SULTANATE OF OMAN

وزارة البيئة والشؤون المناخية
MINISTRY OF ENVIRONMENT AND CLIMATE AFFAIRS

BIENNIAL UPDATE REPORT

Submitted to:

United Nations Framework Convention

on Climate Change

Submitted by:

Ministry of Environment and Climate Affairs

December 2019

SULTANATE OF OMAN

وزارة البيئة والشؤون المناخية
MINISTRY OF ENVIRONMENT AND CLIMATE AFFAIRS

BIENNIAL UPDATE REPORT

Submitted to:

United Nations Framework Convention

on Climate Change

Submitted by:

Ministry of Environment and Climate Affairs

December 2019

FOREWORD

In Paris in December 2015, the global community came together at the 21st meeting of the Conference of the Parties to the United Nations Framework Convention on Climate Change in common cause to reduce greenhouse gas emissions that contribute to climate change and to intensify adapting to its adverse effects. The results of the meeting - keeping global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius - charts a new course in the global effort to confront climate change.

The Sultanate of Oman as a committed partner in this global effort has signed the Paris Agreement on 22 April 2016 and ratified it on 24 April 2019. The Sultanate of Oman has also submitted its Initial National Communication under the UNFCCC in 2013 as well as its Intended Nationally Determined Contributions (INDCs) in accordance with decision 1/CP.19 of the Conference of the Parties.

The Sultanate of Oman has adopted in October 2019, the National Strategy for Adaptation and Mitigation to Climate Change 2020-2040, to build resilience to climate change due to its exposure to the adverse impacts of climate change such as intensifying tropical cyclones, increasing temperatures, and rising sea levels.

This first biannual update report is a fundamental step that shows the Sultanate of Oman is moving forward in the fulfillment of the aspirations of the UNFCCC and its Paris Agreement on climate change. On the other hand, the Sultanate of Oman recognizes a need to control the trend of its greenhouse gas emissions. The Oman vision 2020-2040 has adopted a firm policy for the penetration of Renewables in the energy landscape. The Omani renewable energy plan aims to secure more than 2,600 MW by 2025. This will reduce approximately 6000 tones CO_2 equivalents, which represents an abatement of about 6% of the total GHG emission of 2015.

I would like to extend my deep appreciation to the Global Environmental Facility, to UN Environment Programme, Regional West Asia, Sultan Qaboos University and relevant government entities for their contribution to the development of Oman's first Biannual Update Report.

H.E. Mohammed Bin Salim Bin Said Al Toobi

Minister of Environment and Climate Affairs

List of Contributors

Sultan Qaboos University core team:

- Dr. Ghazi Al-Rawas, Principal Investigator, Department of Civil and Architectural Engineering, Sultan Qaboos University.
- Dr. Yassine Charabi, Co-Principal investigator, BUR Lead author & Chair of the GHG inventory team. Director Center for Environmental Studies and Research, Sultan Qaboos University.
- Dr. Malik Al-Wardy, Technical Coordinator, Department of Soils, Water and Agricultural Engineering, Sultan Qaboos University.

Ministry of Environment and Climate Affairs:

Project management team

- Mr. Ibrahim Ahmed Al-Ajmi, Director of the Project, General Director of Climate Affairs.
- Mr. Khamis Mohammed Al-Zeedi, Deputy Director of the Project, Director of Mitigation Department.
- Mr. Khaled Hilal Al-Tobi, Scientific and Technical coordinator of the Project, Director of Climate Modeling and Studies.
- Mr. Ibrahim Yaqoob Al-Harthi, Climate Affairs Inspector, Directorate General of Climate Affairs.
- Ms. Zainab Mohammed Al-Hashmi, Climate Affairs Specialist, Directorate General of Climate Affairs.
- Ms. Samah Salim Al-Shibli, Climate Affairs Specialist, Directorate General of Climate Affairs.

Technical support team

- Mr. Waleed Suliman Al-Daghari, Director of Adaptation Department, Directorate General of Climate Affairs.
- Ms. Halima Ahmed Al-Rawahi, Climate Affairs Specialist, Directorate General of Climate Affairs
- Ms. Nahla Hamdan Al-Abri, Climate Affairs Specialist, Directorate General of Climate Affairs
- Mr. Hamed Hamood Al-Rahbi, Climate Affairs Technician, Directorate General of Climate Affairs
- Mr. Jalal Salim Al-Mawali, Financial and Administrative Control Specialist, Directorate General of Climate Affairs.
- Maha Ali Al-Balushi Climate Affairs Inspector, Directorate General of Climate Affairs.
- Mr. Saif Majid Al-Balushi, Climate Affairs Inspector, Directorate General of Climate Affairs.
- Mr. Qais Ali Al-Hinai, Climate Affairs Inspector, Directorate General of Climate Affairs.

