.07	7.9	31.6	3.4	1.1E-02
2002	1380.6	1352.1	0.38	0.07	8.0	31.2	3.4	1.1E-02
2003	1597.4	1564.5	0.43	0.08	9.3	35.5	3.9	1.3E-02
2004	1700.3	1665.3	0.46	0.08	9.9	37.3	4.1	1.3E-02
2005	1818.2	1780.8	0.48	0.09	10.6	39.5	4.3	1.4E-02
2006	1930.8	1891.1	0.51	0.09	11.2	41.7	4.6	1.5E-02
2007	2031.0	1989.4	0.54	0.10	11.8	43.5	4.8	1.6E-02
2008	1854.7	1816.8	0.48	0.09	10.9	39.0	4.3	1.4E-02
2009	1985.6	1945.2	0.50	0.10	11.8	41.0	4.6	1.5E-02

Year	CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
2010	2181.0	2136.7	0.55	0.11	13.0	44.4	4.9	1.6E-02
2011	2041.8	2000.8	0.48	0.10	12.5	39.5	4.4	1.4E-02
2012	2140.5	2097.7	0.49	0.10	13.2	39.9	4.5	1.5E-02
2013	2187.4	2143.7	0.51	0.11	13.5	40.8	4.6	1.5E-02
2014	2506.7	2456.6	0.58	0.12	15.5	46.8	5.3	1.7E-02

4.5.4.13. Emissions (Gg) by gas from Railways

Railways sub-category activities resulted in GHG emissions of 39.3 Gg CO_2-eq in 1994 which increased to 54.3 Gg CO_2-eq in 2014 (Table 4.20). The largest share of emissions (90%) was CO_2 in 2014. Emissions of other direct GHGs were insignificant. Of the indirect GHGs, emissions of NO_x were more important than CO with NMVOCs negligible as well as SO_2.

Table 4.20 - Emissions (Gg) by gas from the Railways sub-category

Year	CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1994	39.3	35.1	2.0E-03	1.4E-02	0.58	0.12	5.2E-02	1.0E-04
1995	40.7	36.3	2.0E-03	1.4E-02	0.60	0.12	5.4E-02	1.0E-04
1996	42.0	37.5	2.1E-03	1.4E-02	0.62	0.13	5.5E-02	1.0E-04
1997	43.4	38.7	2.2E-03	1.5E-02	0.64	0.13	5.7E-02	1.0E-04
1998	44.7	39.9	2.2E-03	1.5E-02	0.66	0.13	5.9E-02	1.0E-04
1999	46.1	41.1	2.3E-03	1.6E-02	0.68	0.14	6.1E-02	1.0E-04
2000	46.1	41.1	2.3E-03	1.6E-02	0.68	0.14	6.1E-02	1.0E-04
2001	48.6	43.4	2.4E-03	1.7E-02	0.71	0.15	6.4E-02	1.0E-04
2002	51.1	45.6	2.6E-03	1.8E-02	0.75	0.15	6.7E-02	1.0E-04
2003	53.6	47.9	2.7E-03	1.8E-02	0.79	0.16	7.1E-02	1.0E-04
2004	56.2	50.1	2.8E-03	1.9E-02	0.82	0.17	7.4E-02	1.0E-04
2005	58.7	52.4	2.9E-03	2.0E-02	0.86	0.18	7.7E-02	1.0E-04
2006	60.0	53.6	3.0E-03	2.1E-02	0.88	0.18	7.9E-02	1.0E-04
2007	61.5	54.8	3.1E-03	2.1E-02	0.90	0.18	8.1E-02	1.0E-04
2008	57.2	51.1	2.9E-03	2.0E-02	0.84	0.17	7.5E-02	1.0E-04
2009	56.1	50.1	2.8E-03	1.9E-02	0.82	0.17	7.4E-02	1.0E-04
2010	57.9	51.8	2.8E-03	1.9E-02	0.86	0.18	7.7E-02	1.0E-04
2011	52.4	46.9	2.6E-03	1.8E-02	0.78	0.16	7.0E-02	1.0E-04
2012	56.5	50.5	2.8E-03	1.9E-02	0.84	0.17	7.5E-02	1.0E-04
2013	52.1	46.7	2.5E-03	1.7E-02	0.78	0.16	7.0E-02	1.0E-04
2014	54.3	48.7	2.6E-03	1.8E-02	0.82	0.17	7.3E-02	1.0E-04

4.5.4.14. Emissions (Gg) by gas from the Residential sub-category

Emissions in the Residential sub-category (Gg CO_2-eq) increased from 132.8 in 1994 to reach a peak of 148.4 in 2009 and then regressed to 132.1 Gg CO_2-eq in 2014 (Table 4.21). The major contributor was CO_2. CH_4 was the next contributor to total emissions and N_2O being marginal.

Emissions of NO_x, NMVOC and CO did not change much over the period 1994 to 2014. NO_x stood at around 0.37 Gg, NMVOC around 2.6 Gg and CO around 17 Gg.

Table 4.21 - Emissions (Gg) by gas from the Residential sub-category

Year	CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1994	132.8	102.1	1.2	1.6E-02	0.34	16.0953	2.4	4.4E-02
1995	135.6	104.8	1.2	1.6E-02	0.35	16.1021	2.5	4.4E-02
1996	135.5	104.4	1.2	1.7E-02	0.35	16.4060	2.5	4.5E-02
1997	138.4	107.1	1.2	1.7E-02	0.36	16.4760	2.5	4.5E-02
1998	136.5	104.9	1.3	1.7E-02	0.36	16.7807	2.6	4.6E-02
1999	135.2	103.3	1.3	1.7E-02	0.36	16.8505	2.6	4.6E-02
2000	128.9	96.8	1.3	1.7E-02	0.36	17.0947	2.6	4.7E-02
2001	130.3	98.0	1.3	1.7E-02	0.37	17.1528	2.6	4.7E-02
2002	141.5	109.2	1.3	1.7E-02	0.37	17.1685	2.6	4.7E-02
2003	141.1	108.7	1.3	1.7E-02	0.37	17.2979	2.6	4.8E-02
2004	141.3	108.8	1.3	1.7E-02	0.37	17.3053	2.6	4.8E-02
2005	144.8	112.3	1.3	1.7E-02	0.38	17.3202	2.6	4.8E-02
2006	139.0	106.6	1.3	1.7E-02	0.38	17.4465	2.6	4.8E-02
2007	137.5	105.0	1.3	1.7E-02	0.38	17.4537	2.6	4.8E-02
2008	147.8	115.3	1.3	1.7E-02	0.38	17.4589	2.6	4.8E-02
2009	148.4	115.9	1.3	1.7E-02	0.37	17.4630	2.6	4.8E-02
2010	126.0	93.5	1.3	1.7E-02	0.37	17.4662	2.6	4.8E-02
2011	130.8	98.3	1.3	1.7E-02	0.37	17.4689	2.6	4.8E-02
2012	126.0	93.7	1.3	1.7E-02	0.37	17.3728	2.6	4.8E-02
2013	126.3	94.2	1.3	1.7E-02	0.37	17.4019	2.6	4.8E-02
2014	132.1	100.1	1.3	1.7E-02	0.37	17.4383	2.6	4.8E-02

4.5.4.15. Emissions (Gg) by gas from Fishing (mobile combustion) sub-category

Total GHG emission from the Fishing sub-category increased from 367 Gg CO_2-eq in 1994 to 435 Gg CO_2-eq in 2003 and then fluctuated to reach 273 Gg CO_2-eq in the year 2014 (Table 4.22). The largest share of emissions, above 99%, was CO_2. Emissions of all gases, the direct GHGs and precursors as well as SO_2 followed the same trend as CO_2. SO_2 emissions are relatively more important when compared with the other sub-categories. This decrease observed up to 2003 is due to lower fishing activities as a result of the depletion of fish stocks and the fluctuations thereafter attributable to the imposition of fishing quotas.

Table 4.22 - Emissions (Gg) by gas from the Fishing sub-category

Year	CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1994	367.3	365.3	0.05	3.0E-03	8.9	2.0	0.70	2.3
1995	281.7	280.2	0.04	2.3E-03	6.8	1.9	0.65	1.8
1996	282.2	280.7	0.04	2.3E-03	6.8	2.0	0.68	1.8
1997	238.5	237.3	0.03	1.9E-03	5.7	2.0	0.68	1.5
1998	290.3	288.7	0.04	2.3E-03	6.9	2.3	0.75	1.8
1999	332.7	330.9	0.04	2.7E-03	8.0	2.4	0.82	2.1
2000	324.1	322.4	0.04	2.6E-03	7.7	2.6	0.87	2.0
2001	353.5	351.6	0.05	2.9E-03	8.4	2.8	0.93	2.2
2002	421.3	419.0	0.06	3.4E-03	10.1	3.0	1.02	2.6
2003	434.6	432.3	0.06	3.5E-03	10.4	3.2	1.06	2.7

Year	CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
2004	399.9	397.8	0.05	3.2E-03	9.5	3.2	1.06	2.5
2005	384.4	382.4	0.05	3.1E-03	9.1	3.2	1.08	2.4
2006	304.0	302.4	0.04	2.5E-03	7.2	3.2	1.04	1.9
2007	244.3	243.0	0.03	2.0E-03	5.7	3.1	1.02	1.5
2008	224.7	223.5	0.03	1.8E-03	5.2	3.2	1.03	1.4
2009	256.6	255.3	0.03	2.1E-03	6.0	3.3	1.09	1.6
2010	267.2	265.8	0.04	2.2E-03	6.2	3.5	1.13	1.7
2011	261.5	260.1	0.04	2.1E-03	6.1	3.5	1.15	1.6
2012	314.7	313.0	0.04	2.5E-03	7.4	3.8	1.23	2.0
2013	226.0	224.8	0.03	1.8E-03	5.3	2.7	0.89	1.4
2014	273.0	271.5	0.04	2.2E-03	6.4	2.9	0.96	1.7

4.5.4.16. Emissions (Gg) by gas from Non-Specified subcategory

Emissions from this sub-category are mainly from mobile sources. Total emissions increased gradually from 15.1 Gg CO_2-eq in the year 1994 to 61.1 Gg CO_2-eq in 2014 (Table 4.23). CO_2 represented some 98% of these total emissions in 2014. The other two direct GHGs emissions were marginal. Of the indirect GHGs, emissions of CO and NO_x were minimal and those of NMVOCS were insignificant.

Table 4.23 - Emissions (Gg) by gas from the Non-Specified sub-category

Year	CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1994	15.1	14.9	7.8E-04	7.8E-04	0.16	0.04	8.9E-03	1.0E-04
1995	18.2	17.9	9.4E-04	9.4E-04	0.19	0.04	1.1E-02	1.0E-04
1996	21.2	20.8	1.1E-03	1.1E-03	0.22	0.05	1.2E-02	1.0E-04
1997	24.2	23.8	1.3E-03	1.3E-03	0.25	0.06	1.4E-02	1.0E-04
1998	27.3	26.8	1.4E-03	1.4E-03	0.28	0.06	1.6E-02	1.0E-04
1999	30.3	29.8	1.6E-03	1.6E-03	0.31	0.07	1.8E-02	1.0E-04
2000	33.3	32.8	1.7E-03	1.7E-03	0.34	0.08	2.0E-02	2.0E-04
2001	37.5	36.9	1.9E-03	1.9E-03	0.39	0.09	2.2E-02	2.0E-04
2002	38.3	37.6	2.0E-03	2.0E-03	0.39	0.09	2.2E-02	2.0E-04
2003	42.0	41.3	2.2E-03	2.2E-03	0.43	0.10	2.5E-02	2.0E-04
2004	43.6	42.8	2.3E-03	2.3E-03	0.45	0.10	2.6E-02	2.0E-04
2005	43.8	43.1	2.3E-03	2.3E-03	0.45	0.10	2.6E-02	2.0E-04
2006	45.0	44.2	2.3E-03	2.3E-03	0.46	0.11	2.6E-02	2.0E-04
2007	45.0	44.2	2.3E-03	2.3E-03	0.46	0.11	2.6E-02	2.0E-04
2008	37.6	36.9	1.9E-03	1.9E-03	0.39	0.09	2.2E-02	2.0E-04
2009	38.9	38.2	2.0E-03	2.0E-03	0.40	0.09	2.3E-02	2.0E-04
2010	41.5	40.8	2.1E-03	2.1E-03	0.43	0.10	2.4E-02	2.0E-04
2011	45.3	44.5	2.7E-03	2.3E-03	0.46	0.14	3.0E-02	2.0E-04
2012	51.4	50.5	3.0E-03	2.7E-03	0.52	0.16	3.4E-02	3.0E-04
2013	52.8	51.9	3.1E-03	2.7E-03	0.54	0.16	3.5E-02	3.0E-04
2014	61.1	60.0	3.6E-03	3.2E-03	0.62	0.19	4.0E-02	3.0E-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 1994 to 2014 due to enhanced levels of activities in both seaports and airports.

