REPUBLIC OF NAMIBIA

FIRST NATIONAL INVENTORY DOCUMENT

NID1

1990 – 2022

December 2024

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The Ministry of Environment, Forestry 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 combined first Biennial Transparency Report and fifth National Communication to the United Nations Framework Convention on Climate Change (UNFCCC). This is a great achievement for the Republic of Namibia to be able to raise its reporting standards to meet the Enhanced Transparency Framework and its obligations as a signatory Party to the Convention and its Paris Agreement. This has been possible as a wide range of stakeholders collaborated in the process. The Ministry of Environment, Forestry and Tourism acknowledges the valuable financial support received from the Global Environment Facility through its implementing agency, the United Nations Development Programme (UNDP) country office.

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Abbreviations and acronyms

Abbreviation / acronym	Definition
AD	Activity Data
AFOLU	Agriculture, Forestry and Other Land Use
AR6	Sixth Assessment Report
bm	Biomass
BUR	Biennial Update Report
BTR	Biennial Transparency Report
C	Confidential
CaCO3	Calcium Carbonate
CBIT	Capacity Building Initiative for Transparency
CCU	Climate Change Unit
CH_4	Methane
CMA	Conference of the Parties serving as Meeting of the Parties to the Paris Agreement
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
COP	Conference of the Parties
COVID 19	Coronavirus Disease of 2019
CRT	Common Reporting Table
CSO	Civil Society Organization
DBH/dbh	Diameter at breast height
EF	Emission Factor
EMEP/EEA	European Monitoring and Evaluation Program/European Environment Agency
ETF	Enhanced Transparency Framework
FAO	Food and Agriculture Organisation (of the United Nations)
FL	Forest Land
FRA	Global Forest Resources Assessment 2010
Fx	Flexibility
GEF	Global Environment Facility
Gg	Gigagram (1000 t)
GHG	Greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Agency for International Cooperation)
GL	Guidelines
GWP	Global Warming Potential
HAC	High Activity Clay
HFC	Hydrofluorocarbon
HWP	Harvestable Wood Products
IE	Included Elsewhere

Abbreviation / acronym	Definition
IEA	International Energy Agency
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
KCA	Key Category Analysis
km	Kilometer
kt	kilotonne
LAC	Low Activity Clay
LPG	Liquefied Petroleum Gas
L1	Level assessment 1
LULUCF	Land Use, Land Use Change and Forestry
mm	millimetre
MALF	Ministry of Agriculture and Land Reform
MeatCo	Meat Company of Namibia
MCF	Methane Correction Factor
MEFT	Ministry of Environment, Forestry and Tourism
MgCO3	Magnesium Carbonate
MMS	Manure Management System
MPGs	Modalities, Procedures and Guidelines
MW	MegaWatt
N	Nitrogen
N_2O	Nitrous oxide
NA	Not Applicable
NaTIS	National Traffic Information System
NC	National Communication
NCRC	National Committee on Rio Conventions
NID	National Inventory Document
NDC	Nationally Determined Contribution
NE	Not Estimated
NE*	Not estimated – No method available
NFI	National Forest Inventory
NF3	nitrogen trifluoride
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
NSA	Namibia Statistics Agency

Abbreviation / acronym	Definition
ODS	Ozone Depleting Substances
OL	Other Land
OWL	Other Wooded Land
PA	Paris Agreement
PFC	Perfluorocarbon
PRP	Pasture range and Padlock
PV	PhotoVoltaic
QA	Quality assurance
QC	Quality Control
RA	Reference Approach
RAC	Refrigeration and Air Conditioning
RCMRD	Regional Centre for Mapping Resource for Development
SA	Sectoral Approach
SAPP	South African Power Pool
SF_6	Sulphur hexafluoride
SNC	Second National Communication
SO_2	Sulphur dioxide
t	Tonnes
TACCC	Transparent, Accurate, Consistent, Complete, and Comparable
TC	Tonne carbon
TJ	Tera Joule
TWG	Technical Working Group
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
T1	Tier 1
T2	Tier 2
X	Emission Estimated
yr / yrs	Year / Years
°C	Degree Celsius

Executive Summary

ES.1. Background information on GHG inventories and climate change

The atmospheric level of greenhouse gases (GHGs) has continued to increase during the past five decades, causing global warming and the resulting climate change which is worsening and becoming a serious burden to sustainable socio-economic development. The Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) clearly brought forward the fact that observed changes in weather extremes, such as heatwaves, heavy precipitation, droughts, and tropical cyclones, are due to human influence through its increasing GHG emissions. IPCC considers that the global surface temperature will continue to increase until at least the mid-century under all emissions scenarios and increases of 1.5°C and 2°C will be exceeded during the 21st century unless meaningful reductions in CO2 and other GHGs are realized in the coming decades. Inadequate action would raise the global temperature by between 1.7 °C and 2.4 °C compared to pre-industrial levels and further exacerbate the climate systems.

The Republic of Namibia ratified the United Nations Convention on Climate Change (UNFCCC) on 16 May 1995 as a Non-Annex 1 Party, its Kyoto Protocol on 04 September 2003 and the Paris Agreement (PA) on 21 September 2016. To meet its obligations to these ratifications, Namibia has submitted 4 national communications (NCs) and 4 Biennial Update Reports (BURs), including 5 National Inventory Reports (NIRs) in association with these national reports with the objective of being transparent. The PA is now the platform for the global community to address this most urgent situation.

Namibia has so far compiled and submitted 8 GHG inventories. The country has progressed substantially since the first submission but still has challenges to fully comply with Article 13 of the PA on the Enhanced Transparency Framework (ETF). The first 3 GHG inventories were submitted as chapters in the NC1, NC2 and NC3 in 2002, 2011 and 2015 respectively. With the advent of the BURs as from 2014, Namibia has presented stand-alone NIRs with all its national reports submitted, namely the NIR1 with the BUR1 in 2014, the NIR2 with the BUR2 in 2016, the NIR3 with the BUR3 in 2019, the NIR4 with the NC4 in 2020 and the NIR5 with the BUR4 in 2021. The core component of the first Biennial Transparency Report (BTR1), to be submitted by Parties in December 2024 is the GHG inventory as a stand-alone National Inventory Document (NID) and as a chapter of the BTR. Namibia has thus prepared and submitted this NID in accordance with the Modalities, Procedures and Guidelines contained in Decision 18/CMA.1 within the framework of its BTR1 to meet its obligations under the PA.

Namibia has further developed its GHG Inventory Management System within the wider Measurement, Reporting and Verification (MRV) system for emissions. User friendly tools for collecting data for the inventory have been produced within the framework of the Capacity Building Initiative for Transparency (CBIT) project. Additionally, Namibia has developed and launched its QA/QC plan. Key stakeholders were trained on their use, and they were launched and rolled out during the compilation of this inventory but was only partially successful as the inventory cycle had already started because of the submission deadline of December 2024 for the BTR1.

ES.2. Summary of trends related to national emissions and removals

Namibia remained a net sink over the full time series 1990 to 2022 since removals always exceeded emissions. Total emissions do not show a clear increasing or decreasing trend over the time series but stayed rather stable at slightly above 20,000 kt CO2 e. However, a slight increase of 11% is observed when considering the national emissions of 2022 compared to those of 1990. Removals increased from 89,977 kt CO2 e in 1990 to 122,411 kt CO2 e in 2022 resulting in an increase of 32,434 kt CO2 e (45%) in net removals also for the same period. From 1990 to 2022, the net removals increased by 36%.

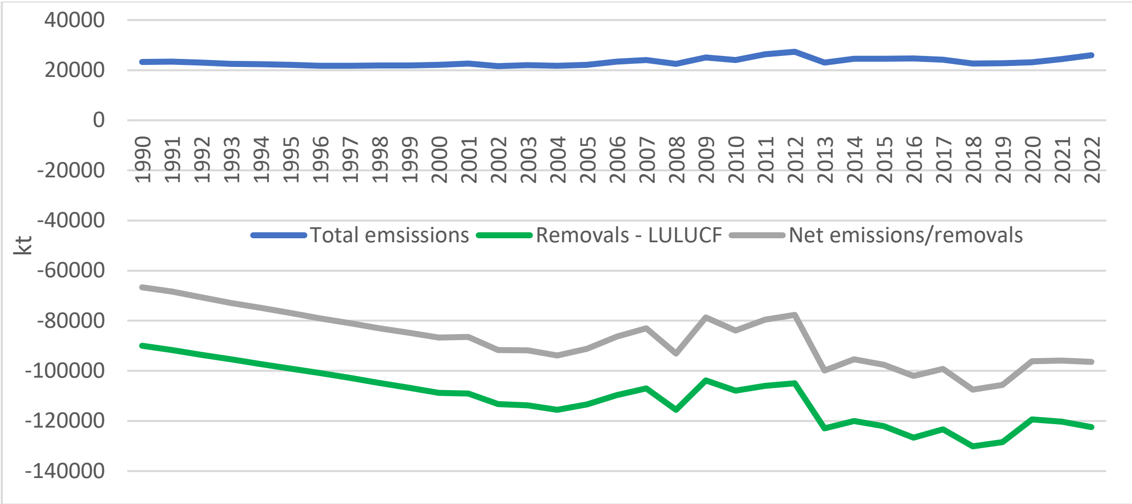

Figure ES1. Trend of national emissions (kt CO2 e), removals and the resultant net removals.

ES.3. Overview of source and sink category estimates and trends

The highest emitting sector remained LULUCF over the full time series followed by Agriculture, Energy, Waste and Industrial Production and Product Use (IPPU). In 2022, the LULUCF sector was responsible for significant removals of 122,411 kt CO2 e. Between 1990 and 2022, gross emissions decreased by 19% in the LULUCF sector but increased by 42% for Agriculture, 258% for Energy, 89% for Waste and 6,324% for IPPU.

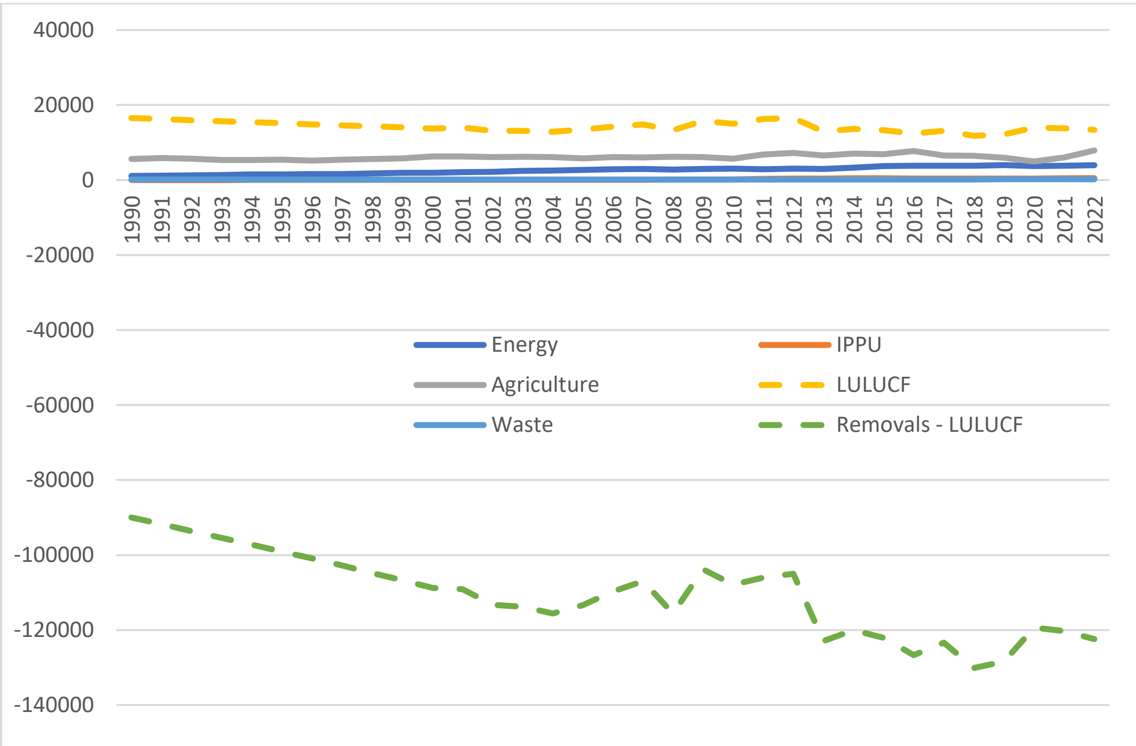

Figure ES2. Trend of aggregated gross emissions (kt CO2 e) by sector

CO2 dominated (more than 50% except for 1990 and 1991) emissions throughout the full time series with 11,373 kt CO2 e in 1990 and 15,469 kt CO2e in 2022, representing an increase of 36%. A reduction of 14% is observed for CH4, from 8,921 kt CO2 e in 1990 to 7,703 kt CO2 e in 2022. Similarly, N2O emissions regressed by 12% from 3,030 kt CO2 e to 2,654 kt CO2e. Emissions of HFCs and SF6 stayed at negligible levels throughout the time series.

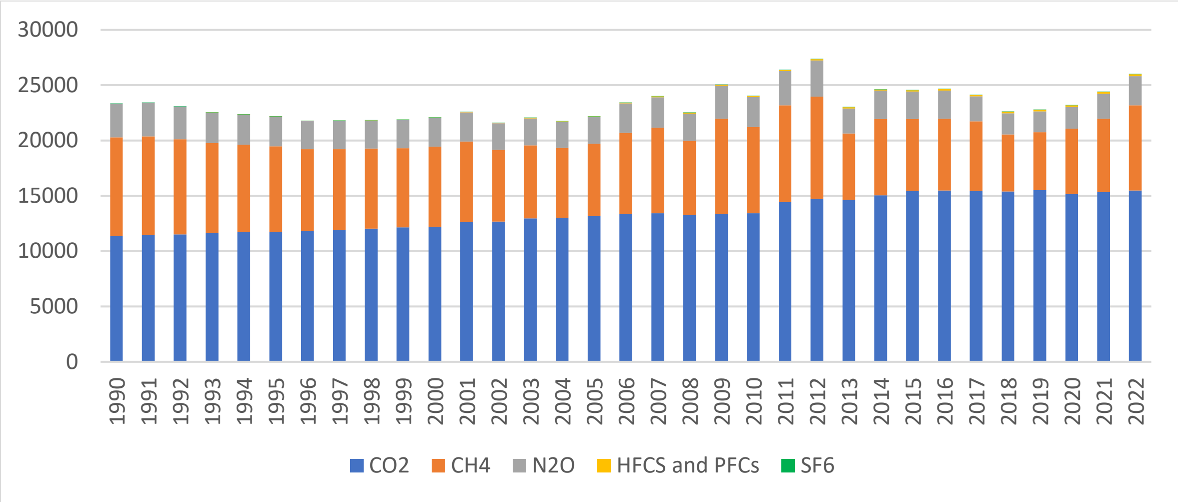

Figure ES3. National aggregated emissions (kt CO2 e) trends by gas

In absolute terms, CO2 emissions increased by 36% from 11,373 kt in 1990 to 15,469 kt in 2022. N2O stayed stable at around 10 kt while CH4 regressed from 319 kt in 1990 to 275 kt in 2022.

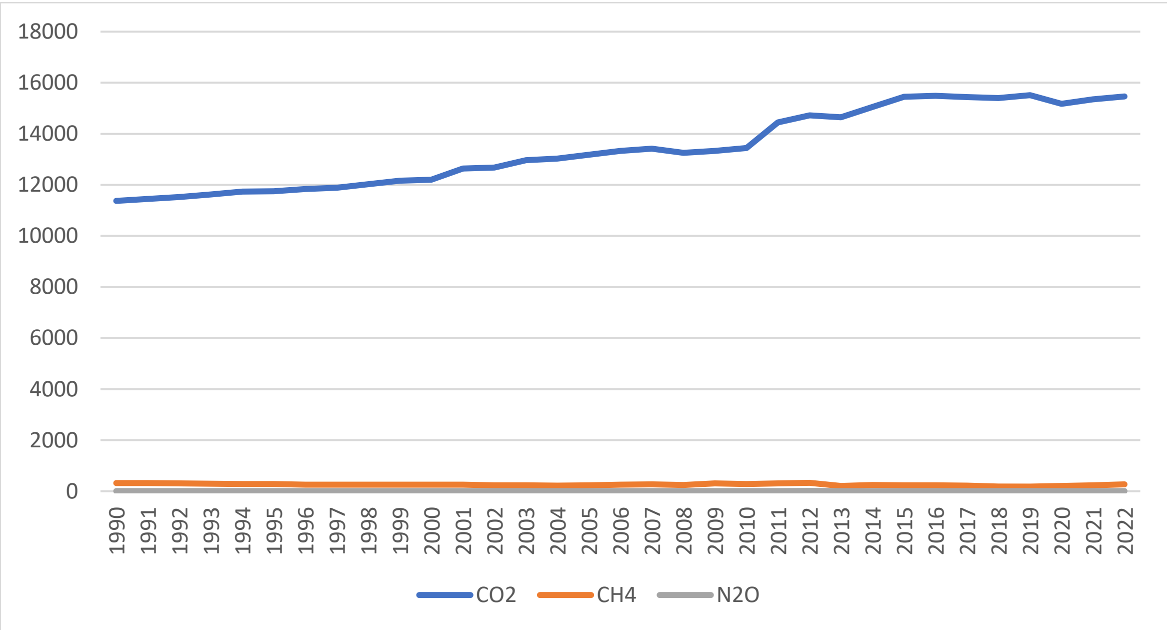

Figure ES4. Trends of absolute emissions (kt CO2 e) by gas

ES.4. Other information (e.g. indirect GHGs, precursor gases)

Overall, CO emissions decreased by 66% from 2,685 kt in 1990 to 902 kt in 2022. SO2 increased from 1.1 kt to 2.7 kt, NMVOCs from 15 to 27 kt while NOx decreased from 51 to 37 kt over the same period.

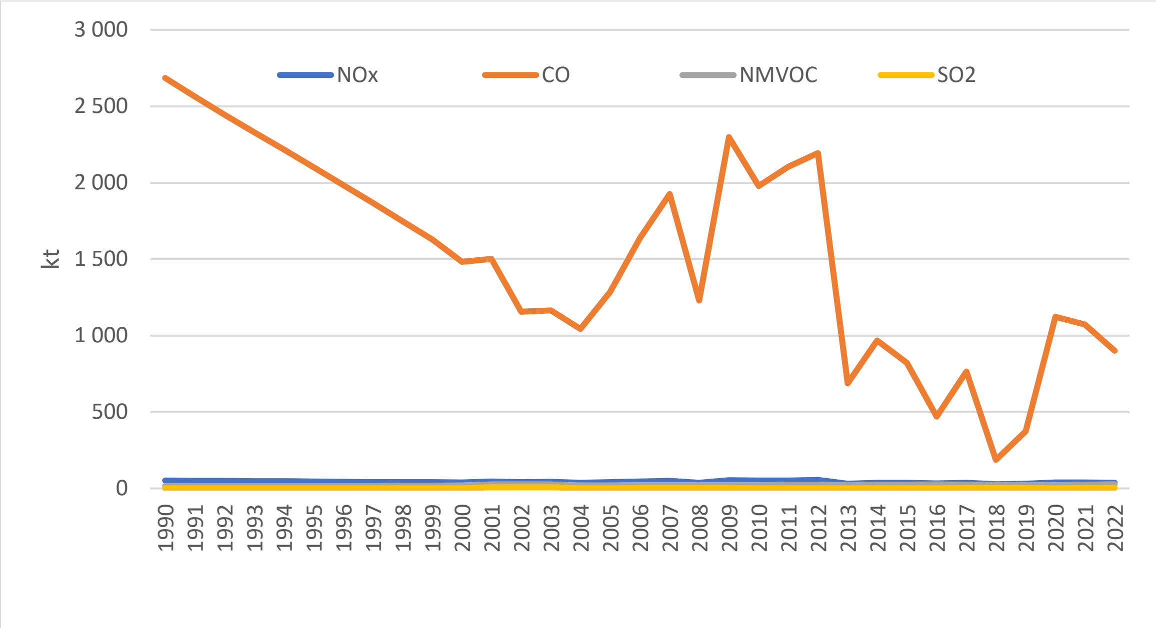

Figure ES5. Trends of emissions (kt) of Indirect GHGs

ES.5. Key Category Analysis

When considering both the level (2022) and trend (1990-2022) assessments with LULUCF (Table ES1), there are 7 key categories in total, 4 common to both the level assessment of 2022 and the trend 1990 to 2022 while the 3 additional ones fall under the latter assessment only.

Table ES1. Summary of Key Categories for level (2022) and trend (1990-2022) assessments with LULUCF

Number	IPCC category code	IPCC category	GHG	Identification criteria	Comment
1	1.A.3.b	Road Transportation - Liquid Fuels	CO2	L1,T1	Quantitative
2	3.A.1	Enteric Fermentation	CH4	L1,T1	Quantitative
3	4.A.1	Forest land Remaining Forest land	CO2	L1, T1	Quantitative
4	4.A.2	Land Converted to Forest land	CO2	T1	Quantitative
5	4.C.2	Land Converted to Grassland	CO2	L1,T1	Quantitative
6	4(IV).A.1.b.	Burning	N2O	T1	Quantitative
7	4(IV).A.1.b.	Burning	CH4	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.

When excluding LULUCF from the assessments for similar time periods, the number of key categories more than doubled, moving from 7 to 15 (Table ES2). This time 9 are common to both types of assessment, and the remaining 6 fall equally at 3 each under the level and trend assessments.

Table ES2. Summary of Key Categories for level (2022) and trend (1990-2022) assessments without LULUCF

Number	IPCC category code	IPCC category	GHG	Identification criteria	Comment
1	1.A.1	Energy industries - Solid Fuels	CO2	T1	Quantitative
2	1.A.2	Manufacturing industries and construction - Solid Fuels	CO2	L1, T1	Quantitative
3	1.A.3.b	Road transportation - Liquid Fuels	CO2	L1, T1	Quantitative
4	1.A.4	Other sectors - Liquid Fuels	CO2	L1	Quantitative
5	1.A.5	Other - Liquid Fuels	CO2	T1	Quantitative
6	1.B.1.b	Fuel transformation	CH4	L1, T1	Quantitative
7	2.A.1	Cement production	CO2	L1, T1	Quantitative

Number	IPCC category code	IPCC category	GHG	Identification criteria	Comment
8	2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	L1, T1	Quantitative
9	3.A	Enteric Fermentation	CH4	L1, T1	Quantitative
10	3.B	Manure Management	CH4	L1, T1	Quantitative
11	3.B	Manure Management	N2O	L1	Quantitative
12	3.D.1	Direct N2O Emissions from managed soils	N2O	L1, T1	Quantitative
13	3.D.2	Indirect N2O Emissions from managed soils	N2O	L1, T1	Quantitative
14	3.B.5	Indirect N2O Emissions from manure management	N2O	L1	Quantitative
15	5.A	Solid Waste Disposal	CH4	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.6. Improvements introduced

- Namibia has fully complied with the MPGs in adopting the 2006 IPCC Guidelines including its Wetlands Supplement and 2019 Refinements.
- The full time series emissions have been aggregated using the Global Warming Potentials of the IPCC Fifth Assessment Report to be in line with the MPGs.
- Other improvements consisted of the widening of the coverage of the inventory through the inclusion of estimation of SF6 in the IPPU sector and Incineration in the Waste sector.
- The new category Exploration of Oil has been covered.
- Another improvement is the partial estimation of emissions for sub-categories under the Manufacturing and Construction category which was assessed in bulk in previous inventories.
- The full time series has been recalculated for Managed and Unmanaged solid waste disposal following changes in the methodology as per the 2019 Refinements and availability of updated activity data.
- Namibia has not resorted to any of the flexibility clauses provided for in the MPGs.
- The KCA has been done and presented with and without LULUCF for the first time as per the MPGs.
- Uncertainties have been assessed on a per category basis as required by the MPGs.
- A detailed national Inventory Improvement Plan has been included in the NID to comply with the MPGs.

Chapter 1. National circumstances, institutional arrangements and cross-cutting information

1.1. Background information on GHG inventories and climate change

The atmospheric level of greenhouse gases (GHGs) has continued to increase during the past five decades, causing global warming and the resulting climate change which is worsening and becoming a serious burden to sustainable socio-economic development. The Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) clearly brought forward the fact that observed changes in weather extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones, are due to human influence through its increasing GHG emissions. IPCC considers that the global surface temperature will continue to increase until at least the mid-century under all emissions scenarios and increases of 1.5°C and 2°C will be exceeded during the 21st century unless meaningful reductions in CO2 and other GHGs are realized in the coming decades. The average rate of global sea level rise has increased from 1.3 mm annually between 1901 and 1971, to 1.9 mm between 1971 and 2006, and further to 3.7 mm between 2006 and 2018 (AR6). Inadequate action would raise the global temperature by between 1.7 °C and 2.4 °C compared to pre-industrial levels and further exacerbate the climate systems.

The Paris Agreement (PA) is now the platform for the global community to address this most urgent situation. All signatory Parties to the PA made commitments in the form of their Nationally Determined Contributions (NDCs). Furthermore, most signatory Parties have revised and updated their NDCs and will undertake future revisions every 5 years, making the PA a long-term dynamic agreement. The Agreement also called on Parties to report by 2020 on their long-term low emissions development strategies. Most Parties reviewed and updated their NDCs to make them more ambitious in view of tackling the cause of the problem, namely the continuing increase in the atmospheric level of GHGs.

The Republic of Namibia ratified the Convention on 16 May 1995 as a Non-Annex 1 Party, its Kyoto Protocol on 04 September 2003 and the PA on 21 September 2016. To meet its obligations to these ratifications, Namibia has submitted 4 national communications (NCs) and 4 Biennial Update Reports (BURs), including 5 National Inventory Reports (NIRs) in association with these national reports with the objective of being transparent. Namibia is eager to stay compliant and has thus prepared this sixth NIR (NIR6) within the framework of its first Biennial Transparency Report (BTR1) combined with its fifth NC (NC5) to honour its commitments in accordance with the Enhanced Transparency Framework of the PA. Namibia has also prepared and submitted its Intended Nationally determined Contributions (INDC) in 2015 to conform with decisions 1/CP.19 and 1/CP.20 of the Conference of the Parties (COP). In line with Article 4 of the PA and Decision 1/CP.21 of the UNFCCC, Namibia revised the INDC (to produce the first Nationally Determined Contribution (NDC) which was submitted in 2021 and updated to give the second revised version in 2023 (https://unfccc.int/sites/default/files/NDC/2024-01/FINAL%20UPDATED%20NAMIBIA%20NDC%202023.pdf).

Namibia has so far compiled and submitted 8 GHG inventories. The country has progressed substantially since the first submission but still has challenges to fully comply with Article 13 of the PA on the Enhanced Transparency Framework (ETF). The first 3 GHG inventories were submitted as chapters in the NC1, NC2 and NC3 in 2002, 2011 and 2015 respectively. With the advent of the BURs as from 2014, Namibia has presented stand-alone NIRs with all its national reports submitted, namely the NIR1 with the BUR1 in 2014, the NIR2 with the BUR2 in 2016, the NIR3 with the BUR3 in 2019, the NIR4 with the NC4 in 2020 and the NIR5 with the BUR4 in 2021. Preparation of the NIRs progress over time to conform to COP decisions through adoption of the latest recommended methodologies and guidelines, enhancing transparency, accuracy and completeness while improving consistency and completeness. To-date, Namibia's latest GHG inventory spanned over the full timeseries 1990 to 2016, has been prepared using the IPCC 2006 guidelines, covered the direct GHGs carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O) and hydrofluorocarbons (HFCs). Perfluorocarbons and nitrogen trifluoride (NF3) have not been identified as GHGs being emitted up to now. The indirect gases nitrogen oxides (NOx), carbon monoxide (NO), Non-Methane Volatile Organic Compounds (NMVOCs) and sulphur dioxide (SO2) have also been estimated in previous GHG inventories.

1.2. National circumstances and institutional arrangements

Namibia's national circumstances are such that the country has been a sink historically, is still so and is anticipated to maintain this status to the 2030 time-horizon. Removals from the LULUCF sector exceeds total emissions from the Energy, IPPU, Agriculture, LULUCF and Waste sectors.

Namibia consolidated the in-house production of its GHG inventory to meet the ETF of the PA. However, due to lack of financial resources to maintain permanent staff for a full institutionalization of the process and insufficient capacity to implement the MPGs, the country outsourced the computation of emissions and report writing to a company and the services of an independent international consultant for performing the QA and capacity building of the GHG inventory working groups under the different sector leads (Figure 1.1) to meet the enhanced transparency and higher standards of reporting.

The responsibilities within the institutional arrangements for the preparation of the NID1 are:

- The CCU of the Ministry of Environment, Forestry and Tourism (MEFT) for inventory coordination, compilation and submission.
- Ministry of Mines and Energy (MME) as lead of the Energy sector working group, including data collection and their quality control.
- The Ministry of Industrialization and Trade acted as lead for the working group of the Industrial Production and Product Use sector, including data collection and their quality control.
- Ministry of Agriculture, Water and Land Reform led the working group for the Agriculture sector, including data collection and their quality control
- The Forestry Department of the MEFT as lead for the Land Use, Land Use Change and Forestry (LULUCF) sector, including data collection and their quality control.
- The Waste Department of the MEFT led the working group for the Waste sector, including data collection and their quality control.
- The Climate Change Unit (CCU) of the MEFT coordinated the production of the GHG inventory and the NID as well as the QA/QC plan.
- External consultant for capacity building and QA.
- The CCU of the MEFT acted as GHG inventory specialist to track capacity building needs, the IPCC process and COP decisions for implementation.

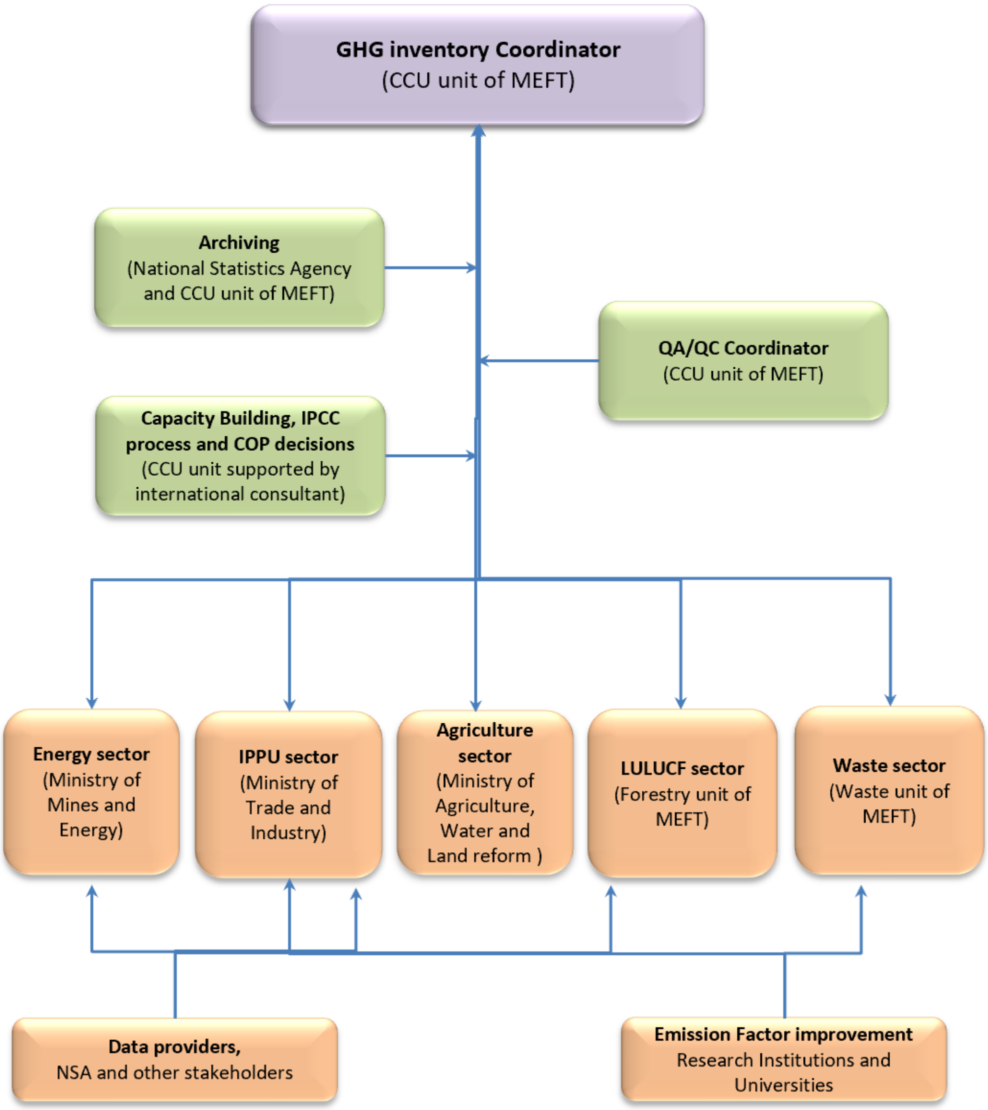

Figure 1.1. Institutional arrangements for compiling the GHG inventory

1.2.1. National entity or national focal point

The CCU of the MEFT monitors and coordinates the production of the GHG inventories for the latter ministry as National Focal Point of the Convention.

1.2.2. Inventory preparation process

The inventory cycle followed for the compilation of the NID1 is presented in Figure 1.2. The different steps adopted for the preparation of the inventory were:

- Drawing up of work plan with timeline and deliverables.
- Allocation of tasks to sectoral experts.
- Collection, quality control and validation of AD.
- Selection of Tier level within each category and sub-category.
- Selection of EFs and Derivation of local EFs wherever possible.
- Validation of AD and EFs during a workshop serving capacity building concurrently.
- Computation of GHG emissions.
- Uncertainty analysis.

- QA/QC of emissions and outputs.
- Assessment of completeness.
- Recalculations.
- Trend analysis.
- Identification of Gaps, constraints, needs and improvements.
- Preparation of the NID in accordance with Annex V of Decision 5/CMA.3 and the MPGs contained in the Annex to Decision 18/CMA.1.
- Circulation of final draft report to stakeholders for comments.
- Integration of stakeholders' comments.
- Validation of GHG inventory and chapter for inclusion in the BTR1; and
- Submission to UNFCCC as a stand-alone NID1 and a component of the BTR1.

Figure 1.2. Inventory cycle of the NID1

1.2.3. Archiving of information

The National Statistics Agency (NSA) of Namibia is the repository of all national data pertaining to the socio-economic development of the country. Moreover, they have the knowledge and facilities to archive data while also supporting the compilation of the GHG inventory through provision of data and other information on the different IPCC sectors as applicable. NSA is a member of the GHG inventory working group and is playing an active role in including in their census some of the data needed for the inventory. Thus, NSA and CCU will be archiving all data, workings and other information on the compilation of the NID1.

1.2.4. Processes for official consideration and approval of inventory

The consideration and approval process involves officials from the Ministries, Departments and Agencies, Academicians, NGOs and CSOs which are members of the National Committee on Rio Conventions (NCRC). The final draft of the NID1 is circulated to them for analysis and comments which are then integrated before recirculation. The NCRC is then convened for a final discussion and approval of the NID1. Once the NID1 is validated and approved, the National Inventory Coordinator prepares a letter of submission to accompany the NID1 and CRTs, which are then submitted electronically to the UNFCCC.

1.3. Brief general description of methodologies (including tiers) and data sources used

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 sections covering the individual IPCC 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)

1.

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 and the Modalities, Procedures and Guidelines contained in the Annex to Decision 18/CMA.1. The IPCC 2006 Guidelines, its Wetlands Supplement and 2019 Refinements, including the category-specific decision tree as applicable, were complemented with the European Monitoring and Evaluation Programme / European Environment Agency (EMEP/EEA) Guidebook 2023 for estimation of emissions of non-CO2 gases as applicable. Equations from the Guidebook were programmed in Excel worksheets, estimations made and entered manually in the sectoral tables generated by the IPCC Inventory Software for reporting in the NID1.

The Tier 2 method has been adopted for estimating emissions in the Road Transportation (1.A.3.b) sector where the vehicle population has been disaggregated in different classes to fit IPCC requirements, coupled with estimated mileage run annually and consumption by vehicle class. Additionally, national EFs and stock factors as appropriate have been derived and adopted to compile estimates at the Tier 2 level for Enteric Fermentation (3.A.1) for Dairy Cows and Non-dairy Cattle in the Livestock and Forest land Remaining Forest land (3.B.1.a) in the LULUCF sector. 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 these key categories and reduced the uncertainty level. The method and Tier level adopted for estimated categories are provided in Table 1.1.

Table 1.1. Method and Tier level adopted for categories estimated

Categories	CO2	CH4	N2O	NOx	CO	NMVOCs	SO2
1 - Energy							
1.A. Fuel combustion activities							
1.A.1. Energy industries							
1.A.1.a. Public electricity and heat production							
1.A.1.a.i. Electricity generation	IPCC T1	IPCC T1	IPCC T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1

Categories	CO2	CH4	N2O	NOx	CO	NMVOCs	SO2
1.A.2. Manufacturing Industries and construction							
1.A.2.e - Food processing, beverages and tobacco	IPCC T1	IPCC T1	IPCC T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1
1.A.2.f - Non-metallic minerals	IPCC T1	IPCC T1	IPCC T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1
1.A.2.g.iii - Mining (excluding fuels) and quarrying	IPCC T1	IPCC T1	IPCC T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1
1.A.2.g.viii - Other	IPCC T1	IPCC T1	IPCC T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1
1.A.3. Transport							
1.A.3.a – Domestic aviation	IPCC T1	IPCC T1	IPCC T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1
1.A.3.b - Road transportation							
1.A.3.b.i - Cars							
1.A.3.b.i.1 - Passenger cars with 3-way catalysts	IPCC T2	IPCC T2	IPCC T2	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1
1.A.3.b.i.2 - Passenger cars without 3-way catalysts	IPCC T2	IPCC T2	IPCC T2	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1
1.A.3.b.ii - Light-duty trucks							
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts	IPCC T2	IPCC T2	IPCC T2	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts	IPCC T2	IPCC T2	IPCC T2	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1
1.A.3.b.iii - Heavy-duty trucks and buses	IPCC T2	IPCC T2	IPCC T2	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1
1.A.3.b.iv - Motorcycles	IPCC T2	IPCC T2	IPCC T2	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1
1.A.3.c - Railways	IPCC T1	IPCC T1	IPCC T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1
1.A.3.d – Domestic navigation	IE	IE	IE	IE	IE	IE	IE
1.A.3.e - Other transportation							
1.A.3.e.ii – Other (please specify) off-road	IE	IE	IE	IE	IE	IE	IE
1.A.4. Other Sectors							
1.A.4.a - Commercial/institutional	IE	IE	IE	IE	IE	IE	IE
1.A.4.b - Residential	IPCC T1	IPCC T1	IPCC T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1
1.A.4.c - Agriculture/forestry/fishing							
1.A.4.c.i - Stationary	IE	IE	IE	IE	IE	IE	IE
1.A.4.c.ii - Off-road Vehicles and other machinery	IE	IE	IE	IE	IE	IE	IE
1.A.4.c.iii - Fishing	IPCC T1	IPCC T1	IPCC T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1
1.A.5. Other							
1.A.5.a - Stationary	IE	IE	IE	IE	IE	IE	IE
1.A.5.b - Mobile	IPCC T1	IPCC T1	IPCC T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1
1.B. Fugitive emissions from fuels							
1.B.1.b. Fuel transformation							
1.B.1.b.i -Charcoal and biochar production	NA	IPCC T1	IPCC T1	IPCC T1	IPCC T1	NE*	NE*
1.B.2. Oil and natural gas and other emissions from energy production							
1.B.2.a. Oil							
1.B.2.a.i. Exploration	IPCC T1	IPCC T1	IPCC T1	NA	NA	NA	NA

Categories	CO2	CH4	N2O	NOx	CO	NMVOCs	SO2
Categories	CO2	CH4	N2O	NOx	CO	NMVOCs	SO2
1.D. Memo Items							
1.D.1. International bunkers							
1.D.1.a. Aviation	IPCC T1	IPCC T1	IPCC T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1
1.D.1.b. Navigation	IPCC T1	IPCC T1	IPCC T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1
1.D.3. CO2 emissions from biomass	IPCC T1	NA	NA	NA	NA	NA	NA

Categories	CO_2	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases	Other halogenated gases	NOx	CO	NMVOCs	SO_2
2 - Industrial Processes and Product Use												
2.A - Mineral Industry												
2.A.1 - Cement production	IPCC T1/T2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D - Non-Energy Products from Fuels and Solvent Use												
2.D.1 - Lubricant Use	IPCC T1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.2 - Paraffin Wax Use	IPCC T1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D.3 - Solvent Use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	EMEP/EEA Tier 1	NA
2.F - Product Uses as Substitutes for Ozone Depleting Substances												
2.F.1 - Refrigeration and Air Conditioning	NA	NA	NA	IPCC T1	NA	NA	NA	NA	NA	NA	NA	NA
2.G - Other Product Manufacture and Use												
2.G.1 - Electrical Equipment	NA	NA	NA	NA	IPCC T1	IPCC T1	NA	NE	NA	NA	NA	NA
2.G.3 - N2O from Product Uses	NA	NA	IPCC T1	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.H - Other												
2.H.2 - Food and Beverages Industry	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	EMEP/EEA Tier 1	NO

GHG source and sink Categories	CO_2	CH_4	N_2O	NOx	CO	NMVOCs	SOx
3. Agriculture							
3.A. Enteric Fermentation	NA		NA	NA	NA	NA	NA
Option A							
3.A.1.a. Dairy cattle	NA	IPCC T2	NA	NA	NA	NA	NA
3.A.1.b. Non-dairy cattle	NA	IPCC T2	NA	NA	NA	NA	NA
3.A.2 Sheep	NA	IPCC T1	NA	NA	NA	NA	NA
3.A.3. Swine	NA	IPCC T1	NA	NA	NA	NA	NA
3.A.4. Other livestock	NA	IPCC T1	NA	NA	NA	NA	NA
3.B. Manure Management							
Option A							
3.B.1.a Dairy cattle	NA	IPCC T1	IPCC T1	NA	NA	EMEP/EEA T1	NA
3.B.1.b. Non-dairy cattle	NA	IPCC T1	IPCC T1	NA	NA	EMEP/EEA T1	NA
3.B.2. Sheep	NA	IPCC T1	IPCC T1	NA	NA	EMEP/EEA T1	NA
3.B.3. Swine	NA	IPCC T1	IPCC T1	NA	NA	EMEP/EEA T1	NA
3.B.4. other livestock	NA	IPCC T1	IPCC T1	NA	NA	EMEP/EEA T1	NA
3.B.5. Indirect N2O emissions	NA	IPCC T1	IPCC T1	NA	NA	NA	NA
3.D – Agricultural soils							
3.D.1. Direct N_2O emissions from managed soils							
3.D.1.a. Inorganic N fertilizers	NA	NA	IPCC T1	NA	NA	NA	NA
3.D.1.b. Organic N fertilizers	NA	NA	IPCC T1	NA	NA	NA	NA
3.D.1.c. Urine and dung deposited by grazing animals	NA	NA	IPCC T1	NA	NA	NA	NA
3.D.2. Indirect N_2O Emissions from managed soils	NA	NA	IPCC T1	NA	NA	NA	NA
3.H. Urea application	IPCC T1	NA	NA	NA	NA	NA	NA

Categories	CO_2	CH_4	N_2O	NOx	CO	NMVOCs
4. LULUCF						
4.A. Forest land						
4.A.1. Forest land remaining forest land	IPCC T2	NA	NA	NA	NA	NA
4(IV).A.1.b. Wildfires	IPCC T1	IPCC T1	IPCC T1	IPCC T1	IPCC T1	IPCC T1
4.A.2. Land converted to forest land	IPCC T2	NO	NO	NO	NO	NO
4.B. Cropland						
4.B.1. Cropland remaining cropland	IPCC T1	NA	NA	NA	NA	NA
4.C. Grassland						
4.C.1. Grassland remaining grassland	IPCC T1	IPCC T1	IPCC T1	IPCC T1	IPCC T1	IPCC T1
4(IV).C.1.b. Wildfires	IPCC T1	IPCC T1	IPCC T1	IPCC T1	IPCC T1	IPCC T1
4.C.2. Land converted to grassland	IPCC T1	NA	NA	NA	NA	NA
4.D. Wetlands						
4.D.1. Wetlands remaining wetlands	IPCC T1	NA	NA	NA	NA	NA
4.E. Settlements						
4.E.1. Settlements remaining settlements	IPCC T1	NA	NA	NA	NA	NA

Categories	CO_2	CH_4	N_2O	NOx	CO	NMVOCs
4.E.2. Land converted to settlements	IPCC T1	NA	NA	NA	NA	NA
4.F. Other land						
4.F.1. Other land remaining other land	IPCC T1	NA	NA	NA	NA	NA
4.G. Harvested wood products	IPCC T1	NA	NA	NA	NA	NA

Categories	CO_2	CH_4	N_2O	NOx	CO	NMVOCs	SO2
5 - Waste							
5.A - Solid Waste Disposal							
5.A.1 Managed waste disposal sites	NA	IPCC T1	NA	NA	NA	EMEP/EEA T1	NA
5.A.2 Unmanaged waste disposal sites	NA	IPCC T1	NA	NA	NA	EMEP/EEA T1	NA
5.C - Incineration and Open Burning of Waste							
5.C.1 - Waste incineration	IPCC T1	IPCC T1	IPCC T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1
5.C.2 - Open Burning of Waste	IPCC T1	IPCC T1	IPCC T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1	EMEP/EEA T1
5.D - Wastewater Treatment and Discharge							
5.D.1 - Domestic Wastewater Treatment and Discharge	NA	IPCC T1	IPCC T1	NA	NA	NE	NA
5.D.2 - Industrial Wastewater Treatment and Discharge	NA	IPCC T1	IPCC T1	NA	NA	EMEP/EEA T1	NA

Default EFs were assessed for their appropriateness prior to their adoption, based on the conditions 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 do 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 working groups and inventory coordinator. Data gaps were filled by the national experts by personally contacting stakeholders 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 functional 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 used for navigation, domestic aviation, food consumption and forest areas by type. Only data for the period 2017 to 2022, the new years added to the previous time series are provided in this NID1. Readers are referred to the NIR5 for AD for the period 1990 to 2016 (https://unfccc.int/sites/default/files/resource/Namibia%20NIR5%20Part%201-Final%20.pdf) for all categories except those recalculated when the full time series 1990 to 2022 are given in this NID1. The data sources for estimated categories for the period 2017 to 2022 are given in Table 1.2.

Table 1.2. Summary of data sources for estimated categories

Greenhouse gas source and sink categories	Data sources
1 - Energy	
1.A - Fuel Combustion Activities	
1.A.1 - Energy Industries	
1.A.1.a – Public electricity and heat production	
1.A.1.a.i - Electricity generation	Nampower
1.A.2 - Manufacturing Industries and Construction	
1.A.2.e - Food processing, beverages and tobacco	Annual reports of some Namibian producers
1.A.2.f - Non-metallic minerals	One cement producer, NSA and gap filling using IPCC splicing techniques
1.A.2.g.iii - Mining (excluding fuels) and quarrying	(i) ECB Project "Energy Policy, Regulatory Framework and Energy Future of Namibia (2011-2013)". (ii) NSA (iii) Gap filling using IPCC splicing techniques
1.A.2.g.viii - Other	(i) Ministry of Industrialization, Trade and SME Development (ii) Gap filling using IPCC splicing techniques (iii) Biomass estimates from AFOLU sector
1.A.3. Transport	
1.A.3.a. Domestic Aviation	(i) Airports authorities (ii) NSA (iii) Gap filling using IPCC splicing techniques
1.A.3.b - Road transportation	(i) NATIS (ii) Road Authority Gasoline and diesel estimated for the different IPCC vehicles classes in the fleet using mileage run by each and fuel consumption indicators for respective years
1.A.3.c - Railways	(i) NSA (ii) TransNamib (iii) National reports
1.A.4 - Other Sectors	
1.A.4.b - Residential	(i) NSA censuses (ii) National imports and exports data (iii) IEA (iv) Ministry of Industrialization, Trade and SME Development (v) Fuelwood and charcoal from AFOLU sector (v) Gap filling using IPCC splicing techniques
1.A.4.c - Agriculture/Forestry/Fishing	
1.A.4.c.iii - Fishing	(i) National imports and exports data (ii) Annual reports of Ministry of Fisheries (iii) National statistics on consumption reports (iv) Gap filling using IPCC splicing techniques
1.A.5 - Other	
1.A.5.b. – Mobile	(i) NATIS (ii) Road Authority (iii) Gap filling using IPCC splicing techniques
1.B - Fugitive emissions from fuels	
1.B.1 - Solid Fuels	
1.B.1.b - Fuel transformation	
1.B.1.b.i - Charcoal and biochar production	(i) National imports and exports data (ii) National statistics on consumption.
1.B.2 - Oil and natural gas and other emission from energy production	
1.B.2.a - Oil	

Greenhouse gas source and sink categories	Data sources
1.B.2.a.i. - Exploration	Ministry of Mines and Energy
2 - Industrial Processes and Product Use	
2.A - Mineral Industry	
2.A.1 - Cement production	(i) Cement producer (ii) National imports and exports data
2.A.2 - Lime production	
2.D - Non-Energy Products from Fuels and Solvent Use	
2.D.1 - Lubricant Use	National imports and exports data
2.D.2 - Paraffin Wax Use	National imports and exports data
2.D.3 - Solvent Use	National imports and exports data
2.F - Product Uses as Substitutes for Ozone Depleting Substances	
2.F.1 - Refrigeration and Air Conditioning	(i) GIZ (2017). Green Cooling Africa Initiative: Final Report Green Cooling Africa Initiative Final Report Part III Refrigeration and Air Conditioning Greenhouse Gas Inventory Technology Gap Analysis Policy Analysis Roadmap Report for Namibia Green Cooling Africa Initiative: Final Report. [online] Available at: https://www.ctc-n.org/system/files/dossier/3b/3000035954_gcai_final_report_part_iii.pdf (ii) NATIS (iii) Road Authority
2.G - Other Product Manufacture and Use	
2.G.1 - Electrical Equipment	NamPower survey
2.G.3 - N2O from Product Uses	(i) National census reports (2003, 2012 and 2016) of Namibia (ii) World Health Organisation
2.H - Other	
2.H.2 - Food and Beverages Industry	(i) National imports and exports data (ii) World Health Organisation
3 - Agriculture	
3.A - Enteric Fermentation	(i) Department of veterinary services – Ministry of Agriculture, Water and Land Reform (ii) Survey for animal population segregation for cattle (NNFU, 2006) (iii) Meat Co slaughterhouse data – Direct communication (iv) Food and Agricultural Organisation - FAOSTATS (v) Characterization of beef cattle breeds by virtue of their performances in the National Beef Cattle Performance and Progeny Testing Scheme (S.J. Schoeman, 1996) - https://www.ajol.info/index.php/sajas/article/view/138388
3.B - Manure Management	(i) Same as 3.A.1 above (ii) Expert judgement for manure management systems
3.D – Agricultural soils	(i) Same as 3.A above (ii) National imports and exports data
4 - Land use and land use change and forestry	
4.A – Forest land 4.B – Cropland 4.C – Grassland 4.D – Wetlands 4.E – Settlements 4.F – Other land	(i) Forestry Department – Ministry of Environment, Forestry and Tourism (ii) National imports and exports data (iii) National census reports (2003, 2012 and 2016) of Namibia (iv) RCMRD land use and land cover maps (v) Forest Assessments reports Namibia (2010) - Food and Agricultural Organisation (https://www.fao.org/docrep/013/al577E/al577E.pdf)
4.G – Harvested wood products	(i) Forestry Department – Ministry of Environment, Forestry and Tourism (ii) National imports and exports data (iii) National census reports (2003, 2012 and 2016) of Namibia
5 - Waste	
5.A - Solid Waste Disposal	(i) Solid waste division – Ministry of Environment, Forestry and Tourism (ii) City councils
5.C - Incineration and Open Burning of Waste	(i) Solid waste division – Ministry of Environment, Forestry and Tourism (ii) City councils

Greenhouse gas source and sink categories	Data sources
5.D - Wastewater Treatment and Discharge	(i) City councils (ii) National census reports (2003, 2012 and 2016) of Namibia
1.D. Memo items	
1.D.1. International bunkers	
1.D.1.a. Aviation	(i) ECB Project "Energy Policy, Regulatory Framework and Energy Future of Namibia (2011-2013)" (ii) Airport Authorities (iii) Extrapolation
1.D.1.b. Navigation	(i) Ministry of Works and Transport, Maritime Affairs (ii) SNC and national statistics (iii) Ministry of Mines and Energy (iv) Interpolation

1.4. Brief description of key categories

Since the software only generates results inclusive of LULUCF and the MPGs contained in Decision 18/CMA.1 require outputs with and without LULUCF, Namibia has developed a tool to perform this task in accordance with the reporting requirements and all members of the GHG inventory working group are trained on its use. The tool was tested by comparing the results obtained with it with those from the software for the level and trend assessment for a few years prior to adoption. It has been applied for the KCA analysis for this NID1.

The KCA was performed using the tool available within the IPCC Inventory Software and the results were exported in an excel file and saved. Excel worksheets were developed from the exported results for determining both the Level and Trend assessments. The Excel worksheets were programmed as per the equations of the IPCC 2006 guidelines to generate results with and without LULUCF. The KCA was truncated at the 95% level. The key categories for the level and trend assessments with and without LULUCF are provided in Annex 1 in detail. Tables 1.3 and 1.4 summarize the key categories for the level assessment for year 2022 and for the trend assessment from 1990 to 2022 with and without LULUCF respectively.

When considering both assessments with LULUCF (Table 1.3), there are 7 key categories in total, 4 common to both the level assessment of 2022 and the trend 1990 to 2022 while the 3 additional ones fall under the latter assessment only.

Table 1.3. Summary of Key Categories for level (2022) and trend (1990-2022) assessments with LULUCF

Number	IPCC category code	IPCC category	GHG	Identification criteria	Comment
1	1.A.3.b	Road Transportation - Liquid Fuels	CO2	L1, T1	Quantitative
2	3.A.1	Enteric Fermentation	CH4	L1, T1	Quantitative
3	4.A.1	Forest land Remaining Forest land	CO2	L1, T1	Quantitative
4	4.A.2	Land Converted to Forest land	CO2	T1	Quantitative
5	4.C.2	Land Converted to Grassland	CO2	L1, T1	Quantitative
6	4(IV).A.1.b.	Burning	N2O	T1	Quantitative
7	4(IV).A.1.b.	Burning	CH4	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.

When excluding LULUCF from the assessments for similar time periods, the number of key categories more than doubled, moving from 7 to 15 (Table 1.4). This time 9 are common to both types of assessment, and the remaining 6 falling equally at 3 each under the level and trend assessments.

Table 1.4. Summary of Key Categories for level (2022) and trend (1990-2022) assessments without LULUCF

Number	IPCC category code	IPCC category	GHG	Identification criteria	Comment
1	1.A.1	Energy industries - Solid Fuels	CO2	T1	Quantitative
2	1.A.2	Manufacturing industries and construction - Solid Fuels	CO2	L1, T1	Quantitative
3	1.A.3.b	Road transportation - Liquid Fuels	CO2	L1, T1	Quantitative
4	1.A.4	Other sectors - Liquid Fuels	CO2	L1	Quantitative
5	1.A.5	Other - Liquid Fuels	CO2	T1	Quantitative
6	1.B.1.b	Fuel transformation	CH4	L1, T1	Quantitative
7	2.A.1	Cement production	CO2	L1, T1	Quantitative
8	2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	L1, T1	Quantitative
9	3.A	Enteric Fermentation	CH4	L1, T1	Quantitative
10	3.B	Manure Management	CH4	L1, T1	Quantitative
11	3.B	Manure Management	N2O	L1	Quantitative
12	3.D.1	Direct N2O Emissions from managed soils	N2O	L1, T1	Quantitative
13	3.D.2	Indirect N2O Emissions from managed soils	N2O	L1, T1	Quantitative
14	3.B.5	Indirect N2O Emissions from manure management	N2O	L1	Quantitative
15	5.A	Solid Waste Disposal	CH4	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.

It is to be noted that Namibia has assessed key categories with and without LULUCF for the first time. The latter exercise has revealed additional key categories, and it has not been possible to move to Tier 2 due to lack of data. In fact, data for the years 2021 and 2022 were already collected when the inventory was compiled and this feature observed. They have all been considered for improvement and prioritized depending on their importance in contributing to emissions. Details on those retained on a priority basis for improvement are provided in the respective improvement plan below.

1.5. Brief general description of QA/QC plan and implementation

Namibia has its own national system for Quality Control (QC) of data which are collected by the different Ministries, Departments and Agencies. All data are quality controlled at different stages of the process until the final Quality Assurance (QA) is made by the NSA before archiving in national databases. The private sector also implements its own QC within its data collection and archiving processes. Thus, the initial phases of the control system remained beyond the GHG inventory compiler and may not fit the QA/QC process of the IPCC exactly.

Hence, with the intent of improving the QA/QC process, Namibia has developed a QA/QC plan and rolled it out during the data collection step of this inventory. The QA/QC plan follows all the steps earmarked in the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2019), including category-specific checklists. The QA/QC plan has been shared with all members of the GHG inventory working groups for adoption after a training session. The initial steps for quality controlling data collection have been integrated in the activity data collection template for each category which is completed by the data collector or provider. The overall QA/QC coordinator rests with the CCU of MEFT with the IPCC sector leads overseeing the QC when data are collected. The rolling out of the QA/QC plan proved to be a very tedious exercise and did not work as expected. This is mainly due to delays in starting the inventory cycle coupled with insufficient availability of the sectoral team leaders. Further strengthening of the QA/QC process will take place during the next data collection round for the next inventory.

Nonetheless, QC and QA procedures, as defined in the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2019), have been implemented as far as possible during the preparation of the inventory. Whenever there were inconsistencies or possible transcription errors, the institution responsible was queried, 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 databases such as those of the Food and Agriculture Organisation (FAO), the United Nations (UN) statistical database and the International Energy Agency (IEA).

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

- Confirm the quality and reliability of data used for computing emissions.
- Review the AD and EFs adopted for each source category as a first step;
- Analyse the time series data to identify and correct outliers, and
- Review and check the calculation steps in the software to ensure accuracy.

1.6. General uncertainty assessment

For this inventory, an Approach 1 uncertainty analysis of the aggregated figures as required by the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2019) 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 values assigned to AD and EFs were from the range recommended by the IPCC Guidelines for the specific gases of each source category. Thus, lower uncertainties were assigned 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 was adopted except for nationally determined EFs when the lower values in 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 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 Guidelines and used in the uncertainty analysis.

The uncertainty analysis could not be performed using the tool available within the IPCC Inventory Software – version 2.91. The results, obtained for the trend assessment particularly, were erroneous. This stemmed from wrong estimates being carried over within the tool of the software. Moreover, the MPGs contained in the Annex to decision 18/CMA.1 require that Parties report uncertainties at category level for all sources and sinks. This is not generated by the software and must be calculated using other methods. To remedy this situation, the equations from the IPCC 2006 guidelines were programmed in an Excel worksheet and the uncertainties determined exactly as in the software. Uncertainties in total emissions were thus calculated in the Excel worksheet including emissions and removals from the LULUCF sector. The combined Uncertainty for the level assessment for the base year 1990 and year-t 2022 is 64.9% and 61.4% respectively while the uncertainty for the trend assessment between the base year 1990 and year-t 2022 is 52.2%. The uncertainties assigned to AD and EFs for each category and the combined uncertainty estimates are provided under the respective categories in this NID.

1.7. General assessment of completeness

An assessment of the completeness of the inventory was made by populating individual IPCC activity areas within each source category covering the 5 sectors. The methodology adopted was according to the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2019) and an additional acronym, namely NE* to indicate that emissions have not been estimated because of a lack of methodology. Hence, the notation keys from the list below have been used as appropriate:

Abbreviation	Meaning
X	Estimated
NA	Not Applicable
NO	Not Occurring
NE	Not Estimated
NE*	Not estimated – No method available
IE	Included Elsewhere
C	Confidential
Fx	Flexibility

The level of completeness depicting the scope of the inventory is provided in Table 1.5 and in the sectoral CRTs in Annex VI to this NIR.

1.7.1. Information on completeness

Estimates varied between categories depending on whether emissions occurred or not in the sub-categories. Categories have been assigned X when estimates from occurring sub-categories have been made even partially, NE when it has not been addressed and NO when it is not leading to emissions. The other notation keys have been used as applicable. Categories not estimated are provided in Table 1.5. Emissions have not been estimated because AD were not available in all cases.

1.7.2. Description of insignificant categories

Namibia is reporting on the emissions of all categories identified as sources and sinks irrespective of any being insignificant as per para. 32 of the MPGs.

1.7.3. Total aggregate emissions considered insignificant

Given that Namibia has not had recourse to the non-mandatory provision of para. 32 of the MPGs, total aggregate emissions considered insignificant are not applicable.