- Zaid Thabit Talib Al-Mamari , Climate Affairs Technician Directorate General of Climate Affairs.

Administrative support

- Mr. Nasser Hamdan Al-Darmaki, Head of Coordination and Follow-up Section, Directorate General of Climate Affairs.
- Ms. Fatima Khalfan Al-Naufalia, coordinator, Directorate General of Climate Affairs.
- Majida Suleiman Al-Habsia, coordinator, Directorate General of Climate Climate Affairs
- Mr. Ibrahim Nasser Al-Waheebi, Driver of the Directorate, Directorate General of Climate Affairs.

International experts from UN Environment Programme, Regional West Asia Office:

- Dr. Abdul-Majeid Haddad, Deputy Director, UN Environment Programme, Regional West Asia Office.
- Mr. Mohammed Angawi, Programme Management Officer, UN Environment Programme, Regional West Asia Office.
- Mr. Vicente Paolo Yu, Expert, UN Environment Programme, Regional West Asia Office.

EXECUTIVE SUMMARY

National Circumstances

The Sultanate of Oman encompasses about 309,500 square kilometers situated along the southeastern corner of the Arabian Peninsula consisting of three major regions: coastal zones (3%) which serves as the main agricultural areas; mountain ranges (15%) where peaks can reach up to 3,075 meters; and interior plains (82%) which consist of low-elevation desert areas. A hot and hyper-arid climate characterizes the Sultanate of Oman, due to its location along the Tropic of Cancer. While the country is well-known for its very hot summers and low annual rainfall, it has become even hotter over the past decades. Regarding water resources, Sultanate of Oman is one of the most water-stressed countries on the planet with less than 1,000 cubic meters in freshwater availability per person per year from three major sources of annual supply: groundwater (78%) is renewable in nature except for interior regions; desalination (15%) of seawater and brackish water; and surface water (6%) from small streams (wadis). The agriculture sector is completely dependent on irrigation, with total cultivated land around 100,917 hectares. Coastal areas account for the largest share of irrigated land (56%), followed by interior plains, oases, and land adjacent to wadis. The country is highly dependent on food imports, particularly cereals (wheat, rice, maize) and animal products (beef, chicken, milk).

On the other hand, fisheries in the country represent an important component of culture and economy, with a large traditional artisanal sector as well as industrial-scale activities. Yellowfin tuna, kingfish, sardines, emperors, and groupers account for a large share of the annual catch from the Sea of Oman and the Arabian Sea. Further, the biodiversity in the country is characterized by desert, mountain, and wetland ecosystems with over 4,000 flora and fauna species. In addition, urban areas are characterized by high growth due to steady internal migration from rural to mostly urban areas in the coastal zone. Today, cities in the Sultanate account for an overwhelming share (78%) of the total population and about half of the urban infrastructure is located within 200 meters of the coastline. The total population in Oman reached 4,638,908 by December 31, 2017, of which 2,546,449 were Omanis. As of April 2019, the total population in Oman was 4,690,187. It is expected that the total population will reach 7,652,342 in 2040. Oman is a hydrocarbon-based economy, constituting 72.9% of total government revenue in 2017. In 2017, GDP reached US$ 70.78 billion compared to US$ 19.507 billion in the year 2000. The average GDP annual growth rate over the period 2014 to 2017 was nearly 2.9%, ranging between -0.9% from 2016 to 2017 and a high of 5% from 2015 to 2016. Over this same period, gross national income per capita decreased at an average rate of -7.07% per year, from US$ 20,469.139 to US$ 15,267.445. Since the 1970s to the present day, the total primary energy supply has relied exclusively on fossil fuel (oil and natural gas). Total energy supply has grown rapidly between 2000 and 2015, from 7.57 to 25.4 kilotons of oil equivalent (kTOE), or 8.4% per year.