Total emissions from international bunkers are given in Table 4.24. It increased by 24% from 214.5 Gg CO_2-eq in the year 1994 to 265.6 Gg CO_2-eq in 2014. CO_2 was the major contributor with slightly more than 99% of total bunkering emissions for all the years. The other direct GHGs CH4 and N2O contributed the remainder.

Table 4.24 – Total emissions (Gg CO_2-eq) and by gas (Gg) from international bunkers

Year	Total CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
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

Total emissions from international aviation increased from 73.4 Gg CO_2-eq to 109.7 Gg CO_2-eq (Table 4.25), representing an increase of 49% in 2014 over the 1994 emissions. Once more, CO2 constituted more than 99% of the aggregated emissions of the direct gases.

Table 4.25 - Total emissions (Gg CO_2-eq) and by gas (Gg) from international aviation

Year	Total CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
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

Year	Total CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
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

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 141.1 Gg CO_2-eq in 1994 to 156.0 Gg CO_2-eq in 2014 (Table 4.26).

Table 4.26 - Total emissions (Gg CO_2-eq) and by gas (Gg) from international water-borne navigation

Year	Total CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
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
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

Year	Total CO_2-eq	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
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

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 4.27. Emissions increased by 4 % from 461.1 Gg in 1994 to 481.3 in 2014 after peaking at 488.8 Gg in 2011.

Table 4.27 - Emissions (Gg CO_2-eq) by gas from Biomass Combustion for Energy Production

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CO_2	461.1	464.7	468.2	471.8	475.4	479.1	482.7	486.4	486.8	487.1	487.4

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

5. Industrial Processes and Product Use (IPPU)

5.1. Description of IPPU sector

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

Emissions were estimated for activities occurring in only four out of the eight categories falling under the IPPU sector and these sub-categories are listed in Table 4.1.

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.H Other	2.H.2 - Food and Beverages Industry 2.H.2.a - Beer manufacturing 2.H.2.a - Bread making

Quite a number of activity areas have not been included given that activity data were still not available to compute the estimates, despite special efforts being devoted to collect these AD. ODS have been identified but they are all blends and work is ongoing to trace the different blends, their composition and the amounts used for estimating emissions. A full survey has to be completed for estimating SF6 from electrical equipment and resources are not available presently to undertake it. Regarding use of N_2O for medical applications, the concerned authorities are being contacted to obtain the required data. These sources are.

- **Product used as substitutes for ozone depleting substances**
  - Refrigeration and air conditioning
  - Fire protection
  - Aerosols
  - Solvents
- **Other products manufacture and use**
  - Disposal of electric equipment

- SF_6 in military applications
- N_2O from medical applications and 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 EMEP/EEA.

5.3. Activity Data

Activity data 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 used 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.

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[1] 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 285,000 tonnes/year at the beginning of the period to reach 385,000 tonnes by 2014 (Table 5.2).

It is worth noting that the cement plant claims to be one of the lowest CO_2 emitting cement factory in the world on account of its use of alternative fuels such as wood chips derived from encroacher bushes and charcoal fines as well as an energy-efficient production process.

5.3.2. Lime Production (2.A.2)

The amount of lime produced in Namibia steadily increased from 1995 when it stood at 5,901 tonnes to reach 21,679 tonnes in 2014. 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

[1] www.ohrongo-cement.com

for the period 1994 to 1999 while the 2000 to 2010 trend was used to extrapolate data for the period 2011 to 2014 (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 reach 102,188 tonnes in 2014 (Table 5.2).

5.3.4. Lubricant Use (2.D.1)

Activity data gaps for Lubricant Use were generated from data 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 1994 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 1994 to 1999 period with an annual use of around 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, production 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 1994 to 1999 and that of 2011 to 2014, 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 1994 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 1994 to 1997 was computed as the average amount of product used during the period 1998 to 2003, export data were retained for the period 1998 to 2002 and linear trending was of import and export data of the period 2003 to 2014 was used to generate data for completing the time series. Asphalt and bitumen use during the period 1994 to

2003 was mainly for maintenance purposes while the steady increase from 2004 onwards was due to development of the road network (Table 5.2).

5.3.9. 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 which were adjusted 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 21 years period under review, to reach almost 400,000 tonnes in 2014.

5.3.10. 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. The AD so obtained showed that wheat consumption increased from 55,865 tonnes in 1995 to reach 91,879 tonnes in 2014.

An extraction rate of 80% of this wheat was adopted to generate flour produced and the latter converted to bread at the rate of 610 g of flour per kg of bread.

Table 5.2 - Activity data for the IPPU sector (1995 - 2014)

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.H.2.a-Beer manufacturing (t)	2.D.H.2.a-Bread making (wheat and flour) (t)
1994	*	5,152	*	34	1,206	16	2,657	485	9,904	45,939
1995	*	5,901	*	854	30,000	16	3,169	485	9,908	55,865
1996	*	6,651	*	854	30,000	16	3,287	485	9,908	60,950
1997	*	7,401	*	854	30,000	16	3,405	485	42,141	45,646
1998	*	8,151	*	854	30,000	16	2,904	742	113,177	60,953
1999	*	8,900	*	854	30,000	16	5,169	92	156,568	75,648
2000	*	9,161	*	965	29,415	16	3,452	263	202,498	64,218
2001	*	10,735	*	448	27,319	16	3,729	1,175	258,058	65,271
2002	*	11,200	35	294	29,577	16	5,481	1,047	185,268	83,019
2003	*	12,400	47,436	2,022	30,332	16	2,224	2,672	264,395	80,685
2004	*	12,600	119,205	543	34,193	16	3,415	4,297	248,612	88,614
2005	*	13,050	132,813	6,179	30,765	16	3,524	5,921	264,516	85,699
2006	*	13,500	129,897	6,966	29,070	16	5,108	7,546	282,645	73,770
2007	*	14,500	150,080	11,197	29,128	16	5,542	9,171	291,301	74,914
2008	*	15,400	145,396	14,880	34,625	16	4,885	10,796	328,516	67,798
2009	*	17,600	150,400	15,404	35,989	16	5,723	12,421	393,881	70,136
2010	*	19,800	151,688	13,896	27,529	16	5,883	14,045	367,496	74,892
2011	284,000	18,996	144,755	15,205	30,000	16	8,397	15,670	385,193	79,918

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.H.2.a-Beer manufacturing (t)	2.D.H.2.a-Bread making (wheat and flour) (t)
2012	428,000	19,890	145,342	15,231	30,000	16	5,427	17,295	410,695	85,445
2013	520,000	20,785	124,924	15,681	30,000	16	5,379	18,920	427,188	89,471
2014	583,000	21,679	102,188	15,372	30,000	16	6,809	20,545	397,039	91,879

*** No activity**

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 5.3.

Table 5.3 - References for 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
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

Aggregated emissions by gas for inventory year 2014

5.5.1.1. Direct gases

The only direct gas emitted from IPPU Sector in 2014 was CO_2 and the emissions amounted to 522.37 Gg CO_2 (Table 5.4).

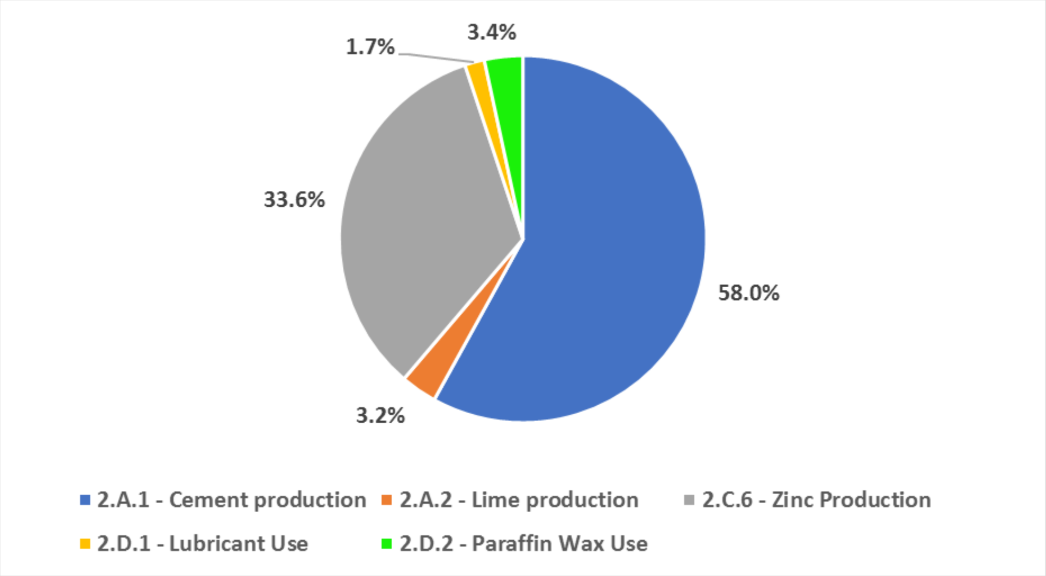


Figure 5.1 - Percentage distribution of emissions for IPPU Sector (2014)

5.5.1.2. Indirect gases

The only one indirect gas that was emitted by the sector in 2014 was HMVOCs of which a total of 2.33 Gg was emitted (Table 5.4).

Table 5.4 - Emissions from IPPU Sector for inventory year 2014

Categories	CO_2 (Gg)	NMVOCs (Gg)
2 - Industrial Processes and Product Use	522.37	2.33
2.A.1 - Cement production	303.16	NA
2.A.2 - Lime production	16.69	NA
2.C.6 - Zinc Production	175.76	NA
2.D.1 - Lubricant Use	9.06	NA
2.D.2 - Paraffin Wax Use	17.69	NA
2.D.3 - Solvent Use	NA	1.29
2.H.2 - Food and Beverages Industry	NA	1.04

5.5.2. Emissions trend of direct GHG and by category for the period 1994 to 2014

5.5.2.1. Direct gases

CO_2 emissions from IPPU Sector during the 1994 to 2014 period are given in Table 5.5. The total emissions of 522.37 Gg CO_2-eq was mainly due to the Cement Production and Zinc Production activities which represented 58.0% (303.16 Gg CO_2-eq) and 33.6% (175.76 Gg CO_2-eq) of emissions respectively. The remaining emissions originated from Paraffin Wax Use (3.4%), Lime Production (3.2%) and Lubricant Use (1.7%).