Table 1.5. Completeness of the inventory

Categories	Net CO2 (1)(2)	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors	Other halogenated gases without CO2 equivalent conversion factors	NOx	CO	NMVOCs	SO2
Total National Emissions and Removals												
1 - Energy												
1.A - Fuel Combustion Activities	X, IE, NE, NO	X, IE, NE, NO	X, IE, NE, NO, NA	NA	NA	NA	NA	NA	X, IE, NE, NO	X, IE, NE, NO	X, IE, NE, NO	X, IE, NE, NO
1.A.1 - Energy Industries	X, NO	X, NO	X, NO, NA	NA	NA	NA	NA	NA	X, NO	X, NO	X, NO	X, NO
1.A.2 - Manufacturing Industries and Construction	X, IE, NO	X, IE, NO	X, IE, NO	NA	NA	NA	NA	NA	X, IE, NO	X, IE, NO	X, IE, NO	X, IE, NO
1.A.3 - Transport	X, IE, NE, NO	X, IE, NE, NO	X, IE, NE, NO	NA	NA	NA	NA	NA	X, IE, NE, NO	X, IE, NE, NO	X, IE, NE, NO	X, IE, NE, NO
1.A.4 - Other Sectors	X, IE, NE	X, IE, NE	X, IE, NE	NA	NA	NA	NA	NA	X, IE, NE	X, IE, NE	X, IE, NE	X, IE, NE
1.A.5 - Other	X, NE	X, NE	X, NE	NA	NA	NA	NA	NA	X, NE	X, NE	X, NE	X, NE
1.B - Fugitive emissions from fuels	X, NO, NA	X, NO, NA	X, NO, NA	NA	NA	NA	NA	NA	X, NO, NA	X, NO, NA	X, NO, NA NE*	NO, NA NE*
1.B.1 - Solid fuels	NO, NA	X, NO, NA	X, NO, NA	NA	NA	NA	NA	NA	X, NO	X, NO	NO, NE*	NO, NE*
1.B.2 - Oil and natural gas and other emissions from energy production	X, NO	X, NO	X, NO	NA	NA	NA	NA	NA	NO, NA	NO, NA	X, NO	NO, NA
1.C - Carbon dioxide Transport and storage	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.C.1 - Transport of CO2	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.C.2 - Injection and storage	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.C.3 - Other	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Categories	Net CO2 (1)(2)	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors	Other halogenated gases without CO2 equivalent conversion factors	NOx	CO	NMVOCs	SO2
2 - Industrial Processes and Product Use												
2.A - Mineral Industry	X, NO	NA	NA	NA	NA	NA	NA	NA	NA, NO	NA, NO	NA, NO	NA, NO
2.A.1 - Cement production	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.2 - Lime production	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.3 - Glass Production	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.A.4 - Other Process Uses of Carbonates	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B - Chemical Industry	NA, NO	NA, NO	NA, NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B.1 - Ammonia Production	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.2 - Nitric Acid Production	NA	NA	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.3 - Adipic Acid Production	NA	NA	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production	NA	NA	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.5 - Carbide Production	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.6 - Titanium Dioxide Production	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.7 - Soda Ash Production	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.8 - Petrochemical and Carbon Black Production	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.B.9 - Fluorochemical Production	NA	NA	NA	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B.10 - Other (Please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C - Metal Industry	NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NO	NO	NO	NO
2.C.1 - Iron and Steel Production	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.C.2 - Ferroalloys Production	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.C.3 - Aluminium production	NO	NA	NA	NA	NO	NA	NA	NO	NO	NO	NO	NO
2.C.4 - Magnesium production	NO	NA	NA	NA	NA	NO	NA	NO	NO	NO	NO	NO

Categories	Net CO2 (1)(2)	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors	Other halogenated gases without CO2 equivalent conversion factors	NOx	CO	NMVOCs	SO2
2.C.5 - Lead Production	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.C.6 - Zinc Production	NO	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.C.7 - Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D - Non-Energy Products from Fuels and Solvent Use	X, NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	X, NA	NA
2.D.1 - Lubricant Use	X	NA	NA	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	NA	NA
2.D.3 - Other (Solvent Use and Asphalt)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	X	NA
2.E - Electronics Industry	NA, NO	NA, NO	NA, NO	NA, NO	NO	NA, NO	NA, NO	NO	NA	NA	NA	NA
2.E.1 - Integrated Circuit or Semiconductor	NA	NA	NA	NO	NO	NO	NO	NO	NA	NA	NA	NA
2.E.2 - TFT Flat Panel Display	NA	NA	NA	NA	NO	NO	NO	NO	NA	NA	NA	NA
2.E.3 - Photovoltaics	NA	NA	NA	NA	NO	NA	NA	NO	NA	NA	NA	NA
2.E.4 - Heat Transfer Fluid	NA	NA	NA	NA	NO	NA	NA	NO	NA	NA	NA	NA
2.E.5 - Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA
2.F - Product Uses as Substitutes for Ozone Depleting Substances	NA	NA	NA	X, NE, NO	NE, NA, NO	NA	NA	NA	NA	NA	NA	NA
2.F.1 - Refrigeration and Air Conditioning	NA	NA	NA	X	NA	NA	NA	NA	NA	NA	NA	NA
2.F.2 - Foam Blowing Agents	NA	NA	NA	NO	NA	NA	NA	NA	NA	NA	NA	NA
2.F.3 - Fire Protection	NA	NA	NA	NE	NE	NA	NA	NA	NA	NA	NA	NA
2.F.4 - Aerosols	NA	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA
2.F.5 - Solvents	NA	NA	NA	NE	NE	NA	NA	NA	NA	NA	NA	NA
2.F.6 - Other Applications (please specify)	NA	NA	NA	NO	NO	NA	NA	NA	NA	NA	NA	NA
2.G - Other Product Manufacture and Use	NA, NO	NA, NO	X, NA, NO	NA, NO	NA, NO	X, NA, NO	NA, NO	NE, NA, NO	NA	NA	NA	NA
2.G.1 - Electrical Equipment	NA	NA	NA	NA	NO	X	NA	NE	NA	NA	NA	NA

Categories	Net CO2 (1)(2)	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors	Other halogenated gases without CO2 equivalent conversion factors	NOx	CO	NMVOCs	SO2
2.G.2 - SF6 and PFCs from Other Product Uses	NA	NA	NA	NA	NO	NO	NA	NO	NA	NA	NA	NA
2.G.3 - N2O from Product Uses	NA	NA	X	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.G.4 - Other (Please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA
2.H - Other	X, NO	X, NO	NA, NO	NA	NA	NA	NA	NA	X, NO	X, NO	X, NO	X, NO
2.H.1 - Pulp and Paper Industry	NO	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO
2.H.2 - Food and Beverages Industry	X	X	NA	NA	NA	NA	NA	NA	X	X	X	X
2.H.3 - Other (please specify)	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
3 - Agriculture												
3.A - Enteric Fermentation	NA	X, NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.A.1 – Dairy cows	NA	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.A.1.a – Other Cattle	NA	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.A.2 – Sheep	NA	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.A.1 – Swine	NA	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.A.4 – All Other animals	NA	X, NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.B – Manure Management	NA	X, NA, NO	X, NO	NA	NA	NA	NA	NA	NA	NA	X, NA	NA
3.B.1 – Dairy cows	NA	X	X	NA	NA	NA	NA	NA	NA	NA	X	NA
3.B.1.a – Other Cattle	NA	X	X	NA	NA	NA	NA	NA	NA	NA	X	NA
3.B.2 – Sheep	NA	X	X	NA	NA	NA	NA	NA	NA	NA	X	NA
3.B.1 – Swine	NA	X	X	NA	NA	NA	NA	NA	NA	NA	X	NA
3.B.4 – All Other animals	NA	X, NO	X, NO	NA	NA	NA	NA	NA	NA	NA	X	NA
3.B.5 – Indirect N2O emissions	NA	NA	X	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C – Rice Cultivation	NA	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D – Agricultural Soils	NA	NA	X, NE, NO	NA	NA	NA	NA	NA	NA	NA	NA	NA

Categories	Net CO2 (1)(2)	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors	Other halogenated gases without CO2 equivalent conversion factors	NOx	CO	NMVOCs	SO2
3.D.1 - Direct N2O Emissions from managed soils	NA	NA	X, NE, NO	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.2 - Indirect N2O Emissions from managed soils	NA	NA	X	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.E – Prescribed burning of savannahs	NA	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.F – Field burning of crop residues	NA	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
3.G – Liming	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.H – Urea Application	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.I – Other carbon containing fertilizers	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.C – Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4 – Land Use, Land Use Change and Forestry												
4.A - Forestland (including 4(IV) A)	X	X, NO	X, NO	NA	NA	NA	NA	NA	X, NO	X, NO	X, NO	NO
4.A.1 - Forest land remaining Forestland (including 4(IV) A)	X	X	X	NA	NA	NA	NA	NA	X	X	X	NO
4.A.2 – Land converted to Forestland	X	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
4.B - Cropland (including 4(IV) B)	NE, NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
4.B.1 - Cropland remaining Cropland	NE	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
4.B.2 – Land converted to Cropland	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
4.C - Grassland (including 4(IV) C)	X	X, NO	X, NO	NA	NA	NA	NA	NA	X, NO	X, NO	X, NO	NO
4.C.1 - Grassland remaining Grassland	NE	X	X	NA	NA	NA	NA	NA	X	X	X	NO
4.C.2 – Land converted to Grassland	X	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
4.D - Wetland (including 4(IV) D)	X	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
4.D.1 - Wetland remaining Wetland	X	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO

Categories	Net CO2 (1)(2)	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors	Other halogenated gases without CO2 equivalent conversion factors	NOx	CO	NMVOCs	SO2
4.D.2 – Land converted to Wetland	NE	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
4.E - Settlements (including 4(IV) E)	X	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
4.E.1 - Settlements remaining Settlements	NE	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
4.E.2 – Land converted to Settlements	X	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
4.F – Other land (including 4(IV) F)	X	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
4.F.1 - Other land remaining Other land	X	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
4.A.2 – Land converted to Other land	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
4.G – Harvested Wood Products	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4.F – Other	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NO
5 - Waste												
5.A - Solid Waste Disposal	NA	X, NO	NA	NA	NA	NA	NA	NA	NO	NO	X, NO	NA
5.A.1. Managed waste disposal sites	NA	X	NA	NA	NA	NA	NA	NA	NO	NO	X	NA
5.A.2. Unmanaged waste disposal sites	NA	X	NA	NA	NA	NA	NA	NA	NO	NO	X	NA
5.A.3. Uncategorized waste disposal sites	NA	NO	NA	NA	NA	NA	NA	NA	NO	NO	NO	NA
5.B - Biological Treatment of Solid Waste	NA	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NA
5.B.1. Composting	NA	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NA
5.B.2. Anaerobic digestion at biogas facilities	NA	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NA
5.C - Incineration and Open Burning of Waste	X	X	X	NA	NA	NA	NA	NA	X	X	X	X
5.B.1. Waste incineration	X	X	X	NA	NA	NA	NA	NA	X	X	X	X
5.B.2. Open burning of waste	X	X	X	NA	NA	NA	NA	NA	X	X	X	X

Categories	Net CO2 (1)(2)	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors	Other halogenated gases without CO2 equivalent conversion factors	NOx	CO	NMVOCs	SO2
5.D - Wastewater Treatment and Discharge	NA	X, NO	X, NO	NA	NA	NA	NA	NA	NO	NO	X, NO	NA
5.B.1. Waste incineration	NA	X	X	NA	NA	NA	NA	NA	NO	NO	X	NA
5.B.2. Open burning of waste	NA	X	X	NA	NA	NA	NA	NA	NO	NO	X	NA
5.B.3. Other	NA	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NA
5.E - Other (please specify)	NO	NO	NO	NA	NA	NA	NA	NA	NO	NO	NO	NA
6 - Other	NE, NA	NA, NO	NE, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
6.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3	NA	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA
6.A - Indirect CO2 emissions from the atmospheric oxidation CH4, CO and NMVOC	NE	NA	NE	NA	NA	NA	NA	NA	NA	NA	NA	NA
6.B - Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.D. Memo Items												
1.D.1. International bunkers	X, NO	X, NO, NA	X, NO, NA	NA	NA	NA	NA	NA	X, NO, NA	X, NO, NA	X, NO, NA	X, NO, NA
1.D.1.a. Aviation	X	X	X	NA	NA	NA	NA	NA	X	X	X	X
1.D.1.b Navigation	X	X	X	NA	NA	NA	NA	NA	X	X	X	X
1.D.2. Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.D.3. CO2 emissions from biomass	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1.D.4. CO2 captured	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

*** No methodology available**

1.8. Metrics

Each GHG has a unique atmospheric lifetime and heat-trapping potential. The radiative forcing, heat trapping potential, effect of a gas is a quantification of its ability to warm the atmosphere. Direct radiative forcing occurs when the gas itself is a GHG, whereas indirect forcing occurs when the oxidation of the original gas produces GHGs or when a gas influences the atmospheric lifetime of another gas.

Global warming potential (GWP) is defined as the time-integrated change in radiative forcing due to the instantaneous release of 1 kg of the gas, expressed relative to the radiative forcing caused by the release of 1 kg of CO2. The GWP concept has been developed to allow the comparison of the ability of each GHG to trap heat in the atmosphere relative to CO2, as well as the characterization of GHG emissions in terms of how much CO2 would be required to produce a similar warming effect over a given time period. This is called the carbon dioxide equivalent (CO2 e) value and is calculated by multiplying the amount of the gas by its associated GWP. This normalization to CO2 e enables the quantification of total national emissions expressed as CO2 e by signatory Parties of the Convention and facilitates the summing up for projecting global warming of the atmosphere and its impacts on the socio-economic development of the world in relation to anticipated climate change. It also enables parties to assess their efforts in mitigating national emissions within their development agenda.

The Intergovernmental Panel on Climate Change (IPCC) develops and updates the GWPs for all GHGs over time, based on scientific progress. Consistent with the MPGs of the ETF under the PA (Annex to Decision 18/CMA.1), the 100-year GWP values provided by the IPCC in its Fifth Assessment Report (IPCC, 2014) and presented in Table 1.6 are used in this report. For example, the 100-year GWP for CH4 used in this inventory is 28, meaning that an emission of 10 kilotonnes (kt) of CH4 is equivalent to 28 x 10 kt = 280 kt CO2 e.

Table 1.6. Global Warming Potentials used in this inventory

Gas	Symbol	Global Warming Potential
Carbon Dioxide	CO_2	1
Methane	CH_4	28
Nitrous Oxide	N_2O	265
HFC - 32	CH2F2	677
HFC - 125	CH2CF3	3,170
HFC - 134a	CF2FCF3	1,300
HFC - 143a	CF3CH3	4,800
Sulphur Hexafluoride	SF6	23,500

1.9. Summary of any flexibility applied

Namibia is not having recourse to any of the flexibility clauses provided for in the MPGs for this inventory.

Chapter 2. Trends in greenhouse gas emissions and removals

2.1. Description of emission and removal trends for aggregated GHG emissions and removals

The trend of national total emissions, removals and net emissions/removals are presented in Figure 2.1. Namibia remained a net sink over the full time series 1990 to 2022 since removals always exceeded emissions. Total emissions do not show a clear increasing or decreasing trend over the time series but stayed rather stable at slightly above 20,000 kt CO2 e due to implementation of mitigation measures and sustainable use of woody biomass. However, a slight increase of 11% is observed when considering the national emissions of 2022 compared to those of 1990. Removals increased from 89,977 kt CO2 e in 1990 to 122,411 kt CO2 e in 2022 resulting in an increase of 32,434 kt CO2 e (45%) in net removals also for the same period. From 1990 to 2022, the net removals increased by 36%.

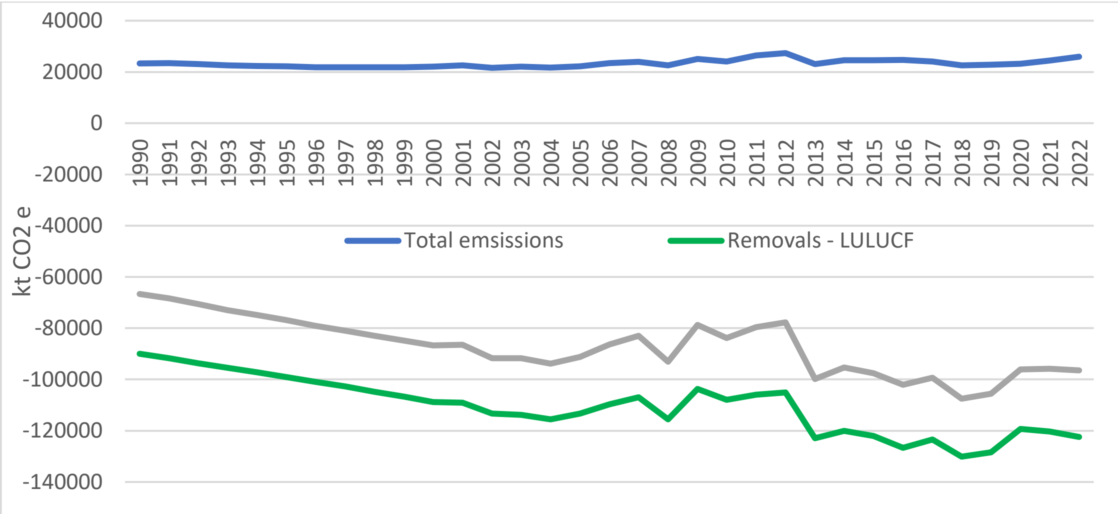

Figure 2.1. Trend of total national emissions (kt CO2 e), removals and the resultant net removals (1990-2022)

2.2. Description of emissions and removals trends by sector and by gas

The gross emissions trends by sector are provided in Figure 2.2.

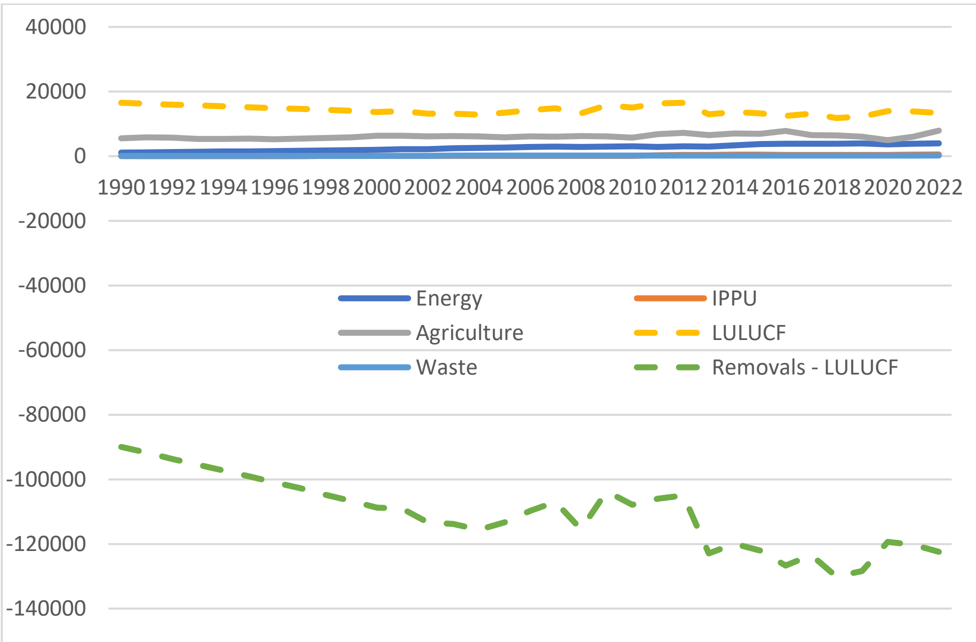

Figure 2.2. Trend of aggregated gross emissions (kt CO2 e) by sector (1990-2022)

The highest emitting sector remained LULUCF over the full time series followed by Agriculture, Energy and Waste and Industrial Production and product use (IPPU). In 2022, the LULUCF sector was responsible for significant removals of 122,411 kt CO2 e. Between 1990 and 2022, gross emissions decreased by 19% in the LULUCF sector but increased by 42% for Agriculture, 258% for Energy, 89% for Waste and 6,324% for IPPU. This abnormal increase in emissions of the IPPU sector is explained by the cessation in Lime Production coupled with a high production of Cement as from 2011. The removals increased by 36% between 1990 and 2022.

The aggregated emissions by gas are given in Figure 2.3 while the share is provided in Figure 2.4. CO2 dominated (more than 50% except for 1990 and 1991) emissions throughout the full time series with 11,373 kt CO2 e in 1990 and 15,469 kt CO2e in 2022, representing an increase of 36%. A reduction of 14% in CH4, from 8,921 kt CO2 e in 1990 to 7,703 kt CO2 e in 2022. Similarly, N2O emissions regressed by 12% from 3,030 kt CO2 e to 2,654 kt CO2e. Emissions of HFCs and SF6 stayed at negligible levels throughout the time series.

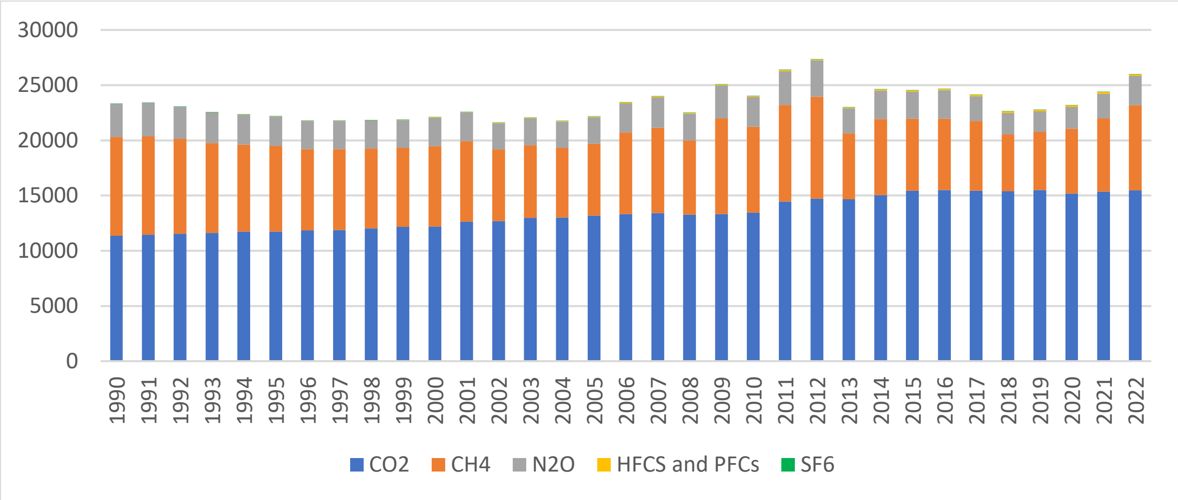

Figure 2.3. National aggregated emissions (kt CO2 e) trends by gas (1990-2022)

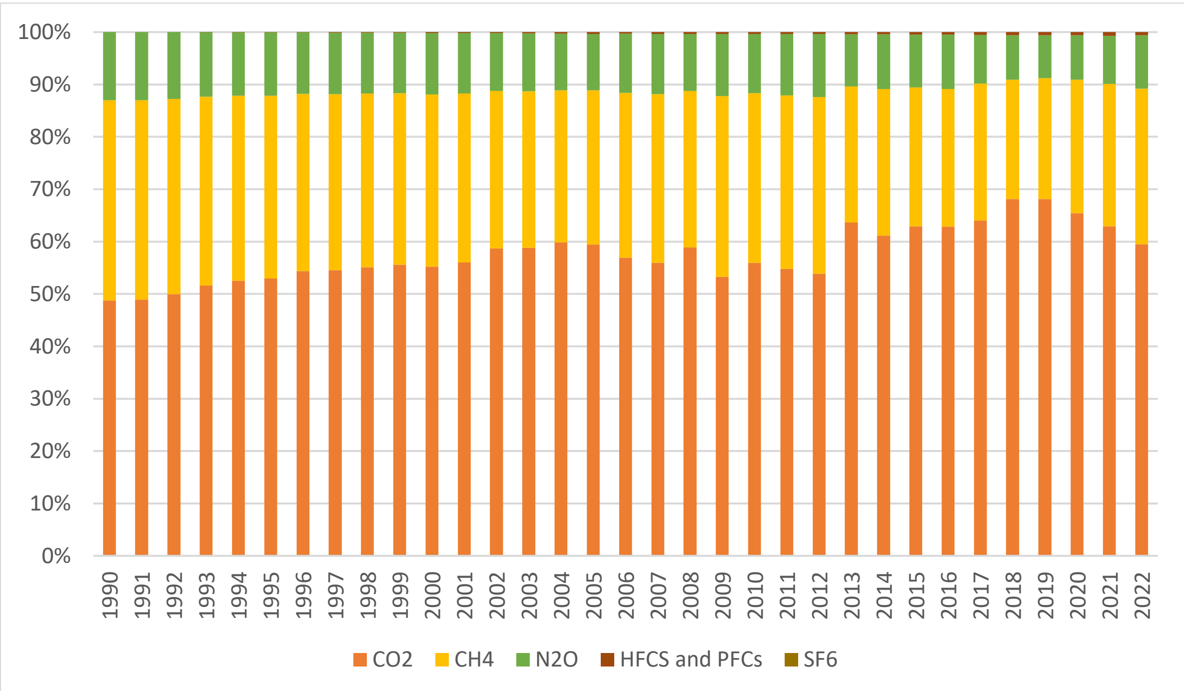

Figure 2.4. Share (%) of aggregated emissions by gas (1990-2022)

In absolute terms, CO_2 emissions increased by 36% from 11,373 kt in 1990 to 15,469 kt in 2022. N_2O stayed stable at around 10 kt while CH_4 regressed from 319 kt in 1990 to 275 kt in 2022.

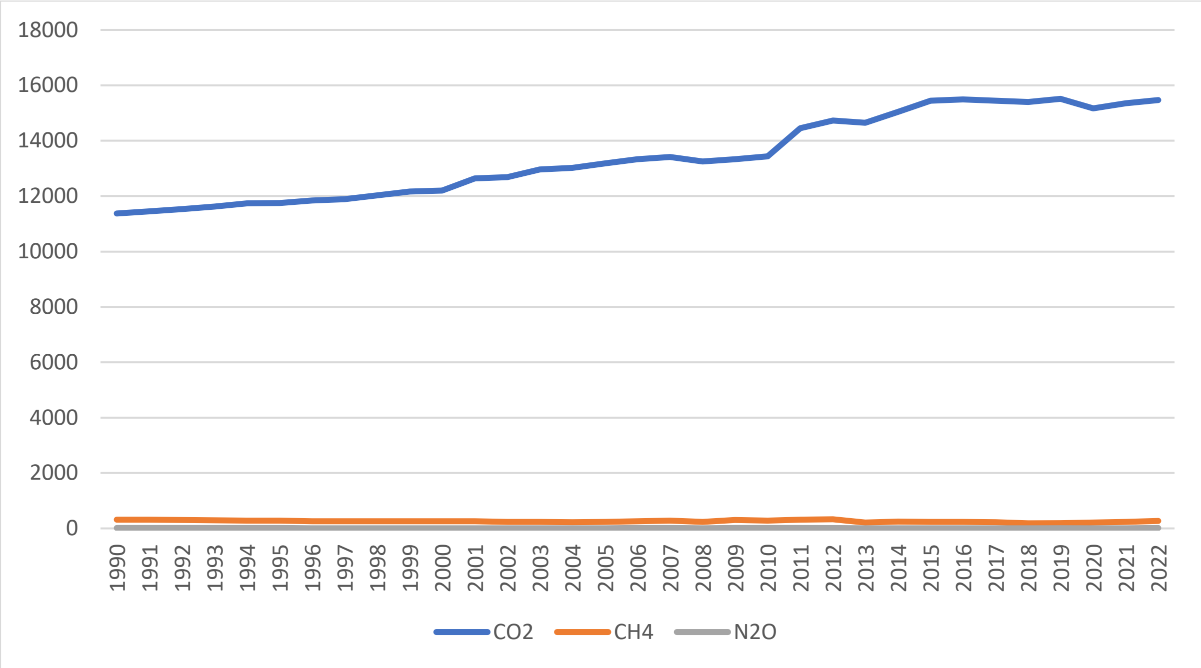

Figure 2.5. Trends of absolute emissions (kt) by gas (1990-2022)

2.3. Indirect gases

Emissions of indirect GHGs are provided in Figure 2.6. Overall, CO emissions decreased by 66% from 2,685 kt in 1990 to 902 kt in 2022. SO_2 increased from 1.1 kt to 2.7 kt, NMVOC from 15 to 27 kt while NO_x decreased from 51 to 37 kt over the same period.

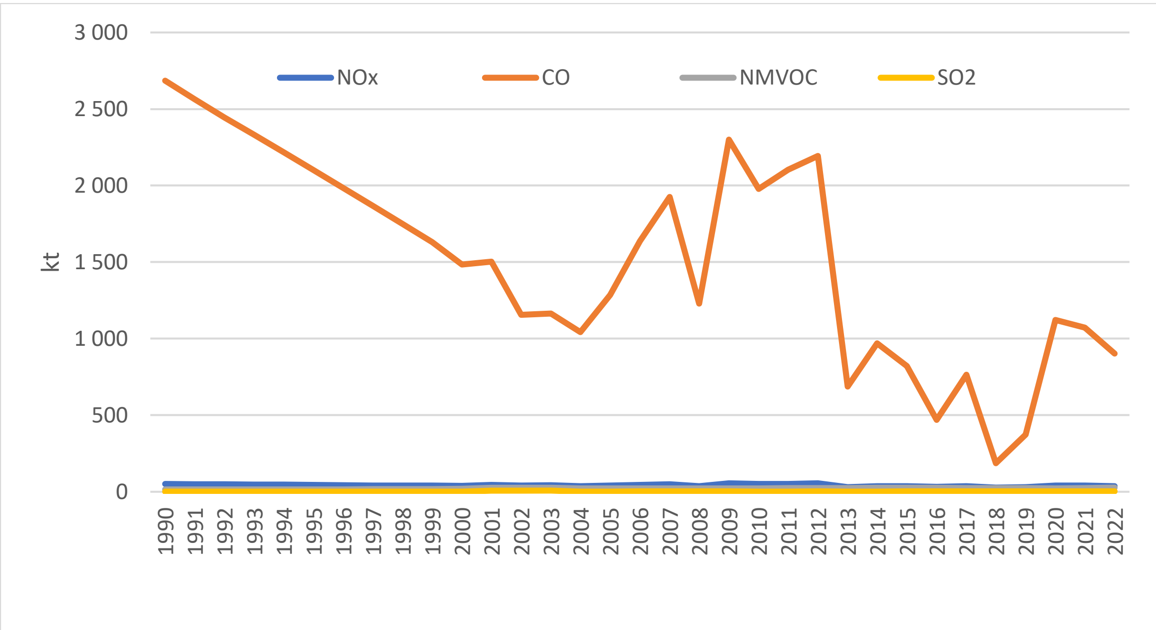

Figure 2.6. Trends of emissions (kt) of Indirect GHGs (1990-2022)

Chapter 3. Energy (CRT sector 1)

3.1. Overview of the Energy sector

Namibia is concerned mostly with activities occurring in the Fuel Combustion Category. Activities occurred under all sub-categories and GHG emissions have been estimated for all of them. Regarding Fugitive emissions, they occurred only from Fuel transformation under Solid Fuels and Exploration under Oil and natural gas and other emissions from energy production categories respectively.

The sources covered in this inventory are:

- Electricity Generation
- Manufacturing Industries and Construction, including mining
- Domestic Aviation
- Road Transportation
- Railways
- Commercial and Institutional
- Residential
- Agriculture, Forestry and Fishing
- Mobile (Other) combustion
- Transformation of solid fuels and
- Exploration of oil

The gases estimated are carbon dioxide (CO2), NOX as nitrogen dioxide, nitrous oxide (N2O), methane (CH4), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO), and sulphur dioxide (SO2).

The inventory of the Energy sector has not changed during the time series. Fuels have been combusted in the respective categories and sub-categories Activities occurring in ……were estimated under the Non-spefified sub-category. In previous inventories, emissions were estimated based on fuels combusted under the category and not at the disaggregated sub-category level. For this inventory, data was available for some sub-categories and their estimates made according to these while for the remaining ones, bulk estimates were made under the Non-Specified Industry sub-category. As well, it has been difficult to obtain AD specific to Agriculture and, Forestry activities but only for the Fishing component.

Progress recorded consist of the continuous updating of information on technology improvements in the Road Transportation sub-category, and derived AD for the residential sector which are based on the censuses results. The biggest challenge remains the organization of stakeholders to regularly perform measurements and record data for sending annually to the MEFT for compiling the GHG inventory. Some problems also occurred with the private sector possibly fearing their data could eventually be accessed by the public. Resources remain a highly limiting factor for government and institutions to invest in staff time and equipment for regular AD collection, especially in key categories to move to Tier 2 to be in accordance with the MPGs.

For the full time series, the IPCC 2006 guidelines have been used at Tier 1 level for estimating emissions. The basic equation used to estimate GHG emissions is given below:

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

Where

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

Emissions in the Energy sector increased by 259% from 1,106 kt CO2 e in 1990 to reach 3,966 kt CO2 e (Figure 3.1) in 2022. The increase between 2010 and 2022 is only 31% which reflects the country's efforts to switch from fossils to renewable energy sources. Fuel combustion dominated the emissions with more than 90% for all years of the time series.

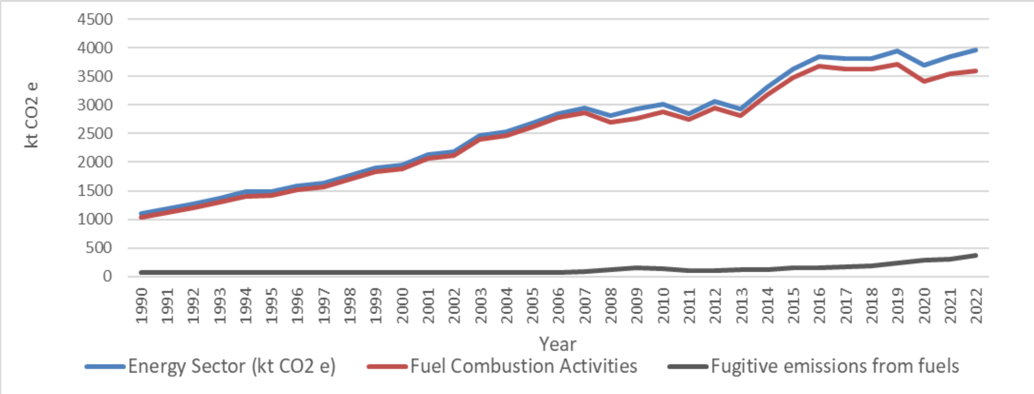

Figure 3.1. Trend of emissions (kt CO2e) for the Energy Sector (1990-2022)

The % share contribution of emissions by category is provided in Figure 3.2. The transport category dominated the emissions for all years of the time series with an increasing trend. Emissions from the Transport category increased from 56% in 1990 to 80% in 2022. The Other Sectors category maintained its second rank but with a decreasing trend from 31% in 1990 to 11% in 2022. Manufacturing Industries and Construction did not change much in their % contribution, which varied between 5% and 10%. Energy Industries fluctuated between less than 1% to 10%, reflecting the national situation with hydroelectricity, being linked with rainfall and weather, generation dominating national production while the Non-Specified (Other) category stayed at minimum throughout the time series.

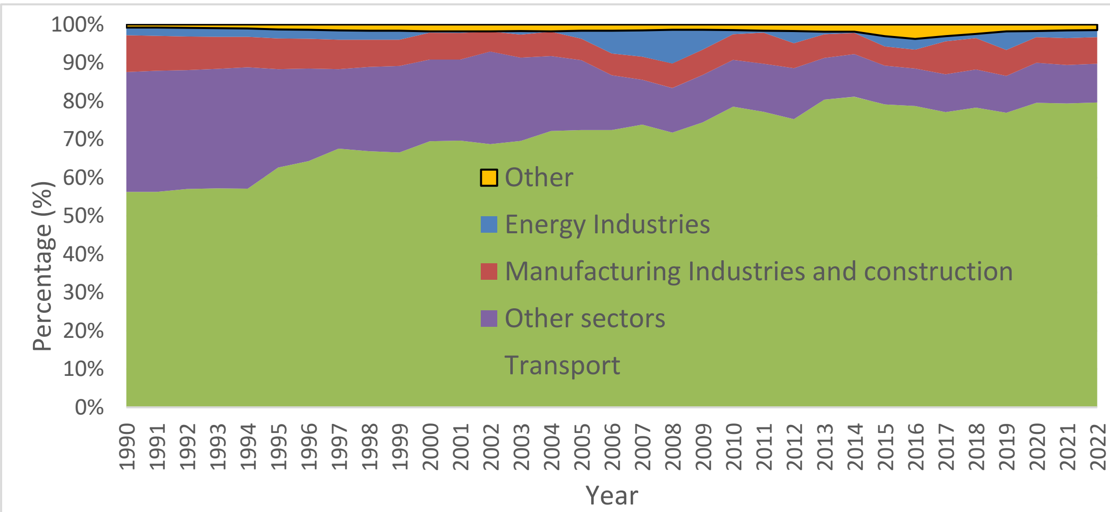

Figure 3.2. Share (%) of Fuel Combustion emissions by category (1990-2022)

The evolution of emissions for selected years for the different occurring categories of the Energy sector and their % increases relative to the years 1990 and 2010 are provided in Table 3.1. Lower increases are observed in 2022 compared to 2010 for most categories, with the highest increase of 159% in

Fugitive emissions. Readers are referred to the NIR5, https://unfccc.int/sites/default/files/resource/Namibia%20NIR5%20Part%201-Final%20.pdf, for annual emissions for the years 1990 to 2016 for the Energy sector and its categories.

Table 3.1. Emissions (kt CO2 e) of the Energy sector by sub sector

Year	1990	2000	2010	2017	2018	2019	2020	2021	2022	2022 to 1990 (% change)	2022 to 2010 (% change)
Energy sector	**1,106**	**1,950**	**3,019**	**3,812**	**3,809**	**3,951**	**3,689**	**3,849**	**3,966**	**259%**	**31%**
1.A - Fuel Combustion Activities	*1,038*	*1,881*	*2,876*	*3,637*	*3,624*	*3,717*	*3,411*	*3,553*	*3,596*	*246%*	*25%*
Energy Industries	22	7	32	48	40	182	52	70	66	200%	106%
Manufacturing Industries & construction	100	131	192	315	297	252	228	250	252	152%	31%
Transport	584	1,308	2,259	2,805	2,837	2,859	2,713	2,820	2,865	391%	27%
Other sectors	324	402	351	358	361	358	358	358	362	12%	3%
Other	8	33	41	111	90	65	60	55	51	538%	24%
1.B - Fugitive emissions from fuels	*69*	*69*	*143*	*176*	*185*	*234*	*278*	*296*	*370*	*436%*	*159%*
1.B.1 Solid Fuels	69	69	143	176	185	234	278	296	370	436%	159%
1.B.2 Oil and Natural Gas	0	0	0	0	0.1	0.0	0.0	0.2	0.2	NA	NA

The trend of emissions of the three direct GHGs are given in Figure 3.3. CO2 dominated the Energy sector emissions throughout the time series, and it increased from 974 to 3,486 kt CO2 (258%). Emissions of CH4 stayed on the low side while N2O remained marginal over the full time series.

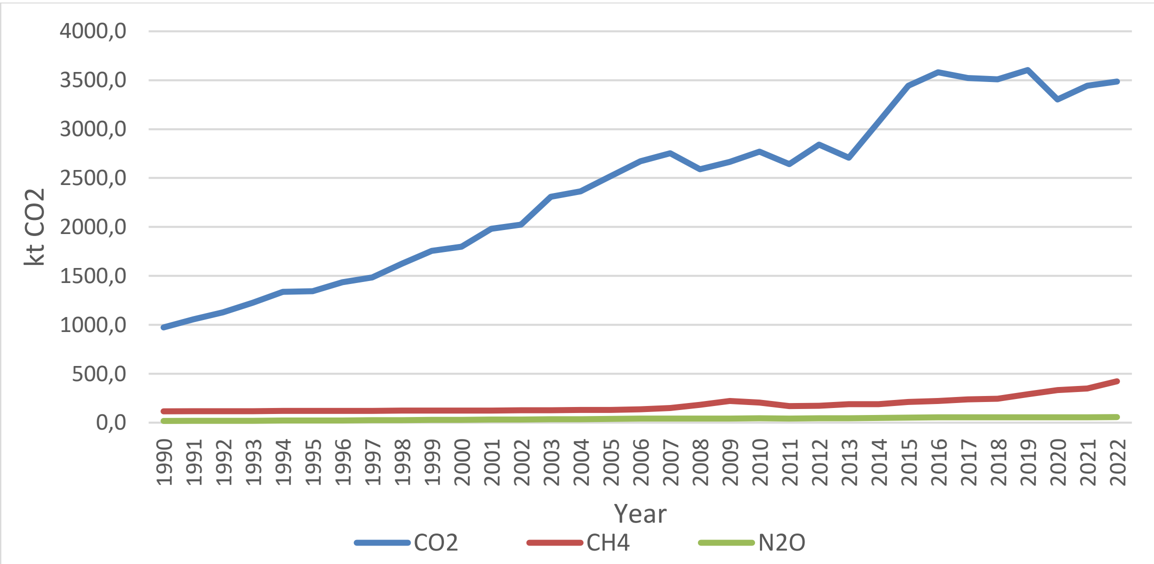

Figure 3.3. Trend of emissions (kt CO2 e) of the Energy sector by gas (1990-2022)

In terms of % share, CO2 emissions varied between 88% and 93% annually. CH4 varied from 5% to 11% of yearly emissions and N2O represented 1% to 2% of emissions. These observations are depicted in Figure 3.4.

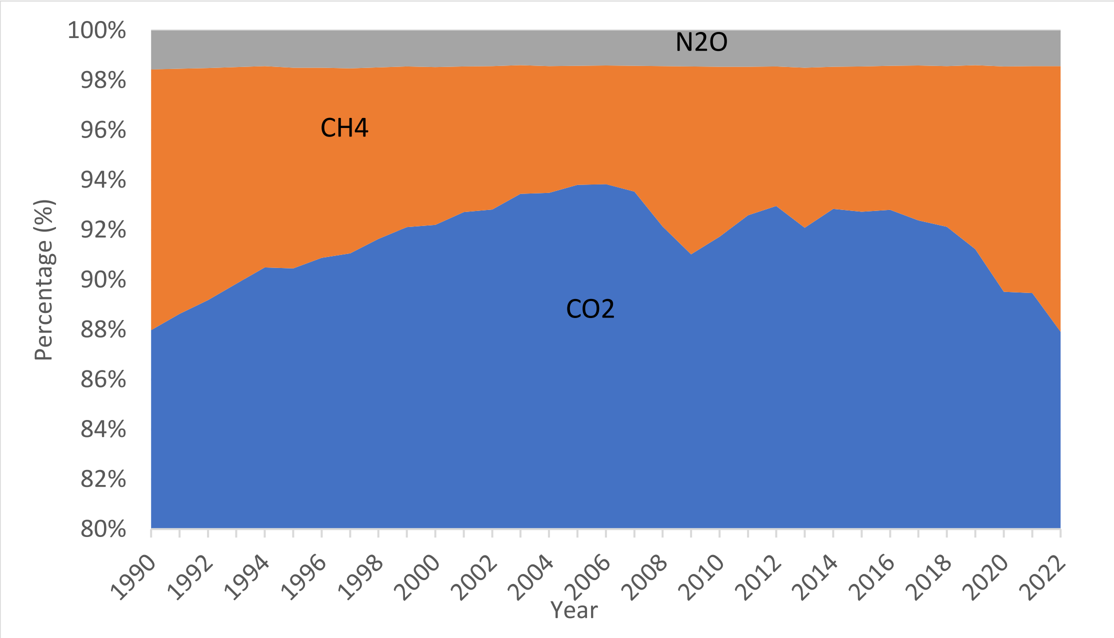

Figure 3.4. Share (%) of emissions by gas for the Energy sector (1990-2022)

3.2. Fuel combustion (CRT 1.A)

Most activities in the Energy sector occurred in the Fuel Combustion sub-sector, in all categories. All categories where emissions occurred have been addressed for all years of the time series. However, lack of disaggregated AD has sometimes driven estimates to be made at the category level instead of sub-category. Efforts deployed to improve this situation in the past years have enabled some additional sub-categories to be addressed separately. Incineration that was not estimated previously is now addressed in this inventory. More details are provided under each category.

3.2.1. Comparison of the sectoral approach with the reference approach

The Sectoral Approach (SA) is a bottom-up one where emissions are estimated for the different activities at the sub-category levels to be then aggregated to bring it to category, sub-sector and sector. It uses more granular data and is expected to better reflect emissions of the Energy sector. On the other hand, the top-down Reference Approach (RA) gives an overall estimate of CO_2 estimated for the different fuels before they are distributed and consumed in the different sectors.

Emissions under the RA and SA approaches for selected years are given in Table 3.2. Emissions increased over time under both approaches. The % difference varied between -13.5% and 11.5% for the selected years with lower differences (-0.4% and 0.5%) noted for years 2017 and 2019 respectively.

Table 3.2. Comparison of emissions (kt) from the RA and SA Approaches

Approach	1990	2000	2010	2017	2018	2019	2020	2021	2022
Reference	932	1,555	2,715	3,506	3,911	3,623	3,399	3,397	3,671
Sectoral	974	1,798	2,769	3,522	3,509	3,604	3,302	3,444	3,486
Difference	-4.3%	-13.5%	-1.9%	-0.4%	11.5%	0.5%	2.9%	-1.4%	5.3%

The difference (%) in fuels consumed and CO_2 emissions from the RA has been estimated and compared with those of the SA (Figures 3.5 and 3.6). Positive as well as negative differences have been noted between the RA and SA approaches both for fuel consumption and CO_2 emissions during the time series 1990 to 2022. From 2017 to 2022, the differences in fuel consumed and CO_2 emissions were among the lowest.

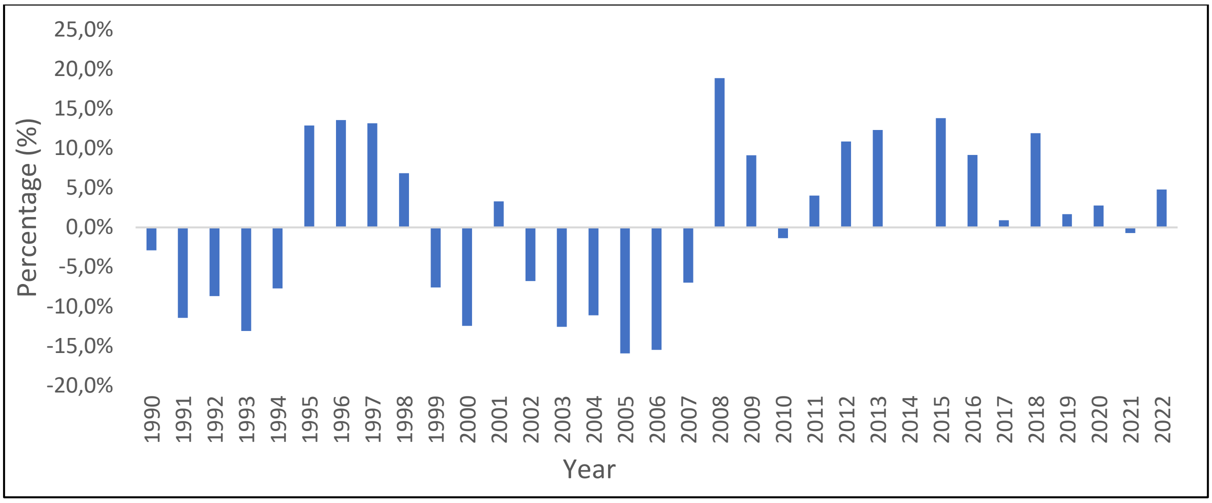

Figure 3.5. % difference between the RA and SA for fuel consumption (1990-2022)

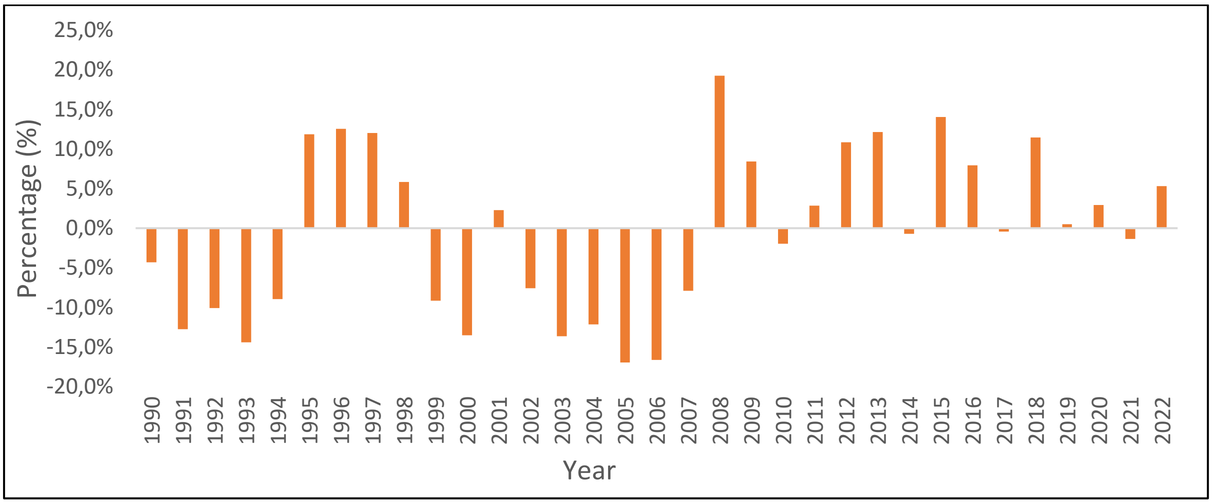

Figure 3.6. % difference between the RA and SA for CO_2 emissions (1990-2022)

3.2.2. International bunkers

International bunkering emissions have been calculated using the Tier I methods of the IPCC 2006 guidelines and the IPCC 2006 software for computations. All categories have been estimated except the 2 sub-categories Multilateral Operations and CO2 capture which did not occur. The estimates for international bunkers have been excluded from the national ones as per the MPGs. AD have been collected from different sources but the same one for each category throughout the time series for consistency purposes and default emissions factors from the IPCC 2006 guidelines have been used for making estimates of emissions.

The AD used for aviation and navigation bunkering are provided in Table 3.3. for the period 2017 to 2022. Readers are referred to the NIR5 for AD on bunkering for the period 1990 to 2016 (https://unfccc.int/sites/default/files/resource/Namibia%20NIR5%20Part%201-Final%20.pdf).

Table 3.3. AD used for International bunkers (2017-2022)

Sub-category	Fuel (t)	2017	2018	2019	2020	2021	2022
Aviation	Jet kerosene	34,444	34,806	34,515	10,265	12,714	34,515
Navigation	Gasoline	18,921	18,921	18,921	18,921	18,921	18,921
	Diesel	686	686	686	686	686	686
	RFO	29,428	29,428	29,428	29,428	29,428	29,428

The EFs for the different fuels used for bunkering are from the IPCC 2006 guidelines and provided in Table 3.4.

Table 3.4. EFs used for estimating international bunkering emissions

Sub-category - International bunkers	Fuel type	Emission Factors of direct gases: Emission factor (kg/TJ)			
		CO2	CH4	N2O	Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories/ Volume 2/Chapter 3 - Mobile Combustion
Aviation	Jet Kerosene	71,500	0.5	2	Tables 3.6.4 and 3.6.5
Navigation	Gasoline	69,300	7	2	Tables 3.5.2 and 3.5.3
	Diesel	74,100	7	2	" "
	RFO	77,400	7	2	" "

	Fuel type	Emission Factors of indirect gases: Emission factor (kg/ton fuel)				
		NOx	CO	NMVOC	SO2	Source: EMEP/EEA air pollutant emission inventory guidebook 2023.
Aviation	Jet Kerosene	12.8	1.10	0.50	1.00	1.A.3. a - Aviation, Table 3-3
Navigation	Gasoline	9.40	573.90	181.50	20.00	1.A.3. d - Navigation Shipping, Table 3-4
	Diesel	72.20	3.84	1.75	1.82	1.A.3. d - Navigation Shipping, Table 3-2
	RFO	69.10	3.67	1.67	19.20	1.A.3. d - Navigation Shipping, Table 3-1

Navigation bunkering exceeded aviation bunkering throughout the time series as depicted in Figure 3.7. A sharper increase is observed over time for aviation bunkering compared to the navigation component. The sharp drops in 2020 and 2021 are attributed to the lockdowns and regression of air travel due to the COVID 19 pandemic.

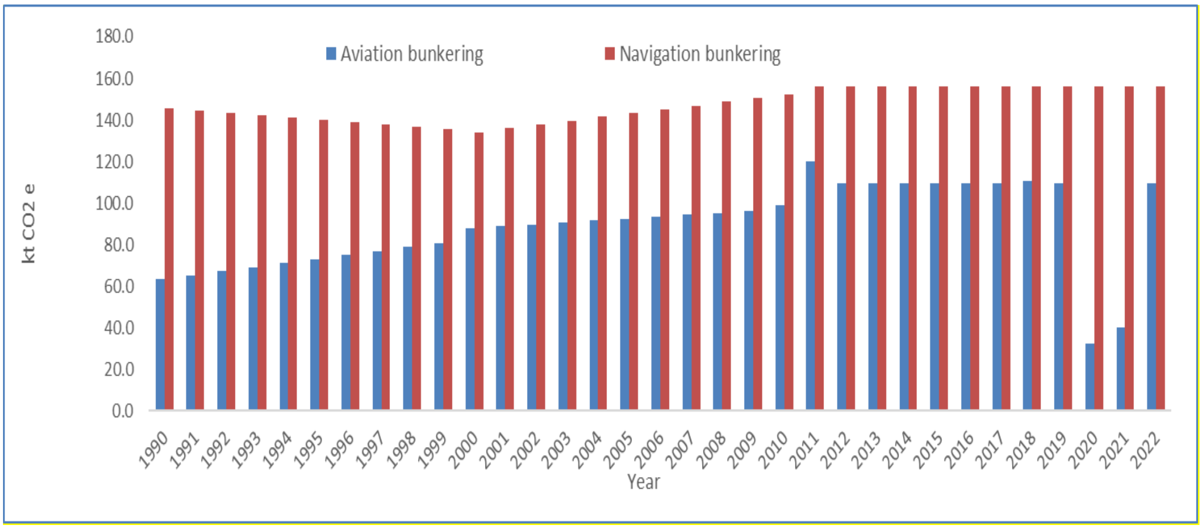

Figure 3.7. Trend emissions (kt CO2 e) for aviation and navigation bunkering (1990-2022)

Combined emissions from bunkering activities increased by 27% relative to 1990 and 6% to 2010 (Table 3.5). Emissions from aviation bunkering increased from 63 in 1990 to 110 kt CO2 e in 2022 which represented an increase of 74%. Emissions from Navigation bunkering regressed from 146 kt CO2 e in 1990 to 134 kt CO2 in the year 2000 to afterwards increase to 156 kt CO2 in 2022.

Table 3.5. Emissions (kt CO2 e) of aviation and navigation bunkering for selected years

Category	1990	2000	2010	2017	2018	2019	2020	2021	2022	2022 to 1990 (% change)	2022 to 2010 (% change)
International bunkers	209	222	251	265	267	266	189	196	266	27%	6%

Category	1990	2000	2010	2017	2018	2019	2020	2021	2022	2022 to 1990 (% change)	2022 to 2010 (% change)
Aviation	63	88	99	109	111	110	33	40	110	74%	11%
Navigation	146	134	152	156	156	156	156	156	156	7%	3%

3.2.3. Feedstocks and non-energy use of fuels

Namibia's industrial sector is still largely undeveloped and hence use of fossil fuels as feedstocks is not common. There are three products of fossil origin that are used for purposes other than energy production. These are Lubricants, Bitumen and Creosote. Amounts used for non-energy purposes have not been allocated to any energy category and subtracted when calculating apparent consumption for the RA. These amounts are provided in Table 3.6.

Table 3.6. Amount of products (t) accounted as Feedstocks and non-energy use of fuels

	2017	2018	2019	2020	2021	2022
Lubricants	11,670	11,117	10,565	9,468	12,536	10,967
Asphalt and bitumen	14,615	17,830	18,501	8,918	9,531	10,973
Creosote	3	4	3	1	2	16

3.2.4. Energy industries (CRT 1.A.1)

The Energy industries category comprises Petroleum Refining, Manufacture of solid fuels and other energy industries. The only activity occurring in Namibia, which has been estimated and reported in this NID, is Electricity generation under Public Electricity and Heat Production. Emissions under Wood and Wood Products, Construction, Textile and Leather, Off road vehicles, Domestic Navigation, Other, Commercial/Institutional – Off Road vehicles, Residential – Off road vehicles and Agriculture/ Forestry/Fishing – Off Road vehicles have been estimated and included elsewhere due to lack of data as the fuel were accounted for in the national energy balance. Categories not estimated are Commercial/Institutional – Stationary Combustion and Agriculture/ Forestry/Fishing – Stationary Combustion. All other categories have been estimated and reported in this NID.

3.2.4.1. Category description

The production of electricity in Namibia is 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 power imported from the South African Power Pool (SAPP) and neighbouring countries. In 2022, about 71% of Namibia's demand came from the SAPP, Zambia and Zimbabwe.

In 2022, Namibia's total installed electricity generation capacity (excluding renewables) was about 509.5 MW for a peak demand of some 637 MW normally. The biggest generation plant is the Ruacana Hydro Power station which generates about 347 MW of electricity while Van Eck Coal power station generates about 120 MW and the Anixas diesel power station at the coast generates 22.5 MW. The Omburu Solar Photovoltaic (PV) Power Station, which is the first fully owned and operated renewable energy project, accounted for 20 MW of electricity in 2022 (NamPower Report 2022). The fossil fuel generation plants are mainly used to supplement the imports and hydro production during peak demand time. Solar and wind potential exists and are tapped substantially at the Residential and Institutional levels but only marginally for generating public electricity up to now.

Emissions varied between 0.5 kt CO2 e and 237 kt CO2 e for the time series 1990 to 2022 (Figure 3.8). This is inherent to the characteristics of the production system, namely droughts and availability of water for the Ruacana hydro plant and imports from the South African Power Pool (SAPP) and neighbouring countries. Hence, the national production levels varied widely between years and is reflected in the emissions.

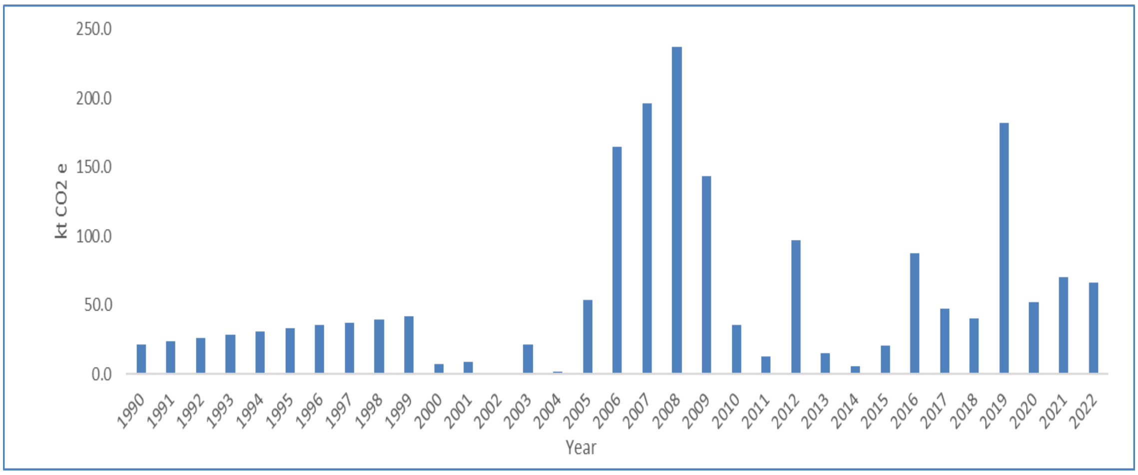

Figure 3.8. Emissions (kt CO2 e) from Electricity generation

Aggregated emissions by direct GHGs are presented in Figure 3.9. CO2 is the major GHG emitted throughout the full time series with more than 99.5%.

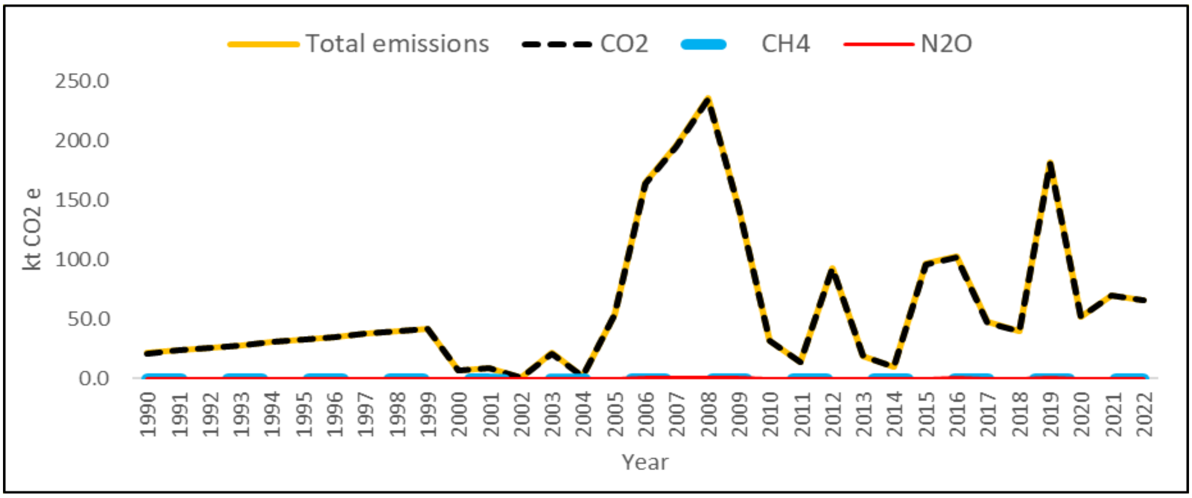

Figure 3.9. Aggregated emissions (kt CO2 e) from electricity generation (1990-2022)

Emissions from Electricity generation for selected years are presented in Table 3.7. It varied between 7 kt CO2 e and 182 kt CO2 e for the selected years.

Table 3.7. Emissions (kt CO2 e) from electricity generation

Year	1990	2000	2010	2017	2018	2019	2020	2021	2022
Emissions (kt CO2 e)	22	7	32	48	40	182	52	70	66

3.2.4.2. Methodological issues

The chosen method is Tier 1 level from the IPCC 2006 guidelines using national AD and default EFs. This category turned out to be a key one under the analysis without LULUCF. AD were not collected and Tier 1 has been adopted. AD used are provided in Table 3.8

Table 3.8. AD (t) used for electricity generation for the period 2017 to 2022.

Fuel (t)	2017	2018	2019	2020	2021	2022
RFO	68	29	1,677	1,815	223	514
Bituminous coal	19,263	16,333	71,817	18,817	28,212	26,318
Diesel	30	14	143	129	32	59

All EFS adopted for this inventory are from the IPCC 2006 guidelines and provided in Table 3.9.

Table 3.9. EFs used for electricity generation (2017-2022)

Sub-category	Emission Factors of direct gases					
	Fuel type	Emission factor (kg/TJ)				Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories/ Volume 2/Chapter 2 - Stationary Combustion
		CO2		CH4	N2O	
	RFO	77,400		3	0.6	Table 2.2
	Bitum. Coal	94,600		1	1.5	Table 2.3
	Diesel	74,100		3	0.6	Table 2.4
Electricity generation	**Emission Factors of indirect gases**					
	Fuel type	Emission factor (kg/TJ)				Source: EMEP/EEA air pollutant emission inventory guidebook 2023, 1.A.1 - Energy Industries.
		NOx	CO	NMVOC	SO2	
	RFO	142.0	15.1	2.3	495.0	Table 3.6
	Bitum. Coal	209.0	8.7	1.0	820.0	Table 3.2
	Diesel	65.0	16.2	0.8	46.5	Table 3.7

No CO2 was captured and stored.

3.2.4.3. Flexibility

Not applied for

3.2.4.4. Uncertainty assessment and time-series consistency

The uncertainties assigned to the AD (Table 3.10) are ±0.2% since they were plant measurements taken daily and aggregated for the year and the ranges, ±7% for CO2 and -70% to +233% for CH4 and -67% to +233% for N2O, from the IPCC 2006 guidelines for the EFs, given that they are the default values that have been used.