Greenhouse gas inventory

For the preparation of its first Biennial Update Report (BUR), the Ministry of Environment and Climate Affairs (MECA) received financial support from the Global Environment Facility (GEF). Project Management & Technical Studies Team composed of the experts of Sultan Qaboos University (SQU), the Directorate General of Climate Affairs and national experts from relevant

public and private entities was constituted for the preparation and implementation of the work program of the Biennial Update Report (BUR). The 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines on National Greenhouse Gas Inventories have been used for reporting GHG inventory for the first BUR of Oman and for the second communication of Oman to UNFCCC. The methodology used has encompassed only TIER 1. Global warming potential (GWP), of the 5th Assessment Report of IPCC, is used to express the GHG in a single unit of carbon dioxide equivalents (CO2 eq). Table ES–1-1 details GHG emissions in Oman by sector and Gas for 2015.

Table ES–1-1: GHG emissions in Oman, 2015 (Gg) (Source: Charabi et al. 2019)

GHG Sources & Sinks	CO_2e	CO_2	CH_4	N_2O	PFCs	HFCs	SF6
Energy	61,488	43,405	639	0.72	0	0	0
Industrial processes and product use	29,181	15,123	5.09	0	0.15	1.04	0
Agriculture, forestry and other land use	1,466	37.4	43.4	0.8	0	0	0
Waste	3,938	0	137.4	0.34	0	0	0
Total National Emissions	**96,072**	**58,565**	**824.9**	**1.86**	**0.15**	**1.04**	**0**

Vulnerability and adaptation

Oman is already subject to extreme climatic conditions that will likely become more extreme due to climate change. Under the effect of climate change, Oman will likely experience adverse impacts on its precious water resources, both surface water, and groundwater. The frequency of destructive flash flooding is already evidenced by an increased frequency of extreme wadi flows while future sea-level rise is projected to impose serious adverse impacts on groundwater quality in some of Oman's most important aquifers. Climate change is expected also to have severe impacts on the marine environment. An increase in water temperatures will contribute to a restructuring of marine ecosystems with implications for ocean circulation, biogeochemical cycling, and marine biodiversity. Due to climate change, the western Arabian Sea will become warmer and more saline. Some of its key chemical properties such as pH, dissolved oxygen, and nitrates are also projected to be adversely impacted. Such changes may pose important threats to the future sustainability of the annual catch of sardines and yellowfin tuna, two species that are central to the commercial fishing industry of Oman.

The future sustainability of Oman's agricultural sector is at risk due to the effect of climate change. As agricultural productivity depends entirely on groundwater, the combined effects of sea-level rise imply a steady decline in cropland available for cultivation and corresponding substantial economic losses to farmer households. Observed and foreseen climate changes have a very negative impact on urban areas, tourism (coastal zones) and infrastructure in the Sultanate of Oman. Apart from the obvious impact of sea-level rise, negative phenomena include most of all, an increased frequency and intensity of extreme events. With climate change, low-lying coastal areas are vulnerable to sea-level rise and storm surges associated with extreme weather events. In addition, flash flooding magnitude and frequency could increase in the future. Future changes in temperature and precipitation are expected to pose

a range of serious health risks to the Omani population in association with flooding, infectious diseases, and heat stress.

Greenhouse gas mitigation

The GHG mitigation plan of the Sultanate of Oman focuses on the energy sector, the sector consistently responsible for the largest share of GHG emissions in the country. In 2018, the Sultanate of Oman has adopted a firm policy aimed at reaching a minimum level of renewable energy penetration of 10% of the electrical generation by 2025. Oman's renewable energy development plan encompasses solar, wind and waste-to-energy. The Omani renewable energy plan aims to secure more than 2,600 MW by 2025. This will reduce approximately 5,737.55 Gg CO2 eq., which represent an abatement of about 6% of the total GHG emission of 2015, and 26.5% of the total GHG emission of 2000.

Other information

The main challenges in the BUR project's activities were related to data collection and data accessibility for the GHG inventory. In 2019, MECA created a National Inventory Management System (NIMS) to sustain National Communication and BURs reporting. In addition, significant steps were taken by MECA since 2015 towards the implementation of a national climate Measurement, Reporting and Verification (MRV) system according to UNFCCC requirements and guidelines. Sustaining Oman's MRV system for the UNFCCC and its Paris Agreement would require continued capacity building for a large number of stakeholders and financial support from international organizations.