Table 5.5 - Emissions trends of CO_2 by category of IPPU Sector for period 1994 to 2014

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	IPPU Sector
1994	0	3.97	0	0.50	17.69	22.16

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	IPPU Sector
1995	0	4.54	0	0.50	17.69	22.73
1996	0	5.12	0	0.50	17.69	23.31
1997	0	5.70	0	0.50	17.69	23.89
1998	0	6.28	0	0.50	17.69	24.47
1999	0	6.85	0	0.50	17.69	25.04
2000	0	7.05	0	0.57	17.34	24.97
2001	0	8.27	0	0.26	16.11	24.64
2002	0	8.62	0.06	0.73	17.44	26.85
2003	0	9.55	81.59	1.19	17.88	110.21
2004	0	9.70	205.03	2.42	20.16	237.31
2005	0	10.05	228.44	3.64	18.14	260.27
2006	0	10.40	223.42	4.11	17.14	255.06
2007	0	11.17	258.14	6.60	17.17	293.08
2008	0	11.86	250.08	8.77	20.41	291.13
2009	0	13.55	258.69	9.08	21.22	302.54
2010	0	15.25	260.9	8.19	16.23	300.57
2011	147.68	14.63	248.98	8.96	17.69	437.94
2012	222.56	15.32	249.99	8.98	17.69	514.53
2013	270.4	16.00	214.87	9.25	17.69	528.21
2014	303.16	16.69	175.76	9.06	17.69	522.37

CO_2 emissions from IPPU Sector increased 23.6 times during the period 1994 to 2014 and the trend was characterised by the two almost exponential surges, attributed to start of production of zinc in 2003 and of cement in 2011 (Figure 5.2). A first significant increase in emissions was noted in 2003 with the start of Zinc Production which caused emissions to rise almost 9 fold to reach 235.22 Gg CO_2-eq by 2004 and then increase at a lower rate up to 2010 to reach 300.57 Gg CO_2-eq As from 2011, the activities for another industry, namely Cement Production, resulted in another jump in emissions which increased 1.7 fold over the following two years, reaching 514.57 Gg in 2012. Emissions from 2013 to 2014 remained fairly constant, reaching 522.37 Gg CO_2-eq at the end of the period.

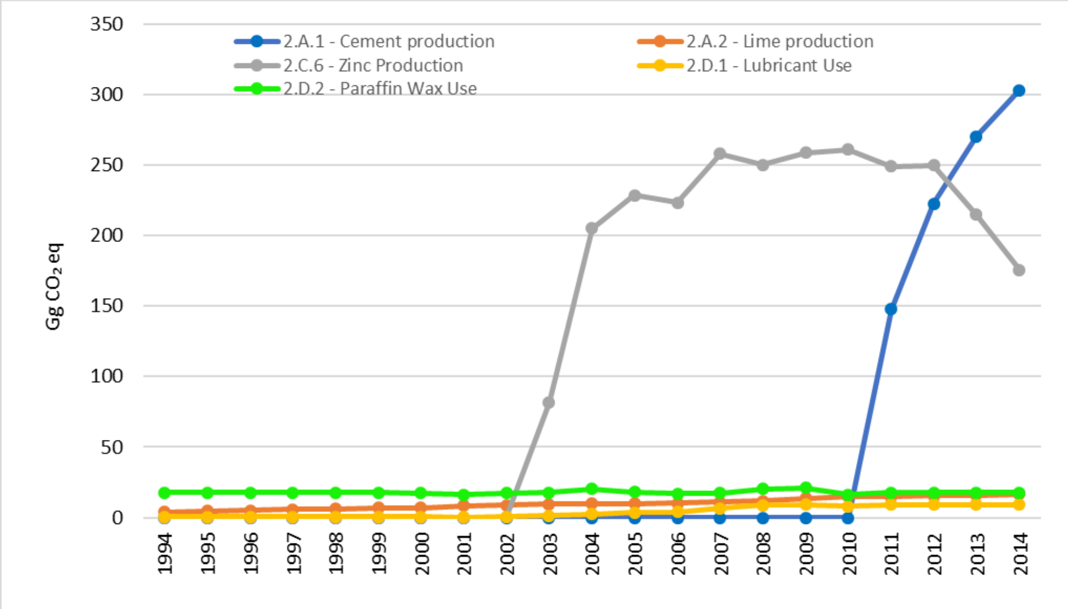


Figure 5.2 - CO_2-eq emission trends for IPPU sector source categories (1994 - 2014)

5.5.3. Emissions trend for IPPU sub-categories for inventory period 1994 to 2014

5.5.3.1. 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 5.6).

In 2014, a total amount of 2.33 Gg of NMVOCs were emitted by the IPPU sector, most of which originating from the use of solvents with 56.2% of emissions (1.29 Gg) and Food and Beverages with 44.8% of emissions at 1.04 Gg. Total emissions of NMVOCs increased by 1.66 Gg from 0.67 in 1994 to 2.33 in 2014. Of this 1.66 Gg, Solvent Use contributed 0.76 Gg and Food and Beverages the remaining 0.9 Gg.

Table 5.6 - NMVOCs emission trends for IPPU sector source categories (1994 - 2014)

Year	2.D.3 - Solvent	2.H.2 - Food and Beverages Industry	Total IPPU Sector
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
1999	0.72	0.51	1.23
2000	0.76	0.57	1.33
2001	0.8	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	1.7

Year	2.D.3 - Solvent	2.H.2 - Food and Beverages Industry	Total IPPU Sector
2006	0.99	0.76	1.75
2007	1.03	0.78	1.8
2008	1.06	0.83	1.9
2009	1.1	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

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.

New country-specific emission and stock factors were derived for the country and for the livestock and land categories. A different set of criteria was adopted to better represent the land classes within the national context since the basis adopted until the previous inventory was no longer representative of the situation of the country.

Namibia provides for a diversity of activities in the AFOLU sector occurring at varying intensities. Commercial and communal systems of production in the livestock and crop sectors are both present. Land use changes due to human activities mainly in forestland, woodland, grassland and cropland were significant contributors to emissions while also acting as sinks, particularly through the phenomenon of bush-encroachment.

6.1.1. Emission estimates for the AFOLU sector

The AFOLU sector remained a sink throughout the timeseries. Net removals increased from 79,331 Gg CO_2-eq in the year 1994 to 102,163 in the year 2014. There was a 33.4% 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 6,145 Gg CO_2-eq. The variation in this sub-category was directly linked to the land area (biomass) burned. The land sub-category removed 87,924 Gg CO_2 in 1994 and reached 109,665 Gg in 2014 (Table 6.1 and Figure 6.1).

Table 6.1 - Aggregated emissions (CO_2-eq) from the AFOLU sector (1994 - 2014)

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
1994	-79,331	2,908	-87,924	5,685
1995	-81,283	2,946	-89,731	5,502
1996	-83,514	2,846	-91,556	5,196
1997	-85,407	2,964	-93,398	5,026
1998	-87,359	3,070	-95,257	4,828
1999	-89,318	3,179	-97,133	4,636
2000	-91,430	3,460	-99,332	4,442
2001	-91,285	3,470	-99,266	4,511
2002	-96,614	3,338	-103,740	3,789
2003	-96,952	3,393	-104,182	3,837
2004	-99,070	3,350	-106,003	3,583
2005	-96,628	3,180	-103,776	3,968
2006	-92,116	3,340	-100,173	4,717
2007	-88,940	3,289	-97,409	5,179

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
2008	-98,721	3,388	-106,030	3,921
2009	-84,838	3,346	-94,181	5,997
2010	-90,000	3,154	-98,418	5,265
2011	-86,121	3,718	-95,679	5,840
2012	-84,610	3,961	-94,716	6,145
2013	-106,072	3,566	-112,595	2,957
2014	-102,163	3,879	-109,665	3,623

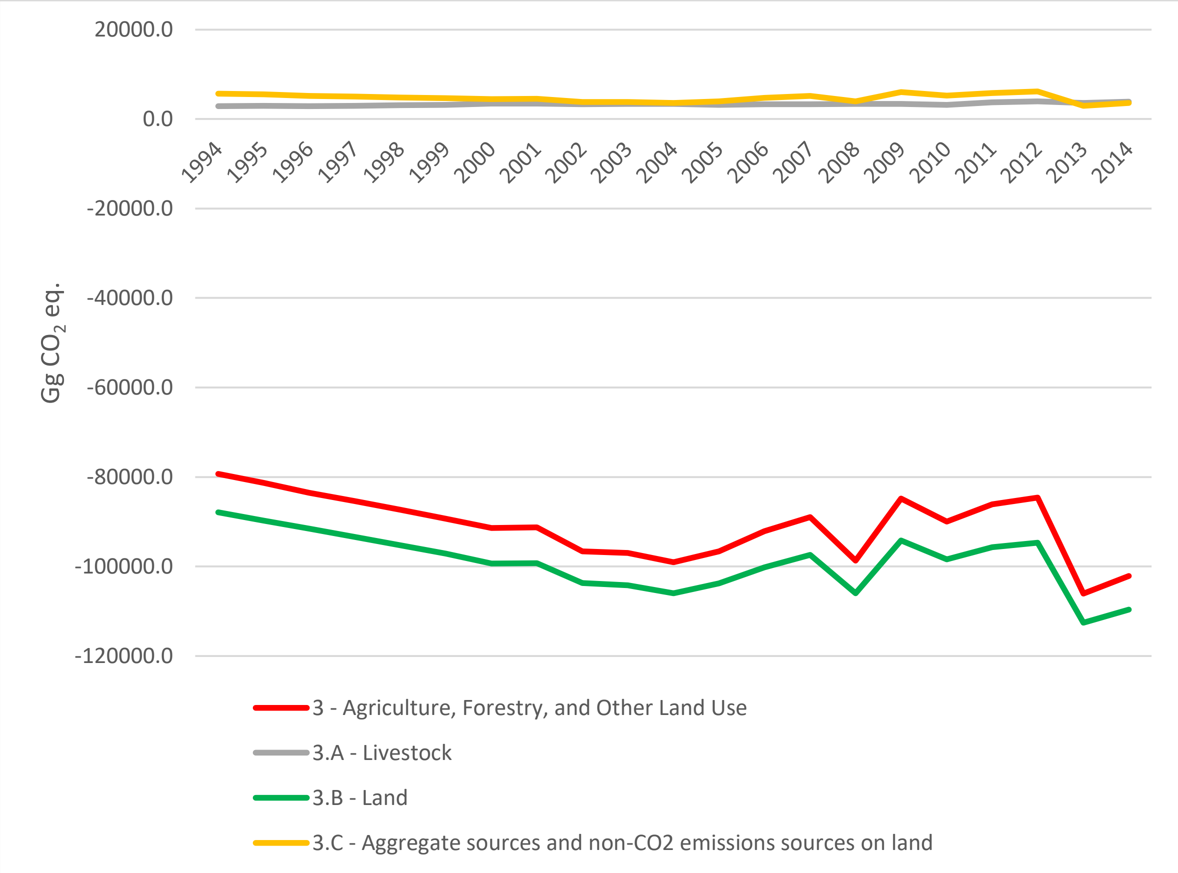


Figure 6.1- Emissions by sub-category (CO_2-eq) in the AFOLU sector (1994-2014)

Table 6.2 shows the evolution in emissions of the direct and indirect GHGs. CO_2 emissions increased steadily from 8,736 Gg in 1994 to reach 9,769 Gg in 2014. However, CO_2 removals far exceeded emissions over the whole period with an increasing trend. Removals increased from 96,659 Gg in 1994 to 119,433 Gg in 2014. The other two direct gases CH4 and N_2O varied over the inventory period on account of the annual variation in the area burnt in forestland and grassland, outcome of wild fires over the country. CH4 emissions ranged from 217 Gg to 318 Gg while N_2O emissions were 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 CH4 and N_2O. NO_x emissions varied between 13.3 and 34.1, CO between 582 Gg and 2190 Gg and NMVOCs between 9.0 Gg and 12.5 Gg. Emissions of CH4 decreased by 15%, N_2O by 9%,

NO_x by 61% and CO by 61% largely due to the annual variation in the area burnt in forestland and grassland that had significantly reduced during 2013 and 2014.