Table 3.10. Uncertainty levels assigned for Energy Industries

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[2]
1.A.1 -Energy industries			
1.A.1.a.i - Electricity generation - Liquid Fuels	CO2	±0.2	±7
	CH4	±0.2	-67 to +233
	N2O	±0.2	-67 to +233
1.A.1.a.i - Electricity generation - Solid Fuels	CO2	±0.2	±7
	CH4	±0.2	-70 to +200
	N2O	±0.2	-67 to +233

1: Source - 2006 Guidelines, Table 2.15, Page 2.41, Chapter 2, Volume 2

2: Source - 2006 Guidelines, Paragraph 2.41, Page 2.38 for CO2 and Table 2.2, Page 2.16 for CH4 and N2O of Chapter 2, Volume 2

The combined uncertainties determined using the tool developed in Excel worksheet in line with the methods contained in the IPCC 2006 guidelines are provided in Table 3.11 for this category. The level assessment uncertainties for the base year 1990 and year-t (2022) are 6.8% and 6.9% while the trend assessment with 1990 as base year and 2022 as year-t is 0.9%.

Table 3.11. Uncertainty assessment for Energy industries

A	B	C	D	E	F	H	H	M
2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (kt CO2e)	Year T (2022) emissions or removals (kt CO2e)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Contribution to variance by category in year 1990	Contribution to variance by category in year 2022	Uncertainty introduced into the trend in total national emissions (%)
1.A - Fuel Combustion Activities								
1.A.1.a.i - Electricity Generation - Liquid Fuels	CO2	0.7	1.8	0.2	7.0	0.0	0.0	0.0
1.A.1.a.i - Electricity Generation - Liquid Fuels	CH4	0.0	0.0	0.2	233.0	0.0	0.0	0.0
1.A.1.a.i - Electricity Generation - Liquid Fuels	N2O	0.0	0.0	0.2	233.0	0.0	0.0	0.0
1.A.1.a.i - Electricity Generation - Solid Fuels	CO2	20.7	64.2	0.2	7.0	45.6	46.0	0.7
1.A.1.a.i - Electricity Generation - Solid Fuels	CH4	0.0	0.0	0.2	200.0	0.0	0.0	0.0
1.A.1.a.i - Electricity Generation - Solid Fuels	N2O	0.1	0.3	0.2	233.0	0.9	0.9	0.0
Sum		21.5	66.3		Sum	46.6	46.9	0.7
Uncertainty in level and trend						6.8	6.9	0.9

The time series is consistent as the AD have always been sourced from the same institution, the default EFs of IPCC used as well as a common methodology (IPCC 2006 Guidelines) for all the years of the time series.

3.2.4.5. QA/QC and verification

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, AD from each generation plant provided by the institution, the appropriate default EFs, time-series consistency, transcription accuracy, the calculations, reference material and conversion factors. Quality Assurance during the estimation steps was done by the GHG inventory Technical Working Group (TWG) and eventually by an independent international expert.

3.2.4.6. Recalculations

Not applicable.

3.2.4.7. Planned improvements

No planned improvement is envisaged.

3.2.5. Manufacturing Industries and Construction (CRT 1.A.2)

3.2.5.1. Category description

The Manufacturing Industries and Construction category covers various sub-categories and activities. For all past years, the inventory has estimated emissions from fuel burned in bulk for all activities under this category, except for mining. This inventory has progressed to be in line with the EFT of the PA but not yet fully. Emissions proper to Food processing, beverages and tobacco and cement production that fall under Non-metallic minerals have been estimated separately in addition to mining. The other occurring activities wood and wood products, textile and leather, and Construction have been estimated under Non-specified Industry. The remaining sub-categories falling under the category Manufacturing Industries and Construction do not occur in Namibia.

The trend of emissions for the Manufacturing industries and construction category is provided in Figure 3.10. Emissions increased slowly over time with Mining and quarrying activities dominating this category. Non-metallic minerals shot up as from 2016 with more fuels being burned for the manufacture of cement by a second factory and this is clearly observed as emissions were computed separately as from as from this year.

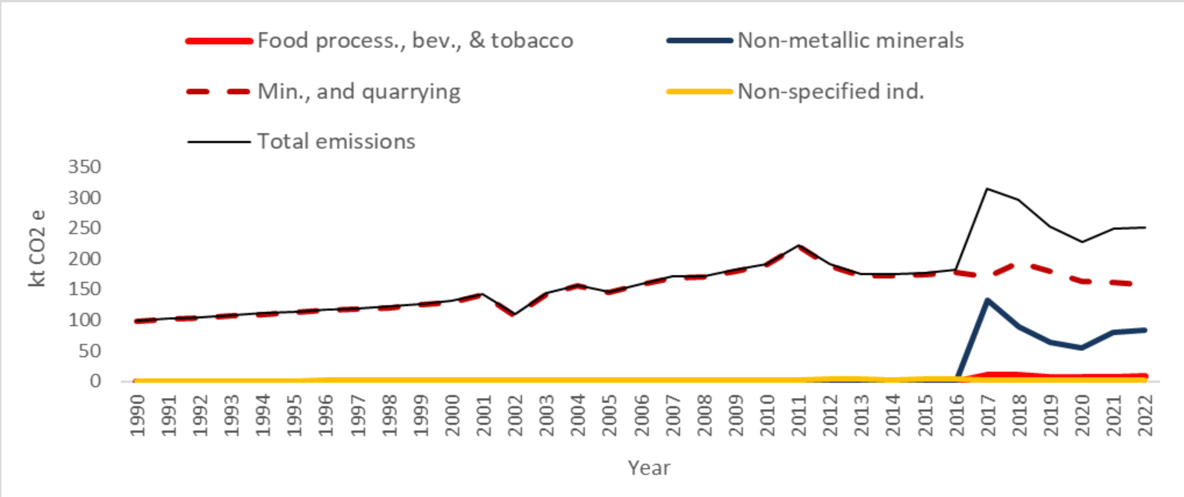

Figure 3.10. Trend of emissions (kt CO2 e) by sub-category from Manufacturing Industries and Construction (1990-2022)

Emissions of the Manufacturing Industries and Construction category increased from 100 kt CO2 e to 252 kt CO2 e during the period 1990 to 2022 (Figure 3.10). Emissions increased by 153% and 31% from 1990 and 2010 respectively to 2022. The emissions for selected years are given in Table 3.12.

Table 3.12. Emissions (kt CO2 e) of the Manufacturing Industries and Construction category

Category	1990	2000	2010	2017	2018	2019	2020	2021	2022	2022 to 1990 (% change)	2022 to 2010 (% change)
Man. Ind. and Construction	100	132	192	314	297	252	228	250	252	152%	31%
Food, Processing, Bev., and Tobacco	IE	IE	IE	10	10	7	7	6	8	-	-
Non-Metallic Minerals	IE	IE	IE	132	89	63	55	80	84	-	-
Mining and Quarrying	99	130	190	170	195	180	164	162	158	60%	-17%
Other	1	2	2	2	3	2	2	2	2	100%	0%

The aggregated emissions by gas are provided in Figure 3.11. CO2 dominated the emissions for all years of the time series, contributing more than 98%.

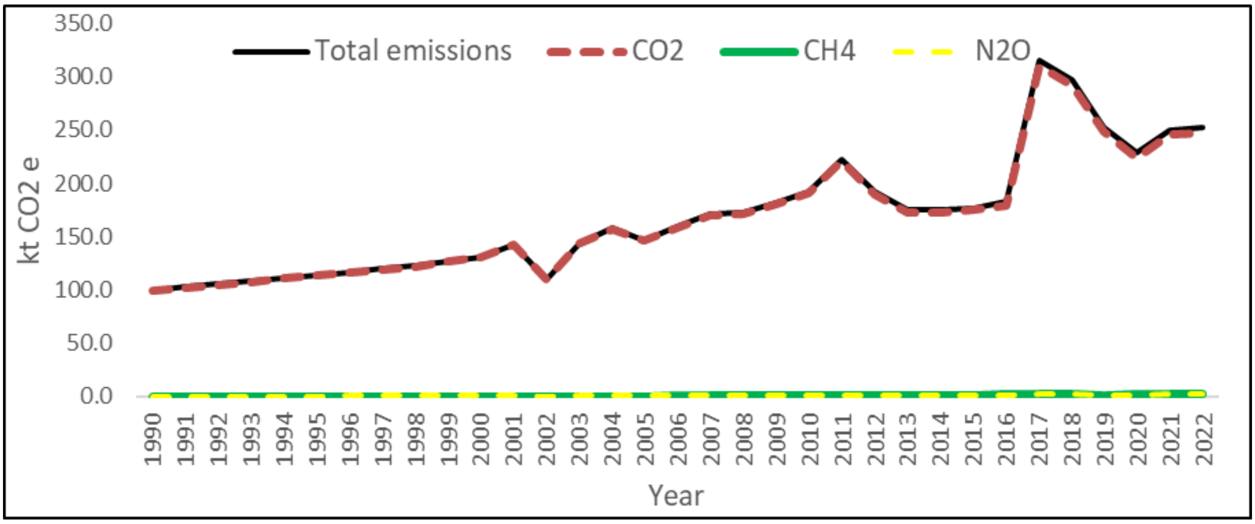

Figure 3.11. Trend of emissions (kt CO2 e) by gas for Manufacturing Industries and Construction (1990-2022)

3.2.5.2. Methodological issues

The chosen method is Tier 1 level with default EFs (Table 3.14) from the IPCC 2006 guidelines for all activities since this category came out as a key one during this compilation and disaggregated data were not available. For the period 1990 to 2016, data for all sub-categories were not available, and emissions were computed at the category level only except for mining. For the period 2017 to 2022, it has been possible to collect national AD for Food processing, beverages and tobacco, Non-metallic minerals and "Other" industry which led to emissions being calculated separately for these sub-categories. These AD for selected years are given in Table 3.13.

No CO_2 was captured in all years of the inventory.

Table 3.13. AD (t) used in the Manufacturing Industries and Construction category

Sub-category	Fuel (t)	2017	2018	2019	2020	2021	2022
Food Proc., Beverages and Tobacco	RFO	3,233	3,186	2,154	2,115	1,873	2,476
	Wood	NO	NO	NO	6,075	7,542	6,755
Non-Metallic Minerals	Coal	51,275	34,358	24,529	21,120	31,586	32,930
	Charcoal	10,280	7,715	3,513	8,629	3,554	7,280
	RDF	3,697	1,885	1,899	744	593	625
	Tyre shavings	148	127	90	70	104	23
	Wood	12,808	26,551	14,921	19,019	26,877	28,964
Mining (excluding fuels) and Quarrying	Gasoline	2,454	2,454	2,454	2,454	2,454	2,454
	Diesel	15,330	14,579	13,828	13,078	12,327	11,576
	Coal	37,727	38,043	38,358	38,674	38,990	39,306
	Waste oil	6,953	15,622	11,023	6,491	6,263	5,525
	Other petr. pdts.	1	2	167	32	34	33
	Petroleum coke	0	27	0	0	0	0
Other	Gasoline	286	291	295	300	304	309
	Diesel	464	565	471	483	393	408

Table 3.14. EFs used for direct gases in the Manufacturing Industries and Construction category

Sub-category	Fuel type	Emission factor (kg/TJ)			Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories/ Volume 2/Chapter 2 - Stationary Combustion
		CO2	CH4	N2O	
Food Proc., Beverages and Tobacco	RFO	77,400	3	0.6	Table 2.3
	Wood	112,000	30	4	" "
INon-Metallic Minerals	Coal	94,600	10	1.5	" "
	Charcoal	112,000	200	4	" "
	RDF[1]	73,300	30	4	" "
	Tyre shavings[2]	84,700	NA	NA	NA
	Wood	112,000	30	4	Table 2.3
Mining (excluding fuels) and Quarrying	Gasoline	69,300	3	0.6	" "
	Diesel	74,100	3	0.6	" "
	Coal	94,600	10	1.5	" "
	Waste oil	73,300	30	4	" "
	Other petr. pdts	73,300	3	0.6	" "
	Petroleum coke	97,500	3	0.6	" "
Other	Gasoline	69,300	3	0.6	" "
	Diesel	74,100	3	0.6	" "
	Wood	112,000	30	4	" "
	Charcoal	112,000	200	4	" "

1: EF is not available in the 2006 GL. It has been equated to the EF of municipal waste (non-biomass fraction) in the GHG software.

2: EF is not available in the 2006 GL. It has been equated for carbon factor to tyre-derived fuel as provided by US Energy Information Administration (https://www.eia.gov/environment/emissions/co2_vol_mass.php).

Table 3.15. EFs used for indirect gases in the Manufacturing Industries and Construction category

Sub- category	Fuel type	Emission factor (g/GJ)				1.A.2 - Combustion in manufacturing industries and construction (1)
		NOx	CO	NMVOC	SO2	
Food Proc., Bev. and Tobacco	RFO	142.0	15.1	2.3	495.0	Table 3.4
	Bitum. Coal	209.0	8.7	1.0	820.0	Table 3.5
Non-Metallic Minerals	Coal	173.00	931.00	88.80	900.00	Table 3.2
	Charcoal	91.00	570.00	300.00	11.00	Table 3.5
	RDF	NA	NA	NA	NA	Not available in GL.
	Tyre shavings	NA	NA	NA	NA	Not available in GL.
	Wood chips	91.00	570.00	300.00	11.00	Table 3.5
Mining (excluding fuels) and Quarrying	Gasoline	513.00	66.00	25.00	47.00	Table 3.4
	Diesel	513.00	66.00	25.00	47.00	" "
	Coal	173.00	931.00	88.80	900.00	Table 3.2
	Waste oil[1]	513.00	66.00	25.00	47.00	Table 3.4
	Other petroleum pdts	513.00	66.00	25.00	47.00	Table 3.4
	Petroleum coke	513.00	66.00	25.00	47.00	" "
Other	Gasoline	513.00	66.00	25.00	47.00	" "
	Diesel	513.00	66.00	25.00	47.00	" "
	Wood fuel	91.00	570.00	300.00	11.00	Table 3.5
	Charcoal	91.00	570.00	300.00	11.00	" "

Source: EMEP/EEA air pollutant emission inventory guidebook 2023

Note: 1: Waste oils has been equated with "Other petroleum products"

3.2.5.3. Flexibility

Not resorted to.

3.2.5.4. Uncertainty assessment and time-series consistency

The uncertainties assigned to the AD (Table 3.16) varied from ±2% to ±10% depending on the quality of the data collected and those for the default EFs from ±7 for CO2 and -50% to +275% for CH4 and N2O depending on activity area, the ranges adopted are from the IPCC 2006 guidelines.

Table 3.16. Uncertainty levels assigned for Manufacturing Industries and Construction

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[2]
1.A.2 -Manufacturing Industries and Construction			
1.A.2. Food and Beverages - liquid fuels	CO2	±2	±7
	CH4	±2	-67 to +233
	N2O	±2	-67 to +233
1.A.2. Food and Beverages - Biomass	CO2	±2	±7
	CH4	±2	-67 to +233
	N2O	±2	-63 to +275
1.A.2. Non metallic minerals - Solid Fuel	CO2	±2	±7
	CH4	±2	-70 to +200
	N2O	±2	-67 to + 233
1.A.2. Non metallic minerals - Biomass	CO2	±2	±7
	CH4	±2	-67 to +233
	N2O	±2	-63 to +275 %
1.A.2 Non metallic minerals - Tyre shavings	CO2	±2	±7
	CH4	±2	-50 to +50
	N2O	±2	-10 to +1000 %
1.A.2 Non metallic minerals - Charcoal	CO2	±2	±7
	CH4	±2	-65 to +200 %
	N2O	±2	-63 to +275 %
1.A.2 Non metallic minerals - Refuse Derived Fuel	CO2	±2	±7
	CH4	±2	-67 to +233 %
	N2O	±2	-67 to +233 %
1.A.2.i - Mining (excluding fuels) and Quarrying - Liquid Fuels	CO2	±10	±7
	CH4	±10	-67 to +233 %
	N2O	±10	-67 to +233 %
1.A.2.i - Mining (excluding fuels) and Quarrying - Solid Fuels	CO2	±10	±7
	CH4	±10	-70 to +200 %
	N2O	±10	-67 to +233 %
1.A.2.i - Mining (excluding fuels) and Quarrying - Other Fossil Fuels	CO2	±10	±7
	CH4	±10	-67 to +233 %
	N2O	±10	-63 to +275 %
1.A.2.m - Other- Liquid fuels	CO2	±10	±7
	CH4	±10	-67 to +233 %
	N2O	±10	-67 to +233 %

1: Source - 2006 Guidelines, Table 2.15, Page 2.41, Chapter 2, Volume 2

2: Source - 2006 Guidelines, Paragraph 2.41, Page 2.38, for CO2 and Table 2.3, Page 2.18 for CH4 and N2O of Chapter 2, Volume 2

The combined uncertainties determined using the generated tool in line with the methods contained in the IPCC 2006 guidelines are provided in Table 3.17 for this category. The uncertainties for the level assessment for the base year 1990 and year-t (2022) are 9.3% and 5.8% respectively while the trend assessment with 1990 as base year and 2022 as year-t is 18%.

Table 3.17. Uncertainty assessment for the Manufacturing Industries and Construction

A	B	C	D	E	F	H	H	M
2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (kt CO2e)	Year T (2022) emissions or removals (kt CO2e)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Contribution to variance by category in year 1990	Contribution to variance by category in year 2022	Uncertainty introduced into the trend in total national emissions
1.A.2.e - Food Processing, Beverages and Tobacco -	CO2	-	7.7	2.0	7.0	0.0	0.1	0.3
1.A.2.e - Food Processing, Beverages and Tobacco -	CH4	-	0.0	2.0	233.0	0.0	0.0	0.0
1.A.2.e - Food Processing, Beverages and Tobacco -	N2O	-	0.0	2.0	233.0	0.0	0.0	0.0
1.A.2.e - Food Processing, Beverages and Tobacco -	CO2	-	0.0	2.0	7.0	0.0	0.0	0.0
1.A.2.e - Food Processing, Beverages and Tobacco -	CH4	-	0.1	2.0	233.0	0.0	0.0	0.0
1.A.2.e - Food Processing, Beverages and Tobacco -	N2O	-	0.1	2.0	275.0	0.0	0.0	0.1
1.A.2.f - Non-Metallic Minerals - Solid Fuels	CO2	-	80.4	2.0	7.0	0.0	5.4	37.0
1.A.2.f - Non-Metallic Minerals - Solid Fuels	CH4	-	0.2	2.0	200.0	0.0	0.0	0.2
1.A.2.f - Non-Metallic Minerals - Solid Fuels	N2O	-	0.3	2.0	233.0	0.0	0.1	0.6
1.A.2.f - Non-Metallic Minerals - Other Fossil Fuels	CO2	-	0.6	2.0	7.0	0.0	0.0	0.0
1.A.2.f - Non-Metallic Minerals - Other Fossil Fuels	CH4	-	0.0	2.0	50.0	0.0	0.0	0.0
1.A.2.f - Non-Metallic Minerals - Other Fossil Fuels	N2O	-	0.0	2.0	1000.0	0.0	0.0	0.0
1.A.2.f - Non-Metallic Minerals - Biomass - solid	CO2	-	0.0	2.0	7.0	0.0	0.0	0.0
1.A.2.f - Non-Metallic Minerals - Biomass - solid	CH4	-	1.6	2.0	233.0	0.0	2.1	13.7
1.A.2.f - Non-Metallic Minerals - Biomass - solid	N2O	-	0.7	2.0	275.0	0.0	0.6	3.8
1.A.2.g.iii - Mining (excluding fuels) and Quarrying - L	CO2	26.2	44.5	10.0	7.0	10.3	4.6	42.2
1.A.2.g.iii - Mining (excluding fuels) and Quarrying - L	CH4	0.0	0.1	10.0	233.0	0.0	0.0	0.0
1.A.2.g.iii - Mining (excluding fuels) and Quarrying - L	N2O	0.1	0.1	10.0	233.0	0.0	0.0	0.0
1.A.2.g.iii - Mining (excluding fuels) and Quarrying - S	CO2	70.5	95.9	10.0	7.0	74.5	21.6	218.0
1.A.2.g.iii - Mining (excluding fuels) and Quarrying - S	CH4	0.2	0.3	10.0	200.0	0.2	0.1	0.2
1.A.2.g.iii - Mining (excluding fuels) and Quarrying - S	N2O	0.3	0.4	10.0	233.0	0.5	0.1	0.7
1.A.2.g.iii - Mining (excluding fuels) and Quarrying - O	CO2	1.3	16.3	10.0	7.0	0.0	0.6	6.2
1.A.2.g.iii - Mining (excluding fuels) and Quarrying - O	CH4	0.0	0.2	10.0	233.0	0.0	0.0	0.1
1.A.2.g.iii - Mining (excluding fuels) and Quarrying - O	N2O	0.0	0.2	10.0	275.0	0.0	0.1	0.3
1.A.2.g.viii - Other - Liquid Fuels	CO2	1.1	2.2	10.0	7.0	0.0	0.0	0.1
1.A.2.g.viii - Other - Liquid Fuels	CH4	0.0	0.0	10.0	233.0	0.0	0.0	0.0
1.A.2.g.viii - Other - Liquid Fuels	N2O	0.0	0.0	10.0	233.0	0.0	0.0	0.0
Sum		99.7	252.0		Sum	85.5	35.5	323.6
Uncertainty in level and trend						9.3	5.8	18.0

The time series is consistent as the AD have always been obtained from the same sources, the default EFs of IPCC used as well as the same methodology for all the years of the time series.

3.2.5.5. QA/QC and verification

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, AD, the appropriate default EFs, time-series consistency, transcription accuracy, the calculations, reference material and conversion factors. Quality

Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

3.2.5.6. Recalculations

Not applicable.

3.2.5.7. Planned improvements

Planned improvements including the timeframe and needs are provided in Table 3.18. This planned improvement is more for the medium term as it has not been prioritized and is foreseen to take time to convince and train the producers to collect and submit disaggregated AD.

Table 3.18. Planned improvements

Item	Improvement	Timeframe	Activity	Needs
AD	Improve the quality of data by sourcing these from the individual producers and operators for remaining sub-categories contributing to emissions	2028	Strengthen the MRV emissions system, CB of data providers	GEF resources under future BTRs

3.2.6. Transport (CRT 1.A.3)

3.2.6.1. Category description

Transport comprises the subcategories Domestic Aviation, Road transportation, Railways, Domestic Navigation and Other transportation. The 3 sub-categories occurring in Namibia, namely Domestic Aviation, Road Transportation and Railways are covered in this inventory. Domestic navigation could not be estimated on a stand-alone basis due to lack of data. Domestic navigation has thus been estimated under the Transport category and characterized as “Included Elsewhere” as the fuel used is delivered by the same stations servicing road transport vehicles.

Road transportation vastly dominated emissions of the transport category which increased steadily as from 1990 to 2022 (Figure 3.12).

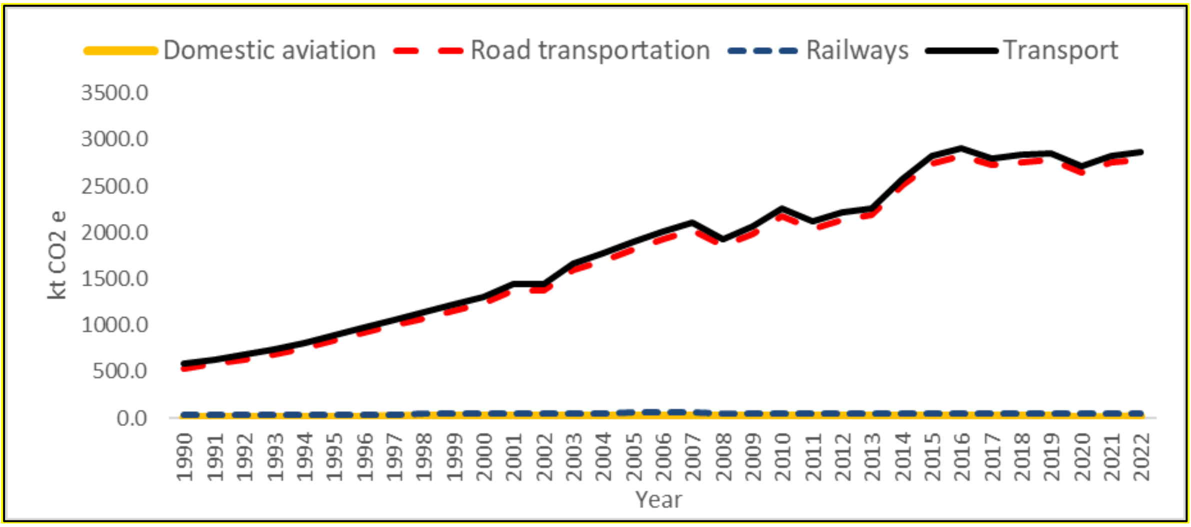

Figure 3.12. Trend of emissions (kt CO2 e) by sub-category for the category, Transport (1990-2022)

Transport emissions increased by 391% and 27% from 1990 to 2022 and 2010 to 2022 respectively. Table 3.19 gives the emissions for selected years.

Table 3.19. Transport emissions (kt CO2 e)

Category/sub-category	1990	2000	2010	2017	2018	2019	2020	2021	2022	2022 to 1990 (% change)	2022 to 2010 (% change)
Transport	584	1,308	2,259	2,805	2,837	2,859	2,713	2,820	2,865	391%	27%

Emissions by gas of the transport category is presented in Figure 3.12. As expected, CO2 contributed a very high percentage compared to the other two direct gases.

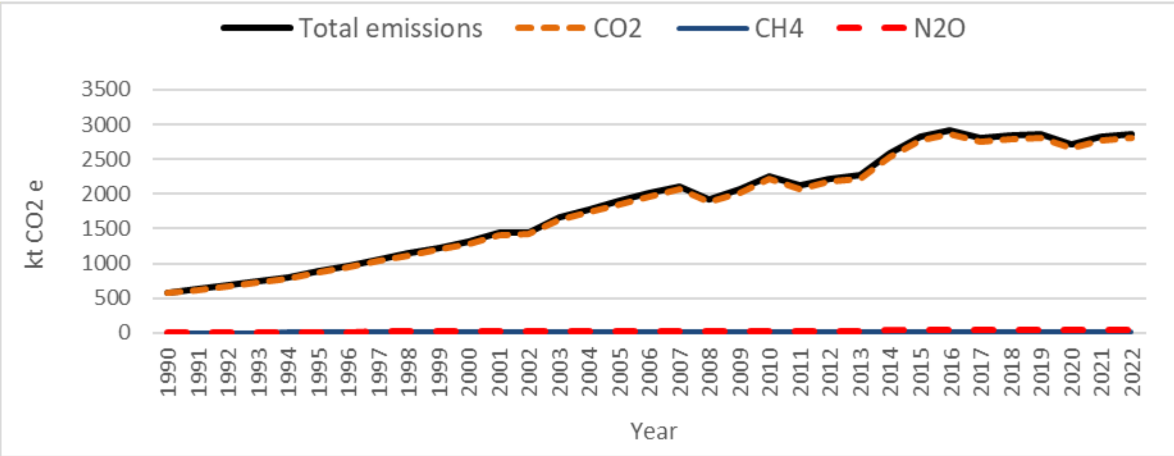

Figure 3.13. Trend of emissions (kt CO2 e) by gas for the category, Transport (1990-2022)

3.2.6.1a Domestic Aviation

This subcategory includes all GHG emissions from domestic air transport (commercial and private) of the country. Emissions increased over the time series from 12 kt CO2 e in 1990 to 23 kt CO2 e in 2022 representing an increase of 92%. Emissions fell drastically in 2020 and 2021 on account of the COVID-19 pandemic but returned to the 2019 level in 2022. The emissions for selected years are given in Table 3.20.

Table 3.20. Emissions (kt CO2 e) for Domestic aviation

Category/sub-category	1990	2000	2010	2017	2018	2019	2020	2021	2022	2022/ 1990	2022/ 2010
Domestic Aviation	12	19	22	23	23	23	11	12	23	92%	5%

3.2.6.1b Road transportation

Road transportation addressed fuel burnt by all vehicles running on roads, whether for commercial, public or own use. The vehicles have been segregated in accordance with the IPCC 2006 guidelines and emissions estimated for each class.

Road Transport emissions (Table 3.21) were estimated at 2,789 kt CO2 e in 2022 compared to 2,180 kt CO2 e in the year 2010 and only 539 kt CO2 e in 1990. This represents increases of 417% and 28% respectively relative to 1990 and 2010. The highest increases are observed for the with, and without 3-way catalyst Light Duty Trucks vehicle classes at 44% relative to 2010 and 389% relative to 1990. Motorcycles contributed marginally to emissions of the Road transport sub-category even if this represented an increase of 100% compared to1990.

Table 3.21. Emissions (kt CO2 e) for Road transportation for selected years

Category/sub-category	1990	2000	2010	2017	2018	2019	2020	2021	2022	2022/ 1990	2022/ 2010
Road transport	539	1,243	2,180	2,728	2,760	2,783	2,649	2,755	2,789	417%	28%
1.A.3.b.i Cars	172	327	520	518	537	554	506	560	559	225%	8%
1.A.3.b.ii Light duty trucks	280	555	948	1220	1291	1368	1380	1383	1369	389%	44%
1.A.3.b.iii Heavy duty trucks and buses	85	360	710	988	929	859	761	809	858	909%	21%
1.A.3.b.iv Motorcycles	1	1	2	2	2	2	2	2	2	100%	0%

3.2.6.1c Railways

The railway system is principally designed to transport cargo and goods to the major cities of the country from and to the port. There is no dedicated railway passenger service even if the cargo trains accommodate a few passengers. The railway system is an old one and has not witnessed any change, which explains the emission estimated over the time series.

Emissions increased by 64% from 33 kt CO2 e in 1990 to 57 kt CO2 e in 2010 but recorded a decrease of 3 kt CO2 e by 2022. These emissions levels give an increase of 64% from 1990 to2022 but a regression of 5% when 2022 is compared to 2010.

Table 3.22. Emissions (kt CO2 e) for Railways for selected years

Category/sub-category	1990	2000	2010	2017	2018	2019	2020	2021	2022	2022/ 1990	2022/ 2010
Railways	33	45	57	54	54	54	54	54	54	64%	-5%

3.2.6.1d Domestic navigation

Included Elsewhere.

Namibia do not have any inland waterway suitable for navigation. The long coastline of the country is mostly uninhabited except for a few towns near the 2 ports. There are however some domestic navigations with charter vessels for tourism and vacation purposes. However, the fuel combusted by these vessels has been difficult to capture. As the fuel has been included elsewhere in the national energy balance this category emissions are reported as “Included Elsewhere” since they have been accounted for in that way.

3.2.6.2. Methodological issues

3.2.6.2a Domestic Aviation

The method prescribed in the IPCC 2006 guidelines was adopted for estimating emissions using the 2006 IPCC software. AD for most years were abstracted from airport profiles data which provided fuels delivered to all international flights and domestic flights. When data was not available, interpolations and or extrapolations were adopted to generate missing data and fill existing gaps. The AD, for the period 2017 to 2022, used for this inventory are provided in Table 3.23.

Table 3.23. AD used for Domestic aviation (2017-2022)

Fuel (t)	2017	2018	2019	2020	2021	2022
Aviation Gasoline	1,980	2,001	1,984	1,825	1,873	1,984
Jet kerosene	5,147	5,201	5,157	1,534	1,900	5,157

The default EFs used are from the IPCC 2006 guidelines for direct gases and the EMEP/EEA guidebook of 2023 for the indirect gases. The EFS are given in Table 3.24.

Table 3.24. EFs used for Domestic aviation (2017-2022)

Sub-category	Emission Factors of direct gases					
	Fuel type	Emission factor (kg/TJ)				Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories/ Volume 2/Chapter 3 - Mobile Combustion
		CO2		CH4	N2O	
Domestic Aviation	Aviation Gasoline	70000		0.5	2	Tables 3.6.4 and 3.6.5
	Jet kerosene	71500		0.5	2	" "
	Emission Factors of indirect gases					
	Fuel type	Emission factor (kg/Ton fuel)				Source: EMEP/EEA air pollutant emission inventory guidebook 2023, 1.A.3.a - Aviation.
		NOx	CO	NMVOC	SO2	
	Aviation Gasoline	4.00	1200.0	19.0	1.0	Table 3.3.
	Jet kerosene	10.3	2.0	0.10	1.0	" "

3.2.6.2b Road transportation

The Tier 2 IPCC 2006 guidelines methodology was adopted for the full time series where the vehicle fleet has been disaggregated into the recommended vehicle classes based on annual national statistics. The mileage run and consumption for each vehicle class is based on a survey conducted for the preparation of the NC2 (https://unfccc.int/documents/133224). The consumption data for the vehicle classes have been revised over time to factor in the technological improvements reported by the manufacturers while the % of each class running on gasoline or diesel was also changed to reflect the market and national circumstances. The mileage run and consumption by vehicle class is given in Table 3.25. Light passenger vehicles and Light Load vehicles dominated the fleet with about 188,000 and 175,000 units in each class respectively.

Table 3.25. Mileage run and consumption by vehicle class (2017-2022)

Sub-category	Indicators	2017	2018	2019	2020	2021	2022
Light passenger motor vehicles less than 12 persons	Est. km/yr	18,000	18,000	18,000	16,200	18,000	18,000
	Est. Cons. (litres /100 km)	7	7	7	7	7	7
	% diesel used	10	10	10	10	10	10
	% gasoline used	90	90	90	90	90	90
	No. of vehicles	174,008	180,568	186,085	188,983	188,408	187,835
Heavy passenger motor vehicles 12 or more persons	Est. km/yr	90,000	90,000	90,000	81,000	90,000	90,000
	Est. Cons. (litres /100 km)	13	13	13	13	13	13
	% diesel used	50	60	70	70	70	70
	% gasoline used	50	40	30	30	30	30
	No. of vehicles	2,933	4,115	5,340	5,537	5,225	4,931
Light load vehicle with GVM 3500 kg or less	Est. km/yr	24,000	24,000	24,000	24,000	24,000	24,000
	Est. Cons. (litres /100 km)	11	11	11	11	11	11
	% diesel used	60	60	65	70	70	70
	% gasoline used	40	40	35	30	30	30
	No. of vehicles	165,667	170,558	174,376	176,206	175,552	174,900
Heavy load vehicle > GVM 3500 kg, not to draw	Est. km/yr	35,000	35,000	35,000	31,500	33,250	35,000
	Est. Cons. (litres /100 km)	16	16	16	16	16	16
	% diesel used	100	100	100	100	100	100

Sub-category	Indicators	2017	2018	2019	2020	2021	2022
	% gasoline used	0	0	0	0	0	0
	No. of vehicles	8,576	9,454	10,312	10,550	10,393	10,238
Heavy load vehicle > GVM 3500 kg, equipped to draw	Est. km/yr	85,000	85,000	85,000	76,500	80,750	85,000
	Est. Cons. (litres /100 km)	28	28	28	28	28	28
	% diesel used	100	100	100	100	100	100
	% gasoline used	0	0	0	0	0	0
	No. of vehicles	12,956	11,862	10,599	10,330	10,464	10,600
Motorcycles	Est. km/yr	6,000	6,000	6,000	5,400	6,000	6,000
	Est. Cons. (litres /100 km)	3	3	3	3	3	3
	% gasoline used	100	100	100	100	100	100
	No. of vehicles	5,471	5,459	5,403	5,309	5,128	4,953
Special vehicles	Est. km/yr	17,000	17,000	17,000	17,000	17,000	17,000
	Est. Cons. (litres /100 km)	18	18	18	18	18	18
	% diesel used	98	98	98	98	98	98
	% gasoline used	2	2	2	2	2	2
	No. of vehicles	13,181	10,588	7,736	7,040	6,545	6,085

Fuel consumed were calculated using the equation

Fuel consumed = No. of vehicles x annual km travelled x Consumption/100 km

Fuel combusted by each class of vehicle thus calculated are provided in Table 3.26. Heavy duty trucks and buses are the highest consumers followed by Light Duty Trucks with 3-way catalysts. Lubricants have been included for motorcycles as they are burned with the fuel in 2-stroke engines of this vehicle class. LPG has not been used in vehicles during the period 2017 to 2022. The fuel consumed thus obtained was then fed into the software to estimate emissions per vehicle class and these summed to provide the estimates for Road transportation.

Table 3.26. Fuel consumption (t) by vehicle class (2017-2022)

Vehicle Type	Fuel (t)	2017	2018	2019	2020	2021	2022
Passenger cars with 3-way catalysts	Gasoline	46,464	48,215	49,688	45,416	50,309	50,156
	Diesel	6,012	6,239	6,429	5,876	6,510	6,490
	LPG	0	0	0	0	0	0
Passenger cars without 3-way catalysts	Gasoline	98,735	102,457	105,588	96,509	106,906	106,581
	Diesel	12,775	13,257	13,662	12,487	13,833	13,791
Light-duty trucks with 3-way catalysts	Gasoline	106,017	110,026	99,264	86,670	86,853	85,998
	Diesel	179,675	192,192	220,414	235,503	235,998	233,676
Light-duty trucks without 3-way catalysts	Gasoline	35,339	36,675	33,088	28,890	28,951	28,666
	Diesel	59,892	64,064	73,471	78,501	78,666	77,892
Heavy-duty trucks and buses	Diesel	305,380	287,282	265,641	235,168	250,113	265,307
Motorcycles	Gasoline	725	723	716	633	679	656
	Lubricants	7	7	7	6	7	7

EFs used were the default values from the IPCC 2006 guidelines for the direct gases and the EMEP/EEA guidebook for the indirect gases. These EFS are given in Table 3.27.

Table 3.27. EFs used for estimating emissions for Road Transportation

Sub-category - Road Transportation	Fuel type	Emission Factors of direct gases			
		Emission factor (kg/TJ)			Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories/ Volume 2/Chapter 3 - Mobile Combustion
		CO2	CH4	N2O	
Passenger cars with 3-way catalysts	Gasoline	69,300	33	3.2	Tables 3.2.1 and 3.2.2
	Diesel	74,100	3.9	3.9	" "
	LPG	63,100	62	0.2	" "
Passenger cars without 3-way catalysts	Gasoline	69,300	33	3.2	" "
	Diesel	74,100	3.9	3.9	" "
Light-duty trucks with 3-way catalysts	Gasoline	69,300	33	3.2	" "
	Diesel	74,100	3.9	3.9	" "
Light-duty trucks without 3-way catalysts	Gasoline	69,300	33	3.2	" "
	Diesel	74,100	3.9	3.9	" "
Heavy-duty trucks and buses	Diesel	74,100	3.9	3.9	" "
Motorcycles	Gasoline	69,300	33	3.2	" "
	Lubricants	73,300	N/A	N/A	Tables 3.2.1

Sub-category - Road Transportation	Fuel type	Emission Factors of indirect gases				
		Emission factor (g/kg fuel)				Source: EMEP/EEA air pollutant emission inventory guidebook 2023, 1.A.3.b - Road Transport
		NOx	CO	NMVOC	SO2	
Passenger cars with 3-way catalysts	Gasoline	8.73	84.70	10.05	0.02	(i) Table 3-5 for CO and NMVOC. (ii) Table 3-6 for NOx. (iii) Emissions of SO2 per fuel type based on formula (2) as shown on page 22 of GB. (iv) Information from oil companies indicate a typical value of Sulphur content at 50 ppm for diesel which is used for SO2 calculation. (v) Sulphur content for gasoline based on information from: https://www.unep.org/topics/transport/partnership-clean-fuels-and-vehicles/sulphur-campaign
	Diesel	12.96	3.33	0.70	0.10	
	LPG	15.20	84.70	13.64	0.08	
Passenger cars without 3-way catalysts	Gasoline	8.73	84.70	10.05	0.02	
	Diesel	12.96	3.33	0.70	0.10	
Light-duty trucks with 3-way catalysts	Gasoline	13.22	152.30	14.59	0.02	
	Diesel	14.91	7.40	1.54	0.10	
Light-duty trucks without 3-way catalysts	Gasoline	13.22	152.30	14.59	0.02	
	Diesel	14.91	7.40	1.54	0.10	
Heavy-duty trucks and buses	Diesel	33.4	7.6	1.9	0.1	
Motorcycles	Gasoline	6.64	497.70	131.40	0.02	
	Lubricants	NA	NA	NA	NA	

3.2.6.2c Railways

No AD was available for Railways for the period 2017 to 2022. Since the amounts of goods reported as transported by trains did not differ much from the years just prior to 2017. Thus, with amounts of goods transported being used as proxy, the average fuel consumption for the years 2014 to 2016 was adopted to fill the data gaps for the period 2017 to 2022. This explains the constant figure of 15,570 tons given in Table 3.28.

Table 3.28. Fuel consumption for Railways (2017-2022)

Sub-category	Fuel (t)	2017	2018	2019	2020	2021	2022
Railways	RFO	15,570	15,570	15,570	15,570	15,570	15,570

All EFs adopted (Table 3.29.) were from the IPCC 2006 guidelines for the direct GHGs and the EMEP/EEA Guidebook for the indirect GHGs.

Table 3.29. EFs adopted for Railways

Sub-category	Emission Factors of direct gases				
	Fuel type	Emission factor (kg/TJ)			Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories/Volume 2/ Chapter 3 - Mobile Combustion
		CO2	CH4	N2O	
Railways	Diesel	74100	4.15	28.6	Table 3.4.1
	RFO	77400	4.15	28.6	" "

Sub-category	Emission Factors of indirect gases					
	Fuel type	Emission factor (kg/Ton fuel)				Source: EMEP/EEA air pollutant emission inventory guidebook 2023, 1.A.3.c – Railways.
		NOx	CO	NMVOC	SO2	
Railways	Diesel	52.40	10.70	4.65	0.005	(i) Table 3-1. (ii) Guidance on page 7 of GB is used for SO2 estimation. (iii) Used EF for diesel as proxy for RFO as relative EF not available for RFO in the GL.
	RFO	52.40	10.70	4.65	0.005	

3.2.6.2d Domestic navigation

No AD or EFs are available since the fuel combusted has been included elsewhere as already explained in section 3.2.6.1d of this report.

3.2.6.3. Flexibility

3.2.6.3a Domestic Aviation

Not resorted to.

3.2.6.3b Road transportation

Not resorted to.

3.2.6.3c Railways

Not resorted to.

3.2.6.3d Domestic navigation

Not applicable.

3.2.6.4. Uncertainty assessment and time-series consistency

3.2.6.4a Domestic Aviation

The uncertainty levels assigned to the AD (Table 3.30) and EFs are the default ranges from the IPCC 2006 guidelines. The uncertainty for AD is in the range of ±80 while for the EFs, values of ±5 has been adopted for CO2 and a range of -57 to +100 for CH4 and -70 to +150 for N2O.

Table 3.30. Uncertainty levels assigned for Domestic aviation

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[2]
1.A.3. a-Domestic Aviation			
1.A.3.a.ii – Domestic aviation - Liquid Fuels	CO2	±80	±5
	CH4	±80	-57 to +100
	N2O	±80	-70 to +150

1: Source - 2006 Guideline, Paragraph 3.6.1.7, Page 3.69, Chapter 3, Volume 2
2: Source - 2006 Guidelines, Paragraph 3.6.1.7, Page 3.69, Chapter 3, Volume 2

The estimated combined uncertainties are 80.2% for the level assessment for both the base year 1990 and year-t 2022, and 209.1% for the trend between base year 1990 and year-t 2022 (Table 3.31).

Table 3.31. Uncertainty assessment for Civil Aviation

A	B	C	D	E	F	H	H	M
2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (kt CO2e)	Year T (2022) emissions or removals (kt CO2e)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Contribution to variance by category in year 1990	Contribution to variance by category in year 2022	Uncertainty introduced into the trend in total national emissions (%)
1.A.3.a - Domestic Aviation - Liquid Fuels	CO2	12.0	22.4	80.0	5.0	6326.99	6327.77	43720.5
1.A.3.a - Domestic Aviation - Liquid Fuels	CH4	0.0	0.0	80.0	100.0	0.0	0.0	0.0
1.A.3.a - Domestic Aviation - Liquid Fuels	N2O	0.1	0.2	80.0	150.0	1.6	1.6	2.4
Sum		12.1	22.6		Sum	6328.6	6329.4	43723.0
Uncertainty in level and trend						80.2	80.2	209.1

The time series is consistent as the AD have always been sourced from the same institution, the default EFs of IPCC used as well as a common methodology for all the years of the time series.

3.2.6.4b Road transportation

The uncertainty level assigned to the AD is ±5 and for EFs, they are ±3.5 for CO2 and for CH4 and N2O the default range -67 to +207 and -68 to +217 respectively. All uncertainty values are from the IPCC 2006 guidelines (Table 3.32).

Table 3.32. Uncertainty levels assigned for Road Transportation

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[2]
1.A.3. b - Road Transportation			
1.A.3.b.i.1 - Passenger cars with 3-way catalysts - Liquid Fuels	CO2	±5	±3.5
	CH4	±5	-67 to +207
	N2O	±5	-68 to +217
1.A.3.b.i.2 - Passenger cars without 3-way catalysts - Liquid Fuels	CO2	±5	±3.5
	CH4	±5	-67 to +207
	N2O	±5	-68 to +217
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts - Liquid Fuels	CO2	±5	±3.5
	CH4	±5	-67 to +207
	N2O	±5	-68 to +217
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts - Liquid Fuels	CO2	±5	±3.5
	CH4	±5	-67 to +207
	N2O	±5	-68 to +217
1.A.3.b.iii - Heavy-duty trucks and buses - Liquid Fuels	CO2	±5	±3.5
	CH4	±5	-67 to +207
	N2O	±5	-68 to +217
1.A.3.b.iv - Motorcycles - Liquid Fuels	CO2	±5	±3.5
	CH4	±5	-67 to +207
	N2O	±5	-68 to +217

1: Source - 2006 Guideline, Page 3.30, Chapter 3, Volume 2
2: Source - 2006 Guidelines, Paragraph 3.2.2, Page 3.29 for CO2 and Table 3.3.2, Page 3.21 for CH4 and N2O, Chapter 3, Volume 2

The estimated combined uncertainties are 3.5% for the level assessment for both the base year 1990 and year-t 2022, and 19.4% for the trend between base year 1990 and year-t 2022 (Table 3.33).

Table 3.33 Uncertainty assessment for Road Transportation

A	B	C	D	E	F	H	H	M
2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (kt CO2e)	Year T (2022) emissions or removals (kt CO2e)	Activity Data Uncerta inty (%)	Emissio n Factor Uncerta inty (%)	Contribut ion to variance by category in year 1990	Contributio n to variance by category in year 2022	Uncertainty introduced into the trend in total national emissions (%)
1.A.3.b.i.1 - Passenger cars with 3-way catalysts - L	CO2	53.9	174.7	5.0	3.5	0.4	0.1	5.7
1.A.3.b.i.1 - Passenger cars with 3-way catalysts - L	CH4	0.7	2.1	5.0	207.0	0.1	0.0	0.3
1.A.3.b.i.1 - Passenger cars with 3-way catalysts - L	N2O	0.7	2.2	5.0	217.0	0.1	0.0	0.3
1.A.3.b.i.2 - Passenger cars without 3-way catalysts	CO2	114.4	371.1	5.0	3.5	1.7	0.7	25.8
1.A.3.b.i.2 - Passenger cars without 3-way catalysts	CH4	1.4	4.4	5.0	207.0	0.3	0.1	1.3
1.A.3.b.i.2 - Passenger cars without 3-way catalysts	N2O	1.4	4.6	5.0	217.0	0.3	0.1	1.2
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts -	CO2	205.2	1008.6	5.0	3.5	5.4	4.9	175.4
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts -	CH4	2.5	4.6	5.0	207.0	0.9	0.1	9.8
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts -	N2O	2.6	13.6	5.0	217.0	1.1	1.1	0.1
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalyst	CO2	68.4	336.2	5.0	3.5	0.6	0.5	19.5
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalyst	CH4	0.8	1.5	5.0	207.0	0.1	0.0	1.1
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalyst	N2O	0.9	4.5	5.0	217.0	0.1	0.1	0.0
1.A.3.b.iii - Heavy-duty trucks and buses - Liquid Fue	CO2	83.9	845.3	5.0	3.5	0.9	3.4	130.2
1.A.3.b.iii - Heavy-duty trucks and buses - Liquid Fue	CH4	0.1	1.2	5.0	207.0	0.0	0.0	0.1
1.A.3.b.iii - Heavy-duty trucks and buses - Liquid Fue	N2O	1.2	11.8	5.0	217.0	0.2	0.8	5.4
1.A.3.b.iv - Motorcycles - Liquid Fuels	CO2	0.7	2.0	5.0	3.5	0.0	0.0	0.0
1.A.3.b.iv - Motorcycles - Liquid Fuels	CH4	0.0	0.0	5.0	207.0	0.0	0.0	0.0
1.A.3.b.iv - Motorcycles - Liquid Fuels	N2O	0.0	0.0	5.0	217.0	0.0	0.0	0.0
Sum		538.7	2788.6		Sum	12.1	12.2	375.9
Uncertainty in level and trend						3.5	3.5	19.4

The time series is consistent as the AD have always been sourced from the same institution, the default EFs of IPCC used as well as a common methodology for all the years of the time series.

3.2.6.4c Railways

The uncertainty level for the AD is ±8 and for the EFs, the default values, -2 to +2 for CO2 and a range of -60 to +151 for CH4 and -50 to +200 for N2O. All uncertainty values assigned are from the IPCC 2006 guidelines to EFs (Table 3.34).

Table 3.34. Uncertainty levels assigned for Railways

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[2]
1.A.3. c - Railways			
1.A.3.c - Railways - Liquid Fuels	CO2	±8	-2 to +2
	CH4	±8	-60 to +151
	N2O	±8	-50 to +200

1: Source - 2006 Guidelines, Page 3.45, Chapter 3, Volume 2

2: Source - 2006 Guidelines, Table 3.41, Page 3.43, Chapter 3, Volume 2

The estimated combined uncertainties are 20.0% and 19.3% for the level assessment for base year 1990 and year-t 2022 respectively and 16.6% for the trend between base year 1990 and year-t 2022 (Table 3.35).

Table 3.35. Uncertainty assessment for Railways

A	B	C	D	E	F	H	H	M
2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (kt CO2e)	Year T (2022) emissions or removals (kt CO2e)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Contribution to variance by category in year 1990	Contribution to variance by category in year 2022	Uncertainty introduced into the trend in total national emissions (%)
1.A.3.c - Railways - Liquid Fuels	CO2	30.2	48.7	8.0	2.0	55.8	56.3	272.8
1.A.3.c - Railways - Liquid Fuels	CH4	0.0	0.1	8.0	151.0	0.0	0.0	0.0
1.A.3.c - Railways - Liquid Fuels	N2O	3.1	4.8	8.0	200.0	344.0	317.8	3.9
Sum		33.3	53.6		Sum	399.8	374.1	276.8
Uncertainty in level and trend						20.0	19.3	16.6

The time series is consistent as the AD have always been sourced from the same institution, the default EFs of IPCC used as well as a common methodology for all the years of the time series.

3.2.6.4d Domestic navigation

Not applicable

3.2.6.5. QA/QC and verification

3.2.6.5a Domestic Aviation

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, AD in terms of fuel by type delivered to aircrafts at airports, the appropriate default EFs, time-series consistency, transcription accuracy, the calculations, reference material and conversion factors. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

3.2.6.5b Road transportation

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, AD in terms of number of vehicles by class, estimated fuel combusted, kilometres run by the different vehicle classes, allocation of vehicle number for type of fuel, the appropriate default EFs, time-series consistency, transcription accuracy, the calculation of fuel consumption and emissions, reference material and conversion factors. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

3.2.6.5c Railways

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, AD in terms of fuel used by trains, the appropriate default EFs, time-series consistency, transcription accuracy, the calculations, reference material and conversion factors. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

3.2.6.5d Domestic navigation

Not applicable.

3.2.6.6. Recalculations

Not applicable.

3.2.6.6a Domestic Aviation

Not applicable.

3.2.6.6b Road transportation

Not applicable.

3.2.6.6c Railways

Not applicable.

3.2.6.6d Domestic

Not applicable.

3.2.6.7. Planned improvements

A brief description of the planned improvements is provided for the transport category here.

3.2.6.7a Domestic Aviation

To date, data collection has been quite erratic and is possibly reducing the accuracy of estimates. Moreover, the number of landings and take-offs have not been captured and the availability of this data will improve the estimates. The plan is to further consult, engage stakeholders and train them on the developed tools to capture the required data, including their QC. It is expected that this will take about 6 years as it is not a priority due to its very low level of contribution in the national estimates and will be dealt with within the framework of the preparation of future national reports.

3.2.6.7b Road transportation

Data used to compute the estimates at Tier 2 level is still based on a survey that was conducted more than a decade ago. Improving estimation at the Tier 2 level is contemplated through the following activities.

1. Conducting a new survey to obtain present data on km run by the different vehicle classes.
2. Collecting up to date data on consumption of fuel by the more recent vehicle fleet.
3. Capture data on the number of vehicles in the different vehicle classes running on gasoline and diesel more precisely.
4. Tracking number of electric and/or hybrid vehicles to integrate in fuel consumption estimates.
5. Collecting data on fuel sold by stations to quality control estimates made from number of vehicles, consumption, and km run.

Resources needed consist of funds to contract an international consultant to design and prepare the survey protocol, finalize the report thereon, prepare the data for feeding in the required format in the software and train stakeholders on the data collection tools and perform the QC, a local consultant to undertake this survey and support the report preparation, enumerators for data collection and travel costs of consultants and enumerators.

Given the size and settlements distribution in Namibia, it is anticipated that the completion of this exercise will take 4 years as from the date of availability of funds which has been earmarked under CBIT2 project under development.

3.2.6.7c Railways

Revisit, consult and engage with the Railways operators and fuel supply companies to obtain data on an annual basis automatically. The stakeholders will also have to be trained in the use of the tools for collection and transmission of data as well as QC of the data.

3.2.6.7d Domestic navigation

This activity has always proven very difficult to deal with and a full review of the situation is required. It is planned to conduct a mapping exercise to identify stakeholders involved in this activity and then consult and engage them in the inventory process. Once engaged they will be trained in the use of the tools for data collection and QC.

The resources needed for completing this exercise are mainly funds to cover the cost of an international consultant to develop and prepare the mapping exercise, finalizing the report and training the stakeholders on the tools and performing the QC, a local consultant to support this task and the report preparation, and travel costs for the consultants.

The timeline to complete this exercise is estimated to be 4 years from the date of appropriation of funds within the framework of future national reports.

3.2.7. Other sectors (CRT 1.A.4)

3.2.7.1. Category description

The Other Sectors category comprises the sub-categories Commercial/Institutional, Residential and Agriculture/Forestry/Fishing. The latter is further subdivided into Stationary combustion, Off-road Vehicles and Other Machinery and Fishing (mobile combustion). In Namibia, all these activities occur at different intensities. Estimates from Residential and Fishing activities, the major sources of emissions, have been computed and accounted for each activity while emissions from the remaining activities in this category have been included elsewhere.

Among the two subcategories assessed, Fishing emissions largely exceeded those from the Residential subcategory. Emissions fluctuated over the time series on account of quotas being allocated for fishing to preserve fish stocks. Residential emissions remained practically constant with the adoption of renewable energy sources, namely solar from PV systems and passive heating using solar water heaters amongst others.

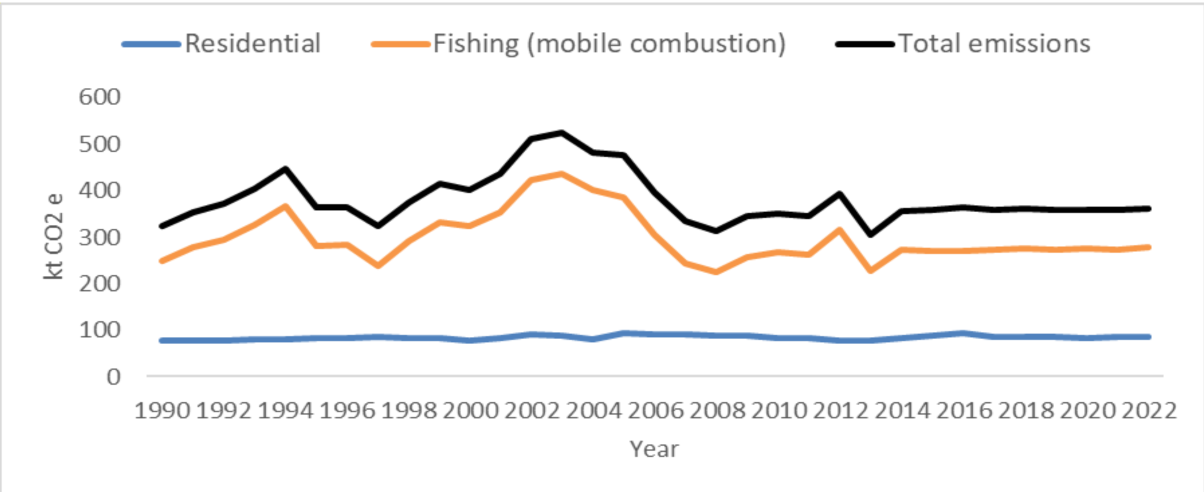

Figure 3.14. Trend of emissions (kt CO2 e) by sub-category for the “Other sectors” category (1990-2022)

CO_2 dominated the emissions (Figure 3.15) in this category but with a lightly lower contribution compared to other categories of the Energy sector. This is due to slightly more CH_4 being emitted with the use of fuelwood in the Residential subcategory.

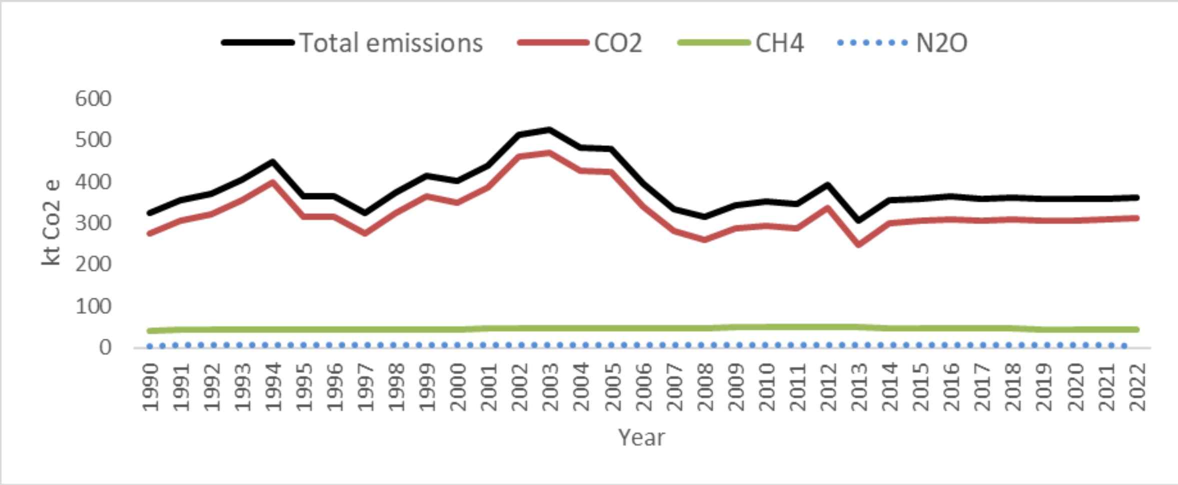

Figure 3.15. Trend of emissions (kt CO_2 e) by gas for the "Other Sectors" category (1990-2022)

Emissions increased by 12% and by 3%, that is from 324 in 1990 and 351 kt CO_2 e in 2000 to 362 kt CO_2 e in 2022. Emissions emanated mainly from Fishing (mobile combustion) activities throughout the time series. Emissions for the Other sectors category for selected years are provided in Table 3.36.

Table 3.36. Emissions (kt CO_2 e) from the Other Sectors category

Category/sub-category	1990	2000	2010	2017	2018	2019	2020	2021	2022	2022/ 1990 (% change)	2022/ 2010 (% change)
Other sectors	324	401	351	358	361	356	358	358	362	12%	3%

3.2.7.1a Commercial/Institutional

Included Elsewhere

It has not been possible to capture data for this sub-category, but the fuel has been combusted elsewhere since it is included in the national energy balance.

3.2.7.1b Residential

Emissions (Table 3.37) increased by 12% from 76 kt CO_2 e in 1990 to 85 kt CO_2 in 2022 but only slightly, by 1%, from 84 kt CO_2 e between 2010 and 2022. This lower increase is explained by the migration of people from the rural to the urban areas where they transitioned from fuelwood to alternative energy sources, coupled with adoption of solar on a personal basis or from small grids for those still staying in rural areas.

Table 3.37. Emissions (kt CO_2 e) from the Residential sub-category for selected years

Category/sub-category	1990	2000	2010	2017	2018	2019	2020	2021	2022	2022/ 1990 (% change)	2022/ 2010 (% change)
Residential	76	77	84	86	86	85	82	84	85	12%	1%

3.2.7.1c Agriculture/Forestry/Fishing

Only emissions from Fishing are estimated in this sub-category as no data are available for Agriculture and Forestry. This has been a difficult challenge and moreover it does not affect the national emissions as the fuel combusted in these activities has been included in the national energy balance. The emissions from Fishing for selected years are given in Table 3.38. They varied over the years as fishing activities are regulated by quotas for preserving fish stocks. It increased by 12% from 1990 to 2022 and only by 4% since 2010.

Table 3.38. Emissions (kt CO2 e) from the Agriculture/Forestry/Fishing sub-category

Category/sub-category	1990	2000	2010	2017	2018	2019	2020	2021	2022	2022/ 1990 (% change)	2022/ 2010 (% change)
Fishing (Mobile Combustion)	248	324	267	272	275	273	276	274	277	12	4

3.2.7.2. Methodological issues

3.2.7.2a Commercial/Institutional

Not applicable as emissions included elsewhere

3.2.7.2b Residential

The method prescribed in the IPCC 2006 guidelines has been adopted for estimating emissions using the 2006 IPCC software. AD for all years were generated, based on the census data on amount of each fuel (Table 3.39) consumed by a household and the number of households, for the years 1991, 2001 and 2011 supplemented by the intercensal data of the year 2016. AD for the years in between the censuses were generated from interpolations between two data points. The AD, for the period 2017 to 2022, used for this inventory are provided in Table 3.39.