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

LIST OF ACRONYMS

AFOLU	Agriculture, Forestry and Other Land Use
CH_4	Methane
CMIP5	Coupled Model Intercomparison Project Phase 5
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
FAO	Food and Agriculture Organization of the United Nations
GCC	Gulf Cooperation Council
GCF	Green Climate Fund
GDP	Gross Domestic Product
Gg	gigagrams (10^9 grams)
GHG	Greenhouse gas
GWP	global warming potential
HFC	hydrofluorocarbons
HadGEM2	Hadely Global Environment Model 2
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPPU	industrial processes and product use
km	kilometer
Km^2	square kilometer
kTOE	thousand tonnes of oil equivalent
MECA	Ministry of Environment and Climate Affairs
MRV	Measurement, Reporting and Verification
MW	megawatts (10^6 watts)
MWh	megawatt-hours (10^6 watt-hours)
N_2O	Nitrous oxide
NAMAs	Nationally appropriate mitigation actions
NCSI	National Center for Statistics and Information
NIMS	National Inventory Management System
PFC	perfluorinated compounds
RCP	Representative Concentration Pathway
TWh	Terawatt-hours (10^12 watt-hours)
UNEP	United Nations Environment Programme

1. National Circumstances

1.1. Geographic information

1.1.1. Topography

The Sultanate of Oman is situated at the southeastern corner of the Arabian Peninsula, encompasses a land area of about 309,500 Km2, and is characterized by a diverse range of topography including mountain ranges, arid deserts, and fertile plains (Figure 1-1). Oman's coastline varies from precipitous cliffs near the shore of Musandam in the far north to shallow sandy beaches in the Al Batinah governorate along the Sea of Oman and the Al Wusta and Dhofar governorates along the Arabian Sea. Mountain ranges in the north and southwest occupy about 15% of the country. Coastal plains occupy about 3%, extending from the Al Batinah governorate to the Salalah Plain, and serve as important agricultural areas. Interior areas occupy the remaining 82% and consist of sandy, wasteland desert with elevations up to 500 meters above sea level (Figure 1-2).

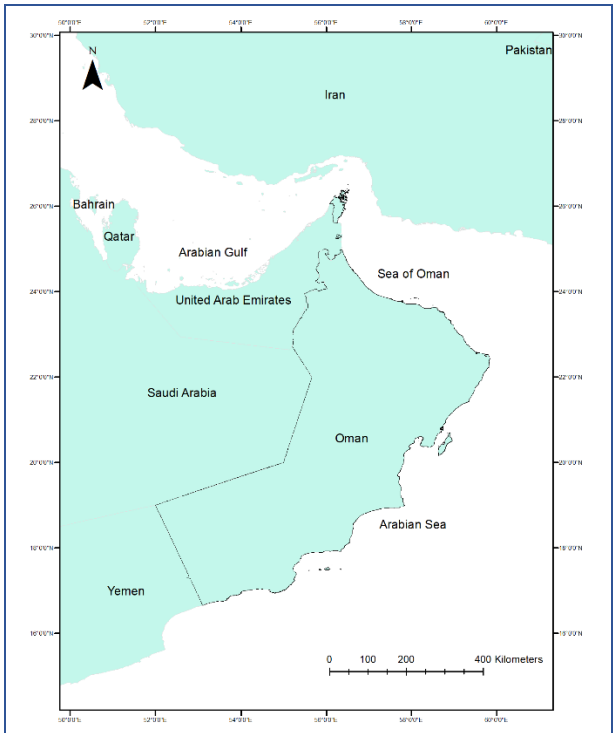


Figure 1-1: Location of Oman on the Arabian Peninsula (source: National Survey Authority)