Table 6.2 - Emissions (Gg) by gas for AFOLU (1994 - 2014)

Year	CO_2 - Emissions	CO_2 - Removals	CO_2 - Net removals	CH_4	N_2O	NO_x	CO	NMVOCs
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	-103,992.2	-95,256.7	250.7	8.5	26.3	1,678.0	9.7
1999	8,735.5	-105,868.6	-97,133.1	247.8	8.4	24.4	1,556.9	10.0
2000	8,735.8	-108,066.7	-99,330.9	251.0	8.5	22.1	1,408.3	11.0
2001	8,949.5	-108,212.1	-99,262.6	252.1	8.7	22.2	1,418.8	10.9
2002	8,948.5	-112,686.5	-103,738.0	223.6	7.8	16.8	1,072.6	10.5
2003	8,947.3	-113,128.4	-104,181.0	226.7	8.0	16.8	1,075.7	10.5
2004	8,947.0	-114,949.2	-106,002.2	216.7	7.7	14.9	956.7	10.6
2005	8,946.6	-112,722.8	-103,776.1	224.4	7.9	18.7	1,196.7	10.1
2006	8,946.6	-109,118.9	-100,172.3	254.0	8.8	24.1	1,545.7	10.7
2007	8,946.7	-106,355.0	-97,408.2	266.5	9.3	28.5	1,829.3	10.5
2008	8,946.5	-114,976.9	-106,030.4	229.4	8.0	17.6	1,129.5	10.7
2009	8,946.6	-103,127.0	-94,180.4	296.5	10.1	34.1	2,189.8	10.7
2010	8,946.5	-107,364.4	-98,417.9	266.2	9.1	29.1	1,868.1	10.3
2011	9,769.1	-105,447.8	-95,678.6	301.4	10.4	31.2	2,003.0	11.7
2012	9,769.2	-104,484.9	-94,715.6	318.4	11.0	32.5	2,091.2	12.4
2013	9,769.0	-122,363.2	-112,594.1	201.7	7.4	9.1	582.4	11.2
2014	9,769.0	-119,433.7	-109,664.7	234.0	8.3	13.3	858.0	12.5

The evolution of aggregated emissions, excluding removals, of the three direct GHGs is presented in Figure 6.2. Total emissions fluctuated between 17,328 Gg CO_2-eq and 17,271 Gg CO_2-eq during the period 1994 to 2014, with a peak of 19,875 Gg CO_2-eq in 2012. Emissions of the three direct GHGs varied during the inventory period. The major contributor to emissions remained CO_2 contributing to around 57% of total emissions of this sector followed by CH_4 with some 28% and N_2O the remaining 15%.

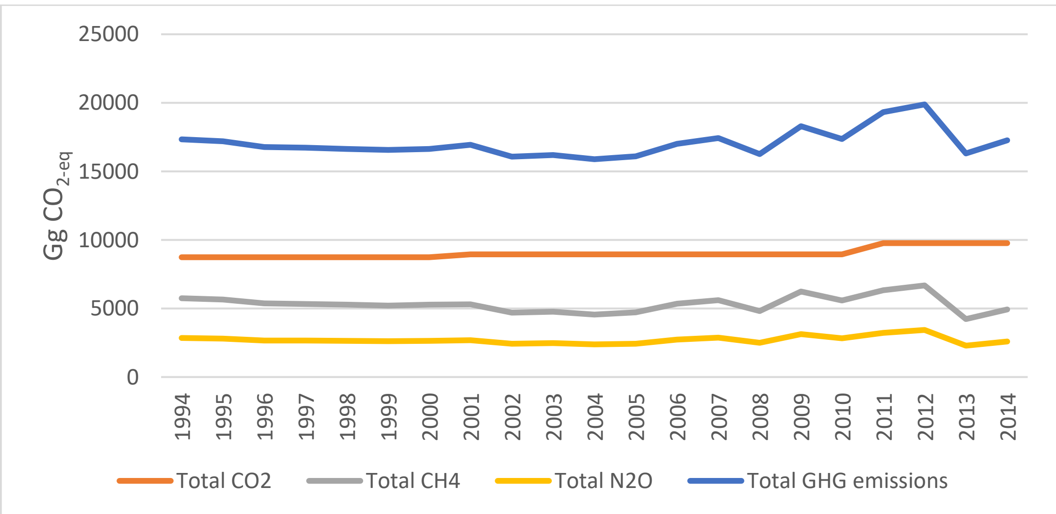


Figure 6.2- Evolution of aggregated emissions (CO_2-eq) in the AFOLU sector (1994 - 2014)

6.2. Livestock

Namibia has an important livestock rearing activity because 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. 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 of this chapter.

6.3.1. Activity Data

6.3.1.1. Source

The FAO database together information from the NSA and annual surveys done by the Ministry of Agriculture was used. Priority was given to country data over the international database. Where local statistics were not available, data from the FAO database was used.

6.3.1.2. Quality control / Quality Assurance

Due to the importance of this sector in the socio-economic context of the country, 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. In fact, national data corresponded with those of the FAO database for most of the years except where the latter organisation resorted to estimations.

6.3.1.3. 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 for 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 the tourist activity.

6.3.1.4. Timeseries Activity Data of NIR3

The population of the different livestock types used as AD for estimating emission is provided in Table 6.3 for the years 1994 to 2014.

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% based on a study on farming practices (NNFU, 2006). 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 (1994 - 2014)

Year	Dairy cows	Cattle	Sheep	Goats	Horses	Mules and asses	Swine	Poultry	Camels
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

The average live weights of the non-dairy cattle classes were obtained from data of the slaughter houses 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, awaiting confirmation of the current liveweight of the population from the dairy farms.

For Tier 2 estimations, 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 below depicts the typical mature weight adopted for the different classes.

Table 6.4 - Typical animal mass adopted for the NIR3

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 in determining the level of emissions. Both enteric fermentation and manure management EFs are dependent of 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 most of the animal classes. The datasets described above were used to calculate the maximum methane production capacity for the cattle classes while default EFs from the IPCC 2006 Guidelines were used for the other animal groups. MCF default EFs were used for animal classes in italics as per Table 6.5.

Table 6.5 - MCF values used for enteric fermentation calculations

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

Animal type		MCF (Kg CH_4/head/yr)
	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 below summarizes the manure management systems for the various animal categories. This is based on information available from the censuses and surveys conducted by the Ministry of Agriculture, Water Affairs and Forestry and NSA while manure management system (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 small area classified as Tropical Dry and 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 categories

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 have 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. This improvement has been included in the NIIP.

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 has been 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. This is being verified for action in the next inventory.

6.4. Results - Emission estimates

The emission estimates from enteric fermentation and manure management are presented in Table 6.7.

Enteric fermentation contributed to around 94% of total emissions of CH4 from the livestock category during the whole time series. Emissions increased from 2,747 Gg CO_2-eq in 1994 to 3,650 Gg CO_2-eq in 2014. The main contributor to this change as from 2011 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 161 Gg CO_2-eq to 229 Gg CO_2-eq in 2014 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

Year	Enteric Fermentation	Manure management
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

The evolution of emissions of the three gases methane, nitrous oxide 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 1994 to 2014. The increase over the period 1994 to 2014 was of the order of 44 Gg (33.1%) for CH_4, 0.14 Gg for (43.4%) for N_2O and 3.3 Gg (35.8%) for NMVOC respectively.

Table 6.8 - Emissions (Gg) by gas for Livestock (1994-2014)

Year	CH_4	N_2O	NMVOCs
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	10.5
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	10.7
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	12.4
2013	163.7	0.414	11.2
2014	178.0	0.455	12.5

6.5. 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. Thus, they have all been accounted for in the compilation of emissions and removals. Activities within the six IPCC land classes and between the classes were taken into consideration. Land use changes has 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

6.5.1. Description

6.5.1.1. Forestland

Forests were divided in two sub-categories and the definitions adopted for the integration of all information from FRA, RCMRD 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): The are three different land classes in this sub category:
    - Woodlands where tree height of 5 m with a canopy cover between 10% and 20%.
    - Shrubland where 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.

A major change from the NIR2 is the reclassification and merger of the bush-encroached grassland with the degraded woodland of Namibia to form the Other Wooded Land sub-class in Forestland.

6.5.1.2. 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. It is estimated that not all land cleared for growing crops are used every year. Thus, no more cropland set aside group had to be created as for the previous NIR.

6.5.1.3. Grassland

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

6.5.1.4. 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.

6.5.1.5. 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.

6.5.1.6. 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 timeseries.

6.5.2. 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 have been derived using data from past forest inventories and other available in-country information and resources.

6.5.3. Activity Data

6.5.3.1. 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 remaining Forestland and OWL.

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 of 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 is menacing the sustainability of the livestock industry. In fact, there is a programme for rehabilitating the rangelands which is presently ongoing.

Thus, deforestation as reported in the Forest Resource Assessments (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 below 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 by 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

Land cover description	Calibrated area in ha	Calibrated area reclassified under new class		
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 Regional Centre for Mapping Resource for Development (RCMRD) were used for generating land use changes for previous NIRs. A summary of the original data is shown in table 6.10. Explanations of the problems encountered with the original data is 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 disappearing in the medium term.
- Non- realistic land use changes recorded such as Settlements being converted to Forest
- Inclusion of vast areas with significant stocks of woody biomass under Grassland
- The area of Other Land double that of previous studies and reports

Namibia is an arid country and the use of satellite imagery to track land cover and land use change can be 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 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 information from maps

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 meeting the requirements of the IPCC land categories. The merger also had to integrate information available with respect to bush encroachment and its related debushing 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)

6.5.3.2. Changes

Forestland

Deforestation

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 trees that are affecting farms, particularly with respect to carrying capacity of livestock. It is reported that 80,000 hectares were debushed 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, the 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 8000 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 project 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 with a tree taking 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,). 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 figure 6.3. It is to be noted that Caprivi has been renamed as Zambezi now.

Figure 12. Relationships between the diameter of trees (in centimetres on y-axis) and estimated ages (in years on x-axis) for Zambezi Teak, Silver-leaf Terminalia, Mopane, Burkea, Kiaat and Variable Combretum in Caprivi and north-central Namibia.[14]

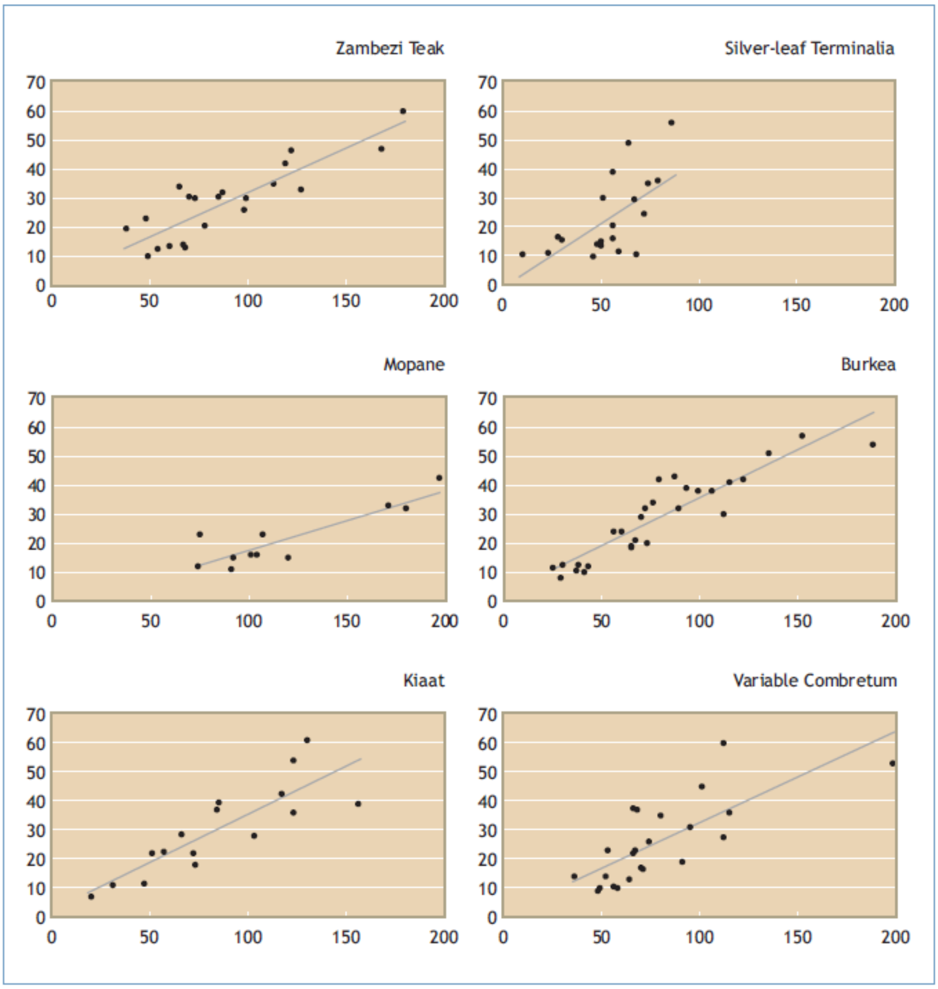


Figure 6.3 - Extract from Forestland and Woodland of Namibia showing age of major species to reach maturity (30 cm at dbh)

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

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.