Table 3.39. AD used for the Residential sub-category (2017-2022)

Fuel type (t)	2017	2018	2019	2020	2021	2022
Other Kerosene	1,376	1,133	1,020	879	1,020	1,133
LPG	10,125	10,611	10,780	9,809	11,054	11,231
Parafin wax	153	16	36	341	67	197
Wood fuel	335,291	329,791	324,039	318,028	311,750	305,828
Charcoal	10,000	10,000	10,000	10,000	10,000	10,000

The adopted default EFs from the IPCC 2006 guidelines for direct GHGs and the EMEP/EEA Guidebook of 2023 are given in Table 3.40.

Table 3.40. EFs used for the Residential sub-category (2017-2022)

Sub-category	Emission Factors of direct gases				
	Fuel type	Emission factor (kg/TJ)			Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories/ Volume 2/Chapter 2 - Stationary Combustion
		CO2	CH4	N2O	
	Other kerosene	71,900	10	0.6	Table 2.5
	LPG	63,100	5	0.1	" "
	Parafin wax	73,300	10	0.6	" "
	Wood fuel	112,000	300	4	" "
	Charcoal	112,000	200	1	" "
Residential	Emission Factors of indirect gases				

Sub-category	Fuel type	Emission factor (kg/TJ)				Source: EMEP/EEA air pollutant emission inventory guidebook 2023, 1.A.4 -Small combustion.
		NOx	CO	NMVOC	SO2	
Residential	Other kerosene	51.0	57.0	0.7	70.0	Table 3-5
	LPG	51.0	26.0	1.9	0.3	Table 3-4
	Parafin wax	51.0	57.0	0.7	70.0	Table 3-5
	Wood fuel	50.0	4,000	600.0	11.0	" "
	Charcoal	50.0	4,000	600.0	11.0	" "

No CO_2 was captured for all the years of the inventory.

3.2.7.2c Agriculture/Forestry/Fishing

AD used for the Fishing category are provided in Table 3.41.

Table 3.41. AD used for Fishing (2017-2022)

Fuel (t)	2017	2018	2019	2020	2021	2022
Gasoline	4,481	4,634	4,787	4,939	5,092	5,244
Diesel	80,425	81,340	80,425	81,340	80,425	81,340

The default EFs from the IPCC 2006 guidelines for direct GHGs and the EMEP/EEA guidebook for the indirect GHGs are given in Table 3.42.

Table 3.42. EFs used for Fishing category (2017-2022)

Sub-category	Emission Factors of direct gases				
Fishing	Fuel type	Emission factor (kg/TJ)			Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories/Volume 2/ Chapter 2 - Stationary Combustion
		CO2	CH4	N2O	
	Gasoline	69,300	7	2	Table 2.5.
	Diesel	74,100	7	2	" "
	Emission Factors of indirect gases				
	Fuel type	Emission factor (kg/Ton fuel)			Source: EMEP/EEA air pollutant emission inventory guidebook 2023, 1.A.3.d - Navigation Shipping.
		NOx	CO	NMVOC	SO2
	Gasoline	9.4	573.9	181.5	20.0	Table 3.4
	Diesel	72.2	3.8	1.8	1.8	Table 3.2

No CO_2 was captured for all the years of the inventory.

3.2.7.3. Description of any flexibility applied

3.2.7.3a Commercial/Institutional

Not applicable.

3.2.7.3b Residential

Not resorted to.

3.2.7.3c Agriculture/Forestry/Fishing

Not resorted to.

3.2.7.4. Uncertainty assessment and time-series consistency

3.2.7.4a Commercial/Institutional

Not applicable.

3.2.7.4b Residential

The uncertainty levels assigned to the AD (Table 3.43) and to the EFs are the default ranges from the IPCC 2006 guidelines. They are ±12.5% and ±70% for Liquid Fuels and solid Biomass respectively for AD. The uncertainty level assigned is ±7% for CO_2 and the range is -63% to 275%, depending on gas, for EFs as depicted in Table 3.43.

Table 3.43. Uncertainty levels assigned for Residential

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[2]
1.A.4.b -Residential			
1.A.4.b - Residential - Liquid Fuels	CO2	±12.5	±7
	CH4	±12.5	-70 to +200 %
	N2O	±12.5	-90 to +200 %
1.A.4.b - Residential - Biomass - solid	CO2	±70	±7
	CH4	±70	-67 to +200%
	N2O	±70	-63 to +275 %

1: Source - 2006 Guidelines, Table 2.15, Page 2.41, Chapter 2, Volume 2

2: Source - 2006 Guidelines, Paragraph 2.4.1, Page 2.38 for CO2 and Table 2.5, Page 2.22 for CH4 and N2O, Chapter 2, Volume 2

The estimated combined uncertainties are 116.1% and 106.1% for the level assessment for base year 1990 and year-t 2022 respectively and 56.3% for the trend between base year 1990 and year-t 2022 (Table 3.44).

Table 3.44. Uncertainty assessment for Residential

A	B	C	D	E	F	H	H	M
2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (kt CO2e)	Year T (2022) emissions or removals (kt CO2e)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Contribution to variance by category in year 1990	Contribution to variance by category in year 2022	Uncertainty introduced into the trend in total national emissions (%)
1.A.4.b - Residential - Liquid Fuels	CO2	29.8	37.7	12.5	7.0	31.5	40.6	76.6
1.A.4.b - Residential - Liquid Fuels	CH4	0.1	0.1	12.5	200.0	0.1	0.0	0.0
1.A.4.b - Residential - Liquid Fuels	N2O	0.0	0.0	12.5	200.0	0.0	0.0	0.0
1.A.4.b - Residential - Biomass - solid	CO2	0.0	0.0	70.0	7.0	0.0	0.0	0.0
1.A.4.b - Residential - Biomass - solid	CH4	41.1	41.7	70.0	200.0	13100.4	10911.8	3049.3
1.A.4.b - Residential - Biomass - solid	N2O	5.1	5.1	70.0	275.0	355.6	296.4	47.7
Sum		76.2	84.6		Sum	13487.5	11248.9	3173.5
Uncertainty in level and trend						116.1	106.1	56.3

The time series is consistent as the AD have always been sourced from the same institution, the default EFs of IPCC used as well as a common methodology for all the years of the time series.

3.2.7.4c Agriculture/Forestry/Fishing

The uncertainty levels assigned to the AD (Table 3.45) are ±25% and for the EFs, default ranges of ±2 for CO2 and ±50 for CH4 and -40 to 140% for N2O. All uncertainty values from the IPCC 2006 have been allocated.

Table 3.45. Uncertainty levels assigned for Fishing

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[1]
1.A.4.c.iii -Fishing			
1.A.4.c.iii - Fishing - Liquid Fuels	CO2	±25	-2 to +2
	CH4	±25	-50 to + 50

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[1]
	N2O	±25	-40 to + 140

1: Source - 2006 Guidelines, Page 3.54, Chapter 3, Volume 2

The estimated combined uncertainties are 24.9% for the level assessment for both the base year 1990 and year-t 2022 and 39.2% for the trend between base year 1990 and year-t 2022 (Table 3.46).

Table 3.46. Uncertainty assessment for Fishing

A	B	C	D	E	F	H	H	M
2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (kt CO2e)	Year T (2022) emissions or removals (kt CO2e)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Contribution to variance by category in year 1990	Contribution to variance by category in year 2022	Uncertainty introduced into the trend in total national emissions (%)
1.A.4.c.iii - Fishing - Liquid Fuels	CO2	246.6	275.3	25.0	2.0	621.6	621.6	1539.7
1.A.4.c.iii - Fishing - Liquid Fuels	CH4	0.9	1.0	25.0	50.0	0.0	0.0	0.0
1.A.4.c.iii - Fishing - Liquid Fuels	N2O	0.5	0.6	25.0	140.0	0.1	0.1	0.0
Sum		248.0	276.9		Sum	621.7	621.7	1539.8
Uncertainty in level and trend						24.9	24.9	39.2

The time series is consistent as the AD have always been sourced from the same institution, the default EFs of IPCC used as well as a common methodology for all the years of the time series.

3.2.7.5. QA/QC and verification

3.2.7.5a Commercial/Institutional

Not applicable.

3.2.7.5b Residential

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, AD in terms of fuel by type combusted for Residential, the appropriate default EFs, time-series consistency, transcription accuracy, the calculations, reference material and conversion factors. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

3.2.7.5c Agriculture/Forestry/Fishing

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, AD in terms of fuel by type combusted for Fishing, the appropriate default EFs, time-series consistency, transcription accuracy, the calculations, reference material and conversion factors. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

3.2.7.6. Recalculations

Not applicable.

3.2.7.6a Commercial/Institutional

Not applicable.

3.2.7.6b Residential

Not applicable.

3.2.7.6c Agriculture/Forestry/Fishing

Not applicable.

3.2.7.7. Planned improvements

3.2.7.7a Commercial/Institutional

To date, it has not been possible to collect data for this sub-category, but the fuel has been included elsewhere as it is comprised in the national energy balance. To improve the accuracy of estimates, it is planned to remedy this shortcoming. Commercial and Institutional operators will be mapped to identify those which are contributing to emissions. They will then be consulted, engaged and trained on the tools to capture and submit the required data, including their QC. It is expected that this will take about 4 years and will be dealt with within the framework of the preparation of future national reports.

3.2.7.7b Residential

No planned improvement.

3.2.7.7c Agriculture/Forestry/Fishing

AD has not been collected to date on fuel burned for Agricultural and Forestry activities due to lack of resources and since these two areas are not expected to contribute to significant emissions. Nevertheless, the fuel consumed is within the national energy balance meaning that its emissions have been included elsewhere as already reported. It is planned to improve the completeness of the inventory through data capture on them in the future.

Operators in these areas will be mapped to identify those which are contributing to emissions. They will then be consulted, engaged and trained on the tools to capture the required data, including their QC. It is expected that this will take about 4 years and will be dealt with within the framework of the preparation of future national reports.

3.2.8. Other (CRT 1.A.5)

3.2.8.1. Category description

The Other category comprises Stationary and Mobile combustion of fuels. Fuel accounted for in the energy balance but not allocated to any other transport sub-category has been burned and emissions estimated in this category under the sub-category Mobile (Other).

Emissions under the Mobile (Other) sub-category increased from 1990 to 2016 generally and regressed after up to 2022. This is due to improved tracking of vehicles and their classification in their respective IPCC classes. The emissions peaked at 139.5 kt CO2 e in 2016 (Figure 3.16).

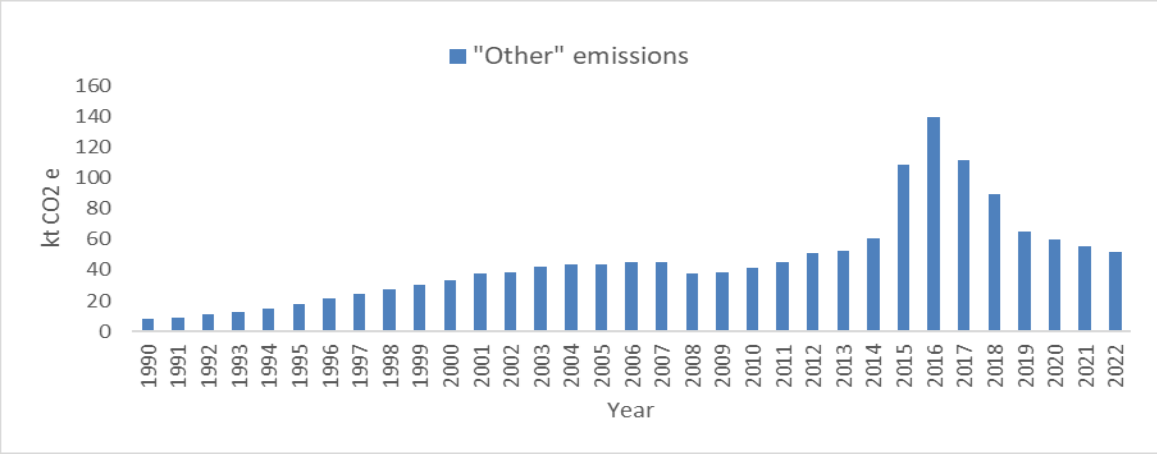

Figure 3.16. Trend of emissions (kt CO2 e) for the Other (mobile) category (1990-2022)

Once more the highest contributor among the 3 direct gases is CO_2 with more than 98%. The emission by gas is given in Figure 3.17.

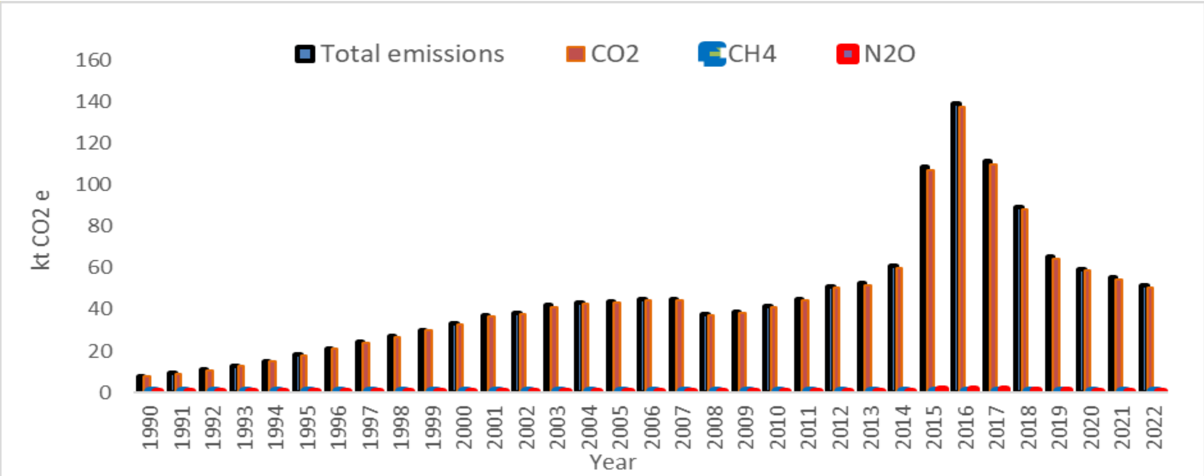

Figure 3.17. Trend of emissions (kt CO2 e) by gas for the category Other (mobile) (1990-2022)

Emissions, provided in Table 3.47, were estimated at 8 kt CO_2 e in 1990, 41 kt CO_2 e in 2010 and 51 kt CO_2 e in 2022. This represented increases of 538% and 24% for 2022 relative to 1990 and 2010.

Table 3.47. Emissions (kt CO2 e) from Other (mobile) category for selected years

Category	1990	2000	2010	2017	2018	2019	2020	2021	2022	2022/1990 (% change)	2022/2010 (% change)
Other (mobile)	8	33	41	111	90	65	60	55	51	538%	24%

3.2.8.2. Methodological issues

The method prescribed in the IPCC 2006 guidelines was adopted for estimating emissions using the 2006 IPCC software. AD for all years were generated based on the annual national energy balance. The AD, for the period 2017 to 2022, used for this inventory are provided in Table 3.48.

Table 3.48. AD used the Other (mobile) category (2017-2022)

Fuel (t)	2017	2018	2019	2020	2021	2022
Gasoline	594	477	348	317	295	274
Diesel	33,871	27,208	19,879	18,090	16,818	15,636

The default EFs, adopted from the IPCC 2006 guidelines for the direct GHGs and from the EMEP/EEA Guidebook of 2023 are given in Table 3.49.

Table 3.49. EFs used for the Other (mobile) sub-category (2017-2022)

Sub-category	Emission Factors of direct gases				
	Fuel type	Emission factor (kg/TJ)			Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories/ Volume 2/Chapter 3 - Mobile Combustion
		CO_2	CH_4	N_2O	
Mobile (Other)	Gasoline	69,300	33	3.2	Tables 3.2.1 and 3.2.2.
	Diesel	74,100	3.9	3.9	" "

Sub-category	Emission Factors of indirect gases					
	Fuel type	Emission factor (g/kg fuel)				Source: EMEP/EEA air pollutant emission inventory guidebook 2023, 1.A.3.b. i-iv: Road Transport
		NO_x	CO	NMVOC	SO_2[1]	
Mobile (Other)	Gasoline	13.22	152.30	14.59	0.02	Tables 3.5 and 3-6
	Diesel	14.9	7.4	1.5	0.1	" "

1: See comments on SO2 calculation at Table 3.26 on EFs for Road Transportation

3.2.8.3. Flexibility

Not resorted to.

3.2.8.4. Uncertainty assessment and time-series consistency

The uncertainty levels assigned to the AD (Table 3.50) is ±5% while for the EFs, the default values from the IPCC 2006 guidelines, ±3.5% for CO_2 and a range from -67% to 217% for CH_4 and N_2O as depicted in Table 3.50 has been used.

Table 3.50. Uncertainty levels assigned for the Other (mobile) category

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[2]
1.A.5.b. Mobile (Other)			
1.A.5.b. Mobile (Other) - Liquid Fuels	CO_2	±5	±3.5
	CH_4	±5	-67 to +207
	N_2O	±5	-68 to +217

1: Source - 2006 Guidelines, Page 3.30, Chapter 3, Volume 2

2: Source - 2006 Guidelines, Paragraph 3.2.2, Page 3.29 for CO2 and Table 3.3.2, Page 3.21 for CH4 and N2O, Chapter 3, Volume 2

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The estimated combined uncertainties are 6.7% for the level assessment for both the base year 1990 and year-t 2022, and 45.5% for the trend between base year 1990 and year-t 2022 (Table 3.51).

Table 3.51. Uncertainty assessment for the Other (mobile) category

A	B	C	D	E	F	H	H	M
2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (kt CO2e)	Year T (2022) emissions or removals (kt CO2e)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Contribution to variance by category in year 1990	Contribution to variance by category in year 2022	Uncertainty introduced into the trend in total national emissions
1.A.5.b - Other (Mobile) - Liquid Fuels	CO2	7.8	50.7	5.0	3.5	36.1	36.1	2066.0
1.A.5.b - Other (Mobile) - Liquid Fuels	CH4	0.0	0.1	5.0	207.0	0.1	0.1	0.1
1.A.5.b - Other (Mobile) - Liquid Fuels	N2O	0.1	0.7	5.0	217.0	8.9	8.8	0.4
Sum		7.9	51.5		Sum	45.1	45.1	2066.5
Uncertainty in level and trend						6.7	6.7	45.5

The time series is consistent as the AD have always been sourced from the same institution, the default EFs of IPCC used as well as a common methodology for all the years of the time series.

3.2.8.5. QA/QC and verification

The quality control checks were in line with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, AD, the appropriate default EFs, time-series consistency, transcription accuracy, the calculations, reference material and conversion factors. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

3.2.8.6. Recalculations

Not applicable.

3.2.8.7. Planned improvements

No planned improvement.

3.3. Fugitive emissions from solid fuels and oil and natural gas and other emissions from energy production (CRT 1.B)

Fugitive emissions comprise two categories, Solid Fuels and Oil, natural gas and other emissions from energy production. Solid Fuels is further subdivided into Coal Mining and Handling, and Fuel Transformation which contain several activity areas, and Other. Only two subcategories are concerned with emissions of Fugitive emissions, namely Fuel Transformation under Solid Fuels, and Oil exploration under Oil and Natural Gas. Both activity areas are covered in this inventory for the years applicable. Emissions are solely from Charcoal and Biochar production for most years as Oil exploration is new and concerns only the 3 recent years.

Emissions from the Solid fuels category which was almost constant from 1990 to 2005 started increasing as from the year 2016 due to development of charcoal production to control invasive bush negative impacts on the carrying capacity of grasslands. It increased steadily following increased charcoal production and shot up substantially in 2022 with the advent of industrial Biochar production as a mitigation measure for enhanced control of the invasive bush. The Oil and gas category through the Exploration subcategory contributed at most 0.2 kt CO2 e and started only in 2018. The emissions for the category and its subcategories are provided in Figure 3.18.

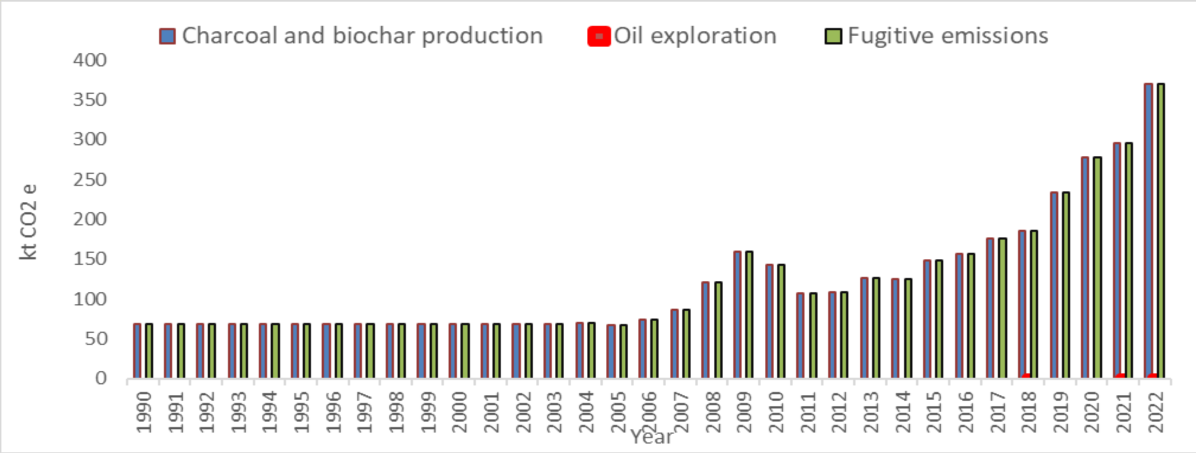

Figure 3.18. Trend of emissions (kt CO2 e) by sub-category for the Fugitive emissions from fuels (1990-2022)

The trend of aggregated emissions for the 3 direct gases are presented in Figure 3.19. In this category, most emissions consisted of CH4 over the full time series. CO2 emissions were almost non-existent until oil exploration started in 2018.

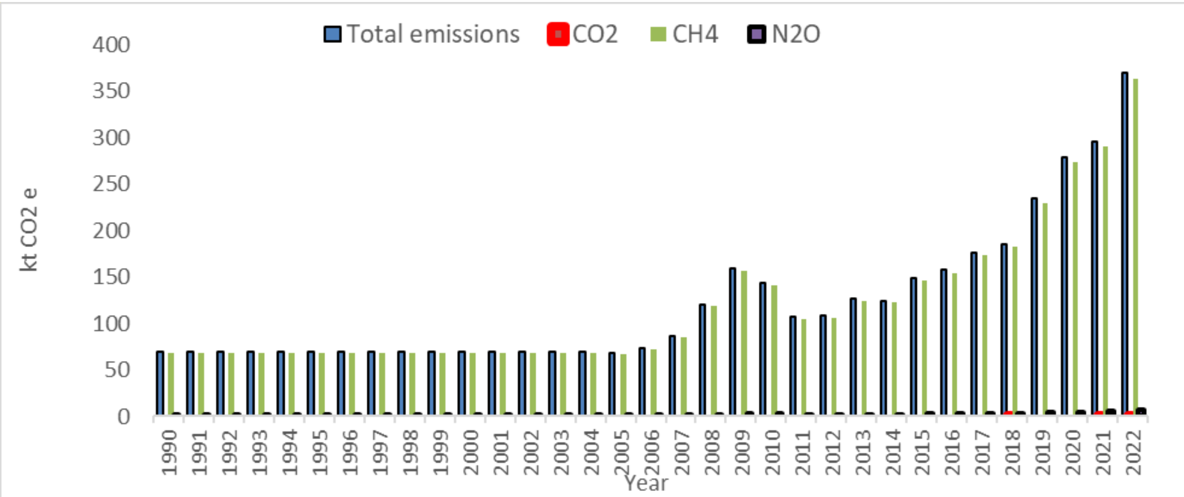

Figure 3.19. Trend of emissions (kt CO2 e) by gas for the Fugitive emissions category (1990-2022)

Emissions from the Fugitive sub-sector are given for selected years in Table 3.52. Charcoal and Biochar production were the sole contributing subcategories under Solid fuels except for the years 2018, 2021 and 2022 when exploration for oil took place on a small scale. Total emissions increased from 69 kt CO2 e in 1990 to 370 kt CO2 e in 2022 which represents an increase of 536%.

Table 3.52. Fugitive emissions (kt CO2 e)

Year	1990	2000	2010	2017	2018	2019	2020	2021	2022
Fugitive emissions	69	69	143	176	185	234	278	296	370

3.4. Solid fuels (CRT 1.B.1)

3.4.1. Category description

The single activity, Fuel Transformation, occurring in the category Solid Fuels is Charcoal and Biochar production. The trend of emissions is provided in Figure 3.20.

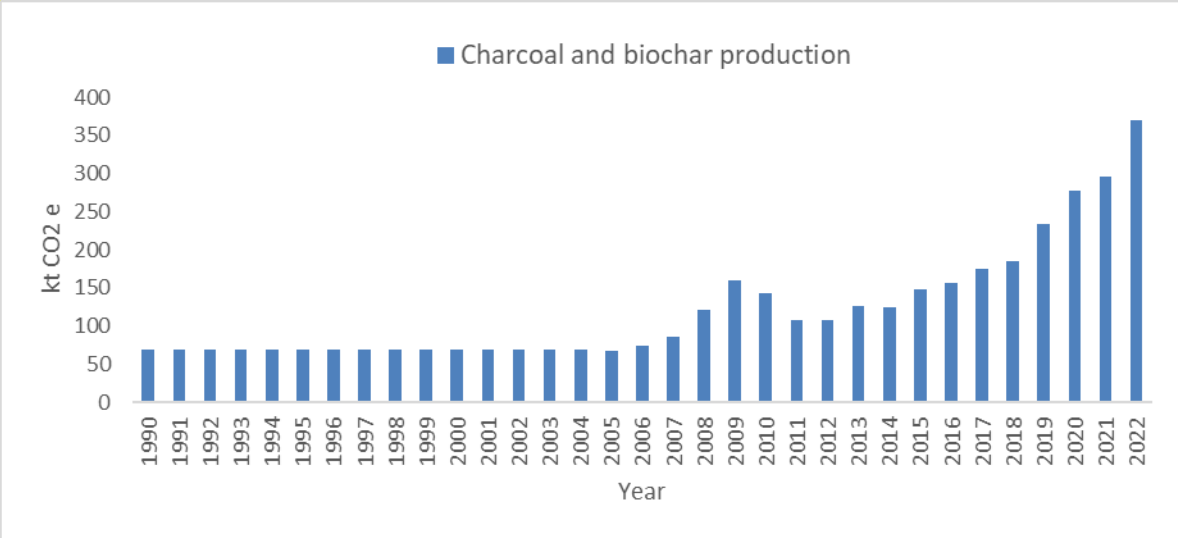

Figure 3.20. Trend of emissions (kt CO2 e) by sub-category, Charcoal and biochar production (1990-2022)

Emissions which were at 69 kt CO2 e from 1990 to 2000 increased regularly to 370 kt CO2 e in 2022 (536%) on account of higher levels of charcoal production and more recently of Biochar as from the year 2022. Emissions for selected years are provided in Table 3.53.

Table 3.53. Emissions (kt CO2 e) from Charcoal and biochar production

Year	1990	2000	2010	2017	2018	2019	2020	2021	2022
Charcoal and biochar production	69	69	143	176	185	234	278	296	370

The trend of emissions by gas is presented in Figure 3.21. CH4 dominated the emissions in this category with no CO2 and very small amounts of N2O since the feedstock is biomass.

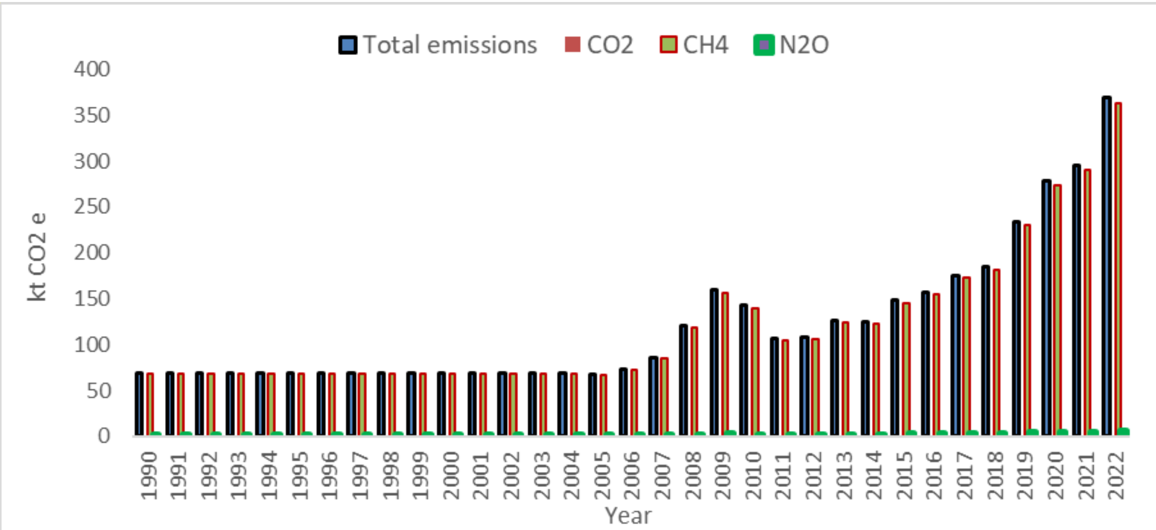

Figure 3.21. Trend of emissions (kt CO2 e) by gas for the category, Charcoal and biochar production (1990-2022)

The trend of emissions by gas for the Oil and gas category for activities under Oil exploration shows a more balanced contribution from the 3 direct gases.

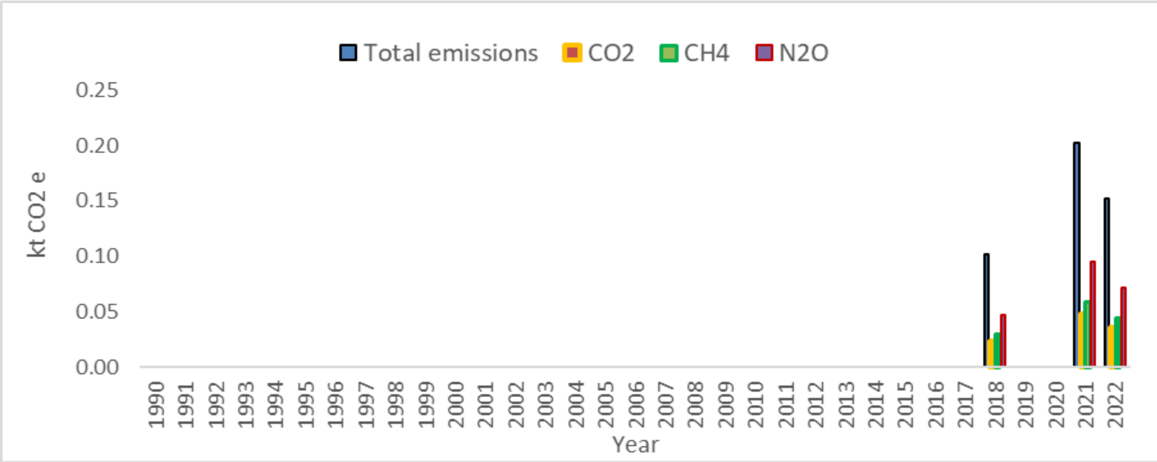

Figure 3.22. Trends of emissions (kt CO2 e) by gas for sub-category, Oil exploration (1990-2022)

3.4.2. Methodological issues

The chosen method is Tier 1 level from the 2019 Refinements of the IPCC 2006 guidelines and national AD and default EFs used are provided in Tables 3.54 and 3.55 respectively.

Table 3.54. AD used for Charcoal and biochar production (2017-2022)

Fuel (t)	2017	2018	2019	2020	2021	2022
Charcoal production	144,684	157,059	199,376	234,013	245,778	300,387
Biochar production [1]	11,191	5,560	5,560	10,623	15,687	29,501

Note 1: Biochar production for year 2022 includes 667 tonnes as being treated with methane recovery

(1) Source: Charcoal production - Trade statistics, NHIES report and Cement producer 1

(2) Source: Biochar production - Namibian Encroacher Bush (Published by the Charcoal Association) - Published 2020

Table 3.55. EFs used for Charcoal and biochar production (2017-2022)

Sub-category	Emission Factors of direct gases					
	Fuel type	Emission factor (kg/TJ)				Source: 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories/ Volume 2/Chapter 4 - Fugitive Emissions
		CO2	CH4	N2O		
	Charcoal production	1,570	40.3	0.08		Table 4.3.3 (New)
	Biochar production	4,300	30	NA		" "
Charcoal and biochar production	Emission Factors of indirect gases					
	Fuel type	Emission factor (kg/Ton fuel)				Source: 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories/ Volume 2/Chapter 4 - Fugitive Emissions
		NOx	CO	NMVOC	SO2	
	Charcoal production	0.07	220.0	NA	NA	Table 4.3.3 (New)
	Biochar production	0.4	54.0	NA	NA	" "

No CO2 was captured and stored.

3.4.3. Flexibility

Not resorted to.

3.4.4. Uncertainty assessment and time-series consistency

The uncertainties assigned to the AD (Table 3.56) are ±10% and the ranges, -38 to +60 for CO2, -68 to +121 for CH4 and -75 to 163 from the IPCC 2006 guidelines for the default EFs. The uncertainties provided for charcoal production has been assigned to biochar production also as it is the dominating activity under this category and only one set of values can be entered in the software.

Table 3.56. Uncertainty levels assigned for Charcoal and biochar production

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[1,2]
1.B -Fugitive emissions from fuels			
1.B.1.c.i - Charcoal and biochar production	CO2	±10	-38 to +60
	CH4	±10	-68 to +121
	N2O	±10	-75 to +163

1: Uncertainty assigned according to expert judgement.

2: Source - 2019 Refinement to the 2006 Guidelines, Table 4.3.3, Page 4.103, Chapter 4, Volume 2.

The combined uncertainties determined by using the tool developed in an Excel worksheet in line with the methods contained in the IPCC 2006 guidelines are provided in Table 3.57 for this sub-category.

The level assessment uncertainties for the base year 1990 and year-t (2022) are 119.2% and 119.4% respectively while the trend assessment with 1990 as base year and 2022 as year-t is 74.5%.

Table 3.57. Uncertainty assessment for sub-category – Charcoal and biochar production

A	B	C	D	E	F	H	H	M
2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (kt CO2e)	Year T (2022) emissions or removals (kt CO2e)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Contribution to variance by category in year 1990	Contribution to variance by category in year 2022	Uncertainty introduced into the trend in total national emissions (%)
1.B.1.b.i - Charcoal and biochar production	CO2	0.0	0.0	10.0	60.0	0.0	0.0	0.0
1.B.1.b.i - Charcoal and biochar production	CH4	67.7	363.2	10.0	121.0	14202.3	14237.3	5545.2
1.B.1.b.i - Charcoal and biochar production	N2O	1.3	6.4	10.0	163.0	9.1	7.9	2.8
Sum		69.0	369.5		Sum	14211.4	14245.2	5548.0
Uncertainty in level and trend						119.2	119.4	74.5

The time series is consistent as the AD have always been sourced from the same institution, the default EFs of IPCC used as well as a common methodology for all the years of the time series.

3.4.5. QA/QC and verification

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, procedures for generating AD, the appropriate default EFs, time-series consistency, transcription accuracy, the calculations, reference material and conversion factors. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

3.4.6. Recalculations

Not applicable.

3.4.7. Planned improvement

Charcoal production is an activity which occurred during all years of the time series while Biochar production increased drastically in 2022 with the commissioning of an industrial plant. Collection of good AD for production has always been a challenge. Thus, the amount of charcoal and Biochar produced have been estimated from the imports and exports data including an allocation for national use. The improvement contemplated will be through the collection of production data from producers. Since the activity is widely distributed across the country, this will be a lengthy exercise. A fresh analysis of the situation will be undertaken during the preparation of the BTR2 with a view to devising a robust improvement plan for implementation. At this stage it is foreseen that this will be completed in about 6 years' time as from the date of availability of funds.

3.5. Category (CRT 1.B.2)

3.5.1. Category description

The single activity Exploration under Oil and Gas occurred for the three years 2018, 2021 and 2022 only.

Emissions were insignificant at 0.1 in 2018 and 0.2 kt CO_2 e for 2021 and 2022.

3.5.2. Methodological issues

The chosen method is Tier 1 level from the IPCC 2006 guidelines using national AD and default EFs that are provided in Tables 3.58 and 3.59 respectively.

Table 3.58. AD used for Oil exploration (2017-2022)

Sub-category	Unit	2017	2018	2019	2020	2021	2022
Oil - exploration	Number of wells	0	2	0	0	4	3

Table 3.59. EFs used for Oil - exploration (2017-2022)

<table>
<tr><th>Sub-category</th><th colspan="6">Emission Factors of direct gases</th></tr>
<tr><td rowspan="7">Oil – Exploration (Onshore conventional)</td><td rowspan="2">Unit</td><td colspan="4">Emission factor (kt/well)</td><td rowspan="2">Source: 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories/ Volume 2/Chapter 4 - Fugitive Emissions</td></tr>
<tr><td colspan="2">CO_2</td><td>CH_4</td><td>N_2O</td></tr>
<tr><td>Number of wells</td><td colspan="2">0.012</td><td>5.3E-04</td><td>9.0E-05</td><td>Table 4.2.4 (Updated)</td></tr>
<tr><td colspan="6">Emission Factors of indirect gases</td></tr>
<tr><td rowspan="2">Fuel type</td><td colspan="4">Emission factor (ton/Unit)</td><td rowspan="2">Source: 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories/ Volume 2/Chapter 4 - Fugitive Emissions</td></tr>
<tr><td>NO_x</td><td>CO</td><td>NMVOC</td><td>SO_2</td></tr>
<tr><td>Number of wells</td><td>N/A</td><td>N/A</td><td>0.08</td><td>N/A</td><td>Table 4.2.4 (Updated)</td></tr>
</table>

No CO_2 was captured and stored.

3.5.3. Description of any flexibility applied

Not resorted to.

3.5.4. Uncertainty assessment and time-series consistency

The uncertainties assigned to the AD (Table 3.60) are ±0.1% and the range ±30% for CO_2 and CH_4, and -10 to +999.0%, from the IPCC 2006 guidelines for the EFs given that they are the default values.

Table 3.60. Uncertainty levels assigned for Charcoal and Biochar production

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[1,2]
1.B -Fugitive emissions from fuels			
1.B.2.a.iii.1 – Oil - Exploration [2]	CO2	±0.1	±30
	CH4	±0.1	±30
	N2O	±0.1	-10 to +999.0

1: Source – Administrative data from Ministry of Mines and Energy.

2: Source - 2019 Refinement to the 2006 Guidelines for National Greenhouse Gas Inventories, Table 4.2.4 (Updated), Page 4.50, Chapter 4, Volume 2

The combined uncertainties were determined using the tool generated in an Excel worksheet in line with the methods contained in the IPCC 2006 guidelines for this sub-category. The level of uncertainty for the year-t (2022) is 470% (Table 3.61). There exists no trend assessment as in 1990 there was no Oil exploration being done.

Table 3.61. Uncertainty assessment for sub-category Oil - Exploration

A	B	C	D	E	F	H	H	M
2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (kt CO2e)	Year T (2022) emissions or removals (kt CO2e)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Contribution to variance by category in year 1990	Contribution to variance by category in year 2022	Uncertainty introduced into the trend in total national emissions
1.B.2.a.i - Exploration	CO2	NA	0.0	0.1	30.0	NA	50.4	NA
1.B.2.a.i - Exploration	CH4	NA	0.0	0,1	30.0	NA	77.1	NA
1.B.2.a.i - Exploration	N2O	NA	0.1	0,1	1000.0	NA	221376.8	NA
Sum		NA	0.2		Sum	NA	221504.4	NA
Uncertainty in level and trend						NA	471	NA

The time series is consistent as the AD have always been sourced from the same institution, the default EFs of IPCC used as well as a common methodology for all the years of the time series.

3.5.5. QA/QC and verification

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, AD from explorers' licenses delivered, the appropriate default EFs, time-series consistency, transcription accuracy, the calculations, reference material and conversion factors. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

3.5.6. Recalculations

Not applicable.

3.5.7. Planned improvements

No category specific improvement.

Chapter 4. Industrial processes and product use (CRT sector 2) IPPU

4.1. Overview of the sector

During these processes, various GHGs, including CO_2, CH_4, N_2O, HFCs and PFCs, can be produced (2019 Refinement to IPCC 2006 Guidelines for National GHG Inventories V3_Ch 1) and emitted. Other gases also emitted in different sub-categories include SF6 and NMVOCs.

Industrial production is not well developed in Namibia with only a few sub-categories from 5 categories accounting for the emissions (Table 4.1). Sub-categories not estimated are Fire protection, Aerosols and Solvents of the Products uses as Substitutes for Ozone Depleting Substances and electrical equipment of the Other Product manufacture and Use category. All other subcategories are not occurring in Namibia.

Table 4.1. IPPU sector categories and sub-categories with emissions occurring

Sectoral Categories	Sub-Categories from which emissions are reported
2.A Mineral Industry	2.A.1 - Cement production only
2.D Non-Energy Products from Fuels and Solvent	2.D.1 - Lubricant Use 2.D.2 – Paraffin wax use 2.D.3.b – Solvent Use - Paint application 2.D.3.c – Solvent Use - Asphalt and bitumen
2.F Product Uses as Substitutes for Ozone Depleting Substances	2.F.1 - Refrigeration and Air Conditioning only
2.G Other Product Manufacture and Use	2.G.1 – Use of electrical equipment 2.G.3 - Medical Applications of N_2O
2.H Other	2.H.2 - Food and Beverages Industry 2.H.2.a - Beer manufacturing 2.H.2.a - Breadmaking

The trend of emissions for the time series 1990 to 2022 is provided in Figure 4.1 and in Table 4.2 for selected years.

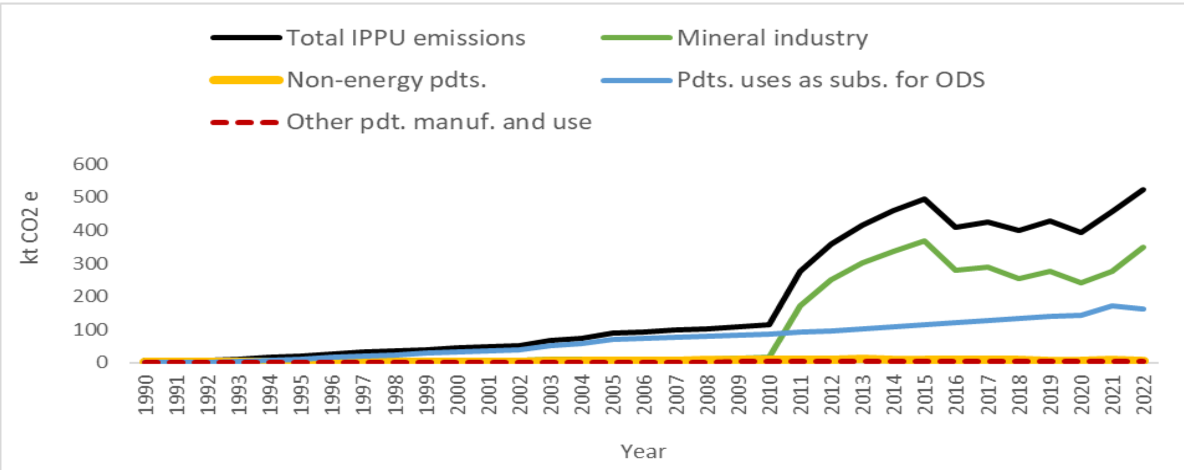

Figure 4.1. Trend of emissions (kt CO2 e) by category for the IPPU sector (1990-2022)

Emissions from the IPPU sector were insignificant in 1990 but increased significantly as from 2011 when cement production activities commenced. Hence, the emissions of 7 kt CO2 e of 1990 increased to only 44 kt CO2 e in 2000 and more than doubled in 2010 to 113 kt CO2 e. It further increased up to 2022 to reach 523 kt CO2 e with increased cement production coupled with emissions from

Refrigeration and Air Conditioning. Emissions from Lime production ceased as from the year 2017. The other sub-categories contributed minimal amounts in 2022.

Table 4.2. Emissions (kt CO2 e) of the IPPU sector

	1990	2000	2010	2017	2018	2019	2020	2021	2022
IPPU	7.1	44.0	113.4	425.7	399.6	426.8	393.3	457.6	522.5
2.A - Mineral Industry	2.2	7.1	15.2	287.7	254.8	276.7	240.7	274.9	350.5
2.D - Non-energy products from fuel and solvents use	3.8	3.6	9.0	7.4	7.2	7.0	6.0	8.1	7.0
2.F - Products Uses as Substitutes for Ozone Depleting Substances	NO	31.7	86.7	127.2	134.1	139.6	143.0	171.0	161.2
2G - Other Product Manufacture and Use	1.1	1.7	2.5	3.3	3.4	3.5	3.6	3.7	3.7

A mix of IPCC tiers 1 and 2 have been used to compute emissions in this sector. The methodological tiers by category/subcategory, including completeness are provided in Tables 1.1 and 1.5 earlier in this report.

4.2. Mineral Industry - Cement production (CRT 2.(I))

4.2.1. Category description

Portland cement represents the major share of all cement produced in Namibia while the rest is masonry and other cement (personal communication). The Cement Production category considers carbon dioxide (CO2) emissions associated with the production of clinker used in both Portland and other cement (IPCC, 2007). There are 2 facilities producing clinker and cement in Namibia and both use dry kilns. These plants are sited around Otzojonzupa in the central part of the country. The Cement Production sub-category accounted for 351 kt of Namibia's total emissions in 2022. Emissions resulting from the combustion of fossil fuels to generate heat to drive the reaction in the kiln have been estimated under the Energy sector as per the IPCC 2006 Guidelines. Production of lime which was an emitting activity ceased as from the year 2015 and is hence not included.

The trend of emissions for the Mineral Industry category is presented in Figure 4.2. and Table 4.3. Emissions increased from 2.2 kt CO2 e in 1990 when it originated from lime production only to jump to 171.1 kt CO2 e in 2011 with the commencement of Cement production to further increase to 351 kt CO2 e in 2022.

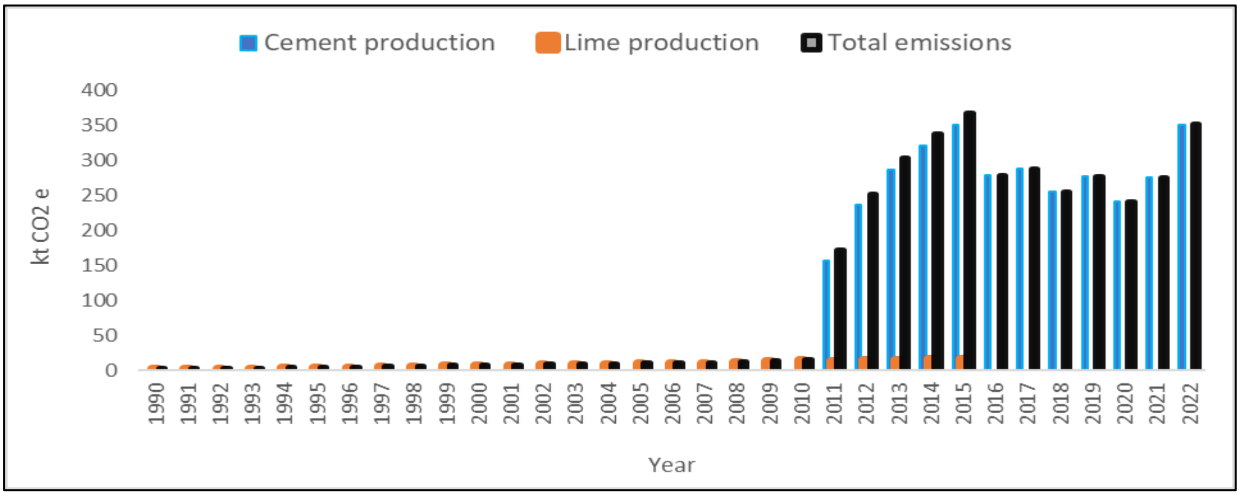

Figure 4.2. Emissions (kt CO2 e) from Mineral industry (1990-2022)

Table 4.3. Emissions (kt CO2 e) from Mineral Industry for selected years

Year	1990	2000	2010	2017	2018	2019	2020	2021	2022
Mineral Industry	2.2	7.1	15.2	287.7	254.8	276.7	240.7	274.9	350.5
2.A.1 - Cement production	NO	NO	NO	287.7	254.8	276.7	240.7	274.9	350.5
2.A.2 – Lime production	2.2	7.1	15.2	NO	NO	NO	NO	NO	NO

4.2.2. Methodological issues

The Tier 2 method (Equation 1 below) based on clinker production was used for one plant where disaggregated data was available and Tier I (Equation 2 below) for the one with no detailed production data.

Equation 1

CO2 emissions = Clinker Amount X Emissions Factor[a] X Correction Factor for Kiln Dust[b]

Equation 2

CO2 emissions = [(Mass balance of cement[c] x Clinker fraction in cement) + (mass balance of clinker[c])] X Default emission factor for clinker

Where

a	= Emission factor determined with fraction of calcium oxide fraction in clinker and corrected for magnesium oxide in clinker
b	= 2% used as per good practice
c	= Mass balance = Local Consumption – import + export

Plant data has been obtained from one producer only. Hence emissions from cement production were estimated based on a mass balance considering known production from one producer, imports, exports and estimated amounts used nationally. Clinker production from one plant was 373,971 tons and cement production of the other facility estimated at 337,137 tons for 2022. The activity data used for the period 2017 to 2022 are given in Table 4.4.

Table 4.4. Activity data used for estimating emissions from Cement Production (t) for selected years

	2017	2018	2019	2020	2021	2022
Plant 1 (Clinker production)	522,392	409,838	268,121	280,745	336,659	373,971
Plant 2 (Cement production)	Not operational	195,767	329,158	204,909	220,798	337,137

The emission factors used for the period 2017 to 2022 are from the IPCC 2006 Guidelines (Volume 3, Chapter 2, Mineral Industry) and given in Table 4.5.

Table 4.5. Emission Factors (t CO2/ t clinker) used for estimating emissions from Cement Production for selected years

		2017	2018	2019	2020	2021	2022
Plant 1 - Clinker production	EF for clinker CaCO3	0.52	0.52	0.52	0.52	0.52	0.51
	EF clinker adjusted for MgCO3	0.54	0.54	0.54	0.54	0.54	0.54
Plant 2 - Cement production	Clinker fraction in cement (%)	0.75	0.75	0.75	0.75	0.75	0.75
	EF for clinker	0.52	0.52	0.52	0.52	0.52	0.52

No CO2 was captured.

4.2.3. Flexibility

Not resorted to.

4.2.4. Uncertainty assessment and time-series consistency

The uncertainty levels assigned to the AD (Table 4.6) are ±2 for producer 1 and ±5 for producer 2. Those for EFs are ±5 for producer 1 and ±70 for producer 2, which is the default range from the IPCC 2006 guidelines.

Table 4.6. Uncertainty levels assigned for Cement production

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[2]
2.A. Mineral industry			
2.A.1. Cement production	CO2	±2 and ±5	±5 and ±70
2.A.2. Lime production	CO2	NA	NA

1: Source - 2006 Guidelines, Table 2.3, Page 2.17, Chapter 2, Volume 3
2: Source - 2006 Guidelines, Table 2.3, Page 2.17, Chapter 2, Volume 3

The estimated combined uncertainties are 15.9% for the level assessment for base year 1990 and 78% for the year-t 2022 while for the trend between base year 1990 and year-t 2022 (Table 4.7), it is 13,480%. This latter level of uncertainty is explained by the fact that the time series is not complete for both activity areas.

Table 4.7. Uncertainty assessment for cement production

2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (Kt CO2e)	Year T (2022) emissions or removals (Kt CO2e)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in base year- 1990	Contribution to Variance by Category in Year T - 2022	Uncertainty introduced into the trend in total national emissions (%)
2.A.1 - Cement production	CO2	0.0	350.5	35.1	70.2	78	0	6154	181621010
2.A.2 - Lime production	CO2	2.2	0.0	15.8	2.0	16	254	0	96461
Sum		**2.2**	**350.5**			**Sum**	254	6154	181717471
						Uncertainty in level and trend	**L - 15.9**	**L - 78.4**	**T - 13480.3**

4.2.5. QA/QC and verification

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method and AD, the appropriate default or plant specific EFs, time-series consistency, transcription accuracy, the calculations, reference material and conversion factors. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

4.2.6. Recalculations

Not applicable.

4.2.7. Planned improvements

The planned improvement consists in convincing the second plant to provide plant specific AD to make estimates at the Tier 2 level. However, this does not appear to be an easy task given that this producer has not responded despite numerous requests. Steps will be taken to investigate the possibility of applying any legislation to oblige this producer to submit the required data. Given this delicate context, it is foreseen that this improvement will drag over the next 3 years. This improvement will be attempted during the preparation of the BTR2.

4.3. Non-energy products from fuels and solvent use (CRT 2.(I))

4.3.1. Category description

The four sub-categories Lubricant Use, Paraffin wax use, Solvent Use (Paint application and Solvent Use), Asphalt and bitumen contribute to emissions in this category. Lubricants are used in vehicles, engines and machines, Paraffin wax in the residential sector, Paint in various sectors of the economy, and Asphalt in road tarring and roof protection while bitumen is primarily used for treating rail sleepers. Only 2 sub-categories out of the four reported emitted CO2, namely Lubricant Use and Paraffin Wax Use. The other gas emitted is primarily NMVOCs.

The trend of emissions from Fuels and solvent use for the time series 1990 to 2022 is provided in Figure 4.3. and Table 4.8. Emissions of CO2 varied between 3.8 kt CO2 e and 9.0 kt CO2 e over the time series 1990 to 2022 with a peak of 9.0 kt CO2 e in 2010. Out of the two sub-categories, Lubricant Use contributed over 90% of the emissions in all years of the time series. Emissions increased by 84% from 1990 to 2022.

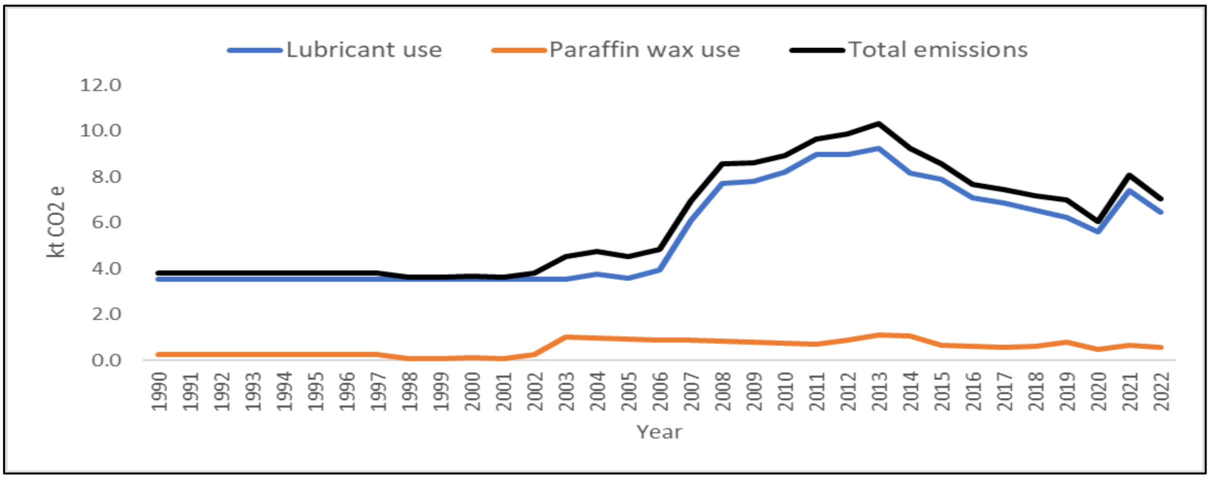

Figure 4.3. Emissions trend (kt CO2 e) from Non-Energy products from Fuels and solvent use (1990-2022)

Table 4.8. Emissions (kt CO2 e) from Non-Energy products from Fuels and solvent use for selected years

	1990	2000	2010	2017	2018	2019	2020	2021	2022
Non-Energy Products	3.8	3.6	9.0	7.4	7.2	7.0	6.0	8.1	7.0

4.3.2. Methodological issues

The IPCC Tier 1 method has been used for estimating CO2 emissions while for the indirect gases, it is the EMEP/EEA Guidebook at Tier 1 level.

Activity data used (Table 4.9) have been derived from the mass balance equation:

Amount used = National production + Imports – Exports

National production, Imports and Exports data are obtained from the National Statistics Agency (NSA).

Table 4.9. Activity data used for Non-Energy products from fuels and solvent use (2017-2022)

	2017	2018	2019	2020	2021	2022
2.D.1 Lubricants	11,670	11,117	10,565	9,468	12,536	10,967
2.D.2 Paraffin wax use (candles)	954	1,020	1,332	789	1,130	946

Default emission factors (Table 4.10) from the IPCC 2006 Guidelines for CO2 estimation.

Table 4.10. Emission factors used for estimating emissions from non-energy products from fuels and solvent use

Source category	Carbon fraction TC/TJ	Oxidation fraction (Oxidized during Use)
2.D.1 Lubricant use	20	0.2
2.D.2 Paraffin Wax use	20	0.2

Source: 2006 IPCC Guidelines – Chapter 5, Volume 3

No CO2 was captured.

4.3.3. Flexibility

Not resorted to.

4.3.4. Uncertainty assessment and time-series consistency

Default Uncertainty values provided for AD and EFs in the IPCC 2006 Guidelines have been used in the tool developed in an Excel sheet for making the assessment.

The uncertainty levels assigned to the AD (Table 4.11) and EFs are the mid values of the default ranges from the IPCC 2006 guidelines. It is ±15% for both Lubricant use and Paraffin wax use for AD. The range is ±50% for Lubricant use and ±100% for Paraffin wax use respectively for EFs as depicted in Table 4.11.

Table 4.11. Uncertainty levels assigned for Non-Energy products from fuels and solvent use

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[2]
2.D. Non-energy products from fuels and solvent use			
2.D.1. Lubricant use	CO2	±15	±50
2.D.2. Paraffin wax use	CO2	±15	±100

1: Refer to IPCC 2006 Guidelines, Page 5.10 and 5.13, Chapter 5, Volume 3

2: Refer to IPCC 2006 Guidelines, Page 5.10 and 5.13, Chapter 5, Volume 3

The estimated combined uncertainty is 49% for the level assessment for both the base year 1990 and year-t 2022 while for the trend between the base year 1990 and year-t 2022 (Table 4.12) it is 36%.

Table 4.12. Uncertainty assessment for Non-Energy products from fuels and solvent use

2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (Kt CO2e)	Year T (2022) emissions or removals (Kt CO2e)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in base year- 1990	Contribution to Variance by Category in Year T - 2022	Uncertainty introduced into the trend in total national emissions (%)
2.D.1 - Lubricant Use	CO2	3.5	6.5	15.0	50.0	52.2	2359.5	2309.3	1302.7
2.D.2 - Paraffin Wax Use	CO2	0.3	0.6	15.0	100.0	101.1	49.4	64.5	13.1
Sum		**3.8**	**7.0**			**Sum**	2409	2374	1316
						Uncertainty in level and trend	**L - 49.1**	**L - 48.7**	**T - 36.3**

The time series is consistent as the AD have always been sourced from the same institution, the default EFs of IPCC used as well as a common methodology applied for all the years of the time series.

4.3.5. QA/QC and verification

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method and AD, the appropriate default EFs, time-series consistency, transcription accuracy, the calculations, reference material and conversion factors. Quality

Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

4.3.6. Recalculations

Not applicable.

4.3.7. Planned improvements

This is not a key category and contributes minimally to national emissions. Hence no improvement is planned.

4.4. Product uses as substitutes for Ozone Depleting Substances (CRT 2.(I))

4.4.1. Category description

Emissions from fluorinated gases used as substitutes for Ozone Depleting Substances (ODS) occur from product use, namely PFCs and HFCs. These gases are used in production as foam blowing agents, in aerosols, fire suppression and other applications. These gases have been introduced on the market in Refrigeration and Air Conditioning (RAC) to replace ODS following the entry into force of the Montreal Protocol in 1989.

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

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

Since the fluorinated gases did not exist in 1990, emissions for that year is zero. In Namibia, only HFCs are responsible for emissions which increased from 32 kt CO2 e in the year 2000 to 161 kt CO2 e in 2022, which represented an increase of 400%. The trend of emissions for the period 1990 to 2022 and emissions for selected years are presented in Figure 4.4 and Table 4.13.

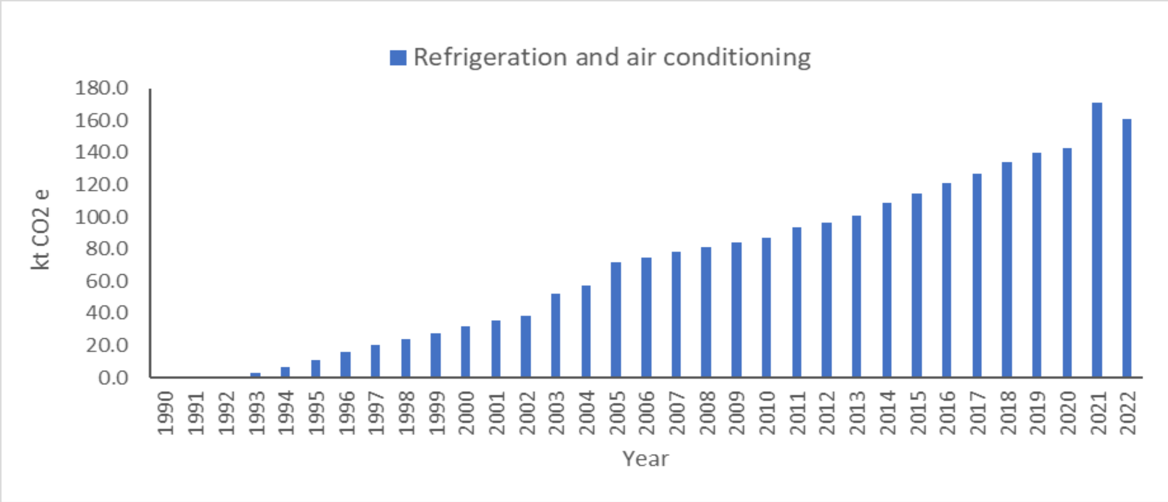

Figure 4.4. Emissions trend (kt CO2 e) for Refrigeration and Air Conditioning (1990-2022)

Table 4.13. Emissions (kt CO2 e) from Refrigeration and Air Conditioning

	1990	2000	2010	2017	2018	2019	2020	2021	2022
2.F.1 - Refrigeration and Air Conditioning	NO	31.7	86.7	127.2	134.1	139.6	143.0	171.0	161.2

4.4.2. Methodological issues

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

A study was undertaken by the German Agency for International Cooperation (GIZ) in 2016 when resources became available to inquire at customs levels and surveyed importers and users of these gases in the industry. Information from that study was partially used to produce a time series for this sub-category. Available information from the report covered:

- Refrigeration and stationary air conditioning
    - New equipment sales from 2010 to 2016 for each type
    - Existing equipment in each year from 2010 to 2016 by equipment type
    - Charge of refrigerant gas in new equipment
    - Refrigerant gas used in each equipment type
- Mobile air conditioning
    - Refrigerant gas used in vehicles in Namibia

The information from 2010 to 2016 was used to generate data for missing years in the timeseries based on the population growth rate of urban regions of Namibia which is estimated to be at 3.88% annually during the period 1990 to 2000 and 4.11 % for the period 2001 to 2010.