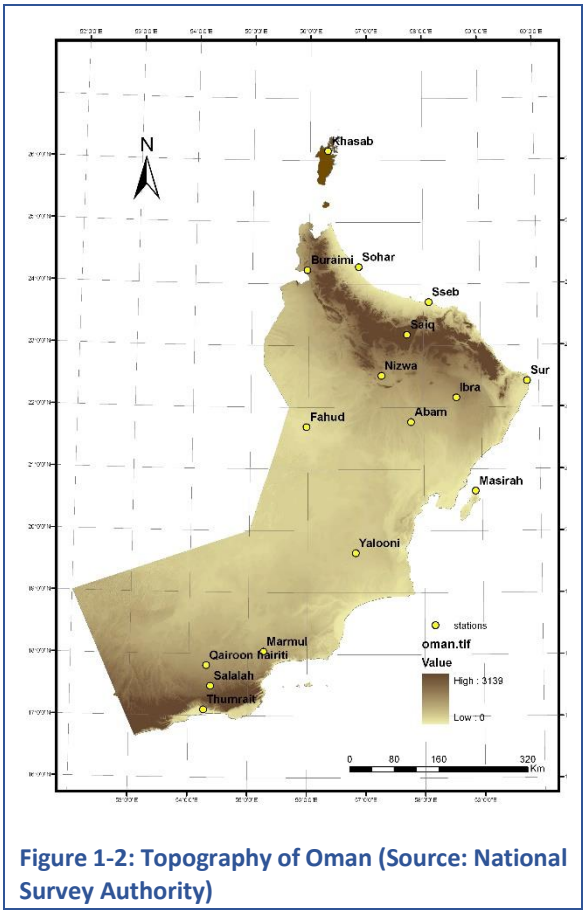


Figure 1-2: Topography of Oman (Source: National Survey Authority)

1.1.2. Climate of Oman

A hot and hyper-arid climate characterizes the Sultanate of Oman, due to its location along the Tropic of Cancer. The large latitudinal extent and complex topography has influenced also the climate pattern of the Sultanate and induced several local climates. Figure 1-4 shows the pattern of the annual mean of temperature over the period 2000-2015. The mountainous region of the Hajar Mountains in the north of Oman and Dhofar Mountains in the south of Oman recorded. The mean temperature of the mountainous region is between 12°C and 18°C. The mean

temperature is about 24°C, over the hillsides of the mountains. This value increases to 26°C, over most of the Omani lands. The Northeast coastline between Muscat and Sur recorded higher values (28°C).

Figure 1-3, shows the annual average precipitation during the period of 2000-2015. The Hajar Mountains recorded the highest rainfall amount with about 300 mm per year. The summer Monsoon influence, the southern part of Oman and the annual average of precipitation fluctuate between 50 to 100 mm. Extreme weather events associated with tropical cyclones in the north Indian Ocean and the Arabian Sea afflict Oman from time to time. There have been destructive tropical depressions, tropical cyclonic storms and severe cyclonic storms that have tracked toward Oman over the past decades. Such storms typically occur during the pre-monsoonal period (May-June) and the post-monsoonal period (October-November).

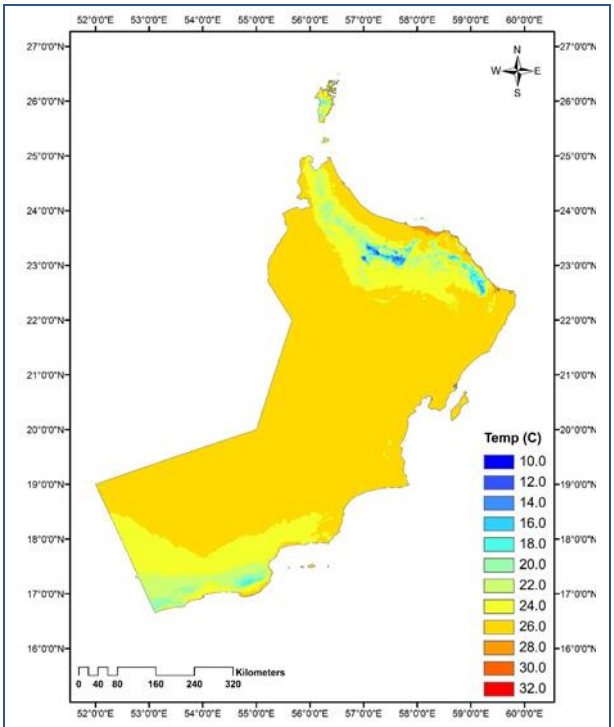


Figure 1-4: Pattern of annual mean temperature, 2000-2015 (Source: Charabi et al. 2015).