6.5.3.3. 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 is reliable.

Cropland area were 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 in 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.

6.5.3.4. Time series AD that has been adopted for the NIR3

Three time periods have been adopted for this NIR3 for determining land use changes between the 6 IPCC classes: 1994 to 2000, 2001 to 2010 and 2011 to 2014. Initial areas for each period and annual change used in land matrices are given in Table 6.11 to 6.13.

Table 6.11 - Total land use adjusted area and annual change used in land matrix (1994 - 2000)

Land Type category	Area (ha)			
	Year 1994	Year 2000	Annual gain	Annual loss
Forestland	8,470,659	8,032,903	-	72,959
OWL	52,209,434	54,291,441	427,496	80,495
Cropland	850,000	625,001	-	37,500
Grassland	8,818,552	7,393,363	80,000	317,532
Wetlands	724,608	724,608	-	-
Settlements	23,958	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 1994 to 2000 is the loss of Grassland to OWL with bush encroachment. Debushing 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)

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	-	-
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 - 2014)

Land Type category	Area (ha)			
	Year 2011	Year 2014	Annual gain	Annual loss
Forestland	7,328,707	7,144,543	10,000	71,388
OWL	57,672,871	58,240,613	289,361	100,114
Cropland	432,777	405,184	-	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 2014, the rate of loss of Cropland and Grassland decreased. The rate of increase of Settlements also slowed.

It is a fact that this approach may not be representative of the national situation, but it is considered better than the one adopted in the previous NIRs. 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.

6.5.3.5. 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 at the Tier 2 level being implemented. Thus, a weighted average of the soil factors, using the areas determined 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 - Importance 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%

6.5.3.6. Climate

In the previous NIRs, 2 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, it was realized that Namibia was assigned with the wrong climate type. 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) This is highly supported from the results of the censuses indicating a much lower use of local wood resources.
(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 to be reclassified as forest or dense woodlands 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 to enable computation of emissions and removals in the software, compilation 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 where by subsistence farming is decreasing and villages are also growing.

6.5.4. Generated data and emission factors

6.5.4.1. 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 area basis for OWL. The areas used pertained to the 1990 areas allocated to these different land cover classes. Table 6.15 summarizes the information form the different reports and the land cover classes considered for deriving the user-defined stock factor for Forestland and OWL.

Table 6.15 - Data from Forest Inventory Reports used to calculate standing biomass in Forests and OWL

Year of report	Forest Inventory	Zone	Land class	Volume of live wood/ha	Volume of deadwood/ha	Area of forest assessed (ha)
2001	Bukalo	NE	FL	27.80	7.83	835
1998	Caprivi	NE	FL	21.37	NA	1,647,959
2003	Hans kanyinga	NE	FL	40.40	2.30	11,692
2003	Kwando	NE	FL	23.10	5.10	19,888
2002	Mashare	NE	FL	22.60	1.80	186,360
2002	Ncamangoro	NE	FL	32.00	2.40	21,866
2003	Ncaute	NE	FL	32.70	2.10	11,908
2002	Ekolola	N	FL	44.00	4.00	578
2004	Okatope	N	FL	24.40	NA	3,826
2000	Okongo	N	FL	45.46	5.60	55,918
2002	Sikanjabuka	NE	FL	52.00	4.00	4,927
2002	Salambala	NE	FL	34.00	2.00	8,362
	Weighted average FL			**22.63**	**2.76**	
2008	Amudilo	N	OWL	6.20	NA	5,800
2016	Ehirovipuka	NW	OWL	3.60	0.12	97,447
2003	Omatendeka	N	OWL	4.00	NA	122,283
2008	Otjinene	E	OWL	4.30	0.70	196,753
2002	Otjituuo	C/E	OWL	1.57	0.10	303,656
2002	Rehoboth	CS	OWL	9.70	0.70	8,732
	Weighted average OWL			**3.11**	**0.31**	
2002	Ohepi	N	WD	28.00	5.80	5,160
2002	Oshampula	N	WD	20.80	5.20	719
2002	Oshikoto	N	WD	18.84	NA	852,051
2007	Ozonahi	C	WD	10.80	0.70	116,834
2003	Uukolonkadi	N	WD	14.30	1.00	83,020
	Weighted average WD			**17.64**	**0.19**	

The data obtained from Table 6.15 were further aggregated on a weight basis to generate country specific biomass stocks. Table 6.16 shows the different biomass factors derived for Forestland, OWL and Grassland categories.

Table 6.16 - Biomass stock factors used in NIR 3 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
OWL	12.13	1.48	36.38	45.6	0.797	0.69
Grassland						1.15

6.5.4.2. Wood removals

Removal of woodfuel was indexed on the use rate of this fuel by urban and rural population respectively. Removal of timber and poles were 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 6.17.

Table 6.17 - Wood removals (t) from various activities

Year	Charcoal production	Fuelwood exported	Fuelwood collected	Poles removal	Bushblock production	Industrial consumption	Total
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

*** Not Occurring**

Woody biomass removals were allocated as follows:

1. Charcoal from OWL as de-bushing activities are the major contributor to charcoal production

2. All fuelwood from OWL.
3. Poles removal were accounted for as 50% from forestland and 50% 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 2014. This mix is based on 1% population migrating from rural to urban areas and relieving the use for dwellings and the shift to other building materials as well as imports of wood for construction purposes.

6.5.4.3. 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 6.18.

Table 6.18 - Distribution of annual area disturbed by fire (1994 - 2014)

Year	Total	Area (ha) disturbed by fire		
		Forestland	OWL	Grassland
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

6.5.4.4. Emissions and Removals estimates

Estimates of emissions and removals for the Land sector is depicted in Table 6.19. 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 removal and sink capacity. The removals in Forestland increased from -96,659 Gg CO_2 in 1994 to peak at -122,363 Gg CO_2 in 2013. Emissions from grassland increased from 8,672 Gg CO_2 to reach 9,756 Gg in 2014. 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 -87,924 Gg CO_2 in 1994 to peak at -112,595 Gg CO_2 in 2013.

Table 6.19 - Emissions (CO_2) for the LAND sector (1994 - 2014)

Year	3.B.1 - Forest land	3.B.3 - Grassland	3.B.5 - Settlements	Net Removals
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	-122,363.2	9755.9	12.8	-112,594.5
2014	-119,433.7	9755.9	12.8	-109,664.9

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

6.6.1. 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.

6.6.2. Methods

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

6.6.3. Activity data

The activity data 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 by 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 below. While the N content of certain straight fertilizers are known, the molecular formula was used in some cases to estimate the N contents of blends/mixtures. The percentages N content adopted are shown in Table 6.20. No import and export data were available for the period 1994 to 1997 and the average of N used in the years 1998 to 2000 was adopted as AD for these years.

Table 6.20: Types of fertilizers used with their assigned N content

Type of fertilizer	N%
Urea	46
Ammonium sulphate	21
Double salts and mixtures of ammonium sulphate and ammonium nitrate	28
Ammonium nitrate	35
Mixtures of ammonium nitrate with inorganic non-fertilizing substances	30
Sodium nitrate	16
Double salts and mixtures of calcium nitrate and ammonium nitrate	27
Mixtures of urea and ammonium nitrate in aqueous or ammoniacal solution	40
Mineral or chemical fertilizers, nitrogenous, not elsewhere specified (nes)	31
Fertilizers in packages of a gross weight =<10kg	12
Mineral or chemical fertilizers with nitrogen, phosphorus and potassium	5
Diammonium hydrogenorthophosphate (diammonium phosphate)	18
Ammonium dihydrogenorthophosphate (monoammonium phosphate)	11
Mineral or chemical fertilizers containing nitrates and phosphates	12
Mineral or chemical fertilizers with nitrogen and phosphorus (nes)	12
Other fertilizers (nes)	12

The N-content attributed to fertilizers without the appropriate information was:

- For the mixture of ammonium nitrate and ammonium sulphate, a 50:50 mix was considered, and the chemical formula applied;
- For unknown nitrogenous mineral or chemical fertilizers, the midpoint between 16 and 46 was used;
- For fertilizers containing N, P and K and the ratio not available, a 5% N content was used; and
- For fertilizers containing N, P and other elements, a 12% N content was adopted.

The total amount of N obtained from the fertilizers used and keyed in the software for estimating emissions is provided in Table 6.21. The very high synthetic N fertilizer used for the period 2011 to 2014 was due to a donation from a friendly country.

Table 6.21 - Amount of N (kg) used from fertilizer application (1994 - 2014)

Type of fertilizer	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Urea N	212,650	212,650	212,650	168,158	142,158	327,634	1,888,517	1,291,430	542,740	368,488	212,650
Synthetic fertilizer N	711,152	711,152	711,152	761,278	579,424	792,753	789,181	1,405,803	1,044,076	4,081,591	711,152

Type of fertilizer	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Urea N	126,153	90,414	173,177	32,491	103,965	50,217	269,867	319,444	212,319	176,470
Synthetic fertilizer N	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

6.6.4. 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.

6.6.5. Emission estimates

The emissions for aggregate sources and non-CO_2 emissions on land are given in Table 6.22. Emissions varied between 3,622 Gg CO_2-eq and 5,685 Gg CO_2-eq for the period 1994 to 2014 with a peak of 6,145 Gg CO_2-eq in 2012. This high variability in estimates is attributed to the varying areas disturbed by wild fires between years and this is very difficult to control.

Table 6.22 - Aggregated emissions (Gg CO_2-eq) for aggregate sources and non-CO_2 emissions on Land (1994 - 2014)

1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
5,685	5,502	5,196	5,026	4,828	4,636	4,442	4,510	3,789	3,837	3,583

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

The emissions by gas are given in Table 6.23. The major gas emitted in this category remained CH_4 throughout the period followed by N_2O. Carbon dioxide emissions were minimal for all years.

Table 6.23 - Emissions (Gg) by gas for aggregate sources and non-CO_2 emissions on Land (2000 - 2012)

Gas	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CO_2	0.3	0.3	0.3	0.3	0.3	0.2	0.5	3.0	2.1	0.9	0.6
CH_4	140.2	132.6	124.9	117.2	109.4	101.5	91.8	92.5	70.0	70.2	62.4
N_2O	8.8	8.8	8.3	8.3	8.2	8.1	8.1	8.3	7.5	7.6	7.3

Gas	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2	0.2	0.1	0.3	0.1	0.2	0.1	0.4	0.5	0.3	0.3
CH_4	78.1	100.8	115.6	73.7	142.9	121.9	130.7	136.5	38.0	56.0
N_2O	7.5	8.4	8.9	7.7	9.7	8.7	10.0	10.6	7.0	7.9

7. Waste

7.1. Description of Waste Sector

In Namibia, solid waste is generated by domestic, industrial, commercial and agricultural activities whereas waste water 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. Greenhouse gas 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.

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 2014 the waste and garbage of 40.9% of Namibian households was sent to waste disposal sites, 36.1% being collected on a regular basis and 4.8% being collected irregularly. There is a sharp contrast between urban and rural areas since, while the waste of 72.1% of urban households was collected on a regular (64.5%) or irregular (7.6%) basis, only 6.2% of the rural households has the same service (4.6% on a regular basis and 1.6% irregularly) (Table 7.1).

Table 7.1 - Percentage distribution of households by means of waste disposal (2014)

Means of waste / garbage disposal	Namibia	Urban	Rural
Regularly collected	36.1	64.5	4.6
Irregularly collected	4.8	7.6	1.6
Burning	34.4	10.3	61.0
Roadside dumping	9.7	9.0	10.5
Rubbish pit	9.6	7.1	12.2
Other	5.5	1.5	10.1
Total	100.0	100.0	100.0

Source: NHIES survey 2011 (Namibian Statistics Agency)

On average, waste collection (regular and irregular basis) remained fairly constant during the 2001 to the 2011 period, moving from 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 2014, the percentage of household serviced gradually decreased to reach 40.0%, both regular and irregular collection decreasing slightly to 36.1% and 4.8% of households respectively (Figure 7.1).