Data obtained from the institution responsible for road transport in Namibia and used for estimating emissions for this category in the Energy sector were used to calculate the annual number of new vehicles entering the country. The AD generated on charge per vehicle by the number of vehicles are presented in Table 5.3 of the NIR5 (https://www.ctc-n.org/system/files/dossier/3b/3000035954_gcai_final_report_part_iii.pdf). R410a gas used in stationary air conditioning consists of R32 and R125 on a 1:1 basis while R507, used in commercial refrigeration, is a 1:1 mix of R125 and R143a as well as R134a.

It is assumed that all the gases were introduced in the country in new equipment as from 1995 except R134a in commercial refrigeration. Unfortunately, it has not been possible to include import and export data in the calculations as disaggregated data by gas is not available. This introduces an underestimate of the emissions as gas used to recharge equipment which leaks, will eventually escape over subsequent years. The AD are provided in Table 4.14.

Table 4.14. Activity data (t) used for estimating emissions from Refrigeration and Air Conditioning (2017-2022)

		2017	2018	2019	2020	2021	2022
Stationary air conditioning	R32	21.73	22.50	23.30	24.13	25.41	26.75
	R125	21.73	22.50	23.30	24.13	25.41	26.75
Mobile air conditioning	R 134a	12.62	13.63	14.34	14.02	12.12	11.99
Commercial refrigeration	R125	10.36	11.08	11.84	12.67	13.64	14.69
	R134a	2.77	2.98	3.21	3.45	3.72	4.01
	R143a	10.36	11.08	11.84	12.67	13.64	14.69

The different gases used as ODS substitutes have different GWPs. EFs and other pertinent information on the gases are given in Table 4.15. The parameters for the constitution of the bank and subsequent emissions from the bank is also given in the same Table. Furthermore, R 600 A (Iso-butane) is not regulated under the Convention and has thus not been reported. Default emission factors (Table 4.15) from the IPCC Guidelines have been adopted.

Table 4.15. Emission Factors used for estimating emissions from Refrigeration and Air Conditioning

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

4.4.3. Flexibility

Not resorted to.

4.4.4. Uncertainty assessment and time-series consistency

Default Uncertainty values provided for AD and EFs from the IPCC 2006 Guidelines have been used in the tool developed in an Excel sheet for making the assessment.

The uncertainty levels assigned to the AD (Table 4.16) and EFs are the default ranges from the IPCC 2006 guidelines. It is ±5% for all gases for both AD and EFs as depicted in Table 4.16.

Table 4.16. Uncertainty levels assigned for Refrigeration and Air Conditioning

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[2]
2.F. Product uses as substitutes for ODS			
2.F.1. RAC (Stationary air conditioning)	R32	±5%	±5%

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[2]
2.F.1. RAC (Mobile air conditioning)	R125	±5%	±5%
	R134a	±5%	±5%
2.F.1. RAC (Commercial refrigeration)	R134a	±5%	±5%
	R125	±5%	±5%
	R143	±5%	±5%

1: Refer to 2006 Guidelines, Page 7.58, Chapter 7, Volume 3

2: Refer to 2006 Guidelines, Page 7.58, Chapter 7, Volume 3

The estimated combined uncertainty for the level assessment for year-t 2022 (Table 4.17) is 4.2%. There are no uncertainties for the base year and for the trend as there are no emissions for 1990 given that this activity was not occurring and hence no trend from this year and 2022 also.

Table 4.17. Uncertainty assessment for Refrigeration and Air Conditioning

2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (Kt CO2e)	Year T (2022) emissions or removals (Kt CO2e)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in base year- 1990	Contribution to Variance by Category in Year T - 2022	Uncertainty introduced into the trend in total national emissions (%)
2.F.1 - Refrigeration and Air Conditioning	CH2F2	-	13.1	5.0	5.0	7	-	0	N/A
2.F.1 - Refrigeration and Air Conditioning	CHF2CF3	-	75.8	5.0	5.0	7	-	11	N/A
2.F.1 - Refrigeration and Air Conditioning	CH2FCF3	-	3.7	5.0	5.0	7	-	0	N/A
2.F.1 - Refrigeration and Air Conditioning	CH3CF3	-	53.3	5.0	5.0	7	-	5	N/A
2.F.1.b - Mobile Air Conditioning	CH2FCF3	-	15.3	5.0	5.0	7		0	N/A
Sum		-	**161.2**			**Sum**	-	17.3	
						Uncertainty in level	-	**L - 4.2**	N/A

The time series is consistent as the AD have always been sourced from the same institution, the default EFs of IPCC used as well as a common methodology for all the years of the time series.

4.4.5. QA/QC and verification

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, AD, the appropriate default EFs, time-series consistency, transcription accuracy, the calculations and reference material. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

4.4.6. Recalculations

Not applicable

4.4.7. Planned improvements

Up to now, Namibia has not practiced recovery of refrigerants when equipment is retired. As per the Kigali agreement, to which Namibia is a signatory Party, arrangements are under way to start recovery of refrigerants upon retirement of equipment. Depending on the date this action will be implemented, this improvement will be introduced in the next BTR (3 years) to improve accuracy and report in future

GHG inventories. No extra resources are expected to be needed as it will be attempted within the framework of future national reports.

4.5. Other product manufacture and use (CRT 2.(I))

4.5.1. Category description

This category comprises three sub-categories and two of these are addressed in this inventory, namely Electrical equipment and N2O from product uses. Emissions from Electrical equipment is an addition in this inventory following a national survey to inventory all equipment existing in the country that is responsible for emissions of SF6, which is the only gas concerned.

The trend of emissions for the series 1990 to 2022 is given in Figure 4.5 and the emissions for selected years in Table 4.18. Emissions increased steadily but slowly for both subcategories, giving a total of 1.1 kt CO2 e in 1990 and 3.8 kt CO2 e in 2022. N2O from product Uses, namely for medical application accounted for the major share, more than two thirds of the emissions.

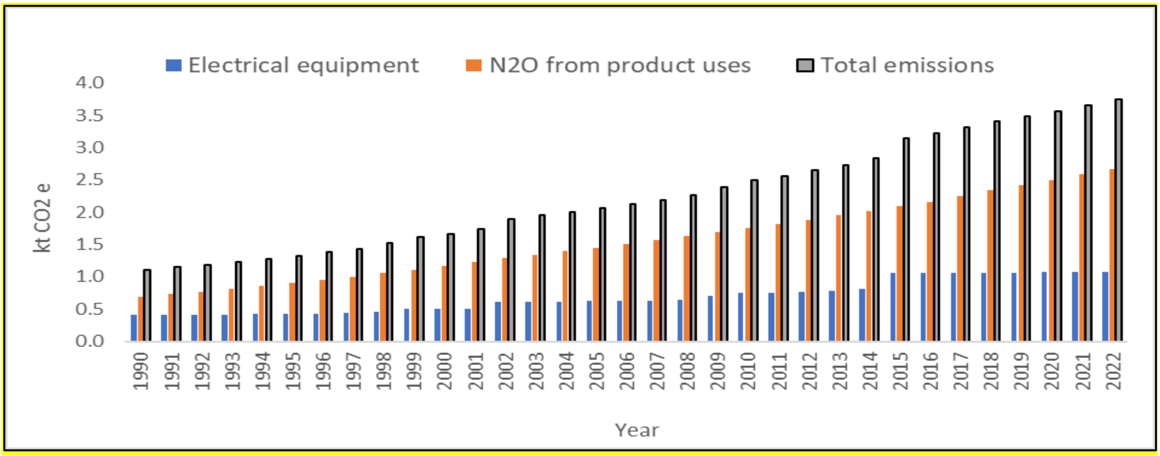

Figure 4.5. Trend of emissions (kt CO2 e) from Other product manufacture and use (1990-2022)

Table 4.18. Emissions (kt CO2e) from Other product manufacture and use

	1990	2000	2010	2017	2018	2019	2020	2021	2022
Other product manufacture and use	1.1	1.7	2.5	3.3	3.4	3.5	3.6	3.7	3.8
2.G.1 - Electrical Equipment	0.4	0.5	0.7	1.1	1.1	1.1	1.1	1.1	1.1
2.G.3 - N2O from Product Uses	0.7	1.2	1.8	2.2	2.3	2.4	2.5	2.6	2.7

4.5.2. Methodological issues

The IPCC Tier 1 method was used to estimate the emissions from the two sub-categories for which estimates were made in this inventory.

To improve the completeness of the inventory, Namibia inventoried all equipment in use within the national electricity grid for SF6 and PFCs loads. This exercise took 2 years and enables the estimation of emissions for this sub-category for the period 1990 to 2022. It has not been possible to track the fate of retired equipment but based on the original date of import and installation, it appears that not many units have been retired. The survey revealed that all equipment contains only SF6 and was sealed pressure type. The IPCC method at Tier 1 level has been adopted and software version 2.91 used to compute emissions for this activity area.

Given that this sub-category is a new introduction in the inventory, AD for all years of the time series 1990 to 2022 (Table 4.19) are provided as opposed to the other activity areas where only the period 2017 to 2022 is covered as the remaining period 1990 to 2016 are already provided in the NIR5 (https://unfccc.int/sites/default/files/resource/Namibia%20NIR5%20Part%201-Final%20.pdf).

Table 4.19. AD (t) used for estimating emissions from Electrical Equipment for selected years

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
SF6 in installed electrical equipment (Sealed Pressure insulators)	8.8	8.8	8.9	8.9	8.9	9.0	9.2	9.3	9.8	10.6	10.7

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
SF6 in installed electrical equipment (Sealed Pressure insulators)	10.8	13.0	13.1	13.1	13.2	13.3	13.4	13.8	15.1	15.9	15.9

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
SF6 in installed electrical equipment (Sealed Pressure insulators)	16.4	16.7	17.4	22.5	22.6	22.6	22.7	22.7	22.7	22.7	22.7

The emission factor used is the one for equipment from Europe (0.002 as fraction lost annually).

N2O used for medical applications also represented a challenge about availability of real-time AD. It has not been possible to capture these on an annual basis. National statistics are not disaggregated enough to obtain the amount of gas imported/exported and hence used. It has not been possible also to capture the amounts used by hospitals and clinics. A time series was constructed based on the following assumptions:

- Number of operations per 100,000 inhabitants for years 1990 and 2015 (WHO website). The data was interpolated and extrapolated to complete the time series
- 90 grams of N_2O used per operation (personal communication)
- All products used are lost as emissions as the gas is not metabolized

AD used for estimating N2O from product uses are provided in Table 4.20. for the period 2017 to 2022.

Table 4.20. AD used for estimating emissions for N2O from product uses (2017-2022)

	2017	2018	2019	2020	2021	2022
Population	2,315,839	2,351,503	2,387,716	2,424,487	2,461,824	2,499,736
Number of surgical operations per 100,000 population	4,160	4,240	4,320	4,400	4,480	4,560
Number of surgical operations	96,339	99,704	103,149	106,677	110,290	113,988
N2O (t) for medical applications	8.7	9.0	9.3	9.6	9.9	10.3

4.5.3. Flexibility

Not applied for

4.5.4. Uncertainty assessment and time-series

The uncertainty levels assigned to the AD (Table 4.22) and EFs are the default ranges from the IPCC 2006 guidelines. It is ±5% for SF6 for Electrical equipment and ±30% for N2O from product use for AD. The range is ±20% and ±2% for Electrical equipment and N2O from product use for EFs respectively as depicted in Table 4.21.

Table 4.21. Uncertainty levels assigned for Other product manufacture and use

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[2]
2.G. Other product manufacture and use			
2.G.1. Electrical equipment	SF6	±5	±20
2.G.3. N2O from product uses	N2O	±30	±2

1: Refer to 2006 Guidelines, Table 8.5, Page 8.21 and Page 8.38, Chapter 8, Volume 3

2: Refer to 2006 Guidelines, Page 8.21 and Page 8.38, Chapter 8, Volume 3

The estimated combined uncertainties are 48% for the level assessment for both the base year 1990 and year-t 2022 while for the trend between base year 1990 and year-t 2022 (Table 4.22) it is 218%.

Table 4.22. Uncertainty assessment for Other product manufacture and use

2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (Kt CO2e)	Year T (2022) emissions or removals (Kt CO2e)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in base year- 1990	Contribution to Variance by Category in Year T - 2022	Uncertainty introduced into the trend in total national emissions (%)
2.G - Other Product Manufacture and Us	SF6	0.4	1.1	60.0	58.3	84	986	570	7127
2.G - Other Product Manufacture and Us	N2O	0.7	2.7	58.3	5.4	59	1338	1751	40319
Sum		**1.1**	**3.7**			**Sum**	2324	2321	47446
						Uncertainty in level and trend	**L - 48.2**	**L - 48.2**	**T - 217.8**

The time series is consistent as the AD have always been computed using the same method, the default EFs of IPCC used as well as a common methodology for all the years of the time series.

4.5.5. QA/QC and verification

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, AD workings, the appropriate default EFs, time-series consistency, transcription accuracy, calculations and reference material. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

4.5.6. Recalculations

Not applicable

4.5.7. Planned improvements

To date for SF_6, the equipment installed by private electricity producers for their own use or Independent Power Producers is not accounted for. The plan is to further consult, engage and train them on the developed tools to capture the required data, including their QC. It is expected that this will take about 4 years as it is not a priority given its very small contribution in the national emissions and will be dealt with within the framework of the preparation of future national reports.

Regarding N_2O uses for medical applications also, the improvement will go through the consultation and engagement of stakeholders involved with the import, distribution, and use of this gas. Once identified and engaged, the stakeholders will be trained in the collection and submission of the required data to improve the quality of the inventory. It is expected that this exercise will take about 4 years for completion as it is not a priority given its very small contribution in the national emissions.

Chapter 5. Agriculture (CRT sector 3)

5.1. Overview of the sector

Agriculture is subdivided into 10 categories. Of these, only 4 categories are responsible for emissions in Namibia. Namibia has an important livestock production activity inherent of its arid climate and extensive grazing areas available. The major livestock is cattle, including some 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 as from 2014 with the setting up of intensive commercial farms. The livestock activity contributes emissions mainly through Enteric Fermentation and Manure management. Crop production also contributes emissions with urea and other organic fertilizers primarily.

The activities addressed are Enteric Fermentation, Manure Management, Agricultural Soils and Urea application. Emissions have been estimated for all 4 categories fully or partially. Direct emissions from managed soils for crop residues has not been estimated due to lack of data. Emissions do not occur from some animals like buffaloes and deer as they do not exist in the country and also from cultivation in organic soils as the latter is non-existent in Namibia. A mix of Tiers 1 and 2 has been adopted for making the emissions estimates.

Total emissions for the Agriculture sector increased from 5,573 kt CO2 e in 1990 to 7,897 in 2022. Enteric fermentation dominated the emissions from the Agriculture sector with more than 68% of the category emissions throughout the time series. The regression in emissions from Enteric Fermentation for the period 2018 to 2021 is attributed to drought and cross border movement to avoid losses and decimation of the livestock population.

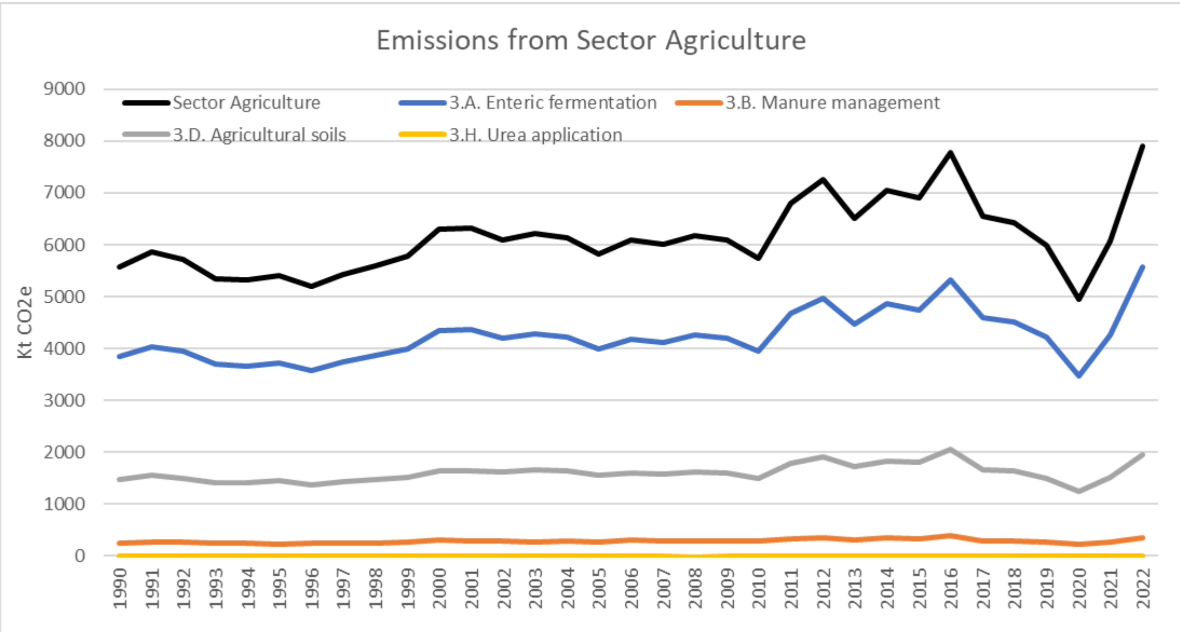

Figure 5.1. Trend of emissions (kt CO2 e) for the Agriculture sector (1990-2022)

Emissions of the Agriculture sector and its categories are provided in Table 5.1 for selected years. Emissions increased by 142% and 138% respectively when comparing 2022 with 1990 and 2010.

Table 5.1. Emissions (kt CO2 e) of the Agriculture sector

	1990	2000	2010	2017	2018	2019	2020	2021	2022
Agriculture	5,572.5	6,292.7	5,730.3	6,552.1	6,428.3	5,984.1	4,953.4	6,061.9	7,896.7

The IPCC 2006 guidelines and its 2019 refinements as applicable have been used for estimating emissions using the 2006 IPCC software v 2.91. The EMEP/EEA Guidebook 2023 was resorted to for estimating emissions of indirect gases not covered by the IPCC guidelines.

5.2. Enteric Fermentation (CRT 3.A)

5.2.1. Category description

The livestock sector of Namibia is characterized by the rearing of cattle, sheep and goats on a commercial basis and at the community level. The animals are responsible for Enteric Fermentation when they digest the grasses they ingest. Other animals contributing to this process are camels, horses, mules and asses, and swine to a much lower degree. The trend of emissions for Enteric fermentation is provided in Figure 5.1.

Emissions from Enteric Fermentation, which are provided in Table 5.2 for selected years, increased by 145% from 3,837 kt CO2 e in 1990 to 5,575 kt CO2 e in 2022. Between 2010 and 2022, the increase is slightly lower at 141%. The livestock group cattle contributed most of the emissions, between 80% and 88%.

Table 5.2. Emissions (kt CO2 e) from enteric fermentation

	1990	2000	2010	2017	2018	2019	2020	2021	2022
3.A. Enteric Fermentation	3,837.4	4,351.7	3,943.6	4,603.8	4,505.3	4,219.3	3,481.7	4,268.2	5,575.4
3.A.1 Dairy cows	3.8	3.8	3.8	5.1	5.1	5.1	5.1	5.1	5.1
3.A.1.a. Other cattle	3,061.5	3,667.6	3,443.4	4,032.0	3,892.1	3,693.6	3,018.3	3,756.5	4,927.9
3.A.2. Sheep	466.0	342.5	193.0	283.7	273.8	217.9	181.8	218.5	308.6
3.A.3. Swine	0.5	0.6	1.8	2.0	2.7	2.9	3.4	2.7	2.7
3.A.4. Other livestock	305.6	337.1	301.5	281.0	331.5	299.8	273.0	285.3	331.1

5.2.2. Methodological issues

Tier 2 level has been maintained for cattle and dairy cows for enteric fermentation since it was a key category and already treated as such in previous inventories. A Tier 1 approach was adopted for all other animal groups. Available country specific data on live weight, pregnancy and other parameters were collected and used. Missing data were generated as described in the EF section later in this chapter.

The FAO database together with information from the NSA and annual surveys done by the Ministry of Agriculture, Water and Land Reform were used. Preference was given to country data over the international database. Where local statistics were not available, data from the FAO database was used. 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 in Namibia (NNFU, 2006). The sub-division of other cattle into the different classes was available for communal animals only. Hence, the same split was adopted for the commercial sector as this is considered as the normal situation for cattle rearing in Namibia.

Table 5.3. Activity data (No.) used for estimating emissions from Enteric Fermentation (2017-2022)

Year	2017	2018	2019	2020	2021	2022
Dairy cows	2,000	2,000	2,000	2,000	2,000	2,000
Commercial cattle						
Mature males	40,755	39,340	37,334	30,509	37,970	49,810
Mature female	342,999	331,093	314,208	256,763	319,556	419,208
Mature male castrate	158,259	152,766	144,975	118,470	147,443	193,422
Young growing male	190,960	184,331	174,931	142,949	177,908	233,388
Young growing female	227,215	219,328	208,142	170,089	211,685	277,698
Communal cattle						
Mature males	75,688	73,061	69,335	56,659	70,515	92,505
Mature female	636,999	614,887	583,530	476,846	593,461	778,529
Mature male castrate	293,910	283,708	269,240	220,016	273,822	359,212
Young growing male	354,639	342,329	324,871	265,477	330,400	433,434
Young growing female	421,970	407,323	386,550	315,879	393,129	515,725
Sheep	2,026,309	1,956,044	1,556,112	1,298,660	1,560,976	2,204,508
Swine	70,908	95,745	102,800	122,001	97,962	95,920
Other livestock						
Goats	1,624,834	1,956,044	1,737,675	1,601,167	1,704,529	2,041,257
Horses	34,872	43,197	35,193	34,740	31,159	38,037
Mules and asses	128,295	128,167	138,380	111,771	110,409	92,994
Camels	6	4	26	56	53	51
Poultry	2,763,908	2,944,766	3,125,623	3,296,211	5,253,382	6,114,213

The average live weights of the non-dairy cattle classes were obtained from data of the slaughterhouses of MeatCo and auction of livestock. Information on development and typical animal mass of the dominant local breeds Brahman and Nguni were used. Daily weight gain was derived from the live weight and age of the different animal groups at slaughtering or auction time. The data was compared and aligned with information obtained from breeding studies done on the 2 main species with various other species (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 also necessary to 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 5.4 depicts the typical mature weight adopted for the different classes.

Table 5.4. Typical animal mass (kg)

Animal type	Description	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

Management practices adopted for livestock have an important impact in determining the level of emissions. Both enteric fermentation and manure management EFs are dependent on such practices, namely the feeding situation, daily work performed, lactation period and frequency of pregnancy and the management of the excreta. Since emissions of enteric fermentation fell in the key categories in previous inventories, the 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 methane emission factor for the cattle classes while default EFs from the IPCC 2006 Guidelines were used for the other animal groups. Default Methane Emission Factors used for the different animal classes are provided in Table 5.5.

Table 5.5. Methane emission factors used for computing enteric fermentation emissions

Animal type	Description	Methane emission factors (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	Description	Methane emission factors (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

Pregnancy has been accounted for dairy, commercial and communal cows. The lactation period of dairy cows is zero as the calves are severed just after birth. Lactation for commercial and communal cows have not been integrated in the derivation of the methane correction factors (MCF) due to inadequacy of accurate information. This improvement has been included in the improvement plan.

The digestible energy is taken from the 2006 IPCC GL, Chapter 10, annex Table 10A2 for animals in large grazing areas (60%) 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 improving the next inventory.

5.2.3. Flexibility

Not resorted to.

5.2.4. Uncertainty assessment and time-series consistency

Default Uncertainty values provided for AD and EFs in the IPCC 2006 Guidelines have been used in the tool developed in Excel worksheet for making the assessment.

The uncertainty levels assigned to the AD (Table 5.6) are ±20% for all animal groups given that the population is regularly collected through surveys and tagging for some species such as cattle, sheep and goats. For the EFs ±20 has been adopted for Dairy cows and other cattle as they are country specific and have been developed on national information while for the remaining animal species the higher level of ±40% has been used.

Table 5.6. Uncertainty levels assigned for Enteric Fermentation

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[2]
3.A. Enteric fermentation			
3.A.1.a.i - Dairy cows	CH4	±20	±20
3.A.1.a.i – Other cattle	CH4	±20	±20

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[2]
3.A.1.c - Sheep	CH4	±20	±40
3.A.1.d - Goats	CH4	±20	±40
3.A.1.e - Camels	CH4	±20	±40
3.A.1.f - Horses	CH4	±20	±40
3.A.1.g – Mules and asses	CH4	±20	±40
3.A.1.h - Swine	CH4	±20	±40

1: Refer to 2006 Guidelines, Page 10.23, Chapter 10, Volume 4

2: Refer to 2006 Guidelines, Page 10.33, Chapter 10, Volume 4

The estimated combined uncertainties are 23% for the level assessment for base year 1990 and 25 for year-t, and 37% for the trend between the base year 1990 and year-t 2022 (Table 5.7).

Table 5.7. Uncertainty assessment for Enteric Fermentation

2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (Kt CO2e)	Year T (2022) emissions or removals (Kt CO2e)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in base year-1990	Contribution to Variance by Category in Year T - 2022	Uncertainty introduced into the trend in total national emissions (%)
3.A - Enteric fermentation									
3.A.1.a.i - Dairy Cows	CH4	3.8	5.1	20.0	20.0	28.3	0.001	0.001	0.001
3.A.1.a.ii - Other Cattle	CH4	3061.5	4927.9	20.0	20.0	28.3	509.179	624.973	1325.422
3.A.1.c - Sheep	CH4	466.0	308.6	20.0	40.0	44.7	29.489	6.129	19.883
3.A.1.d - Goats	CH4	260.4	285.8	20.0	40.0	44.7	9.207	5.254	5.365
3.A.1.e - Camels	CH4	0.0	0.1	20.0	40.0	44.7	0.000	0.000	0.000
3.A.1.f - Horses	CH4	26.2	19.2	20.0	40.0	44.7	0.093	0.024	0.059
3.A.1.g - Mules and Asses	CH4	19.0	26.0	20.0	40.0	44.7	0.049	0.044	0.037
3.A.1.h - Swine	CH4	0.5	2.7	20.0	40.0	44.7	0.000	0.000	0.001
Sum		**3837.4**	**5575.4**			**Sum**	**548.0**	**636.4**	**1350.8**
						Uncertainty in level (L) and trend (T) assessment	**L - 23.4**	**L - 25.2**	**T - 36.8**

The time series is consistent as the AD have always been sourced from the same institutions, the same country specific or default EFs of IPCC as well as a common methodology used for all the years of the time series.

5.2.5. QA/QC and verification

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, AD, the appropriate default and generated country-specific EFs, time-series consistency, transcription accuracy, the calculations and reference material. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

5.2.6. Recalculations

Not applicable.

5.2.7. Planned improvements

Segregation of cattle into subgroups have always been done on the same % for all years of the time series and this have certainly evolved over time. Similarly, several parameters entering the Tier 2 estimation were obtained from scientific studies and complemented with information from other sources such as slaughterhouse and auction data for live weight of animals. These need to be revisited and supplemented with new studies as appropriate. The plan is to collect new data and undertake new studies to confirm or update these parameters. Surveys will be organized, and studies designed and conducted over the next 4 years. Resources will be needed in terms of funds for data collection and conducting trials, contracting an international consultant for designing the surveys and studies, analyzing collected data, publish these in peer reviewed papers or including it in the Emission Factor DataBase (EFDB) for adoption by neighbouring countries where applicable and national consultants for supporting implementation of the surveys and studies, enumerators for conducting the survey, data entry and other tasks as well as travel costs around the country. This item could be included in the CBIT2 proposal.

5.3. Manure Management (CRT 3.B)

5.3.1. Category description

Livestock generates manure which is managed in different ways according to the animal husbandry practices adopted. The management practices are responsible for the emissions levels of CH4 and direct and indirect N2O. The trend of emissions is given in Figure 5.2.

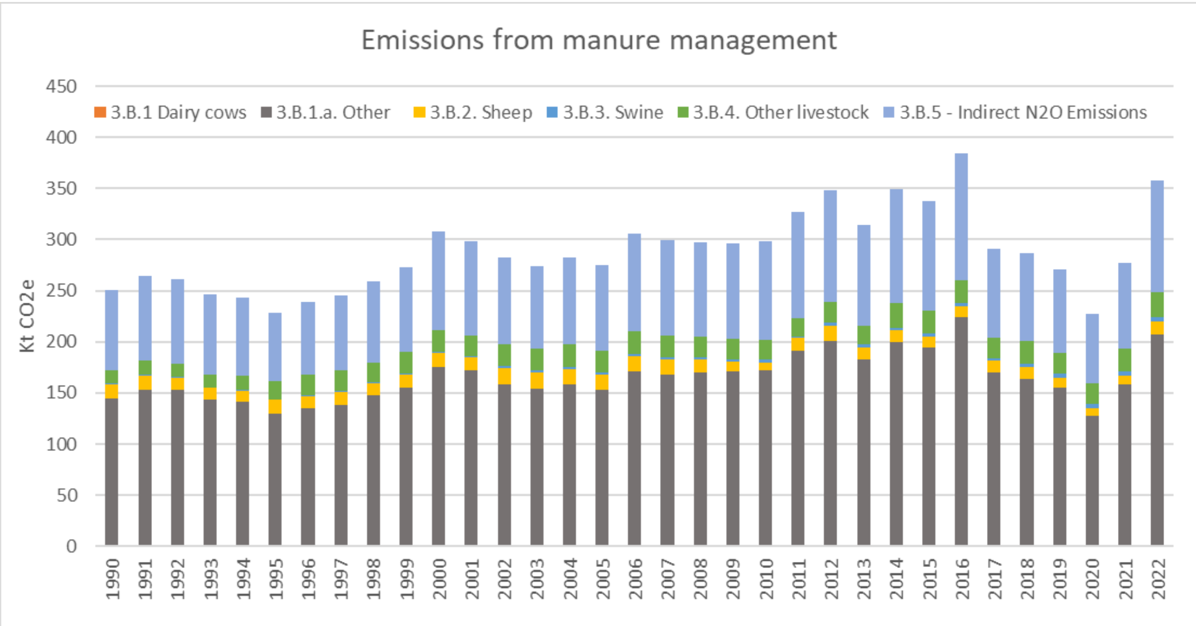

Figure 5.2. Trend of emissions (kt CO2 e) for Manure management (1990-2022)

Emissions for selected years are given in Table 5.8. Emissions increased from 251 kt CO2 e in 1990 to 358 kt CO2 e in 2022. This increase is 143% between 1990 and 2022 and 120% between 2010 and 2022. The Other cattle group of animals was responsible for the major fraction of emissions for all years, with between 55% to 58%.

Table 5.8. Emissions (kt CO2 e) from Manure management for selected years

Year	1990	2000	2010	2017	2018	2019	2020	2021	2022
3.B. Manure Management	250.7	307.5	297.9	291.1	286.3	270.9	226.8	277.1	358.1
3.B.1 Dairy cows	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5
3.B.1.a. Other	144.1	175.4	171.7	169.4	163.5	155.2	126.8	157.8	207.0
3.B.2. Sheep	14.0	13.7	7.7	11.3	11.0	8.7	7.3	8.7	12.3

Year	1990	2000	2010	2017	2018	2019	2020	2021	2022
3.B.3. Swine	0.7	1.0	2.7	3.0	4.0	4.3	5.1	4.1	4.0
3.B.4. Other livestock	13.4	21.3	19.1	19.4	22.1	20.8	19.3	21.7	24.5
3.B.5. Indirect N2O emissions	78.1	95.7	96.4	87.4	85.1	81.3	67.8	84.2	109.6

5.3.2. Methodological issues

Tier 1 method specified in the IPCC 2006 guidelines has been adopted for estimating emissions from Manure Management for all animal groups. Table 5.9 summarizes the manure management systems (MMSs) adopted for the different animal categories. This is based on information available from the censuses and surveys conducted by the Ministry of Agriculture and Land Reform (MALF) and NSA while MMS for cattle are based on expert judgment and on information from the farming systems guide (NNFU, 2006). Experts contacted comprised officers of the MALF, 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 inventories prior to 2018 was 26°C and this was amended to 20°C as from 2019 as it was a mistake. In fact, Namibia falls under a temperate climate according to the IPCC Guidelines except for a small area classified as Tropical Dry and temperature assigned cannot be 26°C. This has been confirmed from processing of historical climate 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 5.9. 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	100% PRP
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

Since emissions estimates from Manure management are made at Tier 1 level, the default EFs (Table 5.10) from the IPCC 2006 guidelines have been adopted.

Table 5.10. EFs used for Manure management

Type of animal	CH4 EF (kgCh4/head/year)	Direct N2O-N EF (kg N2O-N/(kg N in MMS)	Indirect N2O-N EF (kg N2O-N/kg NH3-N + NOx-N Volatilized)
Dairy cows	1.0	0.005	0.01
Commercial cattle (All)	1.0	-	-
Communal cattle (All)	1.0	0.005	0.01
Sheep	0.15	-	-
Goats	0.17	-	-
Camels	1.92	-	-
Horses	1.64	-	-
Mules and asses	0.9	-	-
Swine	1.0	0.005	0.01
Poultry	0.2	0.001	0.01

Source – IPCC Guideline 2006 – Table 10.14, Page 10.38, Chapter 10, Volume 4

5.3.3. Flexibility

Not resorted to.

5.3.4. Uncertainty assessment and time-series consistency

Uncertainty values provided for AD and EFs within the IPCC 2006 Guidelines' ranges have been used in the tool developed in Excel worksheet for making the assessment.

The uncertainty levels assigned to the AD (Table 5.11) and EFs are ±20% and ±30% respectively for all animal groups. Indirect N2O emissions AD uncertainty levels were ±20% while those for EFs were -80 to +400%.

Table 5.11. Uncertainty levels assigned for Manure management

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[2]
3.B. Manure management			
3.B.1 - Dairy cows	CH4	±20	±30
	N2O	±20	±30
3.B.1.a. - Other cattle	CH4	±20	±30
	N2O	±20	±30
3.B.2 - Sheep	CH4	±20	±30
	N2O	±20	±30
3.B.3 - Swine	CH4	±20	±30
	N2O	±20	±30
3.B.4.b - Camels	CH4	±20	±30
	N2O	±20	±30
3.B.4.d - Goats	CH4	±20	±30
	N2O	±20	±30
3.B.4.e - Horses	CH4	±20	±30
	N2O	±20	±30
3.B.4.f – Mules and asses	CH4	±20	±30
	N2O	±20	±30
3.B.4.g - Poultry	CH4	±20	±30
	N2O	±20	±30
3.B.5. Indirect N2O emissions	N2O	±20	-80 to +400

1: Refer to 2006 Guidelines, Page 10.23, Chapter 10, Volume 4
2: Refer to 2006 Guidelines, Page 10.48, Chapter 10, Volume 4

The estimated combined uncertainties are 41% for the level assessment for base year 1990, 40% for year-t and 21% for the trend between base year 1990 and year-t 2022 (Table 5.12).

Table 5.12. Uncertainty assessment for Manure management

2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (Kt CO2e)	Year T (2022) emissions or removals (Kt CO2e)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in base year-1990	Contribution to Variance by Category in Year T - 2022	Uncertainty introduced into the trend in total national emissions (%)
3.B - Manure Management									
3.B.1 - Dairy cows	CH4	0.0	0.1	20.0	30.0	36.1	0.000	0.000	0.000
3.B.1 - Dairy cows	N2O	0.4	0.5	20.0	100.0	102.0	0.021	0.019	0.003
3.B.1.a - Other cattle	CH4	58.4	93.9	20.0	30.0	36.1	70.613	89.373	113.760
3.B.1.a - Other cattle	N2O	85.7	113.1	20.0	100.0	102.0	1214.625	1038.212	176.413
3.B.2 - Sheep	CH4	14.0	12.3	20.0	30.0	36.1	4.043	1.545	2.771
3.B.2 - Sheep	N2O	0.0	0.0	0.0	0.0	0.0	0.000	0.000	0.000
3.B.3 - Swine	CH4	0.5	2.7	20.0	30.0	36.1	1.621	1.603	2.013
3.B.3 - Swine	N2O	0.2	1.3	20.0	100.0	0.0	0.000	0.000	0.000
3.B.4.a - Goats	CH4	8.9	12.6	20.0	30.0	36.1	0.000	0.000	0.000
3.B.4.a - Goats	N2O	0.0	0.0	0.0	0.0	0.0	0.000	0.000	0.000
3.B.4.b - Camels	CH4	0.0	0.0	20.0	30.0	36.1	0.118	0.055	0.086
3.B.4.b - Camels	N2O	0.0	0.0	0.0	0.0	0.0	0.000	0.000	0.000
3.B.4.c - Horses	CH4	2.4	2.3	20.0	30.0	36.1	0.061	0.099	0.131
3.B.4.c- Horses	N2O	0.0	0.0	0.0	0.0	0.0	0.000	0.000	0.000
3.B.4.c - Mules and Asses	CH4	1.7	3.1	20.0	30.0	36.1	0.005	0.073	0.147
3.B.4.c - Mules and Asses	N2O	0.0	0.0	0.0	0.0	102.0	0.010	0.145	0.177
3.B.4.d - Poultry	CH4	0.3	5.1	20.0	30.0	36.1	0.002	0.267	0.656
3.B.4.d - Poultry	N2O	0.1	1.4	20.0	100.0	102.0	0.002	0.153	0.256
3.B.5 - Indirect N2O Emissions	N2O	78.1	109.6	20.0	400.0	400.5	400.948	448.447	162.632
Sum		**250.7**	**358.1**			**Sum**	**1692.1**	**1580.0**	**459.0**
						Uncertainty in level (L) and trend (T) assessment	**L - 41.1**	**L - 39.7**	**T - 21.4**

The time series is consistent as the AD have always been sourced from the same institutions, the default EFs of IPCC used as well as the same methodology adopted for all the years of the time series.

5.3.5. QA/QC and verification

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, AD, the appropriate default EFs, time-series consistency, transcription accuracy, the calculations and reference material. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

5.3.6. Recalculations

Not applicable.

5.3.7. Planned improvements

Estimates of emissions from Manure management have always been made based partially on expert judgement for assigning manure management systems except for dairy cows which is known. This is a potential area of improvement to enhance the accuracy of the estimates as it concerns almost all other animals. The improvement plan includes a countrywide survey to better categorize the different livestock animal groups with respect to the manure management system being practiced. This is also warranted as animal husbandry practices may have evolved over time. The survey contemplated covers the whole territory and the animal groups commercial and communal cattle, sheep and goats, swine and poultry. Support will be needed to cover the costs of an international consultant to design the survey, oversee data collection, analyze the data and generate the manure management characteristics to be adopted for future inventory compilations. Costs of a national consultant to support the international consultant in the work, enumerators to collect the data and travel costs for the international and national consultants and enumerators. The survey, including data analysis, is expected to take 4 years and possibly included in the CBIT2 proposal.

5.4. Agricultural soils (CRT 3.D)

5.4.1. Category description

The category Agricultural Soils comprises two sub-categories and activity areas given in Table 5.13. Both sub-categories occur in Namibia and have been addressed in this inventory.

Table 5.13. Sub-categories and activity areas under Agricultural Soils

Sub-categories and activity areas under Agricultural Soils
3.D.1. Direct N_2O emissions from managed soils
3.D.1.a. Inorganic N fertilizers
3.D.1.b. Organic N fertilizers
3.D.1.c. Urine and dung deposited by grazing animals
3.D.1.d. Crop residues
3.D.1.e. Mineralization/immobilization associated with loss/gain of soil organic matter
3.D.1.f. Cultivation of organic soils (i.e. histosols)
3.D.1.g. Other
3.D.2. Indirect N_2O Emissions from managed soils

Direct N2O emissions from managed soils

Within the sub-category Direct N2O emissions from managed soils, activities covered are use of Inorganic and organic N fertilizers, Urine and dung deposited by grazing animals and Mineralization/immobilization associated with loss/gain of soil organic matter. The remaining activities do not occur in Namibia. Crop residues are usually grazed by animals and thus do not result in emissions.

Indirect N2O emissions from managed soils

Part of the N in manure and fertilizers seeps away from the point of application or discharge. They can then generate N2O that is emitted. These are accounted for under this activity area. It is estimated that they are not carried away or displaced by surface run-off as the temperate dry climate of Namibia has an annual precipitation:potential evapotranspiration ratio of < 1 as per the Atlas of Namibia of 2022 (https://atlasofnamibia.online/chapter-3/download-files).

The trends of emissions for Agricultural soils and its 2 categories are given in Figure 5.3. Direct N2O emissions vastly exceeded Indirect N2O emissions for all years of the time series.

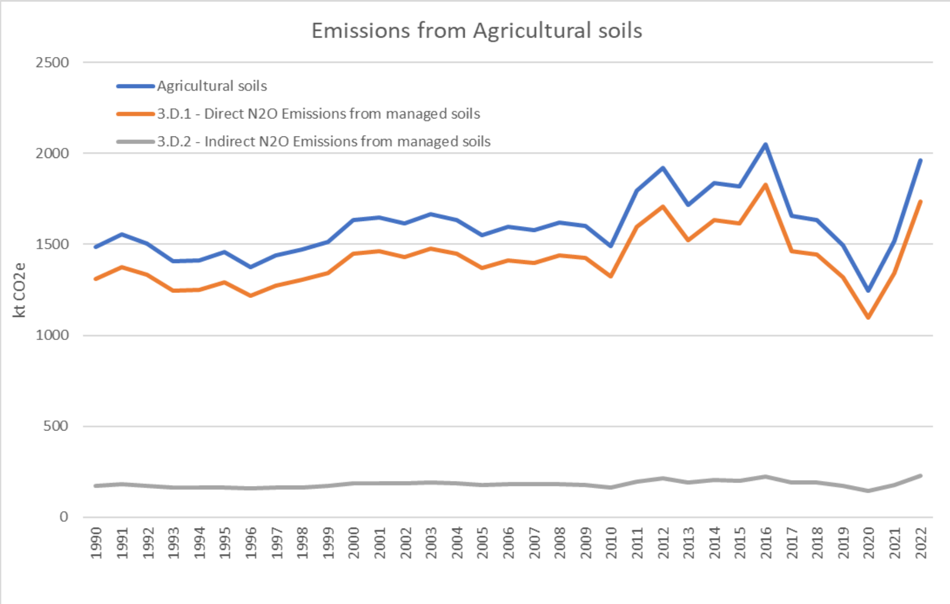

Figure 5.3. Trend of emissions (kt CO2 e) for Agricultural soils (1990-2022)

Emissions for selected years from Agricultural Soils (Table 5.14) increased from 1,484 kt CO2e in 1990 to 1,489 in 2010 and 1,963 (32%) in 2022. The increase between 2010 and 2022 is also 32%.

Direct N2O emissions increased by 33% and 31% respectively for the periods 1990 to 2022 and 2010 to 2022, namely from 1,310 kt CO2 e and 1,324 kt CO2 e to 1,736 kt CO2 e as depicted in Table 5.14.

Indirect emissions steadily increased over time from 174 in 1990 to 227 in 2022, representing an increase of 30%. Between 2010 and 2022, the increase is 37%. The emissions for selected years are presented in Table 5.14.

Table 5.14. Emissions (kt CO2 e) from Agricultural Soils

	1990	2000	2010	2017	2018	2019	2020	2021	2022
3.D. Agricultural soils	1,484.0	1,633.0	1,488.7	1,656.5	1,635.9	1,493.6	1,244.7	1,516.3	1,963.1
3.D.1 Direct N2O emissions from managed soils	1,309.9	1,447.5	1,323.5	1,465.0	1,445.1	1,320.1	1,099.2	1,340.8	1,736.4
3.D.2 Indirect N2O emissions from managed soils	174.2	185.5	165.2	191.5	190.8	173.5	145.5	175.6	226.8

5.4.2. Methodological issues

The method adopted is Tier 1 according to the IPCC 2006 Guidelines and the 2006 IPCC Software – v 2.91 has been used to compute emissions for these categories.

Direct N2O emissions from managed soils

For Direct N_2O emissions from managed soils, AD for fertilizers were calculated from the mass balance of imports and exports data from the NSA which are provided in Table 5.15. The statistics did not provide the exact N content as required for input in the software but rather by fertilizer type. A description of the fertilizers imported and used in the country along with their N content was provided in the NIR3 (Table 6.20, Page 82 - https://unfccc.int/sites/default/files/resource/Namibia-NIR3-Final%20Version-Part1-2018-10-21%20%281%29.pdf). While the N content of certain straight fertilizers is known, the molecular formula was used in some cases to estimate the N contents of blends/mixtures.

Table 5.15. Amount of N (kg) used from fertilizer application (2017 - 2022)

Type of fertilizer	2017	2018	2019	2020	2021	2022
Synthetic fertilizer N	20,606,562	20,451,807	13,021,437	11,437,292	14,487,301	16,768,491

Indirect N_2O emissions from managed soils

The AD are those adopted for computing direct emissions, which are used by default in the software to aggregate emissions from different sources. Here, reference is made to the fertilizers and urea applied and manure generated by livestock. The same AD used for Manure management and Direct N_2O emissions from managed soils are used automatically by the software to estimate these Indirect emissions.

As the IPCC Tier 1 method has been adopted, the default EFs (Table 5.16) from the same guidelines were also used in the 2006 IPCC software – v 2.91 for computing emissions.

Table 5.16. EFs used for Direct and Indirect N_2O emissions for Agricultural soils

Categories	Emission factors
3.D.1. Direct N2O emissions from managed soils	
3.D.1.a. Inorganic N fertilizers	0.01 kg N2O-N/kg N applied
3.D.1.b. Organic N fertilizers	0.01 kg N2O-N/kg N deposited
3.D.1.c. Urine and dung deposited by grazing animals (Sheep, goat, horses, mules and asses, camels)	0.01 kg N2O-N/kg N deposited
3.D.1.c. Urine and dung deposited by grazing animals (Cattle)	0.02 kg N2O-N/kg N deposited
3.D.2. Indirect N2O Emissions from managed soils	0.01 kg N2O-N/ kg NH3-N + NOx-N Volatilized

Source : IPCC Guideline 2006 – Table Tables 11.1 and 11.3, Chapter 11, Volume 4

5.4.3. Flexibility

Not applied for.

5.4.4. Uncertainty assessment and time-series consistency

Default Uncertainty values provided for AD and EFs in the IPCC 2006 Guidelines have been used in the tool provided in the software V 2.91 for making the assessment.

The uncertainty levels assigned to the AD (±20 and ±50) and EFs (-65 to +400) are the default ranges from the IPCC 2006 guidelines depending on sub-category. These are shown in Table 5.17 for the different sub-categories.

Table 5.17. Uncertainty levels assigned for Agricultural soils

2006 IPCC Categories	Uncertainty assigned (%)	
3.D. Agricultural soils	AD[1]	EF[2]
3.D.1. Direct N2O emissions from managed soils		
3.D.1.a. Inorganic N fertilizers	±50	-65 to +200
3.D.1.b. Organic N fertilizers	±20	-70 to +200
3.D.1.c. Urine and dung deposited by grazing animals (Sheep, goat, horses, mules and asses, camels)	±20	-65 to +200
3.D.1.c. Urine and dung deposited by grazing animals (Cattle)	±20	-65 to +200
3.D.2. Indirect N2O Emissions from managed soils	±20	-80 to +400

1: Refer to 2006 Guidelines, Chapter 10 and Chapter 11, Volume 4
2: Refer to 2006 Guidelines, Tables 11.1-11.3, Chapter 11, Volume 4

The estimated combined uncertainties are 314% for the level assessment for both the base year 1990 and year-t 2022, and 95% for the trend between base year 1990 and year-t 2022 (Table 5.18).

Table 5.18. Uncertainty assessment for Agricultural soils

2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (Kt CO2e)	Year T (2022) emissions or removals (Kt CO2e)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in base year-1990	Contribution to Variance by Category in Year T - 2022	Uncertainty introduced into the trend in total national emissions (%)
3.D - Agricultural soils									
3.D.1 - Direct N2O Emissions from managed soils	N2O	1309.9	1736.4	57.4	346.4	351.1	96058.535	96460.960	9036.192
3.D.2 - Indirect N2O Emissions from managed soils	N2O	174.2	226.8	20.0	400.0	400.5	2209.032	2140.047	19.631
	Sum	**1484.0**	**1963.1**			**Sum**	**98267.6**	**98601.0**	**9055.8**
Uncertainty in level (L) and trend (T) assessment							**L - 313.5**	**L - 314.0**	**T - 95.2**

The time series is consistent as the AD have always been sourced from the same institution, the default EFs of IPCC used as well as the same method used to compute emissions for all the years of the time series.

5.4.5. QA/QC and verification

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, the appropriate default EFs, time-series consistency, transcription accuracy, the calculations and reference material. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

5.4.6. Recalculations

Not applicable.

5.4.7. Planned improvements

There is a slight improvement that is contemplated for this activity area, namely tracking the exact N content of a few fertilizers. It is planned to address this problem during the preparation of the next BTR within 3 years' time.

5.5. Urea application (CRT 3.G-J)

5.5.1. Category description

Under the urea application category, emissions are estimated for CO2 emitted when urea is applied to soils. This is a new category as urea was covered only for emissions of N2O previously from the N component of urea along with N from inorganic fertilizers.

Emissions of CO2 from urea application varied between 0.09 kt and 0.82 kt for the time series. This is attributed to uses being related to area under commercial crops primarily which is itself function of rainfall which is erratic in Namibia. Emissions for selected years are presented in Table 5.19 while the trend is given in Figure 5.4.

Table 5.19. Emissions (kt) from Urea application

1990	2000	2010	2017	2018	2019	2020	2021	2022
0.34	0.52	0.08	0.61	0.82	0.37	0.22	0.26	0.09

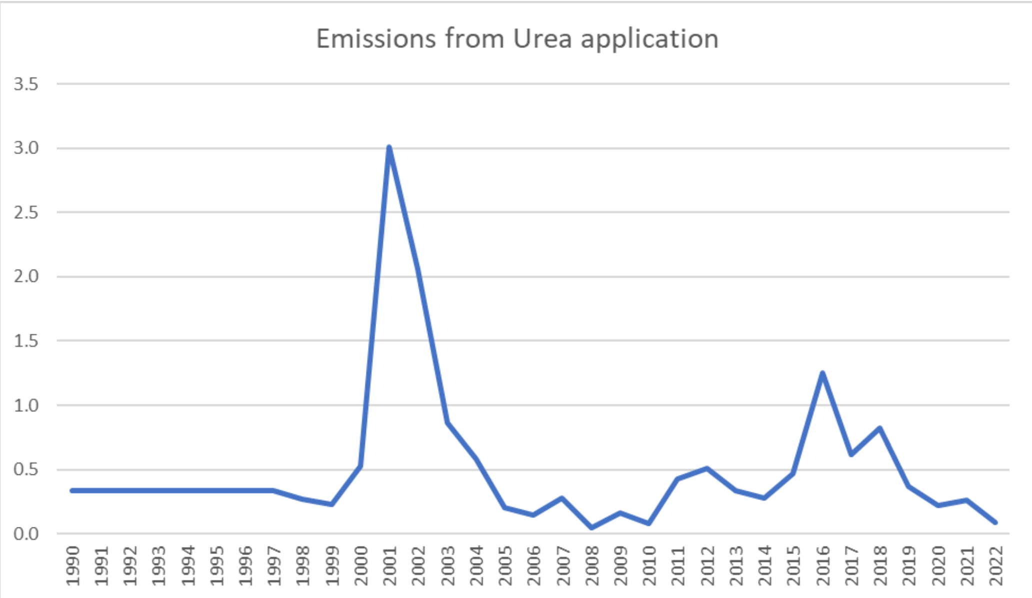

Figure 5.4. Trend of emissions (kt) for Urea application

5.5.2. Methodological issues

Tier 1 from the IPCC 2019 refinements was used to estimate emissions of CO2 from urea application. The data for the full-time series are given in Table 5.20.

Table 5.20. AD (t) used for estimating emissions from urea application (2017-2022)

2017	2018	2019	2020	2021	2022
837	1118	507	297	356	118

The default EF, 0.2 t C/t Urea from the 2019 refinements was used for estimating emissions for all years.

5.5.3. Flexibility

Not resorted to.

5.5.4. Uncertainty assessment and time-series consistency

Default Uncertainty values provided for AD and EFs in the IPCC 2006 Guidelines have been used in the tool developed in Excel worksheet for making the assessment.

The uncertainty levels assigned to the AD (Table 5.21) and EFs are the default ranges from the IPCC 2006 guidelines. It is ±50% and ±20% for AD and EF respectively as depicted in Table 5.21.

Table 5.21. Uncertainty levels assigned for urea application

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[2]
3.H. Urea application	CO2	±50	±20

1: Refer to 2006 Guidelines, Page 11.34, Chapter 11, Volume 4

2: Refer to 2006 Guidelines, Page 11.34, Chapter 11, Volume 4

The estimated combined uncertainties are 54% for the level assessment for both the base year 1990 and year-t 2022, and 18% for the trend between base year 1990 and year-t 2022 (Table 5.22).

Table 5.22. Uncertainty assessment for urea application

2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (Kt CO2e)	Year T (2022) emissions or removals (Kt CO2e)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in base year-1990	Contribution to Variance by Category in Year T - 2022	Uncertainty introduced into the trend in total national emissions (%)
3.H - Urea application									
3.H - Urea application	CO2	0.3	0.1	50.0	20.0	53.9	2900.000	2900.000	326.881
	Sum	**0.3**	**0.1**			**Sum**	**2900.0**	**2900.0**	**326.9**
						Uncertainty in level (L) and trend (T) assessment	**L - 53.9**	**L - 53.9**	**T - 18.1**

The time series is consistent as the AD have always been sourced from the same institution, the default EFs of IPCC used as well as a common methodology for all the years of the time series.

5.5.5. QA/QC and verification

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, AD, the appropriate default EFs, time-series consistency, transcription accuracy, the calculations and reference material. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

5.5.6. Recalculations

Not applicable.

5.5.7. Planned improvements

No planned improvement.

Chapter 6. Land use, land-use change and forestry (CRT sector 4)

6.1. Overview of the sector

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. Two subcategories have not been estimated, namely Land converted to Wetlands and Growth of trees and wood removals from Settlements due to lack of data. Activities not occurring are land converted to Forestland, the Cropland and Other land categories, and land converted to Other Land.

Land use changes have been derived from the land cover maps generated from satellite imagery, more fully described below under land representation and changes. All land classes were

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

The Land Use, Land Use Change and Forestry (LULUCF) sector also include emissions from gain and loss of biomass when a particular land class changes use such as Forestland being converted to Grassland or settlements, burning of biomass caused by wildfires and emissions or removals estimated for Harvested Wood Products (HWP). The sector remained a net sink throughout the time series 1990 to 2022 as shown in Figure 6.1.

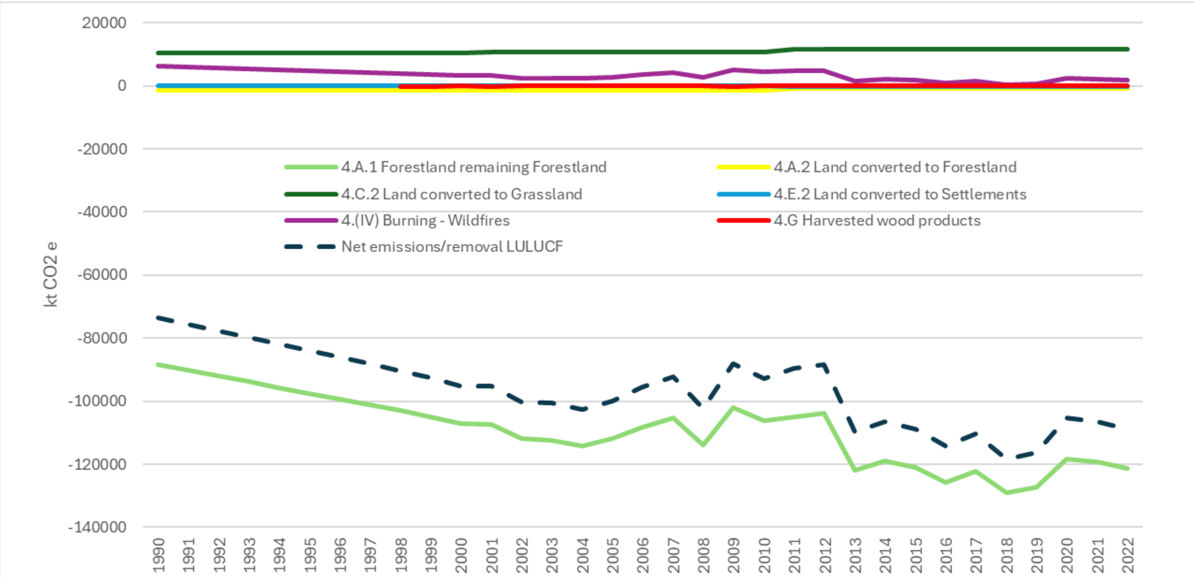

Figure 6.1. Trend of emissions and removals (kt CO2 e) from LULUCF sector (1990-2022)

The net removals increased by 48% from 73,447 kt CO2 e in 1990 to reach 109,011 kt CO2 e in 2022. This increase was 17% when compared to 2010. Land converted to grassland remained the highest emitter (Table 6.1) with 11,607 kt CO2 e in 2022 which is an increase of 12% when compared to 2010 when the category emitted 10,317 kt CO2 e. Emissions from wildfires, which are linked to the area burnt, varied between 6,138 kt CO2 e emitted in 1990 to as low as 170 kt CO2 e in 2018.

Table 6.1. Emissions (kt CO2 e) from LULUCF for selected years

	1990	2000	2010	2017	2018	2019	2020	2021	2022
Net emissions/removal LULUCF	-73,447	-95,081	-92,886	-110,231	-118,320	-116,165	-105,361	-106,455	-109,011
4.A.1 Forestland remaining Forestland	-88,401	-107,139	-106,335	-122,344	-129,091	-127,381	-118,327	-119,209	-121,376
4.A.2 Land converted to Forestland	-1,576	-1,576	-1,478	-952	-952	-952	-952	-952	-952
4.C.2 Land converted to Grassland	10,317	10,317	10,575	11,607	11,607	11,607	11,607	11,607	11,607
4.E.2 Land converted to Settlements	74.6	74.6	67.9	14.9	14.9	14.9	14.9	14.9	14.9
4.(IV) Burning - Wildfires	6,138	3,292	4,368	1,529	170	592	2,334	2,206	1,778
4.G Harvested wood products	-	-49.9	-85.1	-87.4	-69.3	-45.6	-37.1	-121.8	-83.3

6.2. Land-use definitions and the land representation approach(es)

The area of the country is subdivided into the 6 IPCC land classes as follows:

(i) Forest land – Comprising of subclasses Forestland and Other Wooded Land (OWL) which comprises of Woodland, Shrubland and Savannah.
(ii) Cropland – Annual cropland only covered
(iii) Grassland – Pure grassland without woody species
(iv) Wetlands – Flooded land
(v) Settlements – Built up areas and hard structures
(vi) Other land – Desert, Sand, rock outcrops and any land use not covered by the other five classes

The definition of each land class is given under the sections 6.4 to 6.9 below. Approach 2 land representation has been adopted for this inventory and the land use change matrix is further discussed in this report.

Land Use changes

Deforestation is estimated to be under control since the independence of Namibia. Various legislations 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. On account of the thickness of the bush as well as the fact that it has reached more than 5 metres, the change in its classification was warranted.

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

Encroachment has nearly peaked as the Grassland are in the drier environment with rainfall inadequate to support growth of woody biomass, 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 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 preserves the remaining forests and woodlands of the country. The rate of growth of major species is 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 trees growing healthily. 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 took centuries to develop, and the phenomenon of bush encroachment is the recolonization of those spaces by species better adapted to the changed climate. An extract of the report by Mendelson and Obeid is given in the NIR3 (Figure 6.3, Page 74). It is to be noted that Caprivi has been renamed Zambezi now.

6.2. Land use change and land use change matrix

Three time periods have been adopted as from the NIR3 (https://unfccc.int/documents/192582) for determining land use changes between the 6 IPCC classes: 1991 to 2000, 2001 to 2010 and 2011 to 2016. Initial areas for each period and annual change used in land matrices are given in Tables 6.2 to 6.4.

Table 6 2. Total land use (ha) adjusted area and annual change used in land matrix (1991 - 2000)

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

The major change during the period 1991 to 2000 is the loss of Grassland to OWL with bush encroachment. De- bushing activities to the tune of 80,000 ha annually were mitigating that effect. Forestland lost an average of 73,000 ha annually. The same annual land use changes adopted for the period 1991 to 2000 has been applied for the year 1990 to 1991.

Table 6.3. Total land use (ha) adjusted area and annual change used in land matrix (2001 - 2010)

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

Table 6.4. Total land use (ha) adjusted area and annual change used in land matrix (2011 - 2022)

Land Type category	Area (ha)			
	Year 2011	Year 2022	Annual gain	Annual loss
Forestland	7,328,707	6,653,438	10,000	71,388
OWL	57,672,871	59,754,593	289,361	100,114
Cropland	432,777	331,605	-	9,197
Grassland	4,899,273	3,592,740	90,000	208,776
Wetlands	724,608	724,608	-	-
Settlements	38,977	40,227	114	-
Other land	11,463,570	11,463,570	-	-
Total	82,560,782	82,560,782	389,475	389,475

During the period 2011 to 2022, the rate of loss of Cropland and Grassland decreased. The rate of increase of Settlements also slowed down.

It is a fact that this approach, which was adopted in the BUR3, NC4 and BUR4 may not be fully representative of the national situation, but it is considered better than the one adopted in the previous inventories. The intent of the country is to develop a new set of land use land cover maps over a few time steps of the inventory period to overcome potential inaccuracies in the representation of land. There is an element of cost for sourcing and ground truthing maps which is not possible under the normal BTR/NC funding. Namibia will request funds through its CBIT2 project to address this situation with regards and improve estimates for this key category which is the highest contributor in the KCA with LULUCF.

6.3. Country-specific approaches

6.3.1. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation.