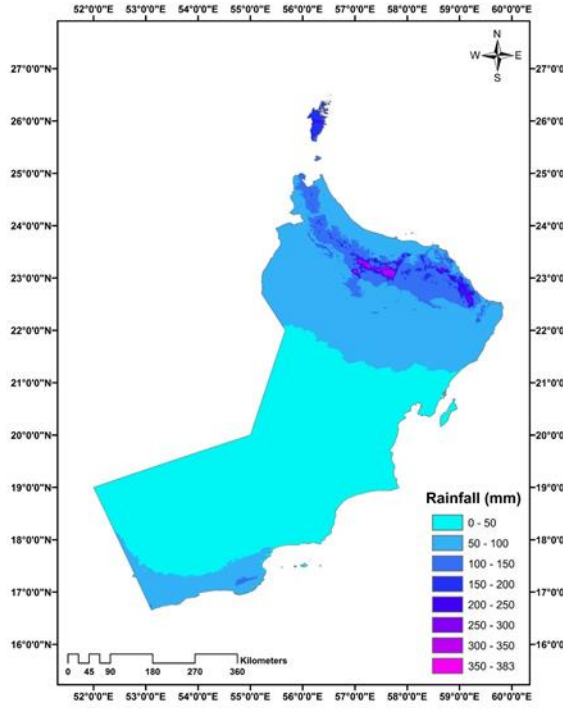


Figure 1-3: Pattern of annual average precipitation, 2000-2015 (Source: Charabi et al. 2015).

1.1.3. Recent climatic Change

Due to climate change, Oman will likely experience higher temperatures, more intense weather events and other climate hazards such as heatwaves and droughts. Outlined here are key climatic trends and projections developed for Oman that account for its unique topography and regional environment and which offer insights into the range of potential future climatic conditions. Over 1980 - 2013, meteorological stations in Oman showed evidence of a clear warming trend, with the highest trends around Khasab, Sohar, Saiq, Seeb and Sur and northwards; and the weakest warming trends along the southeastern coast. Rainfall has also been decreasing although trends are not as strong.

The main observed changes are summarized as follows:

- Mean annual temperature; the change in mean annual temperature for meteorological stations in Oman is ranging from 0.0°C per decade around Masirah to about 0.9°C per decade around Sur. On average, mean temperatures have increased by around 0.4°C per decade across Oman.
- Mean annual maximum temperature; the change in mean annual maximum temperature for meteorological stations in Oman is ranging from -0.6°C per decade around Sohar to about 1.2°C per decade around Khasab. On average, the mean maximum temperatures have increased by about 0.0°C per decade across Oman.
- Mean annual minimum temperature; the change in minimum annual temperature for meteorological stations in Oman is ranging from 0.2°C per decade around Saiq to about 1.7°C per decade around Sur. On average, mean temperatures have increased by around 0.5°C per decade across all areas of Oman.
- Rainfall; there is a high change in rainfall from year to year, with Saiq showing high fluctuations during the 1980s and 1990s. While rainfall trends are less robust compared to temperature trends, rainfall shows a decreasing pattern.

1.1.4. Future Climatic Change

Oman's future climate was projected by statistical downscaling and interpolating the coarse resolution HadGEM2 general circulation model to a finer resolution. Bias correction techniques were applied to ensure that the model closely matched historical climatic conditions in Oman. Clear signs of future climate change are evident. Representative Concentration Pathways or RCPs are GHG concentration pathways used by the IPCC and the RCP projections are used for Oman to develop future projections. Four RCPs were considered: RCP8.5 (business-as-usual), RCP6, RCP4.5, and RCP2.6 (climate stabilization). The results of RCP's show global GHG concentrations per RCP, the increasing trends and projections over two periods substantially affect the country with expected climate change under the projections observed. A short summary of each outcome of RCP's projections provided below:

- Maximum Temperature Change (by 2041-2060, relative to historical period). By the middle of the 21st Century, maximum annual temperatures will have increased substantially regardless of RCP. In the best case (RCB 2.6), maximum temperatures are expected to rise by at least 2°C along with southern coastal areas. In the worst case (RCP 8.5), maximum temperatures are expected to reach 4°C above historical levels in the interior and north.
- Maximum Temperature Change (by 2061-2080, relative to 2041-2060 period). By the late-21st Century, maximum annual temperatures will have changed substantially. In the best case (RCP 2.6), maximum temperatures are expected to decrease by up to 0.5°C in some areas. In the worst case (RCP 8.5), maximum temperatures are expected to increase by 1.0°C above mid-21st Century levels, or 5.0°C above historical levels.
- Minimum Temperature Change (by 2041-2060, relative to historical period). By the mid-21st Century, minimum annual temperatures will also have increased substantially regardless of RCP. In the best case (RCP 2.6), minimum temperatures are expected to rise by at least 2°C along southern coastal areas.

In the worst case (RCP 8.5), maximum temperatures are expected to reach 4.5°C above historical levels in the interior and far north.