Open Burning of Waste

It is estimated that at national level in 2014, the waste and garbage of 32.4% of Namibian households were open burnt, a sharp contrast being observed between urban and rural areas, 10.3 % of urban households being concerned with open burning, while 61.0% of their rural counterparts were concerned by the same method of waste disposal.

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 34.4% in 2014. Data also show that open burning of waste is a far more frequent practice in rural areas as compared to urban ones (Figure 7.1).

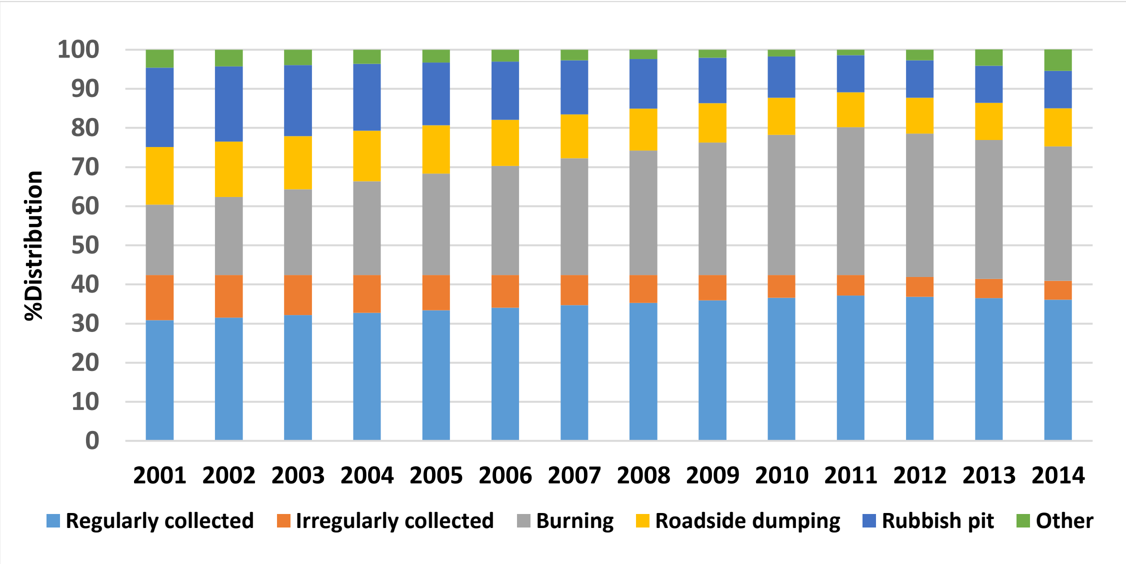


Figure 7.1 - Percentage distribution of households by means of waste disposal (2001 – 2014)

Domestic Wastewater Treatment and Discharge

The estimated percentage distribution of household by type of main toilet facility for the year 2014 is given in Table 7.2. At the country level, a notable fact is that 47.2 % of the population did not have any toilet facility. All regions confounded, 40.3% 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 (7.5%), latrines without ventilation system (3.7%), or had recourse to buckets (1.3%).

Table 7.2 - Estimated percent distribution of household by type of main toilet facility (2014)

Region	Namibia	Urban	Rural

Region	Namibia	Urban	Rural
Private / Shared Flush	40.3	65.4	12.6
Pit Latrine with Ventilation Pipe	7.5	5.5	9.8
Pit Latrine without Ventilation Pipe	3.7	3.1	4.2
Bucket Toilet	1.3	1.2	1.4
Other	47.2	24.8	72.0

Source: Interpolated from Namibia 2011 Population and Housing Census Main Report and Namibia Inter-censal Demographic Survey 2016 Report

Industrial Wastewater Treatment and Discharge

Industrial waste water of relevance to greenhouse gas emissions originates mainly from such activities as fish processing, slaughter houses, meat conditioning, tanneries and breweries. Because unavailable data, only the meat sector and fish processing are covered in this inventory. It should be noted that these two activities account for the major part of industrial waste water 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 on waste characterization. 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 calculated for the period 1995 to 2014.

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. Activity data for the period 1995 to 2014 is given in Table 7.3.

Table 7.3 - Activity data for MSW in Waste sector (1994 - 2014)

Year	Municipal Solid Waste (MSW) (t)			Sent to MSW (Gg)	
	Urban high	Urban low	Rural	Sludge	Industrial waste
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	34.9
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

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 7.4.

Table 7.4 – 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
1994	0.743	0.039	0.002	0.866	0.102	0.025	0.104	0.094	0.013
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

Year	Urban high			Urban low			Rural		
	Centralized aerobic	Latrine	Septic Tank	Centralized aerobic	Latrine	Septic Tank	Centralized aerobic	Latrine	Septic
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

Coupled with the use rate, the fraction of population living in the 3 different zones, 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 7.5.

Table 7.5 – Fraction of population living in the different areas

Year	Fraction population		
	Urban high	Urban low	Rural
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
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

The protein content in the diet of the population is also needed as an activity data for calculations of emissions from domestic waste water. FAO data for years 1999 to 2014 is available. Trending technique was used to generate the date for years 1994 to 1997. Table 7.6 summarizes the data for protein intake by the population.

Table 7.6 – Annual per capita protein intake in Namibia

Year	Protein intake (kg per capita / year)
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

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). The total meat industry product and the amount of waste water 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. Activity data for industrial waste water is given in Table 7.7.

Table 7.7 - Activity data for industrial wastewater (1994 - 2014)

Year	Meat and poultry (t)	Fish processing (t)
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

Year	Meat and poultry (t)	Fish processing (t)
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

7.4. Emission factors

In the absence of country specific emission factors, the default values provided within the IPCC 2006 software and IPCC 2006 Guidelines (Vol 5.3 Ch 3 Table 3.3) were used for estimating GHG emissions.

7.5. Emission estimates

7.5.1. Aggregated emissions by gas for inventory year 2014

In 2014, a total of 152.74 Gg CO_2-eq. were emitted from sector Waste. The most important contributor to emissions was CH_4 with 124.34 Gg CO_2-eq, representing 81.4 % emissions, followed by N_2O with 26.04 Gg CO_2-eq (17.0 % emissions) and CO_2 with 2.36 Gg CO_2-eq (1.5 % emissions) (Figure 7.2).

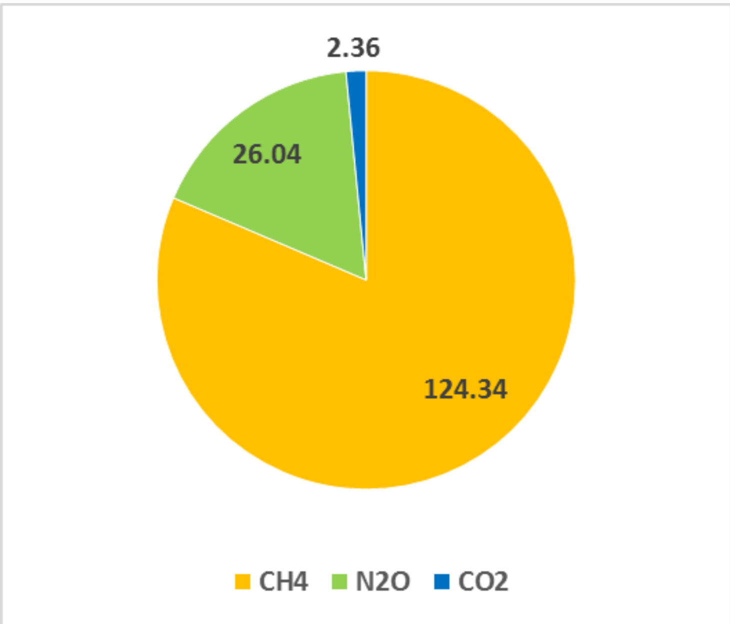


Figure 7.2 - Percentage distribution of emissions for waste Sector (2014)

7.5.2. Other emissions by gas for inventory year 2014

In 2014 sector Waste also emitted 0.54 Gg of NMVOCs, 0.48 Gg NO_x, 0.08 Gg N_2O and 0.02 Gg SO_2 (Figure 7.3).

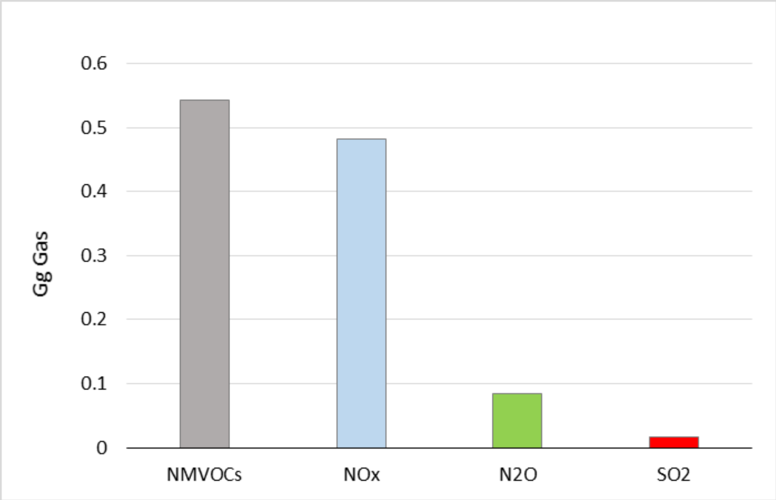


Figure 7.3 - Emissions of N_2O, NO_x, NMVOCs and SO_2 from waste Sector (2014)

7.5.3. Emission trend by gas for the period 1994 to 2014

Analysis of aggregated emission trend by gas (Figure 7.4) shows the following:

(i) CH_4 was the main contributor to emissions from sector waste, with an equivalent of 124.34 Gg CO_2-eq. in 2014, representing 84.4% of total emissions from the sector and a 2.5 fold increase as compared with the 1994 baseline of 50.27 Gg.

(ii) N_2O was the second contributor to emissions with an equivalent of 26.04 Gg CO_2-eq. in 2014, representing 17.1% of total emissions from the sector and a 10% increase from the 1994 level of 23.72Gg.

(iii) CO_2 contributed to a lesser extent than the previous two gases, with 2.36 Gg in 2014, representing 1.5% of total emissions from the sector and an increase of 1.40 Gg from the 1994 level of 0.96 Gg.

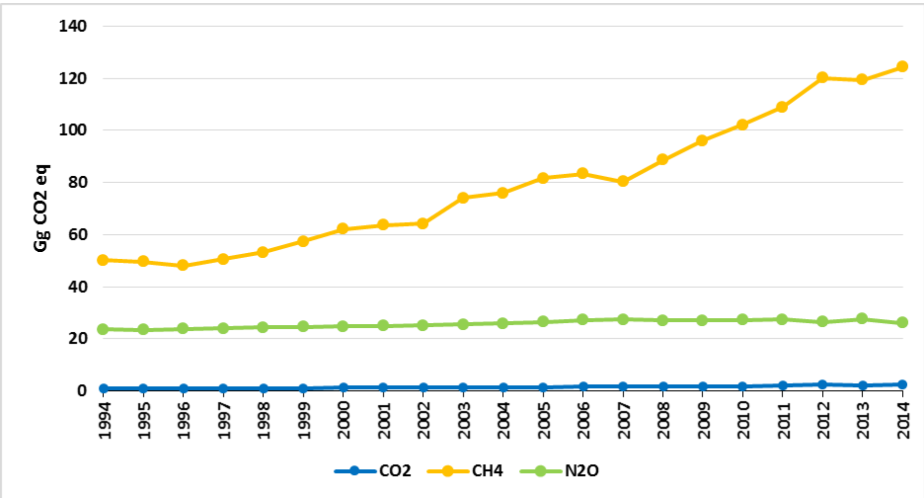


Figure 7.4 - Percentage distribution of emissions for waste Sector (2014)

7.5.4. Emissions by waste categories for inventory year 2014

The total emissions of 152.74 Gg CO_2-eq. recorded in 2014 represent 0.7 % of national emissions. Solid Waste Disposal was the most important contributor to total emissions of the sector with 76.86 Gg CO_2-eq. (50.3% of total), followed by Domestic Wastewater Treatment and Discharge with 34.37 Gg CO_2-eq (22.5%), Open Burning of Waste with 27.12 Gg (17.8%) and Industrial Wastewater Treatment and Discharge with 14.38 Gg CO_2-eq (9.4%) (Table 7.8).