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 by indigenous and exotic species have been observed since a century and have accelerated in the past 3 decades to become a serious problem, especially when the encroachment has been on the grasslands. Invasion is so much an issue that some areas are completely colonized 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 FRA of FAO is considered not representative of the national circumstances. In fact, FAO worked on information from different sources to generate land use and land cover for the year 2000 and adopted a rate of deforestation with estimation/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 the dynamics in land use changes occurring as per national circumstances. Table 6.5 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 Other Land. 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 6.5. Reclassification of various land classes into 3 main classes done in FRA for year 2000 (ha)

Land cover description	Calibrated area in FRA 2000 (ha)	Calibrated area reclassified under new class		
		Forests	OWL	OL
Shrubland	43,460,321	-	-	43,460,321
Forest	99,496	99,496	-	-
Grassland	7,220,148	-	-	7,220,148
Riverine woodland	346,870	208,122	104,061	34,687
Salt pans	538,262	-	-	538,262
Shrubland-Woodland mosaic	14,211,507	-	4,689,797	9,521,710
Sparse grassland and Shrubland	3,576,921	-	-	3,576,921
Woodland	12,875,475	7,725,285	3,862,643	1,287,548
Total	82,329,000	8,032,903	8,656,501	65,639,596

Data from maps produced by the Regional Centre for Mapping Resources for Development (RCMRD) were used for generating land use changes for previous NIR1 and NIR2. A summary of the original data is shown in Table 6.6. Explanations of the problems encountered with the original data is provided in the previous NIRs accessible from the UNFCCC website (https://unfccc.int/reports?f%5B0%5D=corporate_author%3A240&f%5B1%5D=document_type%3A3517) . The changes in land cover from the time series were not sustainable and differed a lot from those adopted in the FRA reports. The major problem areas were:

- Unsustainable deforestation rates that would result in the Forestland and Woodland classes disappearing completely in the medium term.

- Non-realistic land use changes recorded such as Settlements being converted to Forestland.
- Inclusion of vast areas with significant stocks of woody biomass under Grassland.
- The area of Other Land is 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 and at the appropriate period of the year. For example, an image of land with woody biomass can be interpreted as being grassland/shrubland if that image has been taken during the dry season as opposed to the rainy season as the canopy cover will be very different. Additionally, ground truthing of the maps was done on a restricted basis due to lack of resources.

Table 6.6. Summary of original RCMRD Land Cover derived from satellite imagery (ha)

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

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

Forestland areas for 2000 and 2010 were adopted from the FRA reports. 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)

Soil type

Another hurdle is the sub-division of land into 4 different soil types. The High Activity Clay (HAC) and Low Activity Clay (LAC) soil types are the most abundant and kept from the NIR2. While segregation brings accuracy in the estimates, this is not easy to accommodate in the IPCC Inventory Software when the Tier 2 level is 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 6.7.

Table 6.7. Distribution of different soil types in Namibia (ha & %)

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

Climate

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

6.3.2. Information on approaches used for natural disturbances, if applicable

The only disturbance considered in this inventory is the wildfires that result in partial loss of the standing biomass. Wildfires occur in Forestland and Grassland. Information from Forestry Department, MEFT was available for the years 2000 to 2022 for total area burnt. Trending technique was used to generate the areas burnt from 1990 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 section 6.10.

6.3.3. Information on approaches used for reporting Harvested Wood Products

The stock change approach adopted in Namibia's NIR5 and trade statistics on imports and exports from the NSA are available since 1998 and have been adopted as AD. The different conversion factors of the wood products and their categorization are given in the NIR5 report (https://unfccc.int › Namibia NIR5 Part 1-Final). This approach has been maintained in this inventory and data from the NSA for the years 2017 to 2022 have been used for completing the HWP time series.

6.4. Forestland (CRT 4.A)

6.4.1. Description (e.g. characteristics of category)

Forestland was divided in two sub-classes and the definitions adopted for the integration of all information from the FRA (Global Forest Resources Assessment, 2010), RCMRD maps and other reports are provided below:

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

A major change as from the NIR3 is the reclassification and merger of the bush-encroached grassland with the degraded woodlands of Namibia to form the Other Wooded Land sub-class in Forestland. This approach has been adopted as the older versions of the IPCC Inventory Software did not estimate woody biomass changes in Grasslands and most of the activity on woody biomass removals occurred and still occurs in this land class.

The Forestland land class remained a sink throughout the time series 2000 to 2022. The sink capacity varied between 89,977 kt CO2 to 130,043 kt CO2 during this period. The removals increased by 20% and 47% from 1990 to 2010 and 2022 respectively (Table 6.8).

Table 6.8. Emissions (kt CO2 e) from Forestland for selected years

	1990	2000	2010	2017	2018	2019	2020	2021	2022
Net emissions/removal Forestland	-89,977	-108,715	-107,813	-123,296	-130,043	-128,333	-119,279	-120,161	-122,328
4.A.1 Forestland remaining Forestland	-88,401	-107,139	-106,335	-122,344	-129,091	-127,381	-118,327	-119,209	-121,376
4.A.2 Land converted to Forestland	-1,576	-1,576	-1,478	-952	-952	-952	-952	-952	-952

6.4.2. Methodological issues

A Tier 2 level of the IPCC 2006 guidelines was adopted as emissions from Forestland remaining Forestland and land converted to Forestland are key categories. AD, assumptions, parameters underlying the emissions and removals estimates are provided in section 6.3, including the dynamics of changes between the 6 land classes. Assumptions and parameters underlying the emissions and removals are

(i) Compared to FRA data, slower biomass accumulation rates have been adopted over the 20 years of this time series (see matrices provided separately).
(ii) Bush encroachment has resulted in vast areas of land previously classified as shrubland/savanna/grassland to be reclassified as forestland or dense woodlands now.
(iii) Bush encroachment rate and bush clearing have been taken into consideration in the land use changes.
(iv) Emission and stock factors (growing stock, annual growth rates, etc.) have been derived for the country based on the latest information available, namely 18 forest inventories
(v) Most wood removals are accounted for in this new OWL as is presently the case for known uses (Fuelwood, charcoal and biochar production among others) of woody biomass stocks.
(vi) An increase in the Settlement land category is included in the change as population and urbanization are on the rise, based on the census reports.

Generated data and emission factors

Biomass stock factors

The standing biomass stock for Forestland was obtained by averaging the data from Forest inventory reports performed in preserved forests, community forests and conservancies in areas receiving adequate rainfall to maintain trees. Regarding Other Wooded Land, the standing biomass stocks of land defined as woodlands, shrubland and savannahs in forest inventories were pooled to provide a weighted average on an area basis for OWL. The areas used pertained to the 1990 areas allocated to these different land cover classes. The information from the different national forest inventory (NFI) reports and the land cover classes considered for deriving the user-defined stock factor for Forestland and OWL have been provided in the NIR3 (Table 6.15, Page 78). The data obtained from the NFIs were further aggregated on a weight basis to generate country specific (CS) biomass stocks for FL, OWL and GL. Table 6 shows the different biomass factors derived for the Forestland, OWL and Grassland categories.

Table 6.9. Biomass stock factors for FOLU

Land classes	Woody biomass (t/ha)	Deadwood (m3)	Above ground Biomass (t dm/ha)	Age to reach this class (yrs)	Annual growth (t dm/yr)	Grass layer (t dm/ha)
Forestland	22.63	2.76	38.47	100.0	0.385	0.23
OWL	12.13	1.48	36.38	45.6	0.797	0.69
Grassland						1.15

Wood removals

Removal of fuelwood was indexed on its rate of use by urban and rural populations 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 adopted from trade statistics. The amount of wood needed for charcoal production was based on the amount of charcoal produced and a conversion factor of 5 tons of wood for 1 ton of charcoal. This amount of wood removed has not been included as wood removal when it was lower than the above-ground biomass lost during the conversion of OWL to Grassland due to bush control activities. However, as of 2018, the amount of wood needed to produce charcoal exceeded the amount accounted for under land conversion. Thus, the differential was removed as tree-parts from OWL.

Wood removals from the different land classes are provided in Table 6.10.

Table 6.10. Wood removals from the different land classes

Year	Total (m3) wood removed from Forestland remaining forestland	Total (m3) wood removed from OWL	Total (m3) fuel wood removed from OWL	Total (m3) fuel wood removed as tree parts to cater for difference between area debushed and charcoal production
2017	99,943	267,880	558,818	0
2018	99,459	289,656	549,652	266,005
2019	98,904	268,978	540,065	265,993
2020	98,278	284,472	530,046	775,982
2021	97,581	298,386	519,584	775,970
2022	96,812	298,760	509,713	1,058,138

6.4.3. Uncertainty assessment and time-series consistency

Default Uncertainty values provided for AD and EFs in the IPCC 2006 Guidelines have been adopted in the tool designed for this exercise and based on the equations provided in the 2006 IPCC Guidelines for making the assessment.

Uncertainties were assigned for the individual parameters which eventually gave those that have been adopted for assessing uncertainties for the category.

The uncertainty levels assigned to the AD and EFs are based on the default ranges from the IPCC 2006 guidelines. These are shown in Table 6.11 for the different parameters and were ±10% for AD and varied from -30% to +30% for the EFs.

Table 6.11. Uncertainty values assigned for Forestland

Categories and parameters	Uncertainty assigned (%)	
4.A.1 Forestland remaining forestland	AD[1]	EF[2]
Biomass gain	±10	±30
Biomass loss (Wood removals and fuelwood removals)	±10	±20
Biomass loss from disturbance	±10	±15
4.A.2 Land converted to forestland		
Biomass gain	±10	±30
Dead organic matter	±10	±20
Soil organic matter	±10	±10

1: Refer to 2006 Guidelines, Chapter 3, Volume 4

2: Refer to 2006 Guidelines, Chapter 4, Volume 4

The estimated uncertainties for the level assessment are 47% for the base year 1990, 48% for year-t 2022, and 38% for the trend between base year 1990 and year-t 2022 (Table 6.12).

Table 6.12. Uncertainty assessment for Forestland

2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (Kt CO2e)	Year T (2022) emissions or removals (Kt CO2e)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in base year-1990	Contribution to Variance by Category in Year T - 2022	Uncertainty introduced into the trend in total national emissions (%)
4.A - Forestland									
4.A.1. - Forest land Remaining Forest land	CO2	-88401.3	-121375.8	20.0	43.9	48.2	2244.279	2288.962	1456.093
4.A.2.a - Cropland converted to Forest Land	CO2	-206.1	-51.2	17.3	37.4	41.2	0.009	0.000	0.009
4.A.2.b.- Grassland converted to Forest Land	CO2	-1369.6	-900.5	17.3	37.4	41.2	0.394	0.092	0.220
Sum		**-89977.1**	**-122327.5**			**Sum**	**2244.7**	**2289.1**	**1456.3**
						Uncertainty in level (L) and trend (T) assessment	**L - 47.4**	**L - 47.8**	**T - 38.2**

The time series is consistent as the AD adopted have always been from the same source, the same country specific stock factors and EFs used as well as a common methodology applied for all the years of the time series.

6.4.4. Flexibility

Not resorted to.

6.4.5. QA/QC and verification

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, generation of AD, the country specific stock and emission factors, time-series consistency, transcription accuracy, the calculations, reference material and conversion factors. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

6.4.6. Recalculations

Not applicable

6.4.7. Planned improvements

Since estimation of emissions for this category is based on diverse data sources, books, scientific publications, the FAO exercise on Forest Resources Assessments and numerous forest inventories, there exists a need for undertaking studies and assessments concurrently to update various parameters, land use and land use changes, stock and emission factors. The key activities of the improvement plan are listed below.

- Generate new unsupervised land cover land use maps from satellite data for the period 2000 to 2020 at 5 years time steps.
- Ground reference the unsupervised version to finetune and align representativeness of actual conditions in 2022.
- Determine the area converted from and to the Forestland and Grassland classes with respect to the other land classes for the different 5 years steps to 2020.
- Inventory live standing biomass stocks as appropriate for all classes of importance for making estimates.
- Confirm or develop new EFs and stock factors for all Forestland sub-classes.
- Evaluate deadwood amounts in all Forestland sub-classes.

Timeframe: 4 years subject to availability of funds

Needs: Funds to remunerate international and national consultants, international and local travel and DSA, technical assistance through international consultants and purchase of satellite images. One potential source of funding is the CBIT2 project.

6.5. Cropland (CRT 4.B)

6.5.1. Description

Land used for annual cropping solely has been considered as perennial crops occupy minimal areas (less than 100 ha which represents 0.03% of the cropland class and 0.0001% of Namibia). The main crops are maize, wheat, millet, sorghum and vegetables produced under both commercial and communal systems. It is estimated that not all land dedicated to growing crops are used every year because most crops are rainfed due to insufficient water for irrigation because the country is an arid one.

6.5.2. Methodological issues

The IPCC Tier 1 method has been adopted to estimate emissions for Cropland remaining Cropland and Tier 2 for land converted to Cropland. Estimates have been made with the IPCC 2006 software version 2.91.

6.5.3. Uncertainty assessment and time-series consistency

No uncertainty assessment done as there is a lack of information on stock and management factors, particularly for Soil Organic Matter (SOM) and woody biomass that might be present on this land class to estimate any change in carbon stocks.

The time series is consistent as the AD adopted have always been from the same source, the same country specific stock factors and EFs used as well as a common methodology applied for all the years of the time series.

6.5.4. Flexibility

Not resorted to.

6.5.5. QA/QC and verification

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, generation of AD, the appropriate default EFs, time-series consistency, transcription accuracy, the calculations and reference material. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

6.5.6. Recalculations

Not applicable

6.5.7. Planned improvements

It is planned to conduct a survey to identify more precisely the area under perennial crops as well as which crop to refine estimates under Cropland remaining Cropland to back up the mapping exercise to be undertaken for the whole territory of Namibia. Resources will be needed to cover the costs associated with an international consultant for designing the survey, supervising the survey, data analysis and reporting; national consultant for supporting the international consultant, international consultant, national consultant and enumerators travel and Daily Subsistence Allowance (DSA), training of stakeholders on use of tools for data collection and holding of workshops for capacity building of stakeholders.

Additionally, the area of annual and perennial Cropland will be determined under the improvement plan on this issue to provide more precise data on the area and address land use changes into and from Cropland to the other land classes. This concurrent exercise will enable saving of resources and address cross-cutting elements under the LULUCF category.

- Generate new ground unsupervised land cover land use maps from satellite data for the period 1990 to 2020 at 5 years time steps.
- Ground reference the unsupervised version to finetune and align representativeness of actual conditions in 2022.
- Determine the area converted from and to Cropland with respect to the other land classes for the different 5 years steps to 2020.
- Inventory live standing woody biomass stocks from trees and perennial crops.
- Confirm or develop new EFs and stock factors for perennial Cropland and mixed stands.

Timeframe: 4 years subject to availability of funds. One potential source of funding is the CBIT2 project.

6.6. Grassland (CRT 4.C)

6.6.1. Description

Grassland is now redefined as a pure stand without the presence of woody biomass as in the last NIR5 (https://unfccc.int/sites/default/files/resource/Namibia%20NIR5%20Part%201-Final%20.pdf).

Land converted to grassland through debushing/bush control activities emitted 10,317 kt CO2 in 1990 which increased to 11,607 kt CO2 as from 2011. The emissions are given in Table 6.13.

Table 6.13. Emissions (kt CO2 e) from Grassland for selected years

	1990	2000	2010	2017	2018	2019	2020	2021	2022
Net emissions/removal Grassland	10,317	10,317	10,575	11,607	11,607	11,607	11,607	11,607	11,607
4.C.2 Land converted to Grassland	10,317	10,317	10,575	11,607	11,607	11,607	11,607	11,607	11,607

6.6.2. Methodological issues

The method adopted is Tier 1 according to the IPCC 2006 Guidelines and the 2006 IPCC Software – v 2.91 has been used to compute emissions for this category.

6.6.3. Uncertainty assessment and time-series consistency

Default Uncertainty values provided for AD and EFs in the IPCC 2006 Guidelines have been used in the tool developed in Excel worksheet for making the assessment.

The uncertainty levels assigned to the AD (Table 6.14) are ±10% for AD and varied from -30% to +30% for the EFs.

Table 6.14. Uncertainty assessment for Grassland

Categories and parameters	Uncertainty assigned (%)	
4.C.2 Land converted to Grassland	AD[1]	EF[2]
Biomass gain	±10	±30
Dead organic matter	±10	±20
Soil organic matter	±10	±10

1: Refer to 2006 Guidelines, Chapter 3, Volume 4

2: Refer to 2006 Guidelines, Chapter 4, Volume 6

The estimated combined uncertainties are 41% for the level assessment for both the base year 1990 and year-t, and 28% for the trend between the base year 1990 and year-t 2022 (Table 6.15).

Table 6.15. Uncertainty assessment for Grassland

2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (Kt CO2e)	Year T (2022) emissions or removals (Kt CO2e)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in base year-1990	Contribution to Variance by Category in Year T - 2022	Uncertainty introduced into the trend in total national emissions (%)
4.C - Grassland									
4.C.2.a - Forest Land converted to Grassland	CO2	10317.4	11607.0	17.3	37.4	41.2	1700.000	1700.000	759.375
Sum		**10317.4**	**11607.0**			**Sum**	**1700.0**	**1700.0**	**759.4**
Uncertainty in level (L) and trend (T) assessment							**L - 41.2**	**L - 41.2**	**T - 27.6**

The time series is consistent as the AD adopted have always been from the same source, the same country specific stock factors and EFs used as well as a common methodology applied for all the years of the time series.

6.6.4. Flexibility applied

Not resorted to.

6.6.5. QA/QC and verification,

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, the generation of AD, the stock factors and EFs, time-series consistency, transcription accuracy, the calculations and reference material. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

6.6.6. Recalculations

Not applicable

6.6.7. Planned improvements

Estimation of emissions for this category is based on diverse data sources, books, scientific publications, the FAO exercise on Forest Resources Assessments and numerous forest inventories. There is a need to undertake studies and assessments concurrently to update various parameters, rates of conversion of Grassland to other land classes, stock and emission factors. The key activities of the improvement plan are listed below and will be run concurrently with the improvement plan on Forestland, Cropland and Settlements. This concurrent exercise will enable saving of resources and address cross-cutting elements under the LULUCF category.

- Generate new ground unsupervised land cover land use maps from satellite data for the period 1990 to 2020 at 5 years time steps.
- Ground reference the unsupervised version to finetune and align representativeness of actual conditions in 2022.
- Determine the area converted from and to Grassland with respect to the other land classes for the different 5 years steps to 2020.
- Inventory live standing grass biomass stocks.
- Confirm or develop new EFs and stock factors for Grassland.

Timeframe: 5 years subject to availability of funds

Needs: Funds to remunerate international and national consultants, international and local travel and DSA, technical assistance through international consultants and purchase of satellite images. One potential source of funding is the CBIT2 project.

6.7. Wetlands (CRT 4.D)

6.7.1. Description

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.

6.7.2. Methodological issues

Not applicable as no activity occurred in this category.

6.7.3. Uncertainty assessment and time-series consistency

Not applicable as no activity occurred in this category.

The time series is consistent as the AD adopted have always been from the same source, the same country specific stock factors and EFs used as well as a common methodology applied for all the years of the time series.

6.7.4. 6.7.4. Flexibility

Not applicable as no activity occurred in this category

6.7.5. QA/QC and verification

Not applicable as no activity occurred in this category

6.7.6. Recalculations

Not applicable as no activity occurred in this category

6.7.7. Planned improvements

There is no specific improvement plan for Wetlands except for an updating of the area which will be done in the mapping exercise on land cover land use for the Forestland, Grassland and Cropland categories (Refer to the improvement plan under these categories).

6.8. Settlements (CRT 4.E)

6.8.1. Description

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

The land conversions to Settlements emitted 74.6 kt CO2 in 1990 and reduced to 14.9 kt CO2 in 2022. This represents a drop of 80% as per Table 6.16.

Table 6.16 Emissions (kt CO2 e) from Settlements for selected years

	1990	2000	2010	2017	2018	2019	2020	2021	2022
Net emissions/removal Settlements	74.6	74.6	67.9	14.9	14.9	14.9	14.9	14.9	14.9
4.E.2 Land converted to Settlements	74.6	74.6	67.9	14.9	14.9	14.9	14.9	14.9	14.9

6.8.2. Methodological issues

The method adopted is a Tier 1 according to the IPCC 2006 Guidelines and the 2006 IPCC Software – v 2.91 has been used to compute emissions for these categories.

6.8.3. Uncertainty assessment and time-series consistency

Default Uncertainty values provided for AD and EFs in the IPCC 2006 Guidelines have been adopted in the tool provided in software V 2.91 for making the assessment.

The uncertainty levels assigned to the AD and EFs are based on the default ranges from the IPCC 2006 guidelines. These are shown in Table 6.17 for Settlements.

Table 6.17. Uncertainty values assigned to Settlements

Categories and parameters	Uncertainty assigned (%)	
4.C.2 Land converted to Grassland	AD[1]	EF[2]
Biomass (Gain and loss) abrupt	±10	±30
Dead organic matter	±10	±20
Soil organic matter	±10	±10

1: Refer to 2006 Guidelines, Chapter 3, Volume 4

2: Refer to 2006 Guidelines, Chapter 4, Volume 8

The estimated combined uncertainties for the level assessment are 36% for the base year 1990, 41% for year-t 2022, and 5% for the trend between base year 1990 and year-t 2022 (Table 6.18).

Table 6.18. Uncertainty assessment for Settlements

2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (Kt CO2e)	Year T (2022) emissions or removals (Kt CO2e)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in base year-1990	Contribution to Variance by Category in Year T - 2022	Uncertainty introduced into the trend in total national emissions (%)
4.E - Settlements									
4.E.2.a - Forest Land converted to Settlements	CO2	64.8	14.9	17.3	37.4	41.2	1282.332	1700.000	24.957
4.E.2.b - Cropland converted to Settlements	CO2	9.8	0.0	14.1	31.6	34.6	20.747	0.000	0.690
Sum		**74.6**	**14.9**			**Sum**	**1303.1**	**1700.0**	**25.6**
						Uncertainty in level (L) and trend (T) assessment	**L - 36.1**	**L - 41.2**	**T - 5.1**

The time series is consistent as the AD adopted have always been from the same source, the same country specific stock factors and EFs used as well as a common methodology applied for all the years of the time series.

6.8.4. Flexibility

Not resorted to.

6.8.5. QA/QC and verification

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, generation of AD, the appropriate country specific EFs and stock factors, time-series consistency, transcription accuracy, the calculations, reference material and conversion factors. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

6.8.6. Recalculations

Not applicable.

6.8.7. Planned improvements

The area occupied by Settlements has been computed in the same exercise for other land classes to track changes from and into Settlements from the other land classes. The improvement for updating the area under Settlements will be done concurrently when determining this parameter for other land classes from the generation of land use land cover maps from satellite images (refer to the detailed description provided under the Forestland category). Additionally, standing biomass from trees and green spaces and corridors will be assessed to improve the quality of estimates made for Settlements.

Timeframe: 4 years subject to availability of funds.

6.9. Other land (CRT 4.F)

6.9.1. Description

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

6.9.2. Methodological issues

Not applicable as no activity occurred in this category.

6.9.3. Uncertainty assessment and time-series consistency

Not applicable as no activity occurred in this category.

6.9.4. Flexibility

Not resorted to.

6.9.5. QA/QC and verification

Not applicable as no activity occurred in this category.

6.9.6. Recalculations

Not applicable as no activity occurred in this category.

6.9.7. Planned improvements.

The area occupied by Settlements has been computed in the same exercise for other land classes to track changes from and into Other Lands from the other land classes. The improvement for updating the area under Other Lands will be done concurrently when determining this parameter for other land classes from the generation of land use land cover maps from satellite images (refer to the detailed description provided under the Forestland category).

Timeframe: 4 years subject to availability of funds.

6.10. Biomass burning

6.10.1. Description

The dry climatic conditions of Namibia coupled with vast extent of vegetation makes it prone to wildfires. The activities of slash and burn before sowing of crops also contributed to the occurrence and spread of wildfires in the past. These activities are no longer practiced, and the country has invested in making fire breaks leading to a gradual decrease in area burnt during the past decade.

6.10.2. Methodological issues

The method adopted is Tier 1 according to the IPCC 2006 Guidelines and the 2006 IPCC Software – v 2.91 has been used to compute emissions for these categories. Stock factors determined and reported in sections 6.4 and 6.6 have been used. Non-CO2 GHGs and precursor gases have been estimated in these categories to avoid double counting with the CO2 part estimated under disturbance in Forestland and Grassland as described in section 6.3.2 above.

The area burnt is given in Table 6.19.

Table 6.19. Area (ha) burnt by wildfires (2017-2022)

Year	Forestland	Other Wooded land	Grassland
2017	212,319	1,809,390	122,597
2018	23,376	201,652	13,213
2019	80,358	701,738	44,421
2020	313,367	2,770,410	169,261
2021	292,908	2,621,813	154,435
2022	233,411	2,115,450	120,001

The estimated amount of biomass burnt, and combustion factors used in the NIR5 have been kept pending new assessments while default EFs have been used (Table 6.20).

Table 6.20. Biomass available for burning, combustion factor and Emission factors

Parameter	Forestland	Other Wooded land	Grassland
Mass of fuel available for combustion (t dm/ha)	44.7561	41.8966	0.35
Combustion factor	0.0601	0.07514	0.77
CH4 EF (g/kg dm burnt)	6.8	6.8	2.3
N2O EF (g/kg dm burnt)	0.2	0.2	0.21
NOx EF (g/kg dm burnt)	1.6	1.6	3.9
CO EF (g/kg dm burnt)	104	104	65

6.10.3. Uncertainty assessment and time-series consistency

Default Uncertainty values provided for AD and EFs in the IPCC 2006 Guidelines have been used in the tool developed in Excel worksheet for making the assessment.

The uncertainty levels assigned to the AD (Table 6.21) are ±10%. For the EFs, uncertainty levels varied between -29% to +50%.

Table 6.21. Uncertainty values assigned for Biomass burning

Categories	Uncertainty assigned (%)	
4.(IV) Biomass burning	AD[1]	EF[2]
CH4 – Forestland remaining forestland	±10	±29
N2O – Forestland remaining forestland	±10	±50
CH4 – Grassland remaining Grassland	±10	±39
N2O – Grassland remaining Grassland	±10	±48

1: Refer to 2006 Guidelines, Chapter 3, Volume 4

2: Refer to 2006 Guidelines, Chapter 4, Volume 4

The estimated combined uncertainties are 26% for the level assessment for both the base year 1990 and year-t, and 3% for the trend between the base year 1990 and year-t 2022 (Table 6.22).

Table 6.22. Uncertainty assessment for Biomass burning

2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (Kt CO2e)	Year T (2022) emissions or removals (Kt CO2e)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in base year-1990	Contribution to Variance by Category in Year T - 2022	Uncertainty introduced into the trend in total national emissions (%)
4(IV) - Biomass burning									
4(IV).A.1.b wildfires in Forest land remaining forest land	CH4	4770.6	1387.6	10.0	29.0	30.7	568.383	573.302	10.221
4(IV).A.1.b wildfires in Forest land remaining forest land	N2O	1328.0	386.3	10.0	50.0	51.0	121.687	122.740	0.792
4(IV).C.1.b wildfires in Grassland remaining Grassland	CH4	21.3	2.1	10.0	39.0	40.3	0.020	0.002	0.001
4(IV).C.1.b wildfires in Grassland remaining Grassland	N2O	18.4	1.8	10.0	48.0	49.0	0.022	0.002	0.001
Sum		**6138.3**	**1777.8**			**Sum**	**690.1**	**696.0**	**11.0**
						Uncertainty in level (L) and trend (T) assessment	**L - 26.3**	**L - 26.4**	**T - 3.3**

The time series is consistent as the AD have always been taken from the same source, the country specific stock factors and EFs used as well as the same methodology for all the years of the time series.

6.10.4. Description of any flexibility applied

Not resorted to.

6.10.5. Category-specific QA/QC and verification,

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, the source of the AD, the appropriate default EFs, time-series consistency, transcription accuracy, the calculations and reference material. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

6.10.6. Category-specific recalculations,

Not applicable

6.10.7. Category-specific planned improvements,

No planned improvement

6.11. Harvested Wood Products (CRT 4.Gs1-2)

6.11.1. Description

Emissions from wood removal not used as fuel do not necessarily occur in the same year of harvest as there is a lifetime associated with wood used for construction purposes or furniture for example. This sink or emission activity is accounted for under the HWP category and Namibia improved its coverage of emissions/removals in the last NIR5 by including this category.

6.11.2. Methodological issues

As discussed in section 6.3.3 above, the stock change approach adopted in the previous NIR has been kept for this inventory. National statistics on import and export data for the years 2017 to 2022 were aggregated to fit the different inputs required by the IPCC 2006 software version 2.91 for estimating removals/emissions in this category.

The activity data for the different components for years 2017 to 2022 are given in Table 6.23.

Table 6.23. Activity data for the different components of Harvested Wood Products (2017-2022)

Component	Year	2017	2018	2019	2020	2021	2022
Roundwood (m3)	Production	555,985	563,261	544,769	547,678	549,330	543,171
	Import	443	182	577	1,554	179	241
	Export	11,161	2,374	6,469	43,569	58,945	74,324
Sawnwood (m3)*	Import	56,423	43,401	47,204	46,951	59,354	62,182
	Export	4,539	5,537	6,491	8,027	14,943	11,600
Wood-based panels (m3)*	Import	23,667	20,615	19,692	19,348	79,291	30,245
	Export	274	650	312	949	763	374
Paper + Paperboard (t)*	Import	71,003	82,515	62,353	54,033	58,713	63,605
	Export	7,163	8,874	5,128	1,608	1,104	2,969
Wood Pulp (1875)+ recycled paper (t)*	Import	204	90	90	91	62	36
	Export	15,637	16,947	15,467	12,139	13,073	14,622
Industrial roundwood (m3)*	Import	65,365	31,816	43,292	53,905	55,128	51,363
	Export	25,830	53,598	50,293	51,488	48,840	48,674
Chips and particles (m3)	Import	115	443	121	105	69	67
	Export	691	580	1,831	2,546	229	1,857
Wood charcoal (t)	Import	286	104	77	77	46	60
	Export	124,689	139,447	185,940	215,461	232,270	283,201
Wood residues (m3)	Import	1,819	2,228	2,997	3,290	3,268	3,204
	Export	2,233	1,733	423	134	35	76

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

6.11.3. Uncertainty assessment and time-series consistency

Default Uncertainty values provided for AD and EFs in the IPCC 2006 Guidelines have been used in the tool developed in Excel worksheet for making the assessment.

The uncertainty levels assigned to the AD (Table 6.24) are. For the EFs ±20 has been adopted for.

Table 6.24. Uncertainty values assigned for Harvested Wood Products

Category	Uncertainty assigned (%)	
4.G Harvested Wood Products	AD[1]	EF[2]
Harvested Wood Products	±50	±50

1: Refer to 2006 Guidelines, Chapter 12, Volume 4

2: Refer to 2006 Guidelines, Chapter 12, Volume 4

The estimated combined uncertainties are 71% for the level assessment for year-t as shown in Table 6.25.

Table 6.25. Uncertainty assessment for Harvested Wood Products

2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (Gg CO2 equivalent)	Year T (2022) emissions or removals (Gg CO2 equivalent)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in base year-1990	Contribution to Variance by Category in Year T - 2022	Uncertainty introduced into the trend in total national emissions (%)
4.G - Harvested Wood Products									
4.G - Harvested Wood Products	CO2	-	-83.3	50.0	50.0	70.7	-	5000.000	-
Sum		**-**	**-83.3**			**Sum**	**-**	**5000.0**	**-**
Uncertainty in level (L) and trend (T) assessment							**-**	**L - 70.7**	**-**

The time series is consistent as the AD have always been sourced from the same source, the country specific stock factors and EFs used as well as the same methodology for all the years of the time series.

6.11.4. Description of any flexibility applied

Not resorted to.

6.11.5. Category-specific QA/QC and verification,

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, AD, the appropriate default EFs, time-series consistency, transcription accuracy, the calculations, reference material and conversion factors. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

6.11.6. Category-specific recalculations

Not applicable

6.11.7. Category-specific planned improvements,

No improvement planned

Chapter 7. Waste (CRT sector 5)

7.1. Overview of the sector

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

During the period under review, the categories falling under the 3 waste subsectors for which emissions were estimated are:

- 5.A. Solid waste disposal
- 5.C. Incineration and open burning of waste.
- 5.D. Wastewater treatment and discharge.

The trend of emissions for the Waste sector is given in Figure 7.1. Emissions increased by 189% from 108 kt CO2 e in 1990 and by 138% from 148 kt CO2 e in 2010 to reach 203 kt CO2 e in 2022.

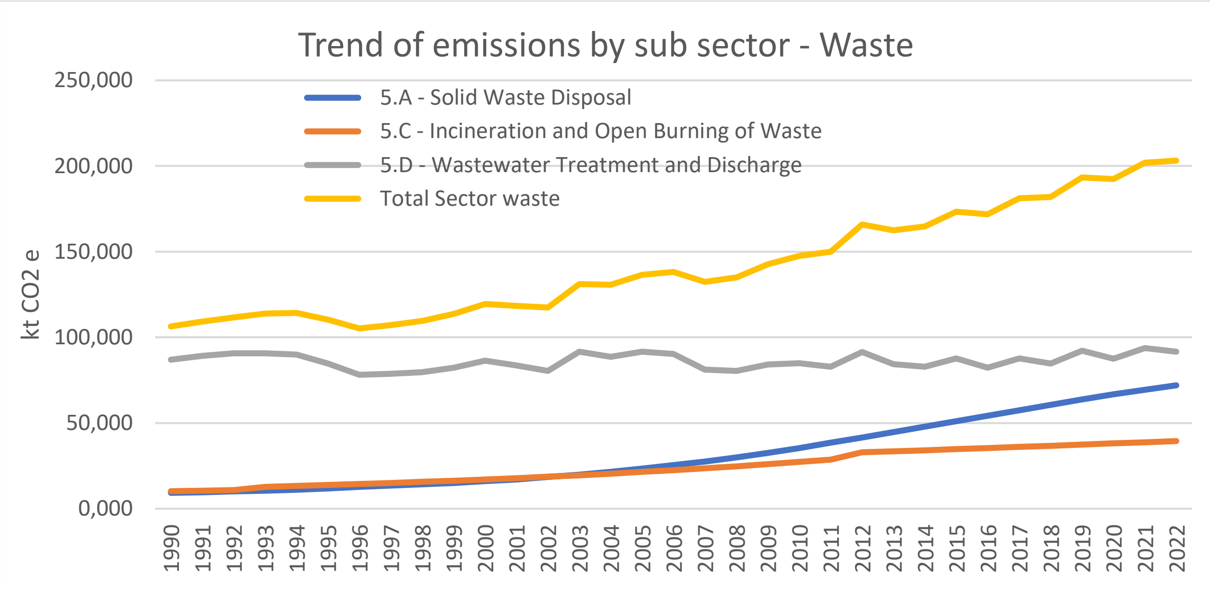

Figure 7.1. Emissions (kt CO2 e) of the Waste sector and its categories (1990-2022)

Emissions are on the rise as depicted in Figure 7.1 and Table 7.1. Out of the 3 contributing subsectors, wastewater treatment and discharge emitted the highest amount for all years of the inventory, but it is on a decreasing trend with its contribution regressing from 81% in 1990 to only 45% in 2022. Emissions from solid waste disposal increased steadily from 9 kt CO2 e in 1990 to 72 kt CO2 e in 2022 (400%). Incineration and open burning also increased over the time series from 10 kt CO2 e in 1990 to 40 kt CO2 e in 2022 representing an increase of 300%.

Table 7.1. Emissions (kt CO2 e) of the Waste sector for selected years

	1990	2000	2010	2017	2018	2019	2020	2021	2022
Waste	107.5	119.5	147.6	181.2	182.0	193.4	192.3	202.0	203.1
5.A. Solid Waste disposal	9.2	16.0	35.4	57.4	60.7	63.8	66.7	69.4	72.0

	1990	2000	2010	2017	2018	2019	2020	2021	2022
5.C Incineration and open burning	10.2	17	27.2	36.1	36.7	37.5	38.1	38.8	39.5
5.D Wastewater treatment and discharge	86.9	86.5	85.0	87.7	84.6	92.1	87.5	93.7	91.7

The share of the gases constituting the emissions in the Waste sector is given in Figure 7.2. CH4 contributed the major share of emissions of the Waste sector for all years of the time series. CH4 represented 83% of the Waste sector emissions in 1990 and it increased to 90% in 2022. The share of CH4 and CO2 are increasing while that of N2O is regressing over time.

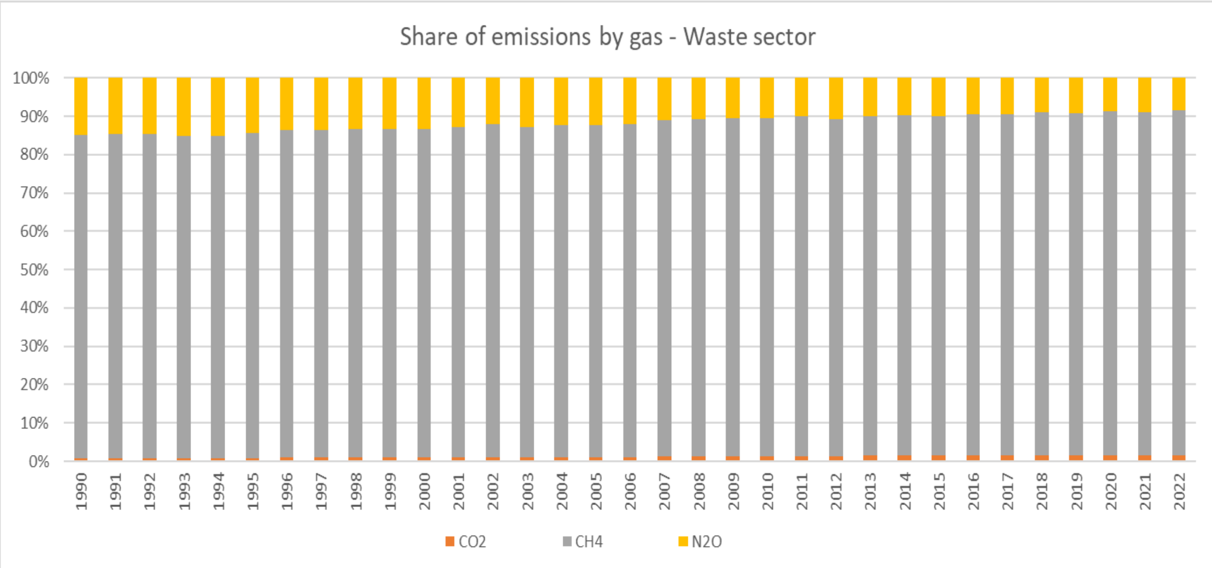

Figure 7.2. Contribution (%) by gas in the emissions of the Waste sector

7.2. Solid waste disposal (CRT 5.A)

Solid waste disposal is subdivided into 3 categories:

1. 5.A.1 – Managed Solid Waste Disposal Sites
2. 5.A.2 – Unmanaged Solid Waste Disposal Sites
3. 5.A.3 – Uncategorized Solid Waste Disposal Sites

Of these, the 2 categories which occurred and have been addressed are Managed waste disposal sites and Unmanaged waste disposal sites. Namibia is thus reporting for 5.A.1 and 5.A.2 in this inventory. For consistency purposes, all years prior to 2017 have been reviewed and estimates recalculated in line with the new methods, updated data on population and recovery of recyclables.

7.2.1. Category description

Managed waste disposal sites

Waste collection is mostly practiced in urban areas. There are three landfill sites in the country, one at Kupferberg in the Khomas region for the separate disposal of general and hazardous waste generated in the City of Windhoek and the area under its jurisdiction, and two others in the region of Erongo which receive waste from Swakopmund and Walvis Bay city councils. Information collected from the three main towns indicates that they are operating well-managed semi-aerobic systems.

Unmanaged waste disposal sites

Waste from other towns and municipalities of the country, other than the 3 reported above, is collected and disposed of in open dump sites. A recent survey undertaken during the compilation of the present inventory indicated that the smaller towns are mostly dealing with their solid waste through shallow unmanaged dumpsites.

Waste generation rates varied between regions with the population living in urban areas having a higher generation rate than in rural areas. It is estimated that the average rural inhabitant generated 0.183 t of household waste per annum in 2022 compared to 0.245 t/cap/year for urban medium, 0.261 t/cap/year for urban low and 0.277 t/cap/year for urban high. The collection rate for urban regions is 100%.

The trend of emissions for solid waste disposal is provided in Figure 7.3 and the emissions for selected years in Table 7.1. Emissions increased from 9 kt CO2 e to 72 kt CO2 e from 1990 to 2022 (683%).

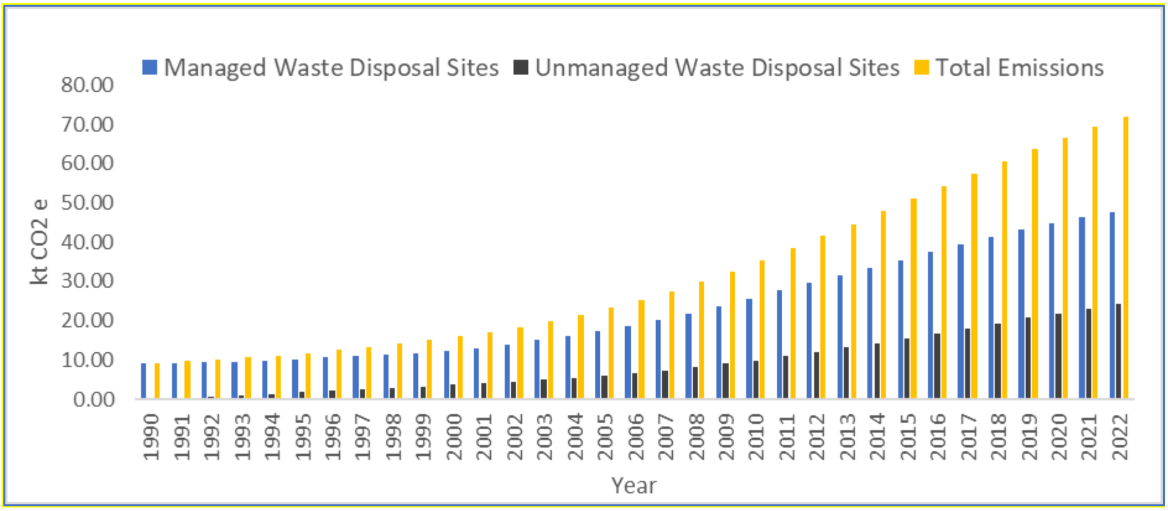

Figure 7.3. Trend (kt CO2 e) of emissions for solid waste

Emissions from managed waste disposal sites were more consequent throughout the time series with more than twice those from Unmanaged waste disposal sites (Table 7.2.).

Table 7.2. Emissions (kt CO2 e) from Solid waste disposal

	1990	2000	2010	2017	2018	2019	2020	2021	2022
5.A. Solid Waste disposal	9.2	16.0	35.4	57.4	60.7	63.8	66.7	69.4	72.0
Managed waste disposal sites	9.2	12.4	25.5	39.4	41.3	43.1	44.8	46.4	47.7
Unmanaged waste disposal sites	-	3.6	9.9	18.0	19.4	20.7	21.9	23.1	24.3

7.2.2. Methodological issues

The Tier 1 method of the IPCC 2006 guidelines was adopted for estimating emissions of solid waste. Given the lack of information on waste composition, estimates were made in the 2006 IPCC software v 2.91 using bulk waste. The urban population of the country was segregated into 3 urbanized levels, namely high, medium and low levels which were assigned to the towns according to their population and level of development. The population was then used with the estimated per capita generation rate of these 4 population groups to calculate the amount of waste generated. The remaining fraction of the population was considered as rural and the amount of waste generated by them calculated in a similar way. The amounts of waste generated were then fed into the software according to the solid waste management type for estimating emissions.

Procedures for generating amount of solid waste

The previous 2 urban subdivisions have now been reclassified in 3, namely.

- Urban high – the capital city Windhoek, the ex-capital city Swakopmund and the port Walvis Bay that are the most populous and socio-economically developed
- Urban medium – Towns with more than 15,000 people and medium socio-economic development compared to the high urban ones – 9 towns considered
- Urban low – Difference between Total urban and (urban high + urban medium)

All population statistics are from the official NSA national censuses of 1991, 2001, 2011 and the intercensal survey of 2016.

Type of waste management system (2019 Refinement):

Adoption of the 2019 Refinements warranted a change from the uncategorized system previously used to the following.

- 100% Managed well semi-aerobic for Urban high.
- 100% Unmanaged shallow (less than 5 m deep) for Urban low and Urban medium

Waste generation rates

Newly collected data from Walvis Bay and Oshakati town councils' weighbridges confirmed previous waste generation rates used as being appropriate. Only a minor correction was done for Urban low and an intermediate generation rate developed for the new Urban medium subdivision. A slight increase in generation rate was adopted to reflect progress in social development and well-being of the population. The same generation rates used in the NIR5 (https://unfccc.int/sites/default/files/resource/Namibia%20NIR5%20Part%201-Final%20.pdf) were maintained. The per capita annual waste generation rates are provided in Table 7.3.

Table 7.3. Waste generation rate (t/cap/year)

	Urban high	Urban medium	Urban Low	Rural
2011	0.228	0.215	0.202	0.134
2012	0.232	0.219	0.206	0.154
2013	0.237	0.223	0.210	0.157
2014	0.241	0.227	0.214	0.160
2015	0.246	0.232	0.218	0.163
2016	0.250	0.236	0.222	0.166
2017	0.254	0.240	0.225	0.169
2018	0.259	0.244	0.229	0.172
2019	0.263	0.248	0.233	0.175
2020	0.268	0.252	0.237	0.177
2021	0.272	0.257	0.241	0.180
2022	0.277	0.261	0.245	0.183

The reclassified population into the 3 urban subdivisions and the rural fraction are provided in Table 7.4. The total urban fraction represented the major share of the country's population.

Table 7.4. Reclassified population in new groups

	Urban high	Urban medium	Urban Low	Rural
2011	432,679	225,859	244,897	1,209,643
2012	447,457	233,864	254,135	1,210,132
2013	462,741	241,995	263,244	1,210,622
2014	478,546	250,252	272,211	1,211,111
2015	494,891	258,639	281,026	1,211,601
2016	511,794	267,156	289,674	1,212,091
2017	529,275	275,814	298,168	1,212,581
2018	547,353	284,608	306,471	1,213,072
2019	566,048	293,538	314,567	1,213,562
2020	585,382	302,608	322,444	1,214,053
2021	605,376	311,820	330,084	1,214,544
2022	626,053	321,175	337,473	1,215,035

Waste recycling

Recycling is a usual practice in the country but started at different periods. The amount of waste recycled has been quantified for the Urban high, Urban medium and Urban low subdivisions (Data from Walvis Bay, literature and information shared by stakeholders) and is provided in Table 7.5. Waste generated less the amount recovered for recycling in these subdivisions were then used for estimating emissions.

Table 7.5. % waste recovered for recycling in the urban areas

	Urban high	Urban medium	Urban Low
2011	10.0		
2012	11.5		
2013	13.2		
2014	15.2		
2015	17.5	5.0	
2016	20.2	5.9	
2017	23.2	7.1	
2018	26.7	8.4	
2019	30.8	10.0	10.0
2020	35.4	11.9	10.0
2021	40.8	14.1	10.0
2022	46.9	16.8	10.0
2023	54.0	20.0	10.0

New approach in Software

Previously national data were entered in the software and then fractionated according to the different systems in use. In the new version, it is now possible to create subdivisions in terms of region with multiple waste management systems. This new approach which has been adopted is an improvement that captures better information to represent the country's circumstances.

Waste composition

No waste composition is available, and thus bulk waste was considered.

Industrial waste

The same method adopted in the NIR5 (https://unfccc.int/sites/default/files/resource/Namibia%20NIR5%20Part%201-Final%20.pdf) has been maintained for estimating industrial waste. The same time series has been updated for the period 2017 to 2022 and entered in Urban high region as all industries are within the city council areas and their waste after sorting are disposed of in the municipal system.

Sludge

The same methodology used for estimating sludge amount for the period 1990 to 2016 (https://unfccc.int/sites/default/files/resource/Namibia%20NIR5%20Part%201-Final%20.pdf) has been used for the additional years 2017 to 2022. Sludge from Walvis Bay and Swakopmund has not been sent to the landfills as they are used as organic amendment in soils and have thus been discounted in the estimates of sludge generated. The use as organic amendment occurs in landscaping activities within city council limits. Sludge from Urban low and medium subdivisions estimated for their respective population using the centralized networks only has been sent to the landfills. Previously the whole population of these regions were used for calculating wastewater generated.

The activity data, namely the amount of waste entering the Managed and Unmanaged waste disposal sites, are provided in Table 7.6.

The amount of waste sent to the disposal sites increased from 1990 following the demographic evolution, extension of urban limits and migration from rural areas. However, a decrease in the amount sent to managed disposal sites occurred as from the year 2020 due to the recycling activities in the three major urban areas, namely Windhoek, Walvis Bay and Swakopmund.

Table 7.6. Amount (t) of disposed of and treated in waste disposal sites

Year	Managed disposal sites	Unmanaged disposal sites
1990	12,908	10,527
1991	15,082	19,547
1992	16,728	21,010
1993	18,554	22,557
1994	20,580	24,191
1995	22,826	25,916
1996	25,318	27,737
1997	28,082	29,656
1998	31,148	31,678
1999	34,548	33,807
2000	38,320	36,047
2001	42,503	38,402
2002	46,237	42,628
2003	50,299	47,180
2004	54,717	52,078
2005	59,524	57,344
2006	64,753	63,000
2007	70,441	69,072

Year	Managed disposal sites	Unmanaged disposal sites
2008	76,630	75,584
2009	83,361	82,562
2010	90,684	90,034
2011	88,786	98,029
2012	92,025	103,585
2013	95,071	109,277
2014	97,842	115,107
2015	100,238	118,077
2016	102,135	123,425
2017	103,383	128,727
2018	103,799	133,927
2019	103,159	131,631
2020	101,192	136,133
2021	97,568	140,315
2022	91,887	144,072

Emission factors appropriate to the new disposal system have been used. They are the defaults from the IPCC 2006 guidelines, 2019 Refinements and are presented in Table 7.7.

Table 7.7. EFs (fraction) used for estimating emissions in Managed waste disposal sites

SWDS type	Methane correction factor	Oxidation factor
Managed well semi-aerobic	0.5	0.1
Unmanaged shallow (less than 5m)	0.4	0.0

7.2.3. Uncertainty assessment and time-series consistency

The uncertainties assigned for solid waste systems (Table 7.8) to the AD are ±30 and ±60 for EFA and are from the IPCC 2006 guidelines for the default EFs.

Table 7.8. Uncertainty levels assigned to Managed waste disposal sites

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[2]
4.A Solid Waste Disposal			
4.A.1 - Managed Waste Disposal Sites and Unmanaged waste disposal sites	CH4	±30	±60

1 and 2: Source - IPCC 2019 Refinement to 2006 Guidelines, Vol. 5, Chapter 3, page 3.20, Table 3.5 (Updated)

The combined uncertainties determined using the tool developed in an Excel worksheet in line with the methods contained in the IPCC 2006 guidelines are provided in Table 7.9 for this sub-category. The uncertainties for the level assessment for the base year 1990 and year-t (2022) are 67% and 50% respectively while the trend assessment with 1990 as base year and 2022 as year-t is 331%.

Table 7.9. Uncertainty assessment to Managed waste disposal sites

2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (Gg CO2 equivalent)	Year T (2022) emissions or removals (Gg CO2 equivalent)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in base year-1990	Contribution to Variance by Category in Year T - 2022	Uncertainty introduced into the trend in total national emissions (%)
4.A Solid Waste Disposal									
4.A.1 - Managed Waste Disposal Sites	CH4	9.2	47.7	30	60	67	4500.0	1975.9	72292.8
4.A.2 - Unmanaged Waste Disposal Sites	CH4	0.0	24.3	30	60	67	0.0	512.1	37271.6
Sum		9.2	72.0			Sum	4500.0	2488.1	109564.4
Uncertainty in level and trend							67	50	331

The time series is consistent as the AD have been calculated using the same methods, the default EFs of IPCC used as well as a common methodology for all the years of the time series.

7.2.4. Flexibility

Not resorted to.

7.2.5. QA/QC and verification

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, procedures adopted for generating amounts of waste AD, the appropriate default EFs, time-series consistency, transcription accuracy, the calculations and reference material. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

7.2.6. Recalculations

Changes in activity data or methodology warrant recalculations as appropriate. Regarding solid waste disposal, the methods have evolved as provided by the latest inventory software which allows for estimating emissions from the different waste management systems separately. Additionally, new information collected for this inventory enabled a reclassification of the population into more disaggregated subdivisions which better reflect the waste generation rates and the national situation. Improved data on waste recovered for recycling or used for energy purposes was also collected. Under these circumstances, it is good practice to recalculate emissions whenever these two factors are concerned to increase accuracy while maintaining consistency of the inventory.

Hence, recalculations have been made for all previous years of the inventory, namely the period 1990 to 2016, to ensure consistency in the inventory by aligning the same method to the extended time series and improving the quality of the AD on population and recycling for more accuracy. More details including the impact on previous estimates are provided in Chapter 10 of this NID. The total emissions from the Solid Waste Disposal sub-sector, comprising of Managed and Unmanaged disposal sites, for the NID1 is compared with the previous GHG inventory NIR5 of Namibia where all the waste was grouped under uncategorized waste disposal sites. The data from the NIR5 has been converted to the AR5 GWP for comparison purposes. The previous and recalculated emissions are given in Table 7.10.

Table 7.10. Comparison of previous emissions (kt CO2 e) with recalculations for the period 1990 to 2016 for waste disposal sites

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
Previous	12.3	14.5	16.7	19.0	21.3	23.7	26.2	28.8	31.5
Recalculated	9.2	9.6	10.1	10.6	11.1	11.8	12.7	13.4	14.2
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Previous	34.3	37.2	40.3	43.7	47.3	51.3	55.6	60.2	65.3
Recalculated	15.0	16.0	17.1	18.4	19.9	21.6	23.4	25.4	27.6
Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Previous	70.7	76.6	82.9	89.8	94.9	100.4	106.2	112.2	118.7
Recalculated	30.0	32.6	35.4	38.5	41.6	44.6	47.8	51.0	54.2

7.2.7. Planned improvements

Estimates of emissions for solid waste can still be improved and the areas listed below have been identified for action. The exercise will be gradual and integrated in the BTR process over the next 4 years.

- Updating of the population on the latest NSA census data to better reflect national circumstances. This is planned for the next inventory with no additional resources needed.
- Undertaking surveys to better capture solid waste generation by the population but this may take time for weighbridges to be purchased and installed due to lack of funds.
- Improving collection of data at weighbridges through better engagement of stakeholders in the inventory process.
- Developing a tool to convert volume of waste to mass through assessment of waste density.
- Determining waste composition at the disposal sites of city councils.
- Undertaking a survey to capture recycling activities, amounts recovered by type of waste and their fate more precisely.
- Improving estimation of emissions from the bulk waste approach to estimates by composition.
- Improving AD collection for Industrial waste through stakeholder consultation and engagement.
- Improving AD collection of sludge, including their fate.

7.3. Incineration and open burning of waste (CRT 5.C)

Incineration and open burning of waste was only partially covered previously, namely the latter only. It has been quite a challenge to improve this subsector but both categories are now covered. Emissions are on the increase especially as from 2017 with the inclusion of Incineration.

7.3.1. Category description

Incineration was not reported previously due to lack of data. Data are now available from the two main cities Windhoek and Walvis Bay which permitted estimation of emissions for incineration. However, some more effort needs to be invested to raise the coverage by capturing missing data.

Open burning of waste has always been addressed and this continued for this inventory. Emissions for selected years provided in Table 7.11 indicate that they are on the increase.

The trend of emissions for Incineration and open burning is depicted in Figure 7.4. Emissions increased from 11.4 kt CO2 e in 1990 to 39.5 kt CO2 e in 2022, which represented an increase of 347% on 1990 and 145% on 2010.

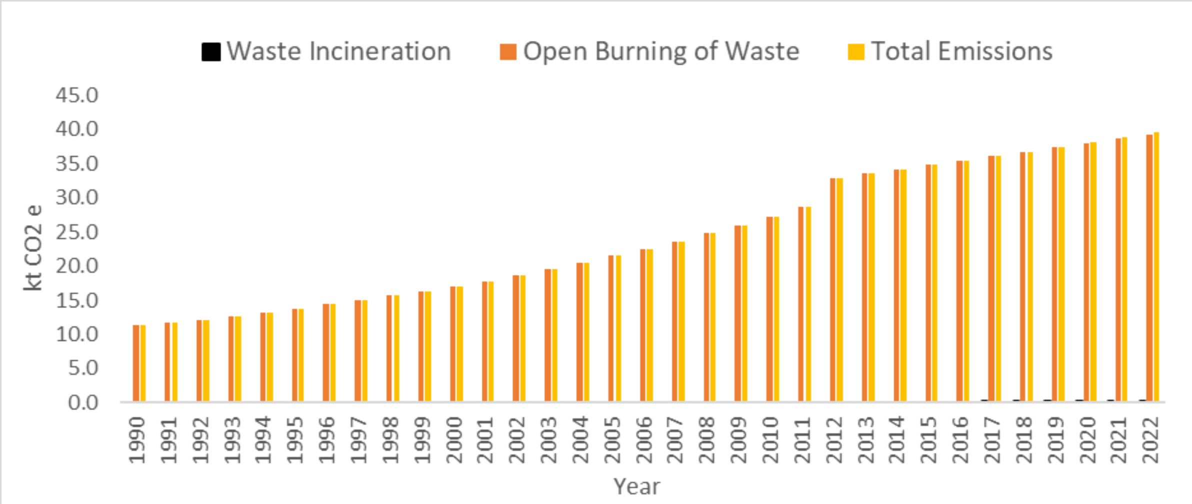

Figure 7.4. Trend of emissions (kt CO2 e) from Incineration and open burning of waste (1990 – 2022)

Table 7.11 show that incineration activities emitted 0.04 kt CO2 e in 2017, and this increased to 0.24 kt CO2 e in 2022. For open burning of waste, emissions increased by 385% and 144% respectively when comparing those of 1990 (11 kt CO2 e) and 2010 (27 kt CO2 e) to the 39 kt CO2 e of 2022.

Table 7.11. Emissions (kt CO2 e) from Incineration and Open burning of waste

	1990	2000	2010	2017	2018	2019	2020	2021	2022
%.C – Incineration and Open burning of waste	11.4	17	27.2	36.1	36.7	37.5	38.1	38.8	39.5
5.C.1 - Waste incineration	NE	NE	NE	0.04	0.06	0.15	0.19	0.21	0.24
5.C.2 - Open Burning of Waste	11.4	17.0	27.2	36.0	36.7	37.3	38.0	38.6	39.2

7.3.2. Methodological issues

Incineration

Stakeholders were consulted and engaged in view of data collection for this category. Data collection was undertaken by requesting them to use the tools provided to them by the Waste TWG members. The data collection process is considered quite satisfactory as the 2 main cities Windhoek and Walvis Bay responded positively and provided the data required as well as information on the characteristics of the incinerators. The Tier 1 method of the IPCC 2006 guidelines was adopted for estimating emissions of the Incineration category. The amounts of waste incinerated are given in Table 7.12.

Table 7.10. Amount (t) of waste incinerated (2017-202)

	Windhoek	Walvis Bay
2017	NA	72.542
2018	55.78	54.238
2019	232.56	15.641

	Windhoek	Walvis Bay
2020	249.03	80.663
2021	296.01	71.245
2022	317.63	91.188

Open burning of waste

All cities and towns of Namibia collect and treat their solid waste in either managed or unmanaged landfills. The remaining rural fraction of the population does not have collection services at their disposal. They thus individually dispose their waste that is mostly organic and also in small amounts. All waste generated in the rural areas is assumed to be open burned since there are no collection facilities operational. They usually burn their waste when it becomes bulky or becomes a sanitation problem. Part of the waste is also fed to animals, but this has been very difficult to capture but has not affected the emissions level as the organic part is renewable and neutral. The amounts of waste generated were obtained by multiplying the population of the rural regions by the per capita generation rate. The Tier 1 method of the IPCC 2006 guidelines was adopted for estimating emissions of the Open burning of waste category. The AD generated and used in the 2006 IPCC software are given in Table 7.13.

Table 7.13. Waste generation and amounts for Open burning of waste (2027-2022)

Year	Generation rate (t/cap/yr)	Population	Amount of waste OB (t)
2017	0.169	1,212,581	204,572
2018	0.172	1,213,072	208,202
2019	0.175	1,213,562	211,835
2020	0.177	1,214,053	215,470
2021	0.180	1,214,544	219,109
2022	0.183	1,215,035	222,750

For Incineration, EFs are linked with technology of incinerator and both data providers availed the information. These guided the selection of the default EFs of the IPCC 2006 guidelines that are depicted in Table 7.14.

Table 7.14. EFs used for Incineration

Information	Windhoek	Walvis Bay
Type of technology	Semi continuous	Batch
Type of incinerator	Stoker	Stocker
Type of waste	Clinical waste	Clinical waste
EF CH4 (kg CH4/Gg wet waste)	6	60
EF N2O(kg N2O/Gg wet waste)	41	56

For CO2 the parameters provided in Table 7.15 were used to estimate emissions.

Table 7.15. Waste characteristics used for Incineration

Dry matter content	Fraction of carbon in dry matter	Fraction of fossil carbon	Oxidation factor
0.65	0.60	0.04	1

Emissions factors used for Open burning of waste and provided in Table 7.16 are those from the IPCC 2006 guidelines. The fraction burned is assumed as 80%.

Table 7.16. EFs used for Open burning of waste

Dry matter content	Fraction of carbon in dry matter	Fraction of fossil carbon	Oxidation factor
0.57	0.32	0.04	0.58

7.3.3. Uncertainty assessment and time-series consistency

The uncertainties assigned to the AD and the default EFs (Table 7.17) are ±40 and ±100 respectively for the 3 gases and are from the IPCC 2006 guidelines.

Table 7.17. Uncertainty levels assigned to Incineration and open burning

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
		AD[1]	EF[2]
4.C.1 - Incineration and Open burning of waste	CO2	±40	±100
4.C.1 – Incineration and Open burning of waste	CH4	±40	±100
4.C.1 – Incineration and Open burning of waste	N2O	±40	±100

1: Source - IPCC 2006 Guidelines, Vol. 5, Chapter 5, page 5.24, paragraph 5.7.2

2: Source - IPCC 2006 Guidelines, Vol. 5, Chapter 5, page 5.23, paragraph 5.7.1

The combined uncertainty determined using the tool developed in an Excel worksheet in line with the methods contained in the IPCC 2006 guidelines is provided in Table 7.18 for this sub-category. The uncertainty for the level assessment for the base year 1990 and the year-t 2022 is 90% and 89% respectively and the trend from the base year to year-t (2022) is 22%.