- Minimum Temperature Change (by 2061-2080, relative to 2041-2060 period). By the late-21st Century, minimum annual temperatures will have changed substantially. In the best case (RCP 2.6), minimum temperatures are expected to decrease by up to 1.5°C in interior areas. In the worst case (RCP 8.5), minimum temperatures increase by 1.5°C above mid-21st Century levels, or 5.5°C above historical levels, in far northern areas.
- Average Annual Rainfall Change (by 2041-2060, relative to historical period). By the mid-21st Century, annual average rainfall shows mixed results. In the best case (RCB 2.6), average annual rainfall is expected to increase by up to 10 mm/year in most areas. In the worst case (RCP 8.5), average annual rainfall decreases by up to 10 mm/year in most areas, with only the southwestern and eastern coastlines showing increases to 10 mm/year
- Average Annual Rainfall Change (by 2061-2080, relative to 2041-2060 period). By the late-21st Century, average annual rainfall will have changed substantially. In the best case (RCB 2.6), average annual rainfall is expected to further decrease by up to 10 mm/year in interior areas. In the worst case (RCP 8.5), average annual rainfall decreases in most areas by up to an additional 10 mm/year below the mid-21st Century levels.

1.1.5. Water Resources

Oman is a water-stressed country, with less than 1,000 cubic meters in freshwater availability per person per year (FAO, 2014). Keeping water supply and demand in equilibrium is a constant challenge. There are four main types of water resources, as described in the bullets below:

- Groundwater accounts for roughly 78% of the water supply. Most are renewable in nature, being recharged annually by rainfall or through surface water infiltration. Non-renewable groundwater exists in the interior regions of Oman in the Al Najd, Al Masarat and Al Sharqi Sands.
- Desalinated water accounts for the next highest share of water supply, about 15%. Currently, there are nearly 100 desalination plants in Oman with roughly a 50-50 split regarding seawater or brackish water as the feedstock.
- Surface water accounts for about 6% of the total water supply. Annual average wadi flow is estimated at 211 million m^3. While average rainfall is estimated at 9.5 billion m3 per year, about 80% of this precipitation evaporates.
- Treated wastewater accounts for the remaining 1% of the total water supply.

1.1.6. Agriculture and livestock

Agricultural production is wholly dependent on irrigation. The total cultivated area has increased from 72,835 hectares in 2000 to 100,917 hectares. Crop production has also increased from 1,212,700 tons in 2000 to 2,622,498 tons in 2017 (National Center for Statistics and Information, 2019). Most of the cultivated area is located in coastal areas, with the most intensely farmed areas located along a 320 km stretch in the Al Batinah coastal region northwest of Muscat, and a 100 km long stretch in Salalah coastal plain in the Dhofar governorate. Other major areas for agricultural production include the interior plains, oases, and the land adjacent to wadis.

The diversified livestock in Oman includes cows, sheep, goats, and camels. The total number of livestock has grown from 1,740,200 in 2000 to 3,502,000 in 2017. The highest rise is registered with goats (978,500 in 2000 to 2,257,000 in 2017), followed by sheep (334,900 in 2000 to 593,000 in 2017) and cows (298,900 in 2000 to 389,000 in 2017) while camels were least (118,900 in 2000 to 263,000 in 2017) (National Center for Statistics and Information, 2019).

1.1.7. Fisheries

Fisheries represent an important element of Oman's culture and economy. As one of the biggest fish producers in the region, fisheries are a significant national income resource after oil. A total of 991 fish species have been identified in Oman's national waters, of which about 50 species are of key importance to the traditional and commercial fishing sectors. In 2018, total fish landings from traditional fisheries were estimated to reach 370,042 tons (National Center for Statistics and Information, 2019).

1.1.8. Mineral Resources

Oman has a vast wealth of industrial rocks, minerals, and metals. Some of its natural resources include — besides petroleum and natural gas — limestone, dolomite, marble, granite, gabbro, gypsum, wollastonite, guano, olivine, and rock salt. Oman has about 950 million tons of gypsum reserves and 500 million tons of dolomite deposits. In 2016, Oman has more than 150 quarrying and mining operations for fill material. During 2000-2015, the main growth in mineral production encompassed an increase in gypsum production by 56%, followed by limestone by 31% and cement by 12%. Oman's mineral industry is expected to continue to grow in the next years.