During the same inventory year, sector waste also emitted 0.48 Gg NO_x, 8.48 Gg CO, 0.54 Gg NMVOC and 0.02 Gg SO_2.

Table 7.8 - Emissions from Waste sector for inventory year 2014

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	2.36	124.34	26.04	152.74	0.48	8.48	0.54	1.67E-02
4.A - Solid Waste Disposal	-	76.86	-	76.86	-	-	0.36	-
4.A.2 - Unmanaged Waste Disposal Sites	-	76.86	-	76.86	-	-	0.36	-
4.C - Incineration and Open Burning of Waste	2.36	20.74	4.03	27.12	0.48	8.48	0.19	1.67E-02
4.C.2 - Open Burning of Waste	2.36	20.74	4.03	27.12	0.48	8.48	0.19	1.67E-02
4.D - Wastewater Treatment and Discharge	-	26.75	22.01	48.75	-	-	1.00E-06	-
4.D.1 - Domestic Wastewater Treatment and Discharge		12.36	22.01	34.37	-	-	8.00E-07	-
4.D.2 - Industrial Wastewater treatment and Discharge	-	14.38	-	14.38	-	-	2.00E-07	-

7.5.5. Emissions by waste categories – trend for period 1994 to 2014

The total emissions of 152.74 Gg CO_2-eq. recorded in 2014 represent an increase of 77.78 Gg CO_2-eq. from the 1994 estimates of 74.96 Gg CO_2-eq. (Figure 7.5), equivalent to a 103.8% rise.

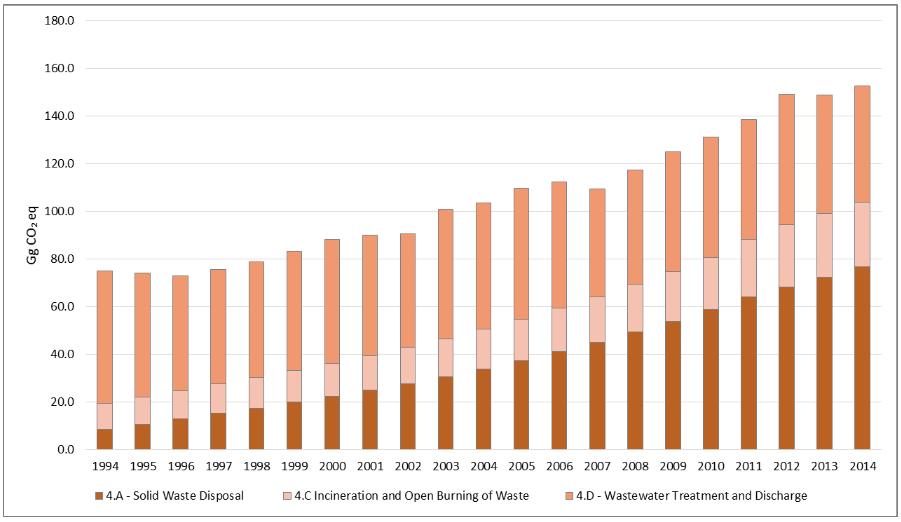


Figure 7.5 - Evolution of emissions (Gg CO_2-eq.) from Waste sector (1995 – 2014)

The increase in emissions was mainly a result of a significant rise in emissions from Solid Waste Disposal which increased 9.1 times from 8.43 Gg CO_2-eq. in 1994 to reach 76.85 Gg CO_2-eq in 2014. In fact, the rise in emissions from Solid Waste Disposal represented as much as 88.0% of the total increase from sector Waste. Total emissions from the other waste categories also increased, except for Industrial Wastewater Treatment and Discharge. Hence, the other categories contributing positively to emissions were: (i) Open Burning of Waste with a 2.5 fold increase, moving from 11.04 Gg CO_2-eq. in 1994 to 27.12 Gg in 2014, and (ii) Domestic Wastewater Treatment and Discharge, recording an increase from 27.24 Gg CO_2-eq. to 34.37 Gg CO_2-eq over the period. As for Industrial Wastewater Treatment and Discharge, emissions decreased from 28.25 Gg CO_2-eq. to 14.38 Gg CO_2-eq over the period equivalent to a reduction of 49.1% (Table 7.9).

Table 7.9 - Emissions (Gg CO_2-eq) from Waste sector (1994 - 2014)

Year	4.A - Solid Waste Disposal	4.C.2 - Open burning of waste	4.D.2 - Industrial Wastewater Treatment and Discharge	4.D.1 - Domestic Wastewater Treatment and Discharge	Sector waste
1994	8.43	11.04	28.25	27.24	74.96
1995	10.61	11.47	24.55	27.53	74.16
1996	12.84	11.92	20.11	28.00	72.87
1997	15.12	12.38	19.68	28.48	75.66
1998	17.45	12.86	19.61	28.79	78.71
1999	19.85	13.36	20.55	29.38	83.14
2000	22.32	13.87	22.33	29.63	88.16
2001	24.87	14.41	20.22	30.37	89.88
2002	27.68	15.11	17.50	30.40	90.69
2003	30.68	15.85	23.48	31.05	101.06
2004	33.90	16.62	21.23	31.69	103.44
2005	37.35	17.42	22.52	32.39	109.68
2006	41.05	18.25	19.88	33.12	112.30
2007	45.03	19.12	11.53	33.77	109.44
2008	49.29	20.02	14.52	33.64	117.48
2009	53.88	20.97	16.30	33.97	125.12
2010	58.80	21.94	16.39	34.23	131.37
2011	64.11	24.14	15.49	34.75	138.49
2012	68.14	26.33	19.67	35.16	149.30
2013	72.39	26.73	15.40	34.37	148.89
2014	76.86	27.12	14.38	34.37	152.74

Emissions of NO_x, CO, and SO_2 from sector Waste increased 2.5 times from their respective 1994 levels and emissions of NMVOCs increased 3.6 fold during the same period (Table 7.10).

Table 7.10 - Emissions (Gg CO_2-eq) from Waste sector (1995 - 2014)

Year	Open Burning of Waste				Domestic Wastewater Treatment and Discharge	Industrial Wastewater Treatment and Discharge	Solid Waste Disposal
	NO_x	CO	NMVOCs	SO_2	NMVOCs	NMVOCs	NMVOCs
1994	0.20	3.45	0.08	0.01	5.00E-07	4.00E-07	0.08
1995	0.20	3.59	0.08	0.01	6.00E-07	3.00E-07	0.08
1996	0.21	3.73	0.08	0.01	6.70E-14	3.00E-07	0.09
1997	0.22	3.87	0.09	0.01	6.00E-07	3.00E-06	0.09

Year	Open Burning of Waste				Domestic Wastewater Treatment and Discharge	Industrial Wastewater Treatment and Discharge	Solid Waste Disposal
	NO_x	CO	NMVOCs	SO_2	NMVOCs	NMVOCs	NMVOCs
1998	0.23	4.02	0.09	0.01	6.00E-07	3.00E-07	0.10
1999	0.24	4.18	0.09	0.01	6.00E-07	3.00E-07	0.10
2000	0.25	4.34	0.10	0.01	6.00E-07	3.00E-07	0.11
2001	0.26	4.51	0.10	0.01	6.00E-07	3.00E-07	0.12
2002	0.27	4.73	0.10	0.01	7.00E-07	2.00E-07	0.14
2003	0.28	4.96	0.11	0.01	7.00E-07	3.00E-07	0.15
2004	0.30	5.20	0.11	0.01	7.00E-07	3.00E-07	0.16
2005	0.31	5.45	0.12	0.01	7.00E-07	3.00E-07	0.18
2006	0.33	5.71	0.13	0.01	7.00E-07	3.00E-07	0.20
2007	0.34	5.98	0.13	0.01	1.00E-06	2.00E-07	0.21
2008	0.36	6.26	0.14	0.01	7.00E-07	2.00E-07	0.23
2009	0.37	6.56	0.14	0.01	7.00E-07	2.00E-07	0.25
2010	0.39	6.86	0.15	0.01	7.00E-07	2.00E-07	0.28
2011	0.43	7.55	0.17	0.01	7.00E-07	2.00E-07	0.30
2012	0.47	8.23	0.18	0.02	8.00E-07	3.00E-07	0.32
2013	0.48	8.36	0.18	0.02	8.00E-07	2.00E-07	0.34
2014	0.48	8.48	0.19	0.02	8.00E-07	2.00E-07	0.36

7.5.5.1. Solid Waste Disposal (4.A)

Solid Waste Disposal was the major contributor to GHG emissions from sector waste as a result of CH_4 emissions of from waste disposal sites. Emissions of CH_4 increased by 9.1 times from 8.43 Gg CO_2-eq in 1994 to reach 76.86 Gg in 2014. (Figure 7.6)

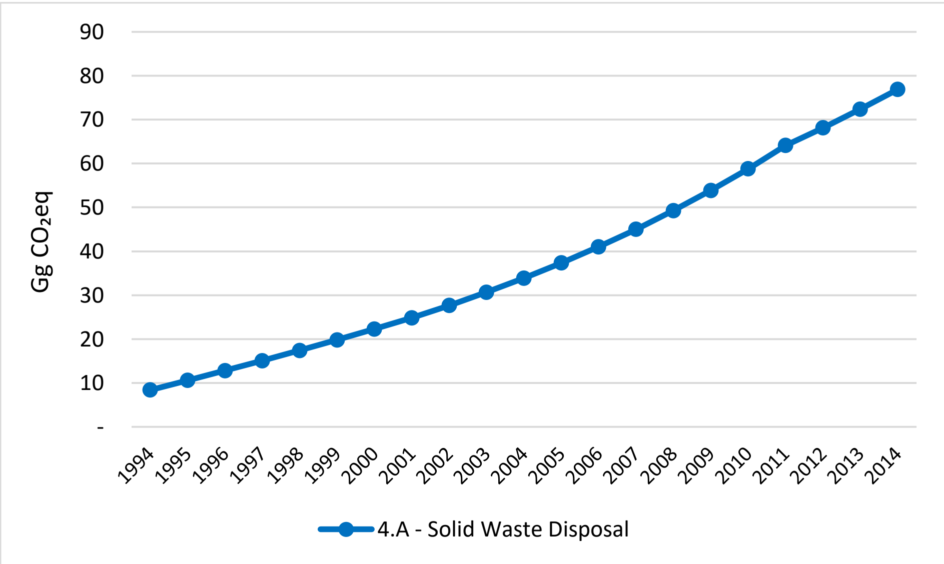


Figure 7.6 - Emissions of CH_4 in CO_2-eq from Solid Waste Disposal (1994 - 2014)

7.5.5.2. Open Burning of Waste (4.C.2)

Emissions from Open Burning of Waste increased from 11.04 Gg CO_2-eq in 1994 to 27.12 Gg CO_2-eq in 2014 – an increase of 16.10 Gg CO_2-eq equivalent 140%. The gases which contributed to the emissions were, in decreasing order of importance, CH_4 (76.5%), N_2O (14.8%) and CO_2 (8.7%) (Figure 7.7).