Table 7.18. Uncertainty assessment for Incineration and Open burning

2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (Gg CO2 equivalent)	Year T (2022) emissions or removals (Gg CO2 equivalent)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in base year-1990	Contribution to Variance by Category in Year T - 2022	Uncertainty introduced into the trend in total national emissions (%)
4.C - Incineration and Open Burning of Waste									
4.C.1 - Waste Incineration	CO2	0.0	0.2	40	100	107.7	0.0	0.4	0.1
4.C.1 - Waste Incineration	CH4	0.0	0.0	40	100	107.7	0.0	0.0	0.0
4.C.1 - Waste Incineration	N2O	0.0	0.0	40	100	107.7	0.0	0.0	0.0
4.C.2 - Open Burning of Waste	CO2	0.8	2.8	40	100	107.7	57.6	56.9	3.5
4.C.2 - Open Burning of Waste	CH4	9.4	32.4	40	100	107.7	7926.3	7830.6	476.9
4.C.2 - Open Burning of Waste	N2O	1.2	4.0	40	100	107.7	122.8	121.4	7.4
Sum		11.4	39.5			sum	8106.7	8009.3	487.8
Uncertainty in level and trend							90	89	22

The time series is consistent as the AD have always been sourced from the same institution, the default EFs of IPCC used as well as a common methodology for all the years of the time series.

7.3.4. Flexibility

Not resorted to.

7.3.5. QA/QC and verification

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, generation of AD, the appropriate default EFs, time-series consistency, transcription accuracy, the calculations and reference material. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

7.3.6. Recalculations

Not applicable.

7.3.7. Planned improvements

Incineration

Estimates of emissions for incineration can still be improved by ensuring AD collection for all operational incinerators. This action will consist of additional stakeholder consultation and engagement. This is planned during the next 2 inventory cycles gradually at no additional cost.

Open burning of waste

Estimates of emissions for Open burning can still be improved and the areas identified for action are listed below.

- Update the population in each subdivision on the latest NSA census data to better reflect national circumstances. This is planned for the next inventory with no additional resources needed.
- Undertake surveys to better capture and improve the quality of data on open burning of waste.
- Develop a tool to convert volume of waste to mass through assessment of density waste density.
- Determine waste composition of waste open burned.
- Undertake a survey to capture recycling activities and amounts recovered by type of waste.
- Improve from making emissions from bulk waste to estimates by composition.
- Improve AD collection for Industrial waste through stakeholder consultation and engagement in rural areas.

7.4. Wastewater treatment and discharge (CRT 5.D)

7.4.1. Category description

Wastewater treatment and discharge comprises 3 categories Domestic wastewater, Industrial wastewater and Other. Two categories occur in Namibia, namely Domestic wastewater and Industrial wastewater and both have been addressed.

The trend of emissions for Wastewater treatment and discharge is provided in Figure 7.5. Emissions from Wastewater treatment and discharge of 2022 increased by 105% and 108% relative to 1990 and 2010 respectively.

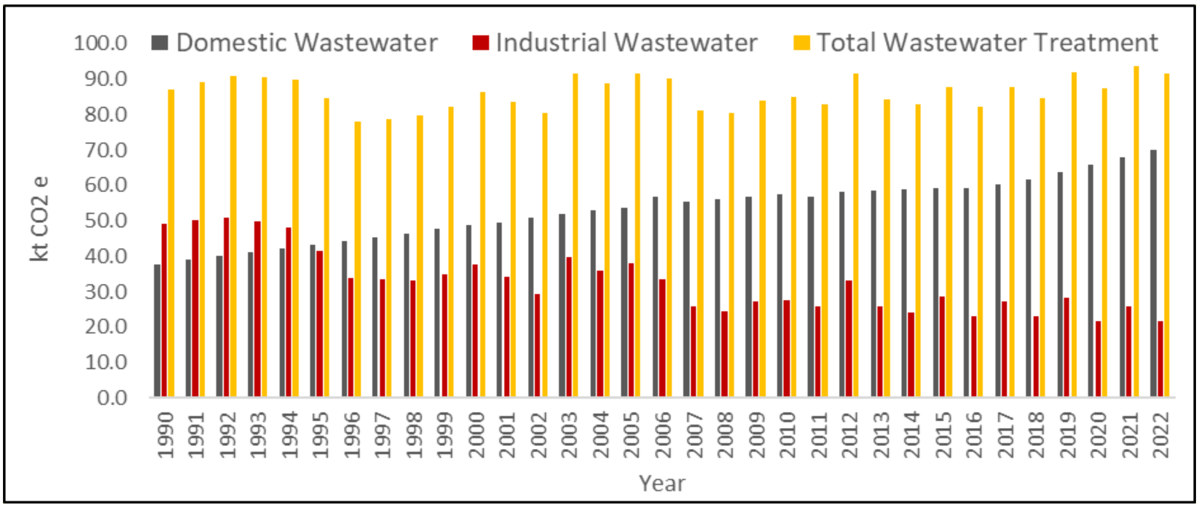

Figure 7.5. Trend of emissions (kt CO2 e) from Wastewater treatment and discharge (1990-2022)

Emissions from the Domestic wastewater and Industrial wastewater categories are provided in Table 7.19 for selected years. Domestic wastewater emissions increased by 186% from 1990 to 2022 and by 122% from 2010 to 2022. Emissions were 37.8 kt CO2 e in 1990, 57.5 kt CO2 e in 2010 and 70.1 kt CO2 e in 2022. For Industrial wastewater it decreased from 49.1 kt CO2 e in 1990 to 27.5 kt CO2 e in 2010 and further to 21.5 kt CO2 e in 2022. This represents a reduction of 22% and 66% when comparing 2022 to 1990 and 2010 respectively.

Table 7.19. Emissions (kt CO2 e) from Domestic wastewater

	1990	2000	2010	2017	2018	2019	2020	2021	2022
5.D. Wastewater treatment and discharge	86.9	86.5	85.0	87.7	84.6	92.1	87.5	93.7	91.7
5.D.1 - Domestic Wastewater Treatment and Discharge	37.8	48.7	57.5	60.4	61.7	63.8	65.9	68.0	70.1
5.D.2 - Industrial Wastewater Treatment and Discharge	49.1	37.8	27.5	27.3	23.0	28.3	21.6	25.7	21.5

7.4.2. Methodological issues

GHG emissions originating from the Waste Sector were estimated following a Tier 1 methodological approach as per the IPCC 2006 Guidelines for National GHG Inventories and computed using the IPCC Inventory Software. All AD were from national sources except protein consumption which was from the FAO stats database, but all EFS were the default values from the IPCC 2006 guidelines.

There has been no change in the methodology adopted to-date for computing emissions of the Domestic wastewater category. In brief, the population of Namibia is segregated into 3 subdivisions, namely an Urban high group comprising the inhabitants of the 3 most advanced cities Windhoek, Swakopmund and Walvis Bay, the other towns and cities as Urban Low and the remainder constituting the rural group. The data from the censuses of NSA for 1991, 2011, and the intercensal survey of 2016 were adopted for assigning use rate of the 3 subdivisions relative to the 3 wastewater treatment systems Centralized aerobic system, Septic System and Latrines. These data are provided in Table 7.20

for population distribution, and Tables 7.21, 7.22 and 7.23 for use rate in Urban high, Urban low and Rural regions respectively.

Table 7.20. Fraction of population used for estimating Domestic wastewater emissions

Year	Urban High	Urban Low	Rural
2017	0.212	0.278	0.510
2018	0.215	0.285	0.500
2019	0.218	0.297	0.497
2020	0.221	0.308	0.494
2021	0.223	0.320	0.491
2022	0.226	0.333	0.487

Table 7.21. Use rate (fraction of population) of wastewater treatment systems in Urban high regions

Year	Centralized aerobic	Latrine	Septic system
2017	0.780	0.025	0.048
2018	0.782	0.024	0.058
2019	0.784	0.023	0.068
2020	0.785	0.023	0.078
2021	0.787	0.022	0.088
2022	0.789	0.021	0.098
2023	0.770	0.029	0.029

Table 7.22. Use rate (fraction of population) of wastewater treatment systems in Urban low regions

Year	Centralized aerobic	Latrine	Septic system
2017	0.404	0.078	0.043
2018	0.376	0.077	0.053
2019	0.348	0.076	0.063
2020	0.320	0.074	0.073
2021	0.292	0.073	0.083
2022	0.264	0.072	0.093
2023	0.563	0.085	0.033

Table 7.23. Use rate (fraction of population) of wastewater treatment systems in Rural regions

Year	Centralized aerobic	Latrine	Septic system
2017	0.069	0.124	0.042
2018	0.066	0.126	0.044
2019	0.063	0.127	0.046
2020	0.060	0.129	0.048
2021	0.057	0.131	0.050
2022	0.055	0.133	0.052

Protein consumption (Table 7.24) was based on FAOSTATS and data gaps were filled by using the trending technique for years not available.

Table 7.24. Annual per capita protein intake (kg/capita/year)

Year	Protein intake (kg/capita/year)
2017	23.470
2018	23.725
2019	24.322
2020	24.628
2021	24.934
2022	25.240

Exploitable data on industrial wastewater production were available only for the meat (beef and sheep) and while for fish (Pilchards and Mackerel processing) the same trend adopted for the NIR5 has been kept for the period 2017 to 2022. Beef production data from MeatCo abattoirs were available from annual reports obtained from the web. No data could be sourced for sheep handled at abattoirs and thus the same value adopted since NIR5 has been adopted to complete the inventory up to 2022. AD for industrial wastewater is given in Table 7.25.

Table 7.25. AD (t) used for Industrial wastewater treatment and discharge

Year	Sheep	Beef	Fish
2017	14,786	22,381	255,485
2018	14,786	20,765	208,634
2019	14,786	29,870	255,485
2020	14,786	9,795	208,634
2021	14,786	9,932	255,485
2022	14,786	9,632	208,634

The default EFs from the IPCC 2006 guidelines used for computing emissions in the Domestic wastewater category are given in Table 7.26.

Table 7.26. Methane correction factor by system type

	Urban High	Urban Low	Rural
Centralized Aerobic system	0[a]	0.3[b]	0.3[b]
Septic system	0.5	0.5	0.5
Latrines	0.1[c]	0.1[c]	0.5[d]

a = Well managed b = Overloaded **c = Dry climate, small family, water table low**

d = Dry climate, communal, water table low

A weighted average for methane emission factor (WEF) for the total population of Namibia was calculated in Excel and used for estimating emissions from domestic wastewater. Parameters from Tables 7.19, 7.20, 7.21, 7.22 and 7.25 were used with a maximum methane production capacity of 0.6 kg CH4/kg BOD to do this estimate. Furthermore, N2O emissions were estimated from domestic wastewater management systems only as per 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

For estimating emissions from Industrial wastewater, the EFs taken from the IPCC 2006 Guidelines (Vol 5.3 Ch 3 Table 3.1) and are given in Table 7.27. N2O emissions are now estimated for this category as per the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Table 7.27. EFs used for computing emissions for Industrial wastewater

	Wastewater generated (m3/t)	COD (kg COD/m3)	CH4 EF (kg Ch4/kg COD)	Total N concentration in wastewater (kg/m3)
Meat and poultry	13	4.1	0.075	0.19
Fish processing	13	2.5	0.075	0.6

7.4.3. Uncertainty assessment and time-series consistency

All uncertainty values assigned are from the IPCC 2006 guidelines and provided in Table 7.28. The uncertainties assigned to the AD and the default EFs for Domestic waster are ±57% and ±141% for both CO2 and N2O. Those assigned to Industrial Wastewater Treatment and Discharge are ±39% for CH4 and ±38% for N2O for AD. The levels assigned for CH4 and N2O for the EFs are ±42% and ±258% respectively.

Table 7.28. Uncertainty levels assigned to Wastewater treatment and discharge

2006 IPCC Categories	Gas	Uncertainty assigned (%)	
			EF[2]
4.D.1 - Domestic Wastewater Treatment and Discharge	CH4[1]	±57	±141
	N2O	±57[2]	±141[3]
Industrial wastewater Treatment and Discharge	CH4[4]	±39	±42
	N2O[5]	±38	±258

1: Source – IPCC 2019 Refinement to 2006 Guidelines, Vol. 5, Chapter 6, page 6.29, Table 6.7 (Updated)

2: Source – IPCC 2019 Refinement to 2006 Guidelines, Vol. 5, Chapter 6, page 6.43, Table 6.11 (Updated)

3: Source – IPCC 2019 Refinement to 2006 Guidelines, Vol. 5, Chapter 6, page 6.39, Table 6.8a (New).

4: Source – IPCC 2006 Guidelines, Vol. 5, Chapter 6, page 6.23, Table 6.10.

5: Source – IPCC 2019 Refinement to 2006 Guidelines, Vol. 5, Chapter 6, page 6.49, Table 6.13(New).

The combined uncertainty determined using the tool developed in an Excel worksheet in line with the methods contained in the IPCC 2006 guidelines is provided in Table 7.29 for this category. The uncertainty for the level assessment for the base year 1990 and year-t (2022) are 71% and 105% respectively. The trend uncertainty with base year 1990 and year-t 2022 is 77%.

Table 7.29. Uncertainty assessment for Wastewater treatment and discharge

2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (Gg CO2 equivalent)	Year T (2022) emissions or removals (Gg CO2 equivalent)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in base year-1990	Contribution to Variance by Category in Year T - 2022	Uncertainty introduced into the trend in total national emissions (%)
4.D - Wastewater Treatment and Discharge									
4.D.1 - Domestic Wastewater Treatment an	CH4	32.6	61.7	57	141	152	3270	10494	5168
4.D.1 - Domestic Wastewater Treatment an	N2O	5.2	8.5	57	141	152	82	198	85
4.D.2 - Industrial Wastewater Treatment an	CH4	38.5	17.0	39	42	58	653	114	248
4.D.2 - Industrial Wastewater Treatment an	N2O	10.6	4.6	38	258	260	1013	169	393
Sum		86.9	91.7			sum	5017.3	10975.1	5894.6
Uncertainty in level and trend							71	105	77

The time series is consistent as the AD have always been sourced from the same institution, the default EFs of IPCC used as well as a common methodology for all the years of the time series.

7.4.4. Flexibility applied

Not resorted to.

7.4.5. QA/QC and verification

The quality control checks were consistent with those of the 2006 IPCC Guidelines which served for developing the QA/QC plan of Namibia. Elements of the QC checks included a review of the estimation models for choice of the most appropriate method, the process adopted for generating AD, the appropriate default EFs, time-series consistency, transcription accuracy, the calculations and reference material and conversion factors. Quality Assurance during the estimation steps was done by the GHG inventory TWG and eventually by independent international experts.

7.4.6. Recalculations

Recalculations of emissions from the Wastewater Treatment and Discharge sub-sector stem from the inclusion of N2O emissions for Industrial wastewater in the 2019 Refinements of the IPCC guidelines and the emissions from Domestic Wastewater for centralized Wastewater Management and Treatment systems only.

The data for the Wastewater Treatment and Discharge sub-sector has been converted to AR5 GWP to compare with the recalculated emissions as per Table7.30. Emissions have increased between 40% to 66% with the recalculation.

Table 7.30. Comparison of previous emissions (kt CO2 e) with recalculations for Wastewater (1990-2016)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
Previous	61.9	63.5	64.3	64.0	63.1	59.0	53.6	53.6	53.8
Recalculated	86.9	89.2	90.8	90.7	90.0	84.7	78.2	78.8	79.7
Year	1999	2000	2001	2002	2003	2004	2005	2006	2007
Previous	55.7	58.4	56.5	52.9	61.6	59.3	61.8	58.9	48.7
Recalculated	82.4	86.5	83.5	80.4	91.6	88.6	91.7	90.3	81.2
Year	2008	2009	2010	2011	2012	2013	2014	2015	2016
Previous	52.7	55.5	56.0	55.6	61.8	56.4	55.6	59.6	55.4
Recalculated	80.3	84.1	85.0	82.8	91.5	84.3	82.9	87.6	82.3

7.4.7. Planned improvements

Planned improvements on Domestic wastewater include accessing the latest census information on population and rate of use of wastewater treatment systems by the respective groups to improve accuracy and assessment of the level of water tables in the populated areas to correct the EF for latrines as appropriate. While the first improvement will be made without additional costs within the framework of the next inventory, the assessment of water tables, including possible fluctuations in relation to the rainfall and dry seasons will take more time and will need resources. This exercise is planned to be completed within a period of 6 years as from when resources become available.

Regarding Industrial wastewater, even if the main industries of the country are assessed, there is need to extend the exercise to include the poultry, beer, dairy and tanning industries. The other item identified is to collect data on the type of management system associated with the industries. This is expected to be completed for inclusion in the next inventory.

Chapter 8. Other (CRT sector 6)

Not applicable

Chapter 9. Indirect carbon dioxide and nitrous oxide emissions

Not estimated

Chapter 10. Recalculations and improvements

10.1. Explanations and justifications for recalculations

Categories considered for recalculations are those where improved AD has been collected, EFS have changed and improved methods available due to updating of the IPCC 2006 Guidelines, namely the adoption of the 2019 refinements. Categories subjected to recalculations are:

Solid Waste disposal

The recalculations of this sub-sector and its categories originate from a lack of information in the previous inventories and an improvement in the IPCC software which now allows for separate emission estimates for the different types of waste disposal sites.

Wastewater Treatment and Discharge

Recalculations of emissions from the Wastewater Treatment and Discharge sub-sector stem from the inclusion of N2O when estimating emissions for Industrial wastewater in the 2019 Refinements of the IPCC guidelines and centralized Wastewater Management and Treatment systems of the Domestic Wastewater sub-sector.

10.2. Implications for emission and removal levels

There are no implications for the emissions level for the period 2017 to 2022. For comparison purposes, previous emissions for the period 1990 to 2016 have been aggregated using the AR5 GWPs to ensure consistency as these GWPs have been used for the period 2017 to 2022.

Solid Waste

Regarding the Solid Waste sub-sector, there is a reduction varying from 3 kt CO2 e to 64 kt CO2 e over the time series which represented about 119% of emissions of 2016 as shown in Table 10.1.

Table 10.1. Comparison of previous emissions (kt CO2 e) with recalculations for waste disposal sites (1990-2016)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
Previous	12.3	14.5	16.7	19.0	21.3	23.7	26.2	28.8	31.5
Recalculated	9.2	9.6	10.1	10.6	11.1	11.8	12.7	13.4	14.2
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Previous	34.3	37.2	40.3	43.7	47.3	51.3	55.6	60.2	65.3
Recalculated	15.0	16.0	17.1	18.4	19.9	21.6	23.4	25.4	27.6
Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Previous	70.7	76.6	82.9	89.8	94.9	100.4	106.2	112.2	118.7
Recalculated	30.0	32.6	35.4	38.5	41.6	44.6	47.8	51.0	54.2

Wastewater

Recalculated emissions increased between 40% to 66% compared to previous ones over the time series as depicted in Table 10.2.

Table 10.2. Comparison of previous emissions (kt CO2 e) with recalculations for Wastewater (1990-2016)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
Previous	61.9	63.5	64.3	64.0	63.1	59.0	53.6	53.6	53.8
Recalculated	86.9	89.2	90.8	90.7	90.0	84.7	78.2	78.8	79.7
Year	1999	2000	2001	2002	2003	2004	2005	2006	2007

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
Previous	55.7	58.4	56.5	52.9	61.6	59.3	61.8	58.9	48.7
Recalculated	82.4	86.5	83.5	80.4	91.6	88.6	91.7	90.3	81.2
Year	2008	2009	2010	2011	2012	2013	2014	2015	2016
Previous	52.7	55.5	56.0	55.6	61.8	56.4	55.6	59.6	55.4
Recalculated	80.3	84.1	85.0	82.8	91.5	84.3	82.9	87.6	82.3

10.3. Implications for emission and removal trends, including time-series consistency

The recalculations have not affected the trend of emissions as the same methods and sources of data have been used for the full time series 1990 to 2022. The recalculation has a very low impact on the trend of national emissions since emissions from solid waste disposal and Wastewater sub-sectors represented only 0.2% and 0.3% of national emissions in 2016.

10.4. Areas of improvement and/or capacity-building in response to the review process

Not applicable as this inventory is not yet reviewed.

10.5. 10.5. Areas of improvement and/or capacity-building related to the flexibility

Not applicable as Namibia has not resorted to any flexibility in this inventory

Annexes to the national inventory document

Annex I: Key categories

Approach

The IPCC tier 1 approach has been adopted but the tool included in the IPCC 2006 software could be only partially used as it does not provide results with and without LULUCF which is mandatory for reporting according to the MPGs of Decision 18/CMA. Hence, equations of the 2006 IPCC Guidelines were used and programmed in an Excel workbook to enable the analysis to be performed with and without LULUCF.

Key categories were truncated at the 95% level for the level assessments for the base year and the last year of the time series, and the trend assessment between the base year to the latest year of the inventory. Both exercises were performed with and without LULUCF.

The results follow and are provided in the following sequence.

1. Table A1.1 KCA Level Assessment for base year 1990 with LULUCF
2. Table A1.2. KCA Level Assessment for base year 1990 without LULUCF
3. Table A1.3. KCA Level Assessment for year-t 2022 with LULUCF
4. Table A1.4. KCA Level Assessment for year-t 2022 without LULUCF
5. Table A1.5. KCA Trend Assessment for time series 1990 - 2022 with LULUCF
6. Table A1.6. KCA Trend Assessment for time series 1990 - 2022 without LULUCF

Table A1.1. Key Category Analysis for the year 1990 - Approach 1 - Level Assessment – With LULUCF

A	B	C	D	E	F	G
IPCC Category code	IPCC Category	GHG	"1990 Ext. (Gg CO_2-eq)"	"|exit| (Gg CO_2-eq)"	Lx,t	Cumulative Total of Column F
4.A.1	Forest land Remaining Forest land	(CO2)	-88,401.3	88,401.3	0.780	0.780
4.C.2	Land Converted to Grassland	(CO2)	10,317.4	10,317.4	0.091	0.871
4.(IV)	Burning	(CH4)	4,791.9	4,791.9	0.042	0.914
3.A.	Enteric Fermentation	(CH4)	3,837.4	3,837.4	0.034	0.947
4.A.2	Land Converted to Forest land	(CO2)	-1,575.7	1,575.7	0.014	0.961

Table A1.2. Key Category Analysis for the year 1990 - Approach 1 - Level Assessment – Without LULUCF

A	B	C	D	E	F	G
IPCC Category code	**IPCC Category**	**GHG**	**"1990 Ext. (Gg CO_2-eq)"**	**"|exit| (Gg CO_2-eq)"**	**Lx,t**	**Cumulative Total of Column F**
3.A.	Enteric Fermentation	(CH4)	3,837.4	3,837.4	0.565	0.565
3.D.1	Direct N2O Emissions from managed soils	(N2O)	1,309.9	1,309.9	0.193	0.758
1.A.3.b	Road Transportation - Liquid Fuels	(CO2)	526.6	526.6	0.078	0.835
1.A.4	Other Sectors - Liquid Fuels	(CO2)	276.4	276.4	0.041	0.876
3.D.2	Indirect N2O Emissions from managed soils	(N2O)	174.2	174.2	0.026	0.901
3.B	Manure Management	(N2O)	86.4	86.4	0.013	0.914
3.B	Manure Management	(CH4)	86.2	86.2	0.013	0.927
3.B.5	Indirect N2O Emissions from manure management	(N2O)	78.1	78.1	0.011	0.938

A	B	C	D	E	F	G
IPCC Category code	**IPCC Category**	**GHG**	**"1990 Ext. (Gg CO_2-eq)"**	**"|exit| (Gg CO_2-eq)"**	**Lx,t**	**Cumulative Total of Column F**
5.D	Wastewater Treatment and Discharge	(CH4)	71.2	71.2	0.010	0.949
1.A.2	Manufacturing Industries and Construction - Solid Fuels	(CO2)	70.5	70.5	0.010	0.959

Table A1.3. Key Category Analysis for the year 2022 - Approach 1 - Level Assessment – With LULUCF

A	B	C	D	E	F	G
IPCC Category code	IPCC Category	GHG	"2022 Ext. (Gg CO_2-eq)"	"|exit| (Gg CO_2-eq)"	Lx,t	Cumulative Total of Column F
4.A.1	Forest land Remaining Forest land	(CO2)	-121,375.8	121,375.8	0.818	0.818
4.C.2	Land Converted to Grassland	(CO2)	11,607.0	11,607.0	0.078	0.896
3.A	Enteric Fermentation	(CH4)	5,575.4	5,575.4	0.038	0.934
1.A.3.b	Road transportation - Liquid Fuels	(CO2)	2,737.9	2,737.9	0.018	0.952

Table A1.4. Key Category Analysis for the year 2022 - Approach 1 - Level Assessment – Without LULUCF

A	B	C	D	E	F	G
IPCC Category code	**IPCC Category**	**GHG**	**"2022 Ext. (Gg CO_2-eq)"**	**"|exit| (Gg CO_2-eq)"**	**Lx,t**	**Cumulative Total of Column F**
3.A.	Enteric Fermentation	(CH4)	5,575.4	5,575.4	0.443	0.443
1.A.3.b	Road transportation - Liquid Fuels	(CO2)	2,737.9	2,737.9	0.218	0.660
3.D.1	Direct N2O Emissions from managed soils	(N2O)	1,736.4	1,736.4	0.138	0.798
1.B.1.c	Fuel transformation	(CH4)	363.2	363.2	0.029	0.827
2.A.1	Cement production	(CO2)	350.5	350.5	0.028	0.855
1.A.4	Other Sectors - Liquid Fuels	(CO2)	312.9	312.9	0.025	0.880
3.D.2	Indirect N2O Emissions from managed soils	(N2O)	226.8	226.8	0.018	0.898
1.A.2	Manufacturing Industries and construction - Solid Fuels	(CO2)	176.3	176.3	0.014	0.912
2.F.1	Refrigeration and Air Conditioning	HFCs	161.2	161.2	0.013	0.925
3.B	Manure Management	(CH4)	132.1	132.1	0.010	0.935
3.B	Manure Management	(N2O)	116.3	116.3	0.009	0.944
3.B.5	Indirect N2O Emissions from manure management	(N2O)	109.6	109.6	0.009	0.953

Table A1.5. Key Category Analysis for the period 1990 - 2022 - Approach 1 - Trend Assessment with LULUCF

A	B	C	D	E	F	G	H
IPCC Category code	**IPCC Category**	**GHG**	**1990 Year Estimate Ex0 (Gg CO_2-eq)**	**2022 Year Estimate Ext (Gg CO_2-eq)**	**Trend Assessment (Txt)**	**% Contribution to Trend**	**Cumulative Total of Column G**
4.A.1	Forest land Remaining Forest land	(CO2)	-88,401.3	-121,375.8	1.108	0.730	0.730
4.(IV)	Burning	(CH4)	4,791.9	1,389.7	0.114	0.075	0.805
1.A.3.b	Road transportation - Liquid Fuels	(CO2)	526.6	2,737.9	0.074	0.049	0.854
3.A.	Enteric Fermentation	(CH4)	3,837.4	5,575.4	0.058	0.038	0.892

A	B	C	D	E	F	G	H
IPCC Category code	**IPCC Category**	**GHG**	**1990 Year Estimate Ex0 (Gg CO_2-eq)**	**2022 Year Estimate Ext (Gg CO_2-eq)**	**Trend Assessment (Txt)**	**% Contribution to Trend**	**Cumulative Total of Column G**
4.C.2	Land Converted to Grassland	(CO2)	10,317.4	11,607.0	0.043	0.029	0.921
4.(IV)	Burning	(N2O)	1,346.4	388.1	0.032	0.021	0.942
4.A.2	Land Converted to Forest land	(CO2)	-1,575.7	-951.7	0.021	0.014	0.956

Table A1.6. Key Category Analysis for the period 1990 - 2022 - Approach 1 - Trend Assessment without LULUCF

A	B	C	D	E	F	G	H
IPCC Category code	**IPCC Category**	**GHG**	**1990 Year Estimate Ex0 (Gg CO_2-eq)**	**2022 Year Estimate Ext (Gg CO_2-eq)**	**Trend Assessment (Txt)**	**% Contribution to Trend**	**Cumulative Total of Column G**
1.A.3.b	Road transportation - Liquid Fuels	(CO2)	526.6	2,737.9	0.382	0.381	0.381
3.A	Enteric Fermentation	(CH4)	3,837.4	5,575.4	0.300	0.299	0.680
3.D.1	Direct N2O Emissions from managed soils	(N2O)	1,309.9	1,736.4	0.074	0.073	0.754
2.A.1	Cement production	(CO2)	0.0	350.5	0.060	0.060	0.814
1.B.1.c	Fuel transformation	(CH4)	67.7	363.2	0.051	0.051	0.865
2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	0.0	161.2	0.028	0.028	0.893
1.A.2	Manufacturing Industries and construction - Solid Fuels	(CO2)	70.5	176.3	0.018	0.018	0.911
5.A	Solid Waste Disposal	(CH4)	9.2	72.0	0.011	0.011	0.922
3.D.2	Indirect N2O Emissions from managed soils	(N2O)	174.2	226.8	0.009	0.009	0.931
3.A	Manure Management	(CH4)	86.2	132.1	0.008	0.008	0.939
1.A.1	Energy industries - Solid Fuels	(CO2)	20.7	64.2	0.008	0.007	0.946
1.A.5	Other (mobile) - Liquid Fuels	(CO2)	7.8	50.7	0.007	0.007	0.954

Annex II: Uncertainty assessment

The MPGs contained in Decision 18/CMA.1 require that countries assess and present Uncertainties at a category level. Thus, the tool embedded in the IPCC 2006 software to perform this disaggregated level of assessment is not suitable as it provides the Uncertainty at the national level only for all categories and sectors merged, both for the level and trend assessments. Hence, a tool was developed in an Excel workbook reflecting exactly the equations of the IPCC 2006 Guidelines to perform the Uncertainty assessments at the category and whole of inventory levels. The results for individual categories have been presented when reporting on these categories and following are the full inventory assessments for the base year 1990 and for year-t 2022 (Table A2.1). The base year 1990 assessment provides the level assessment only whereas the year-t one gives the level results for that year and the trend assessment for the full time series 1990 to 2022.

Table A2.1 Assessment of uncertainty for base year (1990), year T (2022) and in trend: 1990 to 2022.

A	B	C	D	E	F	G	H	H	M
2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (kt CO2 equivalent)	Year T (2022) emissions or removals (kt CO2 equivalent)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in Base Year (1990)	Contribution to Variance by Category in Year T (2022)	Uncertainty introduced into the trend in total national emissions (%)
1.A - Fuel Combustion Activities									
1.A.1.a.i - Electricity Generation - Liquid Fuels	CO2	0.66	1.80	0.2	7	7	0.000	0.000	0.000
1.A.1.a.i - Electricity Generation - Liquid Fuels	CH4	0.00	0.00	0.2	233	233	0.000	0.000	0.000
1.A.1.a.i - Electricity Generation - Liquid Fuels	N2O	0.00	0.00	0.2	233	233	0.000	0.000	0.000
1.A.1.a.i - Electricity Generation - Solid Fuels	CO2	20.75	64.23	0.2	7	7	0.000	0.000	0.000
1.A.1.a.i - Electricity Generation - Solid Fuels	CH4	0.01	0.02	0.2	200	200	0.000	0.000	0.000
1.A.1.a.i - Electricity Generation - Solid Fuels	N2O	0.09	0.27	0.2	233	233	0.000	0.000	0.000
1.A.2.e - Food Processing, Beverages and Tobacco - Liquid Fuels	CO2	0.00	7.74	2	7	7	0.000	0.000	0.000
1.A.2.e - Food Processing, Beverages and Tobacco - Liquid Fuels	CH4	0.00	0.01	2	233	233	0.000	0.000	0.000
1.A.2.e - Food Processing, Beverages and Tobacco - Liquid Fuels	N2O	0.00	0.02	2	233	233	0.000	0.000	0.000
1.A.2.e - Food Processing, Beverages and Tobacco - Biomass - solid	CO2	0.00	0.00	2	7	7	0.000	0.000	0.000
1.A.2.e - Food Processing, Beverages and Tobacco - Biomass - solid	CH4	0.00	0.09	2	233	233	0.000	0.000	0.000
1.A.2.e - Food Processing, Beverages and Tobacco - Biomass - solid	N2O	0.00	0.11	2	275	275	0.000	0.000	0.000
1.A.2.f - Non-Metallic Minerals - Solid Fuels	CO2	0.00	80.37	2	7	7	0.000	0.000	0.000
1.A.2.f - Non-Metallic Minerals - Solid Fuels	CH4	0.00	0.24	2	200	200	0.000	0.000	0.000
1.A.2.f - Non-Metallic Minerals - Solid Fuels	N2O	0.00	0.34	2	233	233	0.000	0.000	0.000
1.A.2.f - Non-Metallic Minerals - Other Fossil Fuels	CO2	0.00	0.64	2	7	7	0.000	0.000	0.000
1.A.2.f - Non-Metallic Minerals - Other Fossil Fuels	CH4	0.00	0.00	2	50	50	0.000	0.000	0.000
1.A.2.f - Non-Metallic Minerals - Other Fossil Fuels	N2O	0.00	0.00	2	1000	1000	0.000	0.000	0.000
1.A.2.f - Non-Metallic Minerals - Biomass - solid	CO2	0.00	0.00	2	7	7	0.000	0.000	0.000
1.A.2.f - Non-Metallic Minerals - Biomass - solid	CH4	0.00	1.58	2	233	233	0.000	0.000	0.000

A	B	C	D	E	F	G	H	H	M
2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (kt CO2 equivalent)	Year T (2022) emissions or removals (kt CO2 equivalent)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in Base Year (1990)	Contribution to Variance by Category in Year T (2022)	Uncertainty introduced into the trend in total national emissions (%)
1.A.2.f - Non-Metallic Minerals - Biomass - solid	N2O	0.00	0.71	2	275	275	0.000	0.000	0.000
1.A.2.i - Mining (excluding fuels) and Quarrying - Liquid Fuels	CO2	26.22	44.52	10	7	12	0.000	0.000	0.000
1.A.2.i - Mining (excluding fuels) and Quarrying - Liquid Fuels	CH4	0.03	0.05	10	233	233	0.000	0.000	0.000
1.A.2.i - Mining (excluding fuels) and Quarrying - Liquid Fuels	N2O	0.06	0.10	10	233	233	0.000	0.000	0.000
1.A.2.i - Mining (excluding fuels) and Quarrying - Solid Fuels	CO2	70.50	95.93	10	7	12	0.000	0.000	0.000
1.A.2.i - Mining (excluding fuels) and Quarrying - Solid Fuels	CH4	0.21	0.28	10	200	200	0.000	0.000	0.000
1.A.2.i - Mining (excluding fuels) and Quarrying - Solid Fuels	N2O	0.30	0.40	10	233	233	0.000	0.000	0.000
1.A.2.i - Mining (excluding fuels) and Quarrying - Other Fossil Fuels	CO2	1.26	16.28	10	7	12	0.000	0.000	0.000
1.A.2.i - Mining (excluding fuels) and Quarrying - Other Fossil Fuels	CH4	0.01	0.19	10	233	233	0.000	0.000	0.000
1.A.2.i - Mining (excluding fuels) and Quarrying - Other Fossil Fuels	N2O	0.02	0.24	10	275	275	0.000	0.000	0.000
1.A.4.b - Residential - Liquid Fuels	CO2	29.84	37.67	12.5	7	14	0.000	0.000	0.000
1.A.4.b - Residential - Liquid Fuels	CH4	0.09	0.09	12.5	200	200	0.000	0.000	0.000
1.A.4.b - Residential - Liquid Fuels	N2O	0.04	0.02	12.5	200	200	0.000	0.000	0.000
1.A.4.b - Residential - Biomass - solid	CO2	0.00	0.00	70	7	70	0.000	0.000	0.000
1.A.4.b - Residential - Biomass - solid	CH4	41.15	41.73	70	200	212	0.017	0.008	0.007
1.A.4.b - Residential - Biomass - solid	N2O	5.06	5.14	70	275	284	0.000	0.000	0.000
1.A.2.m - Non-specified Industry - Liquid Fuels	CO2	1.10	2.25	10	7	12	0.000	0.000	0.000
1.A.2.m - Non-specified Industry - Liquid Fuels	CH4	0.00	0.00	10	233	233	0.000	0.000	0.000
1.A.2.m - Non-specified Industry - Liquid Fuels	N2O	0.00	0.00	10	233	233	0.000	0.000	0.000
1.A.3.a.i - International Aviation (International Bunkers) - Liquid Fuels	CO2	62.90	108.83	80	5	80	0.006	0.008	0.034
1.A.3.a.i - International Aviation (International Bunkers) - Liquid Fuels	CH4	0.01	0.02	80	100	128	0.000	0.000	0.000
1.A.3.a.i - International Aviation (International Bunkers) - Liquid Fuels	N2O	0.47	0.81	80	150	170	0.000	0.000	0.000
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	CO2	12.04	22.41	80	5	80	0.000	0.000	0.001
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	CH4	0.00	0.00	80	100	128	0.000	0.000	0.000
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	N2O	0.09	0.17	80	150	170	0.000	0.000	0.000
1.A.3.b.i.1 - Passenger cars with 3-way catalysts - Liquid Fuels	CO2	53.85	174.66	5	3.5	6	0.000	0.000	0.000
1.A.3.b.i.1 - Passenger cars with 3-way catalysts - Liquid Fuels	CH4	0.67	2.08	5	207	207	0.000	0.000	0.000
1.A.3.b.i.1 - Passenger cars with 3-way catalysts - Liquid Fuels	N2O	0.67	2.17	5	217	217	0.000	0.000	0.000
1.A.3.b.i.2 - Passenger cars without 3-way catalysts - Liquid Fuels	CO2	114.44	371.14	5	3.5	6	0.000	0.001	0.002
1.A.3.b.i.2 - Passenger cars without 3-way catalysts - Liquid Fuels	CH4	1.42	4.43	5	207	207	0.000	0.000	0.000
1.A.3.b.i.2 - Passenger cars without 3-way catalysts - Liquid Fuels	N2O	1.42	4.62	5	217	217	0.000	0.000	0.000

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2006 IPCC Categories	Gas	Base Year (1990) emissions or removals (kt CO2 equivalent)	Year T (2022) emissions or removals (kt CO2 equivalent)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in Base Year (1990)	Contribution to Variance by Category in Year T (2022)	Uncertainty introduced into the trend in total national emissions (%)
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts - Liquid Fuels	CO2	205.25	1008.58	5	3.5	6	0.000	0.004	0.013
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts - Liquid Fuels	CH4	2.46	4.62	5	207	207	0.000	0.000	0.000
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts - Liquid Fuels	N2O	2.55	13.62	5	217	217	0.000	0.001	0.001
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts - Liquid Fuels	CO2	68.42	336.19	5	3.5	6	0.000	0.000	0.001
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts - Liquid Fuels	CH4	0.82	1.54	5	207	207	0.000	0.000	0.000
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts - Liquid Fuels	N2O	0.85	4.54	5	217	217	0.000	0.000	0.000
1.A.3.b.iii - Heavy-duty trucks and buses - Liquid Fuels	CO2	83.93	845.35	5	3.5	6	0.000	0.003	0.010
1.A.3.b.iii - Heavy-duty trucks and buses - Liquid Fuels	CH4	0.12	1.25	5	207	207	0.000	0.000	0.000
1.A.3.b.iii - Heavy-duty trucks and buses - Liquid Fuels	N2O	1.17	11.79	5	217	217	0.000	0.001	0.001
1.A.3.b.iv - Motorcycles - Liquid Fuels	CO2	0.69	2.03	5	3.5	6	0.000	0.000	0.000
1.A.3.b.iv - Motorcycles - Liquid Fuels	CH4	0.01	0.03	5	207	207	0.000	0.000	0.000
1.A.3.b.iv - Motorcycles - Liquid Fuels	N2O	0.01	0.02	5	217	217	0.000	0.000	0.000
1.A.5.b.iii - Mobile (Other) - Liquid Fuels	CO2	7.76	50.66	5	3.5	6	0.000	0.000	0.000
1.A.5.b.iii - Mobile (Other) - Liquid Fuels	CH4	0.01	0.08	5	207	207	0.000	0.000	0.000
1.A.5.b.iii - Mobile (Other) - Liquid Fuels	N2O	0.11	0.71	5	217	217	0.000	0.000	0.000
1.A.3.c - Railways - Liquid Fuels	CO2	30.21	48.69	8	2	8	0.000	0.000	0.000
1.A.3.c - Railways - Liquid Fuels	CH4	0.05	0.07	8	151	151	0.000	0.000	0.000
1.A.3.c - Railways - Liquid Fuels	N2O	3.09	4.77	8	200	200	0.000	0.000	0.000
1.A.3.d.i - International water-borne navigation (International bunkers) - Liquid Fuels	CO2	144.24	154.41	25	2	25	0.003	0.002	0.007
1.A.3.d.i - International water-borne navigation (International bunkers) - Liquid Fuels	CH4	0.38	0.40	25	50	56	0.000	0.000	0.000
1.A.3.d.i - International water-borne navigation (International bunkers) - Liquid Fuels	N2O	1.02	1.08	25	140	142	0.000	0.000	0.000
1.A.4.c.iii - Fishing (mobile combustion) - Liquid Fuels	CO2	246.56	275.27	25	2	25	0.009	0.005	0.021
1.A.4.c.iii - Fishing (mobile combustion) - Liquid Fuels	CH4	0.93	1.04	25	50	56	0.000	0.000	0.000
1.A.4.c.iii - Fishing (mobile combustion) - Liquid Fuels	N2O	0.53	0.59	25	140	142	0.000	0.000	0.000
1.B - Fugitive Emissions from Fuels									
1.B.1.c.i - Charcoal and Biochar production	CO2	0.00	0.00	10	60	61	0.000	0.000	0.000
1.B.1.c.i - Charcoal and Biochar production	CH4	67.70	363.18	10	121	121	0.015	0.210	0.239
1.B.1.c.i - Charcoal and Biochar production	N2O	1.27	6.37	10	163	163	0.000	0.000	0.000
1.B.2.a.iii.1 - Exploration	CO2	0.00	0.04	0.1	30	30	0.000	0.000	0.000
1.B.2.a.iii.1 - Exploration	CH4	0.00	0.04	0.1	30	30	0.000	0.000	0.000

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1.B.2.a.iii.1 - Exploration	N2O	0.00	0.07	0.1	1000	1000	0.000	0.000	0.000
2.A - Mineral Industry									
2.A.1 - Cement production	CO2	0.00	350.55	35.06	70.18	78	0.000	0.082	0.206
2.A.2 - Lime production	CO2	2.24	0.00	15.81	2	16	0.000	0.000	0.000
2.D - Non-Energy Products from Fuels and Solvent Use									
2.D.1 - Lubricant Use	CO2	3.54	6.47	15	50	52	0.000	0.000	0.000
2.D.2 - Paraffin Wax Use	CO2	0.26	0.56	15	100	101	0.000	0.000	0.000
2.F - Product Uses as Substitutes for Ozone Depleting Substances									
2.F.1.a - Refrigeration and Stationary Air Conditioning	CH2F2	0.00	13.14	5	5	7	0.000	0.000	0.000
2.F.1.a - Refrigeration and Stationary Air Conditioning	CHF2CF3	0.00	75.75	5	5	7	0.000	0.000	0.000
2.F.1.a - Refrigeration and Stationary Air Conditioning	CH2FCF3	0.00	3.74	5	0	5	0.000	0.000	0.000
2.F.1.a - Refrigeration and Stationary Air Conditioning	CH3CF3	0.00	53.35	5	5	7	0.000	0.000	0.000
2.F.1.b - Mobile Air Conditioning	CH2FCF3	0.00	15.25	5	5	7	0.000	0.000	0.000
2.G - Electrical Equipment									
2.G.1.b - Use of Electrical Equipment	SF6	0.41	1.07	30	30	42	0.000	0.000	0.000
2.G.3.a - Medical Applications	N2O	0.69	2.67	30	2	30	0.000	0.000	0.000
3.A - Livestock									
3.A.1.a.i - Dairy Cows	CH4	3.85	5.13	20	20	28	0.000	0.000	0.000
3.A.1.a.ii - Other Cattle	CH4	3061.48	4927.90	20	20	28	1.698	2.101	4.423
3.A.1.b - Buffalo	CH4	0.00	0.00	0	0	0	0.000	0.000	0.000
3.A.1.c - Sheep	CH4	465.96	308.63	20	30	36	0.064	0.013	0.045
3.A.1.d - Goats	CH4	260.36	285.78	20	30	36	0.020	0.011	0.016
3.A.1.e - Camels	CH4	0.00	0.07	20	30	36	0.000	0.000	0.000
3.A.1.f - Horses	CH4	26.24	19.17	20	30	36	0.000	0.000	0.000
3.A.1.g - Mules and Asses	CH4	19.04	26.04	20	30	36	0.000	0.000	0.000
3.A.1.h - Swine	CH4	0.50	2.69	20	30	36	0.000	0.000	0.000
3.A.1.i - Poultry	CH4	0.00	0.00	0	0	0	0.000	0.000	0.000
3.A.1.j - Other (please specify)	CH4	0.00	0.00	0	0	0	0.000	0.000	0.000
3.A.2.a.i - Dairy cows	CH4	0.04	0.06	20	30	36	0.000	0.000	0.000
3.A.2.a.i - Dairy cows	N2O	0.36	0.48	20	100	102	0.000	0.000	0.000
3.A.2.a.ii - Other cattle	CH4	58.42	93.88	20	30	36	0.001	0.001	0.002
3.A.2.a.ii - Other cattle	N2O	85.67	113.13	20	100	102	0.017	0.014	0.003
3.A.2.c - Sheep	CH4	13.98	12.35	20	30	36	0.000	0.000	0.000
3.A.2.d - Goats	CH4	8.85	12.57	20	30	36	0.000	0.000	0.000

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3.A.2.e - Camels	CH4	0.00	0.00	20	30	36	0.000	0.000	0.000
3.A.2.e - Camels	N2O	0.00	0.00	0	0	0	0.000	0.000	0.000
3.A.2.f - Horses	CH4	2.39	2.33	20	30	36	0.000	0.000	0.000
3.A.2.g - Mules and Asses	CH4	1.71	3.12	20	30	36	0.000	0.000	0.000
3.A.2.h - Swine	CH4	0.50	2.69	20	30	36	0.000	0.000	0.000
3.A.2.h - Swine	N2O	0.25	1.34	20	100	102	0.000	0.000	0.000
3.A.2.i - Poultry	CH4	0.28	5.14	20	30	36	0.000	0.000	0.000
3.A.2.i - Poultry	N2O	0.11	1.37	20	100	102	0.000	0.000	0.000
3.B - Land									
3.B.1.a - Forest land Remaining Forest land	CO2	-88401.30	-121375.76	20	43.87	48	4115.540	3704.446	2687.826
3.B.1.b.i - Cropland converted to Forest Land	CO2	-206.13	-51.23	17.32	37.42	41	0.016	0.000	0.020
3.B.1.b.ii - Grassland converted to Forest Land	CO2	-1369.62	-900.52	17.32	37.42	41	0.722	0.149	0.481
3.B.3.b.i - Forest Land converted to Grassland	CO2	10317.37	11607.04	17.32	37.42	41	40.990	24.770	21.825
3.B.5.b.i - Forest Land converted to Settlements	CO2	64.75	14.91	17.32	37.42	41	0.002	0.000	0.002
3.B.5.b.ii - Cropland converted to Settlements	CO2	9.80	0.00	14.14	31.62	35	0.000	0.000	0.000
3.C - Aggregate sources and non-CO2 emissions sources on land						0	0.000	0.000	0.000
3.C.1.a - Burning in Forest Land	CO2	0.00	0.00	10	0	10	0.000	0.000	0.000
3.C.1.a - Burning in Forest Land	CH4	4770.63	1387.61	10	29	31	4.851	0.196	5.892
3.C.1.a - Burning in Forest Land	N2O	1327.96	386.26	10	50	51	1.039	0.042	1.343
3.C.1.c - Burning in Grassland	CH4	21.32	2.08	10	39	40	0.000	0.000	0.000
3.C.1.c - Burning in Grassland	N2O	18.42	1.80	10	48	49	0.000	0.000	0.000
3.C.3 - Urea application	CO2	0.34	0.09	50	20	54	0.000	0.000	0.000
3.C.4 - Direct N2O Emissions from managed soils	N2O	1309.87	1736.38	57.45	346.4	351	47.919	40.206	5.197
3.C.5 - Indirect N2O Emissions from managed soils	N2O	174.16	226.76	20	400	400	1.102	0.892	0.032
3.C.6 - Indirect N2O Emissions from manure management	N2O	78.08	109.70	20	400	400	0.222	0.209	0.003
3.D - Other									
3.D.1 - Harvested Wood Products	CO2	0.00	-83.29	50	50	71	0.000	0.004	0.012
4.A - Solid Waste Disposal									
4.A.1 - Managed Waste Disposal Sites	CH4	9.25	47.71	0	0	0	0.000	0.000	0.000
4.A.2 - Unmanaged Waste Disposal Sites	CH4	0.00	24.29	0	0	0	0.000	0.000	0.000
4.C - Incineration and Open Burning of Waste									
4.C.1 - Waste Incineration	CO2	0.00	0.23	40	100	108	0.000	0.000	0.000
4.C.1 - Waste Incineration	CH4	0.00	0.00	40	100	108	0.000	0.000	0.000

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4.C.1 - Waste Incineration	N2O	0.00	0.00	40	100	108	0.000	0.000	0.000
4.C.2 - Open Burning of Waste	CO2	0.80	2.76	40	100	108	0.000	0.000	0.000
4.C.2 - Open Burning of Waste	CH4	9.40	32.43	40	100	108	0.000	0.001	0.002
4.C.2 - Open Burning of Waste	N2O	1.17	4.04	40	100	108	0.000	0.000	0.000
4.D - Wastewater Treatment and Discharge									
4.D.1 - Domestic Wastewater Treatment and Discharge	CH4	32.64	61.66	30	30	42	0.000	0.001	0.002
4.D.1 - Domestic Wastewater Treatment and Discharge	N2O	5.16	8.47	28.28	256	258	0.000	0.001	0.000
4.D.2 - Industrial Wastewater Treatment and Discharge	CH4	38.52	16.97	25	30	39	0.001	0.000	0.000
4.D.2 - Industrial Wastewater Treatment and Discharge	N2O	10.62	4.57	25	30	39	0.000	0.000	0.000
Sum		-66444	-96157		Sum		4214	3773	2728
	Uncertainty in level and trend						64.9	61.4	52.2

Annex III: Detailed description of the reference approach

This annex covers the methodology used for the reference approach and shows a comparison of the energy consumption and the CO2 emission results from the reference approach (RA) and with those estimated by the sectoral approach (SA).

Methodology used for the Reference Approach

The reference approach follows the 2006 IPCC Guideline's designated method. That is, a top-down approach as opposed to the bottom-up approach used for making estimates of emission at the sectoral level. The RA is based on the country's energy statistics for production, imports, exports, international bunkers and stock change to estimate the "apparent consumption" of the different fuels by the country. The IPCC energy conversion factors as well as the carbon content of fuels from the 2006 IPCC GL combined with an oxidation factor assumed to be 1 for each fuel were then used to calculate the CO2 emissions.

Table A3.1. Conversion factors and carbon contents adopted for calculating emissions under the Reference Approach

Fuel	Conversion factor (TJ/Gg)	Carbon content (t C/TJ)
Aviation Gasoline	44.3	19.1
Gas/Diesel oils	43.0	20.2
Jet Kerosene	44.1	19.5
Liquefied Petroleum Gas	47.3	17.2
Motor Gasoline	44.3	18.9
Other Kerosene	43.8	19.6
Residual Fuel Oil	40.4	21.1
Other Petroleum Products	40.2	20.0
Paraffin waxes	40.2	20.0
Petroleum coke	32.5	26.6
Bitumen	40.2	22.0
Lubricants	40.2	20.0
Creosote oils	40.2	20.0
Other Bituminous Coal	25.8	25.8
Refuse Derived Fuels (RDF)	10.0	25.0
Tyre shavings	33.0	23.1
Waste Oils	40.2	20.0
Wood/wood waste	15.6	30.5
Charcoal	11.6	27.3

Given that well-developed national energy balances are not produced by Namibia due to lack of regular data collection, inadequate capacity and lack of resources, data on the energy statistics have been sourced from the UN statistics data portal, IEA website and from the country trade statistics to construct a yearly energy balance for all years of the time series. The annual data from these sources were compared before adoption. In case of data gaps and outliers these have been adjusted using extrapolation and interpolation techniques as appropriate.

It should be noted that the time series 1990 to 2016 have been recalculated using (i) improved data sets on consumption of lubricants and on use of wood fuel for residential purposes, the latter updated on the results of new census and (ii) an adjustment of data sets for imports which was wrongly estimated previously due to misallocation of fuels used for international bunkers.

The previous consumption data for the RA together with the recalculated consumption data and the consumption data for the SA are given in Table A3.2. Positive as well as negative differences have been noted between the RA and SA approaches both for fuel consumption and CO2 emissions during the time series 1990 to 2022. From 2019 to 2022, the differences in fuel consumed were among the lowest, nearly at 5%.

Emissions increased over time though under both approaches. The % difference varied between -16.9% and 19.2% over the time series 1990 to 2022.

Comparison of Reference Approach with Sectoral Approach

The comparison of fuels consumed and emissions estimates, shown in Table A3.2, from the RA and the SA serves as a check of energy available versus that consumed by all sectors. A comparison of RA and SA results for all years from 1990 to 2022 constitutes an integral part of the reporting process to the United Nations Framework Convention on Climate Change (UNFCCC) as per the MPGs contained in Decision 18/CMA.1. This comparison is also provided in Table A3.2

Table A3.2. Comparison of fuel consumed under the Reference and Sectoral Approaches

Year	Reference Approach			Sectoral Approach		Comparison (RA & SA) (%)	
	Previous fuel consumption (TJ)	Recalculated fuel consumption (TJ)	Emissions (kt CO2)	Fuel consumption (TJ)	Emissions (kt CO2)	Fuel consumption	Emissions
1990	13,866	12,919	932	13,303	974	-2.9%	-4.3%
1991	13,738	12,757	920	14,403	1,054	-11.4%	-12.7%
1992	15,051	14,070	1,014	15,408	1,128	-8.7%	-10.1%
1993	15,523	14,542	1,048	16,732	1,224	-13.1%	-14.4%
1994	17,834	16,853	1,217	18,265	1,337	-7.7%	-9.0%
1995	21,748	20,767	1,504	18,395	1,344	12.9%	11.9%
1996	23,282	22,301	1,615	19,638	1,435	13.6%	12.5%
1997	24,022	23,014	1,663	20,335	1,485	13.2%	12.0%
1998	24,741	23,758	1,719	22,234	1,624	6.9%	5.9%
1999	23,817	22,217	1,596	24,038	1,757	-7.6%	-9.1%
2000	22,838	21,637	1,555	24,712	1,798	-12.4%	-13.5%
2001	28,999	28,112	2,027	27,212	1,982	3.3%	2.3%
2002	29,970	26,012	1,870	27,899	2,023	-6.8%	-7.6%
2003	30,297	27,704	1,993	31,680	2,307	-12.6%	-13.6%
2004	29,925	28,894	2,077	32,513	2,364	-11.1%	-12.1%
2005	30,469	29,078	2,092	34,582	2,519	-15.9%	-16.9%
2006	31,814	30,751	2,228	36,381	2,673	-15.5%	-16.6%
2007	36,240	34,859	2,536	37,470	2,754	-7.0%	-7.9%
2008	43,069	41,662	3,089	35,052	2,591	18.9%	19.2%
2009	41,089	39,630	2,890	36,320	2,665	9.1%	8.4%

Year	Reference Approach			Sectoral Approach		Comparison (RA & SA) (%)	
	Previous fuel consumption (TJ)	Recalculated fuel consumption (TJ)	Emissions (kt CO2)	Fuel consumption (TJ)	Emissions (kt CO2)	Fuel consumption	Emissions
2010	38,698	37,541	2,715	38,054	2,769	-1.3%	-1.9%
2011	38,927	37,656	2,719	36,195	2,643	4.0%	2.9%
2012	44,274	42,988	3,151	38,778	2,842	10.9%	10.9%
2013	46,145	41,765	3,037	37,192	2,708	12.3%	12.1%
2014	44,376	42,306	3,052	42,288	3,074	0.0%	-0.7%
2015	53,872	53,623	3,929	47,114	3,445	13.8%	14.0%
2016	55,583	53,451	3,867	48,959	3,582	9.2%	8.0%
2017	N/A	48,080	3,506	47,646	3,522	0.9%	-0.4%
2018	N/A	53,323	3,911	47,654	3,509	11.9%	11.5%
2019	N/A	49,399	3,623	48,583	3,604	1.7%	0.5%
2020	N/A	46,048	3,399	44,811	3,302	2.8%	2.9%
2021	N/A	46,297	3,397	46,638	3,444	-0.7%	-1.4%
2022	N/A	49,464	3,671	47,212	3,486	4.8%	5.3%

Note: NA – Not Applicable

The trends of fuel consumed under the Reference and Sectoral Approaches are presented in Figure A3.1. Generally, fuel consumed increased annually from about 13,000 to 53,000 TJ under the RA as opposed to about 13,000 to 48,000 under the SA.

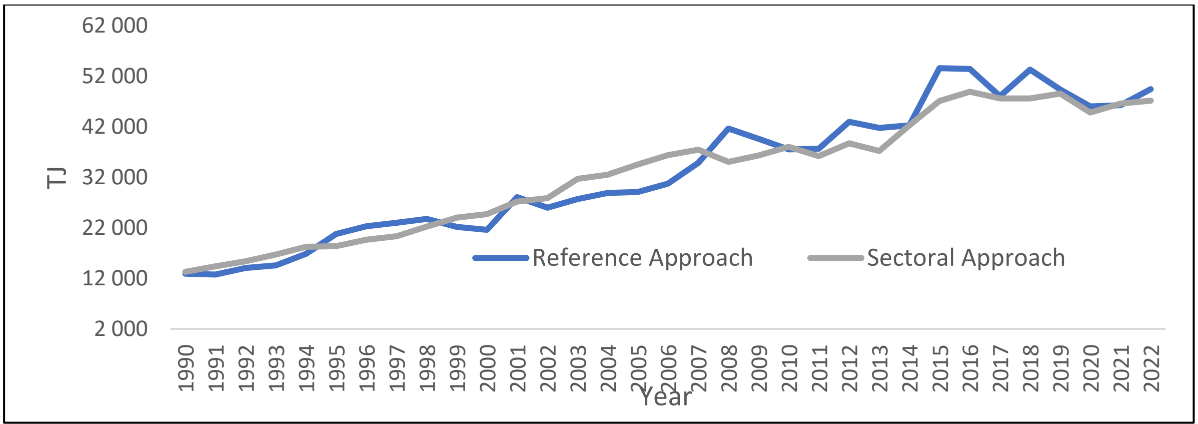

Figure A3.1. Trend in fuel consumption (TJ) for Reference and Sectoral Approach (1990-2022)

The trends of emissions under the Reference and Sectoral approaches are presented in Figure A3.2. The RA recorded an increase of about 3000 kt from about 900 in 1990 to about 3,700 kt in 2022 compared to about 2500 kt from about 1000 kt in 1990 to about 3,500 kt in 2022 for the SA.

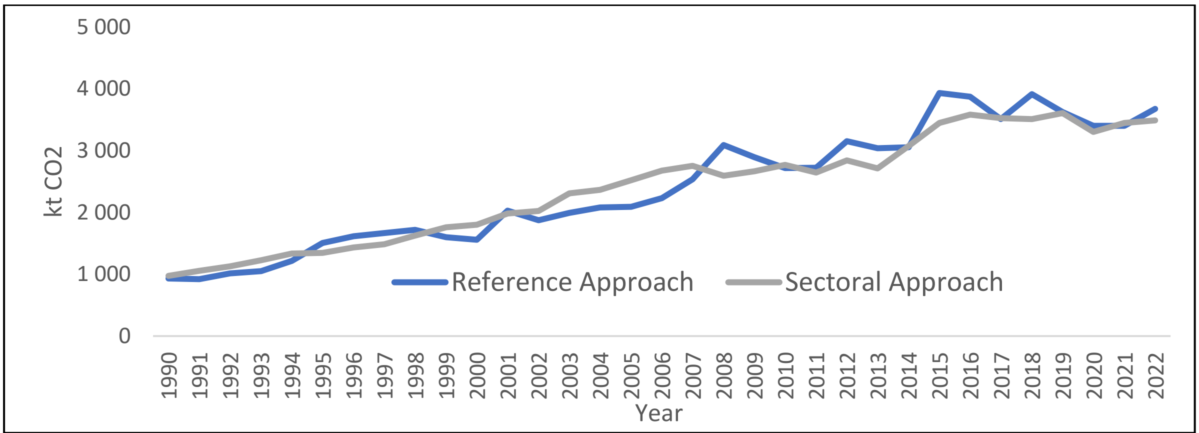

Figure A3.2. Trend in CO2 emissions (kt CO2 e) from the Reference and Sectoral Approach (1990-2022)

The AD for the RA used in the calculation of the CO2 emissions for the time series 1990 to 2022 are provided in Tables A3.3.

Table A3.3. AD used for estimating emissions for the Reference Approach (1990-2022)

1990									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviation Gasoline		2.6				2.6		2.6	115.2
Bitumen		19.0				19.0	19.0	0	0
Creosote oils		0.02				0.02	0.02	0	0
Gas/Diesel Oil		160.5		30.3		130.2		130.2	5599.4
Jet Kerosene		19.7		19.9		-0.2		-0.2	-10.9
LPG		5.0				5.0		5.0	236.5
Lubricants		6.0				6.0	6.0	0.0	0.1
Motor Gasoline		143.5		0.6		142.9		142.9	6328.3
Other Kerosene		3.7				3.7		3.7	162.5
Other Petroleum Pdts.		0.02				0.02		0.02	0.6
Paraffin Waxes		0.02				0.02		0.02	0.8
Petroleum Coke		0.1				0.1		0.1	4.4
Residual Fuel Oil		16.6		14.6		1.9		1.9	78.3
Oth. Bitum. Coal		15.0				15.0		15.0	387.0
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	0.4					0.4		0.4	17.2
Charcoal	10.0					10.0		10.0	295.0
Wood	301.4					301.4		301.4	4701.8
Total Fossil									12919.4

1991									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviat. Gasoline		2.7				2.7		2.7	119.4
Bitumen		19.0				19.0	19.0	0	0
Creosote oils		0.02				0.02	0.02	0	0
Gas/Diesel Oil		159.5		29.8		129.8		129.8	5579.9
Jet Kerosene		20.4		20.6		-0.2		-0.2	-7.5
LPG		5.0				5.0		5.0	236.5
Lubricants		6.0				6.0	6.0	0.0	0.1
Motor Gasoline		141.3		0.6		140.7		140.7	6233.4
Other Kerosene		3.2				3.2		3.2	142.1
Oth. Petr. Pdts.		0.02				0.02		0.02	0.6
Paraffin Waxes		0.02				0.02		0.02	0.8
Petroleum Coke		0.1				0.1		0.1	4.4
Residual Fuel Oil		15.9		14.8		1.1		1.1	42.7
Oth. Bitum. Coal		15.0				15.0		15.0	387.0
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	0.4					0.4		0.4	17.2
Charcoal	10.0					10.0		10.0	295.0
Wood	307.4					307.4		307.4	4795.4
Total Fossil									12756.5

1992									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	Non-energy use (Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviation Gasoline		2.7				2.7		2.7	121.0
Bitumen		19.0				19.0	19.0	0	0
Creosote oils		0.02				0.02	0.02	0	0
Gas/Diesel Oil		180.0		29.3		150.7		150.7	6479.8
Jet Kerosene		21.1		21.2		-0.1		-0.1	-4.2
LPG		5.0				5.0		5.0	236.5
Lubricants		6.0				6.0	6.0	0.0	0.1
Motor Gasoline		150.5		0.6		149.9		149.9	6639.1
Other Kerosene		3.4				3.4		3.4	150.9
Other Petroleum Pdts.		0.02				0.02		0.02	0.6
Paraffin Waxes		0.02				0.02		0.02	0.8
Petroleum Coke		0.1				0.1		0.1	4.4
Residual Fuel Oil		17.8		14.9		2.8		2.8	114.3
Oth. Bitum. Coal		12.0				12.0		12.0	309.6
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	0.4					0.4		0.4	17.2
Charcoal	10.0					10.0		10.0	295.0
Wood	309.4					309.4		309.4	4827.1
Total Fossil									14070.1

1993									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviat. Gasoline		2.8				2.8		2.8	122.5
Bitumen		19.0				19.0	19.0	0	0
Creosote oils		0.02				0.02	0.02	0	0
Gas/Diesel Oil		183.4		28.8		154.7		154.7	6650.4
Jet Kerosene		21.7		21.8		0.0		0.0	-0.8
LPG		6.0				6.0		6.0	283.8
Lubricants		6.0				6.0	6.0	0.0	0.1
Motor Gasoline		155.5		0.6		154.8		154.8	6859.5
Other Kerosene		3.3				3.3		3.3	142.6
Oth. Petr. Pdts.		0.02				0.02		0.02	0.6
Paraffin Waxes		0.02				0.02		0.02	0.8
Petroleum Coke		0.1				0.1		0.1	4.4
Residual Fuel Oil		17.8		15.1		2.7		2.7	109.8
Oth. Bitum. Coal		13.6				13.6		13.6	350.9
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	0.4					0.4		0.4	17.2
Charcoal	10.0					10.0		10.0	295.0
Wood	311.4					311.4		311.4	4858.2
Total Fossil									14541.8

1994									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	Non-energy use (Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviation Gasoline		2.8				2.8		2.8	124.1
Bitumen		19.0				19.0	19.0	0	0
Creosote oils		0.02				0.02	0.02	0	0
Gas/Diesel Oil		218.9		28.3		190.6		190.6	8195.9
Jet Kerosene		22.4		22.4		0.1		0.1	2.5
LPG		6.0				6.0		6.0	283.8
Lubricants		6.0				6.0	6.0	0.0	0.1
Motor Gasoline		165.9		0.6		165.3		165.3	7323.5
Other Kerosene		8.1				8.1		8.1	353.5
Other Petroleum Pdts.		0.02				0.02		0.02	0.6
Paraffin Waxes		0.02				0.02		0.02	0.8
Petroleum Coke		0.1				0.1		0.1	4.4
Residual Fuel Oil		20.1		15.2		4.8		4.8	195.4
Oth. Bitum. Coal		13.6				13.6		13.6	350.9
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	0.4					0.4		0.4	17.2
Charcoal	10.0					10.0		10.0	295.0
Wood	313.4					313.4		313.4	4889.3
Total Fossil									16852.5

1995									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviat. Gasoline		2.8				2.8		2.8	125.7
Bitumen		19.0				19.0	19.0	0	0
Creosote oils		0.02				0.02	0.02	0	0
Gas/Diesel Oil		280.5		27.8		252.8		252.8	10868.5
Jet Kerosene		23.1		23.0		0.1		0.1	5.9
LPG		7.0				7.0		7.0	331.1
Lubricants		6.0				6.0	6.0	0.0	0.1
Motor Gasoline		182.6		0.6		181.9		181.9	8060.3
Other Kerosene		12.1				12.1		12.1	530.3
Oth. Petr. Pdts.		0.02				0.02		0.02	0.6
Paraffin Waxes		0.02				0.02		0.02	0.8
Petroleum Coke		0.1				0.1		0.1	4.4
Residual Fuel Oil		25.5		15.4		10.1		10.1	409.7
Oth. Bitum. Coal		16.0				16.0		16.0	412.8
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	0.4					0.4		0.4	17.2
Charcoal	10.0					10.0		10.0	295.0
Wood	315.4					315.4		315.4	4920.4
Total Fossil									20767.4

1996									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	Non-energy use (Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviation Gasoline		2.9				2.9		2.9	127.2
Bitumen		19.0				19.0	19.0	0	0
Creosote oils		0.02				0.02	0.02	0	0
Gas/Diesel Oil		291.6		27.3		264.4		264.4	11367.4
Jet Kerosene		23.8		23.6		0.2		0.2	9.2
LPG		7.0				7.0		7.0	331.1
Lubricants		6.0				6.0	6.0	0.0	0.1
Motor Gasoline		196.2		0.6		195.6		195.6	8664.8
Other Kerosene		12.7				12.7		12.7	554.5
Other Petroleum Pdts.		0.02				0.02		0.02	0.6
Paraffin Waxes		0.02				0.02		0.02	0.8
Petroleum Coke		0.1				0.1		0.1	4.4
Residual Fuel Oil		36.9		15.6		21.4		21.4	862.7
Oth. Bitum. Coal		14.0				14.0		14.0	361.2
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	0.4					0.4		0.4	17.2
Charcoal	10.0					10.0		10.0	295.0
Wood	317.4					317.4		317.4	4951.4
Total Fossil									22301.1

1997									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviat. Gasoline		2.9				2.9		2.9	128.8
Bitumen		19.0				19.0	19.0	0	0
Creosote oils		0.02				0.02	0.02	0	0
Gas/Diesel Oil		314.1		26.8		287.3		287.3	12353.6
Jet Kerosene		24.5		24.2		0.3		0.3	12.6
LPG		8.0				8.0		8.0	378.4
Lubricants		6.0				6.0	6.0	0.0	0.1
Motor Gasoline		201.1		0.6		200.5		200.5	8880.7
Other Kerosene		16.7				16.7		16.7	731.0
Oth. Petr. Pdts.		0.02				0.02		0.02	0.6
Paraffin Waxes		0.02				0.02		0.02	0.8
Petroleum Coke		0.1				0.1		0.1	4.4
Residual Fuel Oil		21.2		15.7		5.5		5.5	222.5
Oth. Bitum. Coal		11.0				11.0		11.0	283.8
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	0.4					0.4		0.4	17.2
Charcoal	10.0					10.0		10.0	295.0
Wood	319.4					319.4		319.4	4982.3
Total Fossil									23014.5

1998									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	Non-energy use (Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviation Gasoline		2.9				2.9		2.9	130.4
Bitumen		19.0				19.0	19.0	0	0
Creosote oils		0.02				0.02	0.02	0	0
Gas/Diesel Oil		318.5		26.3		292.2		292.2	12563.4
Jet Kerosene		25.1		24.8		0.4		0.4	15.9
LPG		7.4				7.4		7.4	349.8
Lubricants		6.0				6.0	6.0	0.0	0.1
Motor Gasoline		209.8		0.6		209.2		209.2	9269.3
Other Kerosene		15.9				15.9		15.9	694.8
Other Petroleum Pdts.		0.02				0.02		0.02	0.8
Paraffin Waxes		0.05				0.05		0.05	2.0
Petroleum Coke		0.0				0.0		0.0	0.0
Residual Fuel Oil		22.9		15.9		7.0		7.0	284.7
Oth. Bitum. Coal		16.7				16.7		16.7	430.1
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	0.4					0.4		0.4	17.2
Charcoal	10.0					10.0		10.0	295.0
Wood	321.4					321.4		321.4	5013.3
Total Fossil									23758.4

1999									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviat. Gasoline		3.0				3.0		3.0	131.9
Bitumen		19.0				19.0	19.0	0	0
Creosote oils		0.02				0.02	0.02	0	0
Gas/Diesel Oil		291.6		25.8		265.9		265.9	11432.2
Jet Kerosene		28.8		25.4		3.4		3.4	151.6
LPG		7.0				7.0		7.0	330.5
Lubricants		6.0				6.0	6.0	0.0	0.2
Motor Gasoline		217.8		0.6		217.2		217.2	9621.8
Other Kerosene		9.8				9.8		9.8	427.4
Oth. Petr. Pdts.		0.00				0.00		0.00	0.0
Paraffin Waxes		0.03				0.03		0.03	1.2
Petroleum Coke		0.6				0.6		0.6	18.9
Residual Fuel Oil		16.0		16.0		0.0		0.0	-0.5
Oth. Bitum. Coal		3.3				3.3		3.3	85.1
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	0.4	0.0				0.4		0.4	17.2
Charcoal	10.0					10.0		10.0	295.0
Wood	323.3					323.3		323.3	5044.1
Total Fossil									22217.5

2000									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	Non-energy use (Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviation Gasoline		3.0				3.0		3.0	133.5
Bitumen		19.0				19.0	19.0	0	0
Creosote oils		0.02				0.02	0.02	0	0
Gas/Diesel Oil		291.8		25.2		266.5		266.5	11461.5
Jet Kerosene		26.5		27.7		-1.2		-1.2	-51.1
LPG		5.7				5.7		5.7	269.8
Lubricants		6.0				6.0	6.0	0.0	0.2
Motor Gasoline		213.8		0.6		213.2		213.2	9446.8
Other Kerosene		4.8				4.8		4.8	209.2
Other Petroleum Pdts.		0.00				0.00		0.00	0.0
Paraffin Waxes		0.02				0.02		0.02	0.6
Petroleum Coke		0.2				0.2		0.2	6.4
Residual Fuel Oil		18.6		16.2		2.4		2.4	95.2
Oth. Bitum. Coal		1.8				1.8		1.8	45.6
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	0.5					0.5		0.5	19.4
Charcoal	10.0					10.0		10.0	295.0
Wood	325.3					325.3		325.3	5075.0
Total Fossil									21637.3

2001									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviat. Gasoline		3.0				3.0		3.0	135.1
Bitumen		19.0				19.0	19.0	0	0
Creosote oils		0.02				0.02	0.02	0	0
Gas/Diesel Oil		412.6		24.7		388.0		388.0	16682.6
Jet Kerosene		27.2		27.9		-0.8		-0.8	-33.4
LPG		7.8				7.8		7.8	368.8
Lubricants		6.0				6.0	6.0	0.0	0.2
Motor Gasoline		240.9		0.6		240.3		240.3	10646.8
Other Kerosene		6.3				6.3		6.3	276.7
Oth. Petr. Pdts.		0.00				0.00		0.00	0.0
Paraffin Waxes		0.01				0.01		0.01	0.2
Petroleum Coke		0.0				0.0		0.0	0.0
Residual Fuel Oil		16.6		17.4		-0.8		-0.8	-30.8
Oth. Bitum. Coal		2.2				2.2		2.2	56.9
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	0.2					0.2		0.2	9.0
Charcoal	10.0					10.0		10.0	295.0
Wood	327.3					327.3		327.3	5105.8
Total Fossil									28112.1

2002									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	Non-energy use (Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviation Gasoline		3.1				3.1		3.1	136.7
Bitumen		19.0				19.0	19.0	0	0
Creosote oils		0.02				0.02	0.02	0	0
Gas/Diesel Oil		351.4		24.0		327.4		327.4	14077.5
Jet Kerosene		27.9		28.2		-0.4		-0.4	-15.8
LPG		9.8				9.8		9.8	462.6
Lubricants		6.0				6.0	6.0	0.0	0.2
Motor Gasoline		253.0		0.6		252.4		252.4	11182.0
Other Kerosene		4.0				4.0		4.0	177.3
Other Petroleum Pdts.		0.04				0.04		0.04	1.7
Paraffin Waxes		0.01				0.01		0.01	0.5
Petroleum Coke		0.0				0.0		0.0	0.6
Residual Fuel Oil		14.1		18.6		-4.5		-4.5	-182.8
Oth. Bitum. Coal		5.7				5.7		5.7	146.5
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	0.6					0.6		0.6	24.8
Charcoal	10.0					10.0		10.0	295.0
Wood	330.7					330.7		330.7	5159.3
Total Fossil									26011.9

2003									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviat. Gasoline		3.1				3.1		3.1	138.2
Bitumen		19.0				19.0	19.0	0	0
Creosote oils		0.02				0.02	0.02	0	0
Gas/Diesel Oil		379.4		23.4		356.0		356.0	15306.2
Jet Kerosene		28.5		28.5		0.0		0.0	1.6
LPG		9.1				9.1		9.1	428.5
Lubricants		6.0				6.0	6.0	0.0	0.2
Motor Gasoline		265.1		0.6		264.5		264.5	11717.2
Other Kerosene		4.0				4.0		4.0	174.0
Oth. Petr. Pdts.		0.02				0.02		0.02	0.8
Paraffin Waxes		0.01				0.01		0.01	0.2
Petroleum Coke		0.0				0.0		0.0	0.1
Residual Fuel Oil		13.1		19.8		-6.7		-6.7	-270.4
Oth. Bitum. Coal		6.5				6.5		6.5	167.0
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	1.0					1.0		1.0	40.6
Charcoal	10.0					10.0		10.0	295.0
Wood	334.2					334.2		334.2	5212.9
Total Fossil									27704.1

2004									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	Non-energy use (Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviation Gasoline		3.2				3.2		3.2	139.8
Bitumen		29.8				29.8	29.8	0	0
Creosote oils		0.02				0.02	0.02	0	0
Gas/Diesel Oil		399.9		22.8		377.1		377.1	16215.5
Jet Kerosene		29.2		28.8		0.4		0.4	18.9
LPG		6.1				6.1		6.1	287.8
Lubricants		6.4				6.4	6.4	0.0	0.2
Motor Gasoline		277.2		0.6		276.6		276.6	12252.4
Other Kerosene		3.8				3.8		3.8	167.9
Other Petroleum Pdts.		0.03				0.03		0.03	1.0
Paraffin Waxes		0.17				0.17		0.17	7.0
Petroleum Coke		0.2				0.2		0.2	6.9
Residual Fuel Oil		13.3		21.0		-7.7		-7.7	-310.2
Oth. Bitum. Coal		0.9				0.9		0.9	24.0
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	2.1					2.1		2.1	82.4
Charcoal	10.0					10.0		10.0	295.0
Wood	337.6					337.6		337.6	5266.7
Total Fossil									28893.6

2005									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviat. Gasoline		3.2				3.2		3.2	141.4
Bitumen		19.8				19.8	19.8	0	0
Creosote oils		0.03				0.03	0.03	0	0
Gas/Diesel Oil		382.8		22.1		360.6		360.6	15507.9
Jet Kerosene		29.9		29.1		0.8		0.8	36.2
LPG		10.0				10.0		10.0	473.0
Lubricants		6.1				6.1	6.1	0.0	0.2
Motor Gasoline		289.3		0.6		288.7		288.7	12787.5
Other Kerosene		3.9				3.9		3.9	169.2
Oth. Petr. Pdts.		0.21				0.21		0.21	8.2
Paraffin Waxes		0.34				0.34		0.34	13.7
Petroleum Coke		0.0				0.0		0.0	0.0
Residual Fuel Oil		9.4		22.2		-12.8		-12.8	-517.3
Oth. Bitum. Coal		12.9				12.9		12.9	334.1
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	3.1					3.1		3.1	124.2
Charcoal	10.0					10.0		10.0	295.0
Wood	341.1					341.1		341.1	5320.7
Total Fossil									29078.3

2006									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	Non-energy use (Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviation Gasoline		3.2				3.2		3.2	142.9
Bitumen		7.7				7.7	7.7	0	0
Creosote oils		0.10				0.10	0.10	0	0
Gas/Diesel Oil		405.3		21.5		383.8		383.8	16504.6
Jet Kerosene		17.1		29.4		-12.3		-12.3	-543.2
LPG		9.5				9.5		9.5	447.5
Lubricants		6.7				6.7	6.7	0.0	0.2
Motor Gasoline		301.4		0.6		300.7		300.7	13322.7
Other Kerosene		4.7				4.7		4.7	207.7
Other Petroleum Pdts.		0.15				0.15		0.15	5.9
Paraffin Waxes		0.24				0.24		0.24	9.6
Petroleum Coke		0.8				0.8		0.8	26.5
Residual Fuel Oil		11.3		23.4		-12.2		-12.2	-491.1
Oth. Bitum. Coal		37.8				37.8		37.8	975.5
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	3.5					3.5		3.5	140.0
Charcoal	10.0					10.0		10.0	295.0
Wood	344.5					344.5		344.5	5374.8
Total Fossil									30749.0

2007									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviat. Gasoline		3.3				3.3		3.3	144.5
Bitumen		9.4				9.4	9.4	0	0
Creosote oils		0.05				0.05	0.05	0	0
Gas/Diesel Oil		464.8		20.9		443.9		443.9	19088.9
Jet Kerosene		32.5		29.7		2.9		2.9	125.8
LPG		8.9				8.9		8.9	422.1
Lubricants		10.4				10.4	10.3	0.0	0.3
Motor Gasoline		313.5		0.6		312.8		312.8	13857.9
Other Kerosene		3.1				3.1		3.1	135.5
Oth. Petr. Pdts.		0.19				0.19		0.19	7.8
Paraffin Waxes		0.37				0.37		0.37	14.9
Petroleum Coke		0.0				0.0		0.0	0.0
Residual Fuel Oil		11.0		24.6		-13.6		-13.6	-550.3
Oth. Bitum. Coal		53.8				53.8		53.8	1387.1
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	5.6					5.6		5.6	225.1
Charcoal	10.0					10.0		10.0	295.0
Wood	348.0					348.0		348.0	5429.1
Total Fossil									34859.4

2008									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviation Gasoline		3.3				3.3		3.3	146.1
Bitumen		16.6				16.6	16.6	0	0
Creosote oils		0.00				0.00	0.00	0	0
Gas/Diesel Oil		524.3		20.2		504.0		504.0	21673.1
Jet Kerosene		48.3		30.0		18.3		18.3	807.5
LPG		8.4				8.4		8.4	398.2
Lubricants		13.1				13.1	13.1	0.0	0.3
Motor Gasoline		325.6		0.7		324.9		324.9	14393.0
Other Kerosene		2.7				2.7		2.7	118.3
Other Petroleum Pdts.		0.15				0.15		0.15	6.2
Paraffin Waxes		0.50				0.50		0.50	20.1
Petroleum Coke		0.0				0.0		0.0	0.0
Residual Fuel Oil		23.7		25.8		-2.1		-2.1	-86.7
Oth. Bitum. Coal		150.6				150.6		150.6	3886.7
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	7.4					7.4		7.4	299.1
Charcoal	10.0					10.0		10.0	295.0
Wood	351.5					351.5		351.5	5483.5
Total Fossil									41661.9

2009									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviat. Gasoline		3.3				3.3		3.3	147.6
Bitumen		15.8				15.8	15.8	0	0
Creosote oils		0.00				0.00	0.00	0	0
Gas/Diesel Oil		515.7		19.6		496.1		496.1	21333.8
Jet Kerosene		38.8		30.3		8.5		8.5	376.2
LPG		7.9				7.9		7.9	374.4
Lubricants		13.2				13.2	13.2	0.0	0.2
Motor Gasoline		347.8		0.7		347.1		347.1	15377.7
Other Kerosene		2.3				2.3		2.3	100.0
Oth. Petr. Pdts.		0.10				0.10		0.10	4.1
Paraffin Waxes		0.63				0.63		0.63	25.3
Petroleum Coke		0.0				0.0		0.0	0.0
Residual Fuel Oil		25.0		27.0		-2.0		-2.0	-81.2
Oth. Bitum. Coal		64.4				64.4		64.4	1662.6
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	7.7					7.7		7.7	309.6
Charcoal	10.0					10.0		10.0	295.0
Wood	355.0					355.0		355.0	5538.0
Total Fossil									39630.3

2010									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviation Gasoline		3.4				3.4		3.4	149.2
Bitumen		15.2				15.2	15.2	0	0
Creosote oils		0.01				0.01	0.01	0	0
Gas/Diesel Oil		519.7		19.0		500.7		500.7	21529.3
Jet Kerosene		26.7		31.1		-4.4		-4.4	-193.2
LPG		7.4				7.4		7.4	351.1
Lubricants		13.9				13.9	13.9	0.0	0.3
Motor Gasoline		345.0		0.7		344.3		344.3	15253.7
Other Kerosene		2.3				2.3		2.3	100.0
Other Petroleum Pdts.		1.39				1.39		1.39	55.8
Paraffin Waxes		0.16				0.16		0.16	6.6
Petroleum Coke		0.2				0.2		0.2	5.0
Residual Fuel Oil		12.3		28.3		-16.0		-16.0	-645.2
Oth. Bitum. Coal		25.0				25.0		25.0	643.9
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	7.1					7.1		7.1	284.1
Charcoal	10.0					10.0		10.0	295.0
Wood	358.5					358.5		358.5	5592.7
Total Fossil									37540.6

2011									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviat. Gasoline		3.4				3.4		3.4	150.8
Bitumen		15.8				15.8	15.8	0	0
Creosote oils		0.01				0.01	0.01	0	0
Gas/Diesel Oil		521.7		18.9		502.8		502.8	21620.4
Jet Kerosene		28.0		37.8		-9.8		-9.8	-431.8
LPG		7.3				7.3		7.3	347.6
Lubricants		15.2				15.2	15.2	0.0	0.3
Motor Gasoline		354.4		0.7		353.7		353.7	15669.0
Other Kerosene		1.9				1.9		1.9	81.7
Oth. Petr. Pdts.		1.42				1.42		1.42	57.0
Paraffin Waxes		0.06				0.06		0.06	2.4
Petroleum Coke		0.3				0.3		0.3	9.1
Residual Fuel Oil		13.9		29.4		-15.6		-15.6	-629.1
Oth. Bitum. Coal		18.5				18.5		18.5	476.6
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	7.5					7.5		7.5	302.5
Charcoal	10.0					10.0		10.0	295.0
Wood	363.3					363.3		363.3	5667.9
Total Fossil									37656.4

2012									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviation Gasoline		3.4				3.4		3.4	152.3
Bitumen		16.0				16.0	16.0	0	0
Creosote oils		0.01				0.01	0.01	0	0
Gas/Diesel Oil		569.4		18.9		550.5		550.5	23669.6
Jet Kerosene		43.2		34.5		8.8		8.8	386.2
LPG		6.1				6.1		6.1	286.2
Lubricants		15.2				15.2	15.2	0.0	0.3
Motor Gasoline		365.2		0.7		364.5		364.5	16149.4
Other Kerosene		2.7				2.7		2.7	117.3
Other Petroleum Pdts.		0.89				0.89		0.89	35.8
Paraffin Waxes		0.04				0.04		0.04	1.4
Petroleum Coke		0.0				0.0		0.0	0.0
Residual Fuel Oil		14.9		29.4		-14.5		-14.5	-585.8
Oth. Bitum. Coal		96.4				96.4		96.4	2485.9
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	7.2					7.2		7.2	289.4
Charcoal	10.0					10.0		10.0	295.0
Wood	359.2					359.2		359.2	5603.8
Total Fossil									42988.0

2013									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviat. Gasoline		3.5				3.5		3.5	153.9
Bitumen		20.7				20.7	20.7	0	0
Creosote oils		0.01				0.01	0.01	0	0
Gas/Diesel Oil		552.9		18.9		533.9		533.9	22959.5
Jet Kerosene		33.0		34.5		-1.5		-1.5	-64.0
LPG		6.4				6.4		6.4	303.0
Lubricants		15.7				15.7	15.7	0.0	0.3
Motor Gasoline		376.1		0.7		375.4		375.4	16629.9
Other Kerosene		2.0				2.0		2.0	89.3
Oth. Petr. Pdts.		0.93				0.93		0.93	37.5
Paraffin Waxes		0.24				0.24		0.24	9.6
Petroleum Coke						0.0		0.0	0.0
Residual Fuel Oil		29.8		29.4		0.4		0.4	15.9
Oth. Bitum. Coal		51.5				51.5		51.5	1328.5
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	7.5					7.5		7.5	301.7
Charcoal	10.0					10.0		10.0	295.0
Wood	354.9					354.9		354.9	5536.3
Total Fossil									41765.0

2014									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviation Gasoline		3.5				3.5		3.5	155.4
Bitumen		43.2				43.2	43.2	0	0
Creosote oils		0.01				0.01	0.01	0	0
Gas/Diesel Oil		561.1		18.9		542.2		542.2	23314.6
Jet Kerosene		32.1		34.5		-2.4		-2.4	-104.1
LPG		8.6				8.6		8.6	406.6
Lubricants		13.8				13.8	13.8	0.0	0.3
Motor Gasoline		386.9		0.7		386.2		386.2	17110.4
Other Kerosene		1.8				1.8		1.8	78.9
Other Petroleum Pdts.		0.22				0.22		0.22	8.6
Paraffin Waxes		0.11				0.11		0.11	4.3
Petroleum Coke		0.0				0.0		0.0	0.8
Residual Fuel Oil		53.5		29.4		24.0		24.0	970.8
Oth. Bitum. Coal		3.0				3.0		3.0	77.5
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	7.0					7.0		7.0	282.1
Charcoal	10.0					10.0		10.0	295.0
Wood	350.3					350.3		350.3	5465.3
Total Fossil									42306.3

2015									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviat. Gasoline		3.5				3.5		3.5	157.0
Bitumen		45.4				45.4	45.4	0	0
Creosote oils		0.00				0.00	0.00	0	0
Gas/Diesel Oil		773.0		18.9		754.1		754.1	32425.4
Jet Kerosene		42.0		34.5		7.5		7.5	331.9
LPG		10.8				10.8		10.8	510.2
Lubricants		13.4				13.4	13.4	0.0	0.3
Motor Gasoline		397.8		0.7		397.1		397.1	17590.9
Other Kerosene		2.1				2.1		2.1	89.8
Oth. Petr. Pdts.		0.42				0.42		0.42	16.8
Paraffin Waxes		0.26				0.26		0.26	10.4
Petroleum Coke		0.0				0.0		0.0	0.0
Residual Fuel Oil		24.9		29.4		-4.6		-4.6	-184.2
Oth. Bitum. Coal		93.5				93.5		93.5	2411.5
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	6.5					6.5		6.5	262.5
Charcoal	10.0					10.0		10.0	295.0
Wood	345.6					345.6		345.6	5390.7
Total Fossil									53622.7

2016									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviation Gasoline		3.6				3.6		3.6	158.6
Bitumen		28.4				28.4	28.4	0	0
Creosote oils		0.00				0.00	0.00	0	0
Gas/Diesel Oil		807.0		18.9		788.1		788.1	33887.4
Jet Kerosene		42.0		34.5		7.5		7.5	331.9
LPG		12.3				12.3		12.3	579.9
Lubricants		12.0				12.0	12.0	0.0	0.3
Motor Gasoline		408.6		0.7		407.9		407.9	18071.3
Other Kerosene		1.3				1.3		1.3	55.2
Other Petroleum Pdts.		1.51				1.51		1.51	60.5
Paraffin Waxes		0.24				0.24		0.24	9.7
Petroleum Coke		0.1				0.1		0.1	4.4
Residual Fuel Oil		27.4		29.4		-2.0		-2.0	-82.5
Oth. Bitum. Coal		5.1				5.1		5.1	132.2
Refuse Derived Fuel						0		0	0
Tyre shavings						0		0	0
Waste Oils	6.0					6.0		6.0	241.6
Charcoal	10.0					10.0		10.0	295.0
Wood	340.5					340.5		340.5	5312.5
Total Fossil									53450.6

2017									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviat. Gasoline		2.0				2.0		2.0	87.7
Bitumen		17.6				17.6	17.6	0	0
Creosote oils		0.00				0.00	0.00	0	0
Gas/Diesel Oil		751.3		18.9		732.4		732.4	31494.1
Jet Kerosene		39.6		34.4		5.1		5.1	227.0
LPG		10.1				10.1		10.1	478.9
Lubricants		11.7				11.7	11.7	0.0	0.3
Motor Gasoline		309.7		0.7		309.0		309.0	13687.9
Other Kerosene		1.4				1.4		1.4	60.3
Oth. Petr. Pdts.		0.001				0.001		0.001	0.040
Paraffin Waxes		0.15				0.15		0.15	6.2
Petroleum Coke		0				0		0	0
Residual Fuel Oil		55.9		29.4		26.5		26.5	1069.5
Oth. Bitum. Coal		25.1				25.1		25.1	646.6
Refuse Derived Fuel	3.7					4		4	37
Tyre shavings	0.1					0.1		0.1	4.9
Waste Oils	7.0					7.0		7.0	279.5
Charcoal	20.3					20.3		20.3	598.3
Wood	348.1					348.1		348.1	5430.3
Total Fossil									48079.8

2018									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviation Gasoline		2.0				2.0		2.0	88.6
Bitumen		18.2				18.2	18.2	0	0
Creosote oils		0.004				0.004	0.004	0	0
Gas/Diesel Oil		759.2		18.9		740.3		740.3	31831.2
Jet Kerosene		40.0		34.8		5.2		5.2	229.4
LPG		10.6				10.6		10.6	501.9
Lubricants		11.1				11.1	11.1	0.0	0.3
Motor Gasoline		312.9		0.7		312.2		312.2	13832.1
Other Kerosene		1.1				1.1		1.1	49.6
Other Petroleum Pdts.		0.002				0.002		0.002	0.1
Paraffin Waxes		0.02				0.02		0.02	0.6
Petroleum Coke		0.03				0.03		0.03	0.9
Residual Fuel Oil		56.5		29.4		27.1		27.1	1093.7
Oth. Bitum. Coal		57.2				57.2		57.2	1476.1
Refuse Derived Fuel	1.9					2		2	19
Tyre shavings	0.1					0.1		0.1	4.2
Waste Oils	15.6					15.6		15.6	628.0
Charcoal	17.7					17.7		17.7	522.6
Wood	356.3					356.3		356.3	5558.9
Total Fossil									49755.6

2019									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU(Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviat. Gasoline		2.0				2.0		2.0	87.9
Bitumen		18.6				18.6	18.6	0	0
Creosote oils		0.00				0.00	0.00	0	0
Gas/Diesel Oil		755.2		18.9		736.3		736.3	31659.4
Jet Kerosene		39.7		34.5		5.2		5.2	227.4
LPG		10.8				10.8		10.8	509.9
Lubricants		10.6				10.6	10.6	0.0	0.3
Motor Gasoline		310.3		0.7		309.6		309.6	13716.0
Other Kerosene		1.0				1.0		1.0	44.7
Oth. Petr. Pdts.		0.17				0.17		0.17	6.7
Paraffin Waxes		0.04				0.04		0.04	1.4
Petroleum Coke		0.0				0.0		0.0	0.0
Residual Fuel Oil		56.0		29.4		26.6		26.6	1073.5
Oth. Bitum. Coal		62.3				62.3		62.3	1606.8
Refuse Derived Fuel	1.9					2		2	19
Tyre shavings	0.1					0		0	3
Waste Oils	11.0					11.0		11.0	443.1
Charcoal	13.5					13.5		13.5	398.6
Wood	339.0					339.0		339.0	5287.8
Total Fossil									49399.2

2020									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU (Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviation Gasoline		1.8				1.8		1.8	80.8
Bitumen		8.9				8.9	8.9	0	0
Creosote oils		0.001				0.001	0.001	0	0
Gas/Diesel Oil		695.2		18.9		676.3		676.3	29079.2
Jet Kerosene		11.8		10.3		1.5		1.5	67.6
LPG		9.8				9.8		9.8	464.0
Lubricants		9.5				9.5	9.5	0.0	0.2
Motor Gasoline		285.4		0.7		284.7		284.7	12612.3
Other Kerosene		0.9				0.9		0.9	38.5
Other Petroleum Pdts.		0.03				0.03		0.03	1.3
Paraffin Waxes		0.34				0.34		0.34	13.7
Petroleum Coke		0				0		0	0
Residual Fuel Oil		51.5		29.4		22.1		22.1	891.7
Oth. Bitum. Coal		98.0				98.0		98.0	2527.5
Refuse Derived Fuel	0.7					1		1	7.4
Tyre shavings	0.1					0.1		0.1	2.3
Waste Oils	6.5					6.5		6.5	260.9
Charcoal	18.6					18.6		18.6	549.6
Wood	343.1					343.1		343.1	5352.7
Total Fossil									46047.5

2021									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU (Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviat. Gasoline		1.9				1.9		1.9	83.0
Bitumen		9.6				9.6	9.6	0	0
Creosote oils		0.002				0.002	0.002	0	0
Gas/Diesel Oil		711.0		18.9		692.1		692.1	29758.8
Jet Kerosene		14.6		12.7		1.9		1.9	83.8
LPG		11.1				11.1		11.1	522.9
Lubricants		12.54				12.54	12.53	0.01	0.3
Motor Gasoline		292.9		0.7		292.3		292.3	12947.2
Other Kerosene		1.0				1.0		1.0	44.7
Oth. Petr. Pdts.		0.03				0.03		0.03	1.4
Paraffin Waxes		0.07				0.07		0.07	2.7
Petroleum Coke		0				0		0	0
Residual Fuel Oil		52.9		29.4		23.5		23.5	948.3
Oth. Bitum. Coal		63.7				63.7		63.7	1642.8
Refuse Derived Fuel	0.6					0.6		0.6	5.9
Tyre shavings	0.1					0.1		0.1	3.4
Waste Oils	6.3					6.3		6.3	251.8
Charcoal	13.6					13.6		13.6	399.8
Wood	346.2					346.2		346.2	5400.2
Total Fossil									46296.8

2022									
Fuel	Production (Gg)	Imports (Gg)	Exports (Gg)	International Bunkers (Gg)	Stock change (Gg)	Apparent Consumption (Gg)	NEU (Gg)	Apparent consumption excl. NEU (Gg)	Apparent consumption excl. NEU (TJ)
Aviation Gasoline		2.0				2.0		2.0	87.9
Bitumen		11.0				11.0	11.0	0	0
Creosote oils		0.02				0.02	0.02	0	0
Gas/Diesel Oil		726.8		18.9		707.9		707.9	30438.4
Jet Kerosene		39.7		34.5		5.2		5.2	227.4
LPG		11.2				11.2		11.2	531.2
Lubricants		10.97				10.97	10.96	0.01	0.2
Motor Gasoline		300.5		0.7		299.8		299.8	13282.1
Other Kerosene		1.1				1.1		1.1	49.6
Other Petroleum Pdts.		0.03				0.03		0.03	1.3
Paraffin Waxes		0.20				0.20		0.20	7.9
Petroleum Coke		0				0		0	0
Residual Fuel Oil		54.3		29.4		24.9		24.9	1004.8
Oth. Bitum. Coal		139.7				139.7		139.7	3604.4
Refuse Derived Fuel	0.6					0.6		0.6	6.3
Tyre shavings	0.02					0.02		0.02	0.76
Waste Oils	5.5					5.5		5.5	222.1
Charcoal	17.3					17.3		17.3	509.8
Wood	341.5					341.5		341.5	5328.1
Total Fossil									49464.5

Annex IV: QA/QC plan

Introduction

An important goal of the Intergovernmental Panel for Climate Change (IPCC) inventory guidance is to support Parties to develop national greenhouse gas (GHG) inventories that can be readily assessed in terms of quality. It is good practice to implement quality assurance/quality control (QA/QC) and verification procedures in the development of national GHG inventories to meet this goal. QA/QC procedures also serve to improve the inventory.

This manual is designed to guide and facilitate Namibia in performing the QA/QC and Verification of its future GHG inventories in a well-structured and smooth manner. A QA/QC and Verification system contributes to the objectives of good practice in inventory development, namely, to improve transparency, consistency, comparability, completeness, and accuracy of national GHG inventories.

Quality Control

Quality Control refers to a system of routine technical activities to assess and maintain the quality of the inventory by personnel compiling the inventory through the following procedures:

- Provides routine and consistent checks to ensure data integrity, correctness, and completeness.
- Identifies and addresses errors and omissions.
- Documents and archives inventory material and records of all QC activities.

QC activities include general methods such as accuracy checks on data acquisition and calculations, and the use of approved standardized procedures for emission and removal calculations, measurements, estimating uncertainties, archiving information and reporting. QC activities also include technical reviews of categories, activity data, emission factors, other estimation parameters, and methods.

Quality Assurance

Quality Assurance refers to a planned system of review procedures conducted by personnel not directly involved in the compilation of the inventory, preferably by independent experts upon a completed inventory after implementation of QC procedures.

The QA exercise reviews and verifies that:

- Measurable objectives (data quality objectives and QA/QC plan) were met.
- Ensures that the inventory represents the best possible estimates of emissions and removals.
- Support the effectiveness of the QC programme.

Verification

Verification refers to the collection of activities and procedures conducted during the planning and development steps, or after completion of an inventory that can help to establish its reliability for the intended applications of the inventory. In this manual, verification refers specifically to those methods that are external to the inventory and apply independent data, including comparisons with inventory estimates made by other bodies or through alternative methods. Verification activities may be constituents of both QA and QC, depending on the methods used and the stage at which independent information is used.

Practical Considerations of a QA/QC and Verification system

Key factors guiding the compilation of GHG inventories of Non-Annex I countries are:

- Compilers have limited resources.

- QC requirements, improved accuracy and lower uncertainty must be balanced against timeliness and cost effectiveness.

Considerations to fit above situation

- Resources allocated to QA/QC for different categories and the compilation process.
- Time allocated to conduct the checks and reviews of emissions and removal estimates.
- Frequency of QA/QC checks and reviews on different parts of the inventory.
- Level of QA/QC appropriate for each category.
- Availability and access to information on AD, EFs, other parameters such as uncertainties and documentation.
- Collection of additional data specifically required, e.g., alternative data sets for comparisons and checks.
- Procedures to ensure confidentiality of inventory and category information.
- Requirements for documenting and archiving information.
- Whether increased effort on QA/QC will result in improved estimates and reduced uncertainties.
- Whether sufficient independent data and expertise are available to conduct verification activities.

Drivers for prioritizing categories within the QA/QC and Verification system

- Are key category identified quantitatively (KCA) or qualitatively? For example:

  - Considerable uncertainty associated with the estimates.
  - Important changes in the characteristics of the category (technology changes or management practices).
  - Significant changes occurred recently in the estimation methodology for the category.
  - Significant changes in the trend of emissions or removals for this category.

- Use of complex modelling or large inputs from outside databases.
- EFs or other parameters used significantly differ from IPCC defaults or data used in other inventories.
- Long period since EFs or other parameters have been updated for this category.
- Significant amount of time since this category last underwent thorough QA/QC and verification.
- Major change in the way data are processed or managed for this category.
- Overlap with estimates of other categories (use of common AD) that can result in double counting or underestimation.

Elements of a QA/QC and Verification system

- Participation of an inventory compiler who is also responsible for coordinating QA/QC and verification activities and definition of roles/responsibilities within the inventory.
- A QA/QC plan.
- General QC procedures that apply to all inventory categories.
- Category-specific QC procedures.
- QA and review procedures.
- Interaction of the QA/QC system with uncertainty analyses.
- Verification activities.
- Reporting, documentation, and archiving procedures.

Roles and Responsibilities

- The inventory compiler should be responsible for coordinating the institutional and procedural arrangements for inventory activities. It is *good practice* for the inventory compiler to define specific responsibilities and procedures for the planning, preparation, and management of inventory activities, including:
- Inventory coordination (CCU of MEFT).
- Data collection (MME for Energy, MIT for IPPU, MAWLR for Agriculture and MEFT for LULUCF and Waste.
- Selection of methods, emission factors, activity data and other estimation parameters (Working groups led by MME for Energy, MIT for IPPU, MAWLR for Agriculture and MEFT for LULUCF and Waste).
- Estimation of emissions or removals (Working groups led by MME for Energy, MIT for IPPU, MAWLR for Agriculture and MEFT for LULUCF and Waste).
- Uncertainty assessment (Inventory compiler – Working groups and CCU of MEFT).
- KCA with and without LULUCF (Inventory compiler – Working groups and CCU of MEFT).
- QA/QC and verification activities (QA/QC Coordinator from CCU of MEFT supported by working groups and International expert/GSP for QA).
- Documentation and archiving (NSA and CCU of MEFT).

The QA/QC plan

A fundamental element of the system

The QA/QC plan is a fundamental element of the system and comprises the following characteristics:

- Should outline the activities to be implemented according to the GHGIMS/inventory cycle.
- Should include a scheduled time frame for the activities as earmarked in the inventory cycle.

Key features

Key features of the QA/QC plan are:

- An internal document to track QA/QC and verification activities.
- The inventory meets the IPCC reporting standards, inclusive of improvements.
- Once developed, it can be documented for use in subsequent inventories after necessary modifications.

An important component of the QA/QC plan is the data quality objectives, against which an inventory is assessed during a review. Data quality objectives may be based upon and refined from the following inventory principles:

- Timeliness
- Completeness
- Consistency
- Comparability
- Accuracy
- Transparency
- Improvement

General QC procedures

General QC procedures include generic quality checks related to calculations, data processing, completeness, and documentation that are applicable to all inventory source and sink categories. Table 1, General inventory level QC procedures, lists the general QC checks that the inventory compiler should use routinely throughout the preparation of the inventory. The checks in Table 1 should be applied irrespective of the type of data used to develop the inventory estimates. They are equally applicable to categories where default values or national data are used as the basis for the estimates. The results of these QC activities and procedures should be documented as set out in the Section 11.1, Internal Documentation and Archiving.

Although general QC procedures are designed to be implemented for all categories and on a routine basis, it may not be necessary or possible to check all aspects of inventory input data, parameters and calculations every year. Checks may be performed on selected sets of data and processes. A representative sample of data and calculations from every category may be subjected to general QC procedures each year. In establishing criteria and processes for selecting sample data sets and processes, it is good practice for the inventory compiler to plan to undertake QC checks on all parts of the inventory over an appropriate period of time as determined in the QA/QC plan.

Table A4.1. General QC procedures

QC Activity	Procedures
Assumptions and criteria for the selection of AD, EFs and other estimation parameters are documented	• Cross-check descriptions of AD, EFs, and other estimation parameters with information on categories and ensure that these are properly recorded and archived
Transcription errors in data input and references	• Confirm that bibliographical data references are properly cited in the internal documentation • Cross-check a sample of input data from each category (either measurements or parameters used in calculations) for transcription errors
Emissions and removals are calculated correctly	• Reproduce a set of emissions and removals calculations (Excel or CRT) • Use a simple approximation method that gives similar results to the original and more complex calculation to ensure that there is no data input error or calculation error
Parameters and units are correctly recorded and appropriate conversion factors are used	• Units are properly labelled in calculation sheets • Units are correctly carried through from beginning to end of calculations • Conversion factors are correct • Temporal and spatial adjustment factors are used correctly
Integrity of database files	• Examine the included intrinsic documentation to: - confirm that the appropriate data processing steps are correctly represented in the database - confirm that data relationships are correctly represented in the database - ensure that data fields are properly labelled and have the correct design specifications - ensure that adequate documentation of database and model structure and operation are archived
Consistency in data between categories	• Identify parameters (e.g., activity data, constants) that are common to multiple categories and confirm that there is consistency in the values used for these parameters in the emission/removal calculations
Movement of inventory data through processing steps is correct	• Emissions and removals data are correctly aggregated from lower reporting levels to higher reporting levels when preparing summaries • Emissions and removals data are correctly transcribed between different intermediate products
Review of internal documentation and archiving	• There is detailed internal documentation to support the estimates and enable reproduction of the emissions, removals and uncertainty estimates • Inventory data, supporting data, and inventory records are archived and stored to facilitate detailed review • The archive is closed and retained in a secure place following completion of the inventory • The integrity of any data archiving arrangements of outside organisations involved in inventory preparation is ensured

Other considerations

When estimates are prepared by outside consultants or agencies, the inventory compiler should ensure that the QC procedures are performed and recorded.

When the inventory relies upon official national statistics, the QC procedures implemented on these national data are equivalent with those of the 2006 IPCC Guidelines.

Particular attention should be given to categories that rely on external, and shared databases (e.g., livestock, No. of vehicles) to ensure that adequate QC has been conducted by the data provider.

Due to the quantity of data that needs to be checked for some categories, automated checks are encouraged where possible. An automated range check for the input values as recorded in the database (integrated in data portal system) could be implemented.

Category specific QC procedures

Category-specific QC complements general inventory QC procedures and encompasses the following:

- Requires knowledge of the specific category, the types of data available and the parameters associated with emissions or removals and are performed in addition to the general QC checks.
- Applies on a case-by-case basis, focusing on key categories and on categories where significant methodological and data revisions have taken place such as adoption of higher tier methods.
- Includes both emissions (or removals) calculations and activity data.

QC of Emission Factors

IPCC Defaults

When using IPCC default emission factors, it is good practice to assess their applicability to national circumstances and their impact on the uncertainty levels.

Default EFs can be compared with site or plant-level factors to determine their representativeness even if information is available for a small percentage of sites or plants only.

Country-specific EFs

These may be developed at a national or sub-national level based on prevailing technology, science, local characteristics and other criteria, after appropriate checks to evaluate the quality of data used in its development.

QC checks on the background data used to develop EFs

If EFs are based on site-specific or source-level testing, the inventory compiler should check if the measurement programme included appropriate QC procedures.

When EFs are based on secondary data sources, such as published studies or other literature, the compiler could attempt to determine whether QC activities conducted during the original preparation of the data are consistent with applicable IPCC procedures and published studies have undergone peer review.

It is important to investigate any potential conflict-of-interest, when these might influence results, e.g., financial interests.

QC checks on Models

Models are means of extrapolating and/or interpolating a limited set of known data, requiring assumptions and procedural steps to represent the entire process. If QA/QC associated with models is inadequate or not transparent, the inventory compiler should attempt to establish checks on the models and data, in particular:

- Appropriateness of model assumptions, extrapolations, interpolations, calibration-based modifications, data characteristics, and their applicability to the GHG inventory methods and national circumstances.
- Availability of model documentation, including descriptions, assumptions, rationale, and scientific evidence and references supporting the approach and parameters used for modelling.
- Types and results of QA/QC procedures, including model validation steps, performed by model developers and data suppliers.
- Plans to periodically evaluate and update or replace assumptions with appropriate new measurements.

Comparison with IPCC default factors

Inventory compilers should compare country-specific factors with relevant IPCC default emission factors, taking into consideration the characteristics and properties on which the default factors have been developed. The intent of this comparison is to determine whether country-specific factors are reasonable, given similarities or differences between the national source/sink category and the 'average' category represented by the defaults.

Comparison of emission factors between countries

When using between-country emission factor comparisons as a QC check, it is important to investigate similarities and differences in national circumstances for the relevant category. This comparison could be made for each source/sink category and possible aggregations. Comparisons between countries can also be made using aggregate emissions divided by activity data (implied emission factors).

Comparison to plant-level emission factors

An additional step is to compare the country specific factors with site-specific or plant-level factors if these are available. For example, if there are emission factors available for a few plants (but not enough to support a bottom-up approach) these plant-specific factors could be compared with the aggregated factor used in the inventory to provide an indication of the appropriateness of the country-specific factor.

Direct Emission Measurements

Emissions from a category may be estimated using direct measurements in the following ways:

- Sample emissions measurements from a facility to develop a representative emission factor for that individual site, or for the entire category (i.e., for development of a national emission factor).
- Continuous emissions monitoring (CEM) data to compile an annual estimate of emissions for a particular process.

QC of Activity Data

National Level AD

QC checks of reference source for national activity data

When using national AD from secondary sources, it is good practice to evaluate and document the associated QA/QC activities since most AD are originally prepared for purposes other than as input to estimates of GHG emissions.

Determine if the level of QC associated with secondary AD includes, at a minimum, the QC procedures. If the QA/QC is adequate, then the inventory compiler can simply reference the data source and document the applicability of the data used.

Establish QA/QC checks on the secondary data if the associated QC is inadequate or if the data have been collected using standards/definitions that deviate from the IPCC Guidelines.

If no alternative data sources are available, the inventory compiler should document the inadequacies associated with the secondary data QC as part of its summary report on QA/QC

Comparisons with independently compiled data sets

Where possible, a comparison of the national AD with independently compiled AD (other) sources should be undertaken.

Examples

- Many of the agricultural source-categories rely on government statistics for AD such as livestock populations and production by crop type. Comparisons can be made to similar statistics prepared by the FAO.
- Similarly, the IEA maintains a database on national energy production and usage that can be used for checks in the energy sector.
- Industry trade associations, university research, and scientific literature are also possible sources of independently derived AD to use in comparison checks.
- AD may also be derived from balancing approaches.

Ascertain whether alternative AD sets are really based on independent data. International information is often based on national reporting which is not independent from the data used in the inventory.

Comparisons with samples

The availability of partial data sets at sub-national levels may provide opportunities to check the reasonableness of national activity data. For example, if national production data are being used to calculate the inventory for an industrial category, it may also be possible to obtain plant-specific production or capacity data for a subset of the total population of plants. Extrapolation of the sample production data to a national level can then be done using a simple approximation method. The effectiveness of this check depends on how representative the sub-sample is of the national population, and how well the extrapolation technique captures the national population.

Trend checks of activity data

National activity data should be compared with previous year's data for the category being evaluated. Activity data for most categories tend to exhibit relatively consistent changes from year to year without sharp increases or decreases. If the national activity data for any year diverge greatly from the historical trend, they should be checked for errors. If a calculation error is not detected, the reason for the sharp change in activity should be confirmed and documented.

Site specific AD

QC checks of measurement protocol

The inventory compiler should establish whether individual sites carried out measurements using recognized national or international standards.

- If the measurements conform to recognized national or international standards and a QA/QC process is in place, then no further QA/QC will be necessary. Acceptable QC procedures in use at the site may be directly referenced.
- If the measurements do not conform to standard methods and QA/QC is not acceptable, then the inventory compiler should carefully evaluate use of these activity data

Comparisons between sites and with national data

Comparisons of activity data from different reference sources and geographic scales can play a role in confirming activity data.

For example, a comparison of production data across different sites, possibly with adjustments made for plant capacities, can indicate the reasonableness of the production data. Any identified outliers should be investigated to determine if the difference can be explained by the unique characteristics of the site or if there is an error in the reported activity data.

Production and consumption balances

Site-specific or activity data checks may be applied to methods based on product usage.

Example: Estimation of SF6 emissions from the use in electrical equipment or ozone depleting substances

- Relies on an account balance of gas purchases, gas sales for recycling, the amount of gas stored on site (outside of equipment), handling losses, refills for maintenance, and the total holding capacity of the equipment system. This account balance system should be used at each facility where the equipment is in place.
- A QC check of overall national activity could be made by performing the same kind of account balancing procedure on a national basis. This national account balancing would consider national sales of SF6 for the use in electrical equipment, the nation-wide increase in the total handling capacity of the equipment that may be obtained from equipment manufacturers, and the quantity of SF6 destroyed in the country.
- The results of the bottom-up and top-down account balancing analyses should agree, or large differences should be explained.

Calculation-related QC

Checks of the calculation algorithm will safeguard against duplication of inputs, unit conversion errors, or similar calculation errors. Independent 'back-of-the-envelope' calculations, based on simplified algorithms, can be used. If the original calculation and the simple approximate method disagree, examine both approaches to find the reason for the discrepancy.

It is a prerequisite that all calculations leading to emission or removal estimates be fully reproducible.

- Discriminate between input data, the conversion algorithm of a calculation and the output
- The input, output and calculation procedure should be recorded in a spreadsheet which is documented and archived

Documentation of calculations

When using spreadsheets:

- Clearly reference the data source of any numbers typed into the spreadsheet.
- Provide subsequent calculations, in the form of formulas, so that auditing tools can be used to track back from a result to the source data, and calculations can be evaluated by analyzing the formulae.
- Clearly mark cells in the spreadsheet containing derived data as 'results' and annotate them as to how and where they are then used.
- Document the spreadsheet itself specifying its name, version, authors, updates, intended use and checking procedures so that it can be used as a data source of the derived results and referenced further on in the inventory process.

When using databases:

- Clearly reference the source data tables using a referencing column that links to the data source.
- Use queries when processing the data, where practical, as these provide the means to track back to the source data tables.
- Where queries are not practical and new tables of data need to be generated, make sure that scripts or macros of the commands used to derive the new data set are recorded and referenced in a referencing column of the dataset.
- Document the database itself specifying its name, version, authors, intended use and checking procedures so that it can be used as a data source.

QA Procedures

QA comprises activities outside of the inventory compilation. It includes reviews and audits to assess the quality of the inventory, determine the conformity of the procedures and identify areas where improvements need to be made.

QA procedures may be applied at different levels (internal/external) and are used in addition to the general and category-specific QC procedures. The inventory may be reviewed in full or in parts.

Objective: Conduct an unbiased review of the inventory by independent experts from other agencies or national or international experts or groups not closely connected with the national inventory compilation.

- When independent reviewers from the inventory compiler are not available, persons who are at least not involved in the portion being reviewed can also perform QA.
- Conduct a basic expert peer review of all categories before completing the inventory to identify potential problems and correct these where possible. Key categories should be prioritized as well as those with significant changes in methods or data.

Expert peer review

Consists of a review of calculations and assumptions by experts in relevant technical fields. The objective of the expert peer review is to ensure that the inventory's results, assumptions, and methods are reasonable as judged by those knowledgeable in the specific field.

There are no standard tools or mechanisms for expert peer review, and its use should be considered on a case-by-case basis.

The results of expert analyses from the UNFCCC processes should also be considered as part of the overall QA improvement process.

All expert peer reviews should be well documented, preferably in a report or checklist format that shows the findings and recommendations for improvement.

Audits

Audits may be used to evaluate how effectively the inventory complies with the minimum QC specifications outlined in the QC plan.

It is important that the auditor be independent of the inventory compiler as much as possible to be able to provide an objective assessment of the processes and data evaluated.

Audits may be conducted during the preparation of an inventory, following inventory preparation, or on a previous inventory.

They provide an in-depth analysis of the respective procedures taken to develop an inventory, and of the documentation available. It is good practice for the inventory compiler to develop a schedule of audits at strategic points in inventory development.

Audits related to initial data collection, measurement work, transcription, calculation and documentation may be conducted.

Audits can be used to verify that the QC steps have been implemented, that category-specific QC procedures have been implemented according to the QC plan, and that the data quality objectives are met.

QA/QC and Uncertainty estimates

The QA/QC process and uncertainty analyses provide valuable feedback to one another.

The uncertainty analysis provides insights into weaknesses in the estimate, the sensitivity of the estimate to different variables, and the greatest contributors to uncertainty, all of which can assist in setting priorities for improving data sources or methodologies.

- It is good practice to apply QC procedures to uncertainty estimation to confirm that calculations are correct, and that data and calculations are well documented.
- The assumptions on which uncertainty estimation has been based should be documented for each category.
- Calculations of category-specific and aggregated uncertainty estimates should be checked, and any error addressed.

For uncertainty estimates involving expert judgement, the qualifications of experts should also be checked and documented, as should the process of eliciting expert judgement, including information on the data considered, literature references, assumptions made, and scenarios considered.

Verification

Includes comparisons with emissions or removals estimates prepared by other bodies and from fully independent assessments, e.g., atmospheric concentration measurements.

Provides information for countries to improve their inventories and is part of the overall QA/QC and verification system.

The considerations for selecting verification approaches include scale of interest, costs, desired level of accuracy and precision, complexity of design and implementation of the verification approaches, availability of data, and the required level of expertise needed for implementation

Where verification techniques are used, they should be reflected in the QA/QC plan. The limitations and uncertainties associated with the verification technique itself should be thoroughly investigated prior to its implementation so that the results can be properly interpreted.

Comparison of National estimates

Applying lower tier methods

Lower tier IPCC methods are typically based on ‘top-down’ approaches that rely on highly aggregated data. When using higher tier bottom-up approaches, comparisons with lower-tier methods can be used as a simple verification tool such as for CO_2 from fossil fuel combustion when the reference approach estimate can be compared to the sum of sectoral-based estimates.

Applying higher tier methods

Higher tier methods are typically based on detailed bottom-up approaches that rely on highly disaggregated data and a well-defined sub-categorization of sources and sinks. It may be difficult to fully implement a higher tier approach because of lack of sufficient data or resources. However, the availability of even partial estimates for a subcategory of sources may provide a valuable verification tool for the inventory.

Comparison with independently compiled estimates

Comparison with other independently compiled inventory data on national level (if available) are a quick option to evaluate completeness, approximate emission (removal) levels and correct category allocations such as national level CO_2 emissions estimates associated with the combustion of fossil fuel compiled by the International Energy Agency (IEA).

Comparisons of intensity indicators between countries

Emission (removal) intensity indicators may be compared between countries (e.g., emissions per capita, industrial emissions per unit of value added, transport emissions per car, emissions from power generation per kWh of electricity produced, emissions from dairy ruminants per ton of milk produced). These indicators provide a preliminary check and verification of the order of magnitude of the emissions or removals.

Documentation, Archiving and Reporting

Internal documentation and archiving

Document and archive all information on the planning, preparation, and management of inventory activities. This includes:

- Responsibilities, institutional arrangements, and procedures for the planning, preparation, and management of the process.
- Assumptions and criteria for the selection of AD and EFs.
- EFs and other estimation parameters used, including all references.
- AD or sufficient information to enable them to be traced to the referenced source.
- Information on the uncertainty associated with AD and EFs.
- Rationale for choice of methods.
- Methods used, including those used to estimate uncertainty and those used for recalculations.
- Changes in data inputs or methods from previous inventories (recalculations).
- Identification of individuals providing expert judgement for uncertainty estimates and their qualifications to do so.
- Details of electronic databases or software used in the production of the inventory, including versions, operating manuals, hardware requirements and any other information required to enable their later use.
- Worksheets and interim calculations for category estimates, aggregated estimates and any recalculations of previous estimates.
- Final inventory report and any analysis of trends.
- QA/QC plans and outcomes of QA/QC procedures.
- Secure archiving of complete datasets, including shared databases used in inventory development.

Reporting

Report a summary of implemented QA/QC activities and key findings as a supplement to each country's national inventory. It is not practical or necessary to report all the internal documentation that is retained.

In this summary, the inventory compiler should focus on the following activities:

- Reference to a QA/QC plan, its implementation schedule, and the responsibilities for its implementation should be discussed.
- Activities performed internally and external reviews conducted for each source/sink category and on the entire inventory.
- Presentation of the key findings, describing major issues regarding quality of input data, methods, processing, or estimates for each category and how they were addressed or planned to be addressed in the future.
- Explanation of significant trends in the time series, particularly where trend checks point to substantial divergences. Any effect of recalculations or mitigation strategies should be included in this discussion.

Annex V: Any additional information, as applicable, including detailed methodological descriptions of source or sink categories and the national emission balance

Not Applicable

Annex VI: Common reporting tables

PROBLEMS ENCOUNTERED WHEN GENERATING CRTs

The CRTs for the GHG Inventory for years 1990 to 2022 as generated by the UNFCCC ETF Tool are available at XXXXXXXXXXXXXXXXXXXXX – please html insert link.

The process for complying to the reporting requirements has been affected by the frequent improvements made to the IPCC GHG Software reflected in the updates released since mid-2023. This NID has been produced with the version 2.910 downloaded in April 2024 and the calculations were completed in May 2024. However, the interoperability for generating CRTs of all sectors was not fully functional in that version. A draft NID was produced in August 2024.

The 2.93 version of the software was released at end August 2024, and it is a complete version with improved interoperability to enable the generation of CRTs for all sectors. The original database from the 2.91 version was updated to the 2.93 version and JSON files produced using the ETF tool on the UNFCCC website in October 2024. A QA/QC exercise of the CRTs from the ETF Tool was done, and the following have been observed;

1. The completeness Table 1.5 in this NID reflects the circumstances of emitting categories in the country. However, the notification key "NE" is assigned by the CRT export function of the IPCC software to numerous categories where emissions are not occurring (NO). It has not been possible to amend the CRTs manually as it is a very heavy and time-consuming exercise considering that the time series is 33 years. It is proposed to manually correct this shortcoming in the next BTR with the appropriate notification key "NO" or "IE". It would be much appreciated if the interoperability module could be enhanced to avoid this problem in the future.
2. The following data are not being transferred from the JSON file of the software to the ETF tool:
    a. NMVOC emissions (entered manually in the sectoral table of the software) from fuel use assigned to sub-category 1.A.3.b.iii (Heavy duty trucks and buses) leading to a lower total NMVOC emissions for the Energy sector.
    b. NMVOC emissions from Solvent Use 2.D.3 - Other (Solvent Use and Asphalt), estimated using the EMEP EEA Guidelines, were entered manually in the software but are not transferred by the interoperability tool and thus the total NMVOC emissions from the IPPU sector in the CRTs are lower than that reported in this NID.
    c. Emissions from "Other Fossil Fuels" (Waste Oil, Refuse Derived Fuels and tyre shavings) in the Reference Approach is not calculated in the ETF tool as the carbon content has not been loaded through the JSON production and transfer process.
    d. Emissions/removals from the "Harvested Wood Products" category are loaded in the ETF tool but not included in LULUCF CRTs nor in National aggregated totals.
3. The categories below, where the emissions calculated with version 2.91 of the IPCC GHG inventory software are different from those of version 2.93.
    a. There has been a change in the worksheet for estimating GHG emissions from Cement production at Tier 1 level from the 2.91 to the 2.93 version of the software with the inclusion of the CKD correction factor. This has increased the emissions from the fraction estimated at Tier 1 by 2% in the CRTs compared to the emissions reported in the NID. The difference represents 0.01% of national emissions in 2022.
    b. The worksheet for estimating RAC gas emissions from Refrigeration and Air Conditioning has also changed from the 2.91 to the 2.93 version and the emissions from the category 2.F.1 - Refrigeration and Air Conditioning are different between the ones in the NID and

the CRTs. The difference varies between 3% to 7% depending on the gas. Emissions from Refrigeration and Air Conditioning represented only 0.06% of national emissions in 2022.