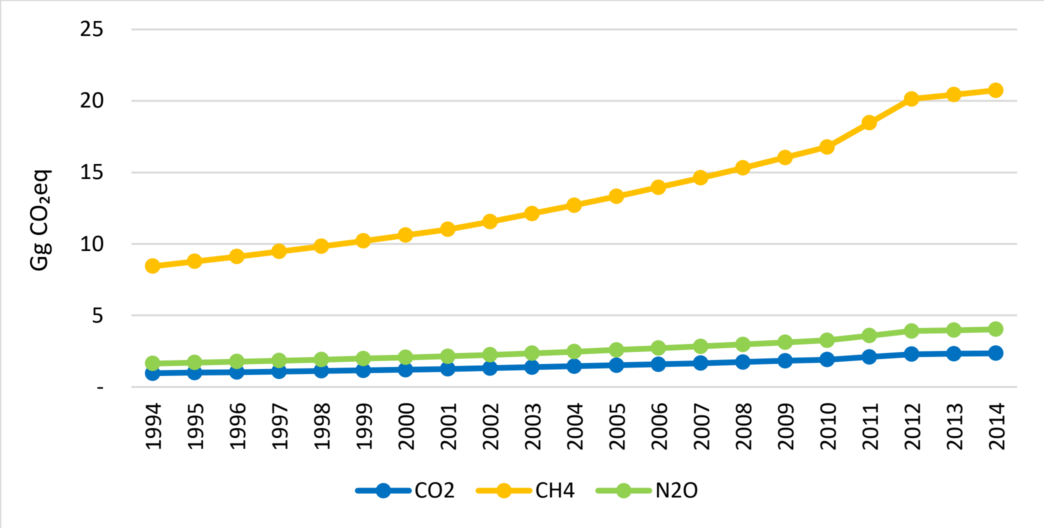


Figure 7.7 - Emissions of CH_4 in CO_2-eq from Solid Waste Disposal (1994 - 2014)

The sector also emitted NO_x, CO, NMVOCs and SO_2. The emission trends for these gases, all of which experienced a 150% increase from 1994 to 2014, is provided in Table 7.11.

Table 7.11 - Emissions (Gg CO_2-eq) from Waste sector (1995 - 2014)

Gas	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
NO_x	0.20	0.20	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.30	0.31	0.33	0.34	0.36	0.37	0.39	0.43	0.47	0.48	0.48
CO	3.45	3.59	3.73	3.87	4.02	4.18	4.34	4.51	4.73	4.96	5.20	5.45	5.71	5.98	6.26	6.56	6.86	7.55	8.23	8.36	8.48
NMVOCs	0.08	0.08	0.08	0.09	0.09	0.09	0.10	0.10	0.10	0.11	0.11	0.12	0.13	0.13	0.14	0.14	0.15	0.17	0.18	0.18	0.19
SO_2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02

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

Emissions of CH_4 from Domestic Wastewater Treatment and Discharge increased 140%, gradually from 5.15 Gg CO_2-eq in 1994 to 11.88 Gg CO_2-eq in 2014 while emissions of N_2O increased from 22.41 Gg CO_2-eq in 1994 to peak at 25.53 Gg CO_2-eq in 2007 and thereafter decrease to 22.01 Gg CO_2-eq in 2014 as shown in Figure 7.8.

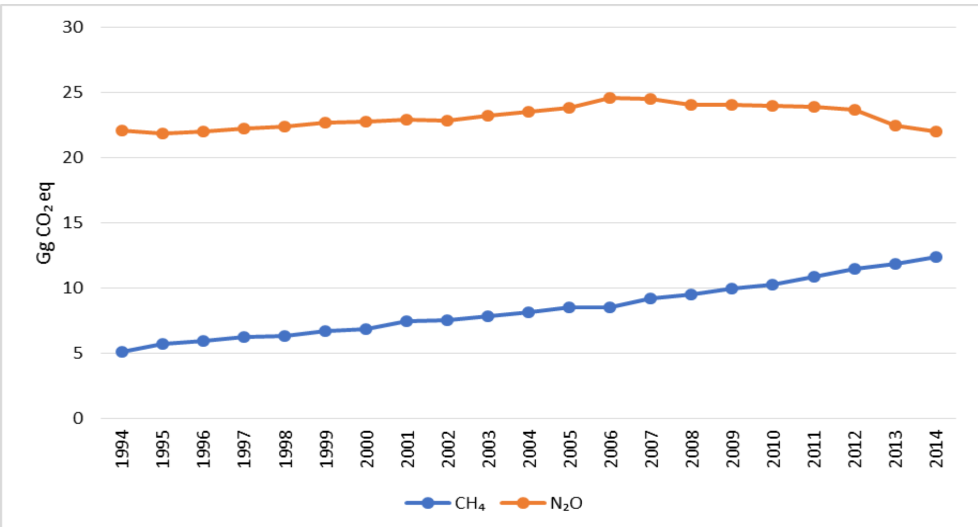


Figure 7.8 - Emissions of CH_4 in CO_2-eq from Solid Waste Disposal (1994 - 2014)

The relatively small amount of NMVOCs emitted from this source increased from 5.0E-07 Gg in 1994 to 8.0E-07 Gg in 2014, equivalent to a 60% rise.

7.5.5.4. Industrial Wastewater Treatment and Discharge (4.D.2)

There was a net reduction of emissions of CH_4 from Industrial Wastewater Treatment and Discharge decreased from 28.25 Gg CO_2-eq in 1994 to 14.38 Gg-eq in 2014, that is, a reduction of 49.1%. However, the evolution varied between years in relation to production levels as depicted in Figure 7.9 in CO_2 equivalent.

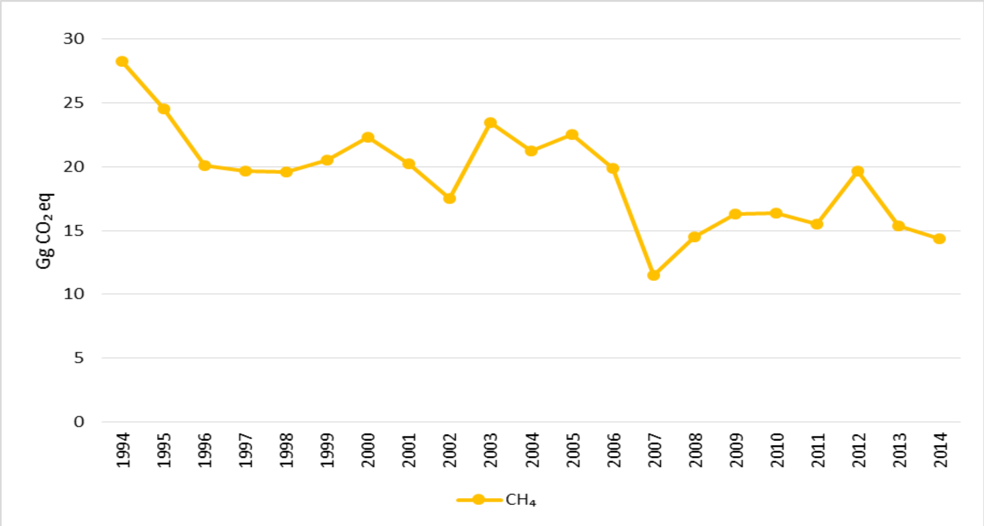


Figure 7.9 - Emissions (Gg) from Industrial Wastewater Treatment and Discharge (1995 – 2014)

The relatively small amount of NMVOCs emitted from this source increased slightly from 4.00E-07 Gg in 1994 to 2.0E-07Gg in 2014), equivalent to a 50.0% reduction.

8. References

Archer, S.R., Davies, K.W., Fulbright, T.E., McDaniel, K.V., Wilcox, B.P. and Predick, K.I., 2011, Bush Management as a Rangeland Conservation Strategy: A Critical Evaluation, in D.D. Briske (ed.), Conservation Benefits of Rangeland Practices: Assessment, Recommendations, and Knowledge Gaps, United States Dept. Agriculture, Natural Resources Conservation Service.

Barnes JI, Nhuleipo O, Muteyauli PI and MacGregor, J, 2005. Preliminary economic asset and flow accounts for forest resources in Namibia

Dieckman U and Muduva T., 2010. Charcoal production, Practices and implications.

Colin, Christian and Associates, 2010, The Effect of Bush Encroachment on Groundwater Resources in Namibia: A Desk Top Study, Namibia Agriculture Union, Windhoek, Namibia.

De Klerk, J.N., 2004, Bush Encroachment in Namibia, Report on Phase 1 of the Bush Encroachment, Monitoring and Management Project, Ministry of environment and Tourism, John Meinert Printers, Windhoek.

Elliott, C. 2012, Prefeasibility Study for Biomass Power Plant, Namibia. Biomass Supply Chain Assessment, WSP Environment & Energy South Africa, Bryanston, South Africa.

Feller S., Mahony J., Sasanowich R., and Wise J. 2006. Development of the Bushblock industry in Namibia

Food and Agriculture Organization of the United Nations (FAO), 2014, Country profiles: Namibia. Available at http://faostat.fao.org/site/666/default.aspx

Food and Agriculture Organization of the United Nations (FAO), 2010, Global Forest Resources Assessment 2010.

GDP Inflation/Economic indicator of countries (2014). Namibia Annual GDP and GDP growth rate/forecast (1980-2015). http://www.gdpinflation.com/2014/08/namibia-aanual-gdp-and- gdp-growth-rate.html

Government of Namibia (July 2002). Initial National Communication to the United Nations framework convention on climate change. Windhoek: Ministry of Environment and Tourism.

Government of the Republic of Namibia (GRN), 2004, Namibia Vision 2030: Policy framework for long-term national development, Windhoek.

Hager, C., Schultz, R. and Von Oertzen, 2007, Turning Namibian Invader Bush into Electricity: The CBEND Project, 12th Congress of the Agricultural Scientific Society of Namibia, Neudam, Namibia.

Humavindu, M.N. and Stage, J., 2013, Key Sectors of the Namibian Economy, Journal of Economic Structures, 2, 1-15.

IPCC, 2003. Good Practice Guidance for Land Use, Land Use Change and Forestry.

IPCC, 1996. *Revised 1996 IPCC Guidelines.*

IPCC 2006, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

Meat Board of Namibia, 2012, Annual Report 2012.

Meatco, 2012, Annual Report 2011/12.

Mendelsohn J., Jarvis Alice., Roberts Carole., and Robertson Tony. 2002. Atlas of Namibia.

Mendelson J. and Obeid, 2004. Forests and woodlands of Namibia

Ministry of Agriculture, Water and Forestry., 2014. Annual report 2013-2014.

Ministry of Agriculture, Water and Forestry., (Personal Communication) Burning AD Dept Forestry.

Ministry of Environment and Tourism, 2010. National Policy on Climate Change for Namibia

Ministry of Fisheries and Marine Resources., 2005. Annual report 2005.

Namibia Statistics Agency (2012). Namibia 2011 Population and Housing Census Main Report. Republic of Namibia, Windhoek.

Namibia Statistics Agency (2012). Namibia Household Income & Expenditure Survey (NHIES) 2009/2010. Republic of Namibia, Windhoek.

Namibia Statistics Agency (2014). Namibia Population Projections 2011-2041. Census Main Report. Republic of Namibia, Windhoek, September 2014.

Namibia Statistics Agency (NSA), 2012, National Household Income and Expenditure Survey.

Namibia Statistics Agency (NSA), 2013, Profile of Namibia.

Namibia Statistics Agency (NSA), 2014a, Namibia 2011 Census Mortality Report.

Namibia Statistics Agency (NSA), 2014b, Namibia 2013 Demographic and Health Survey, Main Report

National Planning Commission (2002). Second National Development Plan (NDP2) 2002/2003 – 2006/2007. National Planning Commission, Windhoek, Republic of Namibia

National Planning Commission (2008). Third National Development Plan (NDP3) 2007/2008 – 2011/2012. National Planning Commission, Windhoek, Republic of Namibia

National Planning Commission (2012). Third National Development Plan (NDP3) 2012/2013 – 20161/2017. National Planning Commission, Windhoek, Republic of Namibia

Republic of Namibia (2004). Namibia Vision 2030 – Policy Framework for Long-term National Development Main Document. Office of the President. Windhoek, Republic of Namibia.

Republic of Namibia (July 2011) Namibia Second National Communication to the United Nations Framework Convention on Climate Change. Ministry of Environment and Tourism

Routhauge A., 2014. Baseline Assessment for the De-Bushing Programme in Namibia.

Schoeman S.J., 1996. Characterization of beef cattle breeds by virtue of their performance in the National Beef Cattle Performance and Progeny Testing Scheme, South African Journal of Animal Science, 1996, 26 (1)

Wikipedia (2015). Demographics of Namibia. http://www.wikipedia.org/wiki.