1.2. Population

1.2.1. Growth Trend and Projection

The total population of the Sultanate reached 4,690,187 in April 2019, where Omani citizens accounted for 56.3% of the total population, and 43.6% are expatriate population. Over the period 1993-2019, the population grew at a rate of 3.5% per year, with most of the growth coming in urban areas. According to the National Center for Statistics and Information, (2019), the population of the Sultanate of Oman will reach 7,652,342 in 2040. In the early 1970s, more than 85% of the total population of Oman was living in rural areas. Conversely, in 2014, urbanization reached 77.2% (World Bank Statistics, 2019).

In April 2019, 57.5% of the population in Oman is concentrated in Muscat and the Al-Batinah coastal plain. This plain, which serves as Oman's main agricultural areas, has elevations ranging from 0 to 500 m and its width in the middle is around 50 km. The Al-Batinah coastal plain has been experiencing rapid development in the past five decades and its attractiveness will continue in the future due to the recent implementation of heavy industrial activities. Other major population centers include the regions of Ad Dharirah, Ad Dakhliyah, and Ash Sharqiyah in the Al Hajar Mountains. Most of the remaining population resides in the Dhofar region near the southwestern part of the country.

Oman has a large and increasing percentage of its population between 15 and 64 years of age. Illiteracy has decreased substantially in recent decades, falling to 4% by 2016. The government

currently spends roughly 6.3% of total annual expenditures on health care or roughly US$ 421 per person per year. All public health indicators show good trends in life expectancy, child mortality rate, and maternal mortality rate, consistent with rates in other GCC countries.

1.2.2. Urban Settlement

Utilization of the coast increased dramatically during the past five decades in Oman, a trend that seems certain to continue through the 21st century. Coastal population growth in Oman has led to the widespread conversion of natural coastal landscapes to industrial and residential uses. The Sultanate of Oman has 7 seven Governorates with coastal borders, namely: Musandam, North Al-Batinah, South Al-Batinah, Muscat, Al-Wusta and Dhofar and 47.7% of the total built-up areas of the seven coastal Governorates of Oman are settled within a 200m distance of the shoreline.

1.3. Economy

Oman has the fifth largest economy in the GCC region. In 2017, GDP reached US$ 70.78 billion compared to US$ 19.507 billion in the year 2000 (The World Bank, 2019). The average GDP annual growth rate over the period 2014 to 2017 was nearly 2.9%, ranging between -0.9% from 2016 to 2017 and a high of 5% from 2015 to 2016. However, over this same period (2014-2017) the gross national income per capita decreased at an average rate of -7.07% per year, from US$ 20,469.139 to US$ 15,267.445. The sharp decline in crude oil prices in the global market led to a sharp fall in Omani oil export receipts, which in turn explains the reduction in the gross national income per capita. The average price for the crude oil of Oman dropped from US$103.23 per barrel in 2014, US$ 56.45 per barrel in 2015, to US$ 40.14 per barrel in 2016. (The World Bank, 2019).

The structure of the Omani economy has changed significantly over the years. In 2000, the oil and gas sector represented the largest share of GDP at nearly 48%. By 2016, the oil and gas share had dropped by nearly half, to only 27.4% of GDP. During this period, the share of services has increased from 42% in 2000 to 53.5%in 2016 and industry has exhibited notable increases from 8.4% in 2000 to 20.1% in 2016, while the agriculture share of GDP has stayed relatively flat, with a contribution of less than 2% (Central Bank of Oman, 2019).

The Sultanate of Oman was the first country in GCC to release “Oman Vision 2020” in 1995. Overall, the Omani vision 2020, paved the road for successful economic diversification, while the contribution of oil to the national economy still stands at 27.4% in 2016. Oman is pinning its hopes on Vision 2040 to kindle a coherent development framework and galvanize the collective resources necessary to propel the Sultanate towards a sustainable, knowledge-based economy. The Vision 2040 is also an ambitious strategy towards a post-oil economy. The motivation behind Vision 2040 is to operate as the guiding document for the development of national implementation programs, including the next five-year plan between 2021 and 2025. Explicitly, economic diversification and fiscal sustainability will be consolidated through the achievements of the following goals:

a) Leading sectors to achieve economic diversification and integration with sub-sectors to be identified every five years
b) A diversified, integrated and competitive economy that is future-oriented and is driven by innovation and entrepreneurship

c) Well-versed, integrated and sustainable fiscal, monetary and economic policies; together with budgets that effectively utilize public revenues
d) A regulatory environment that is flexible and abreast that ensures equal opportunities
e) Advanced technological infrastructure that is enabling for all sectors and capable of accommodating latest developments and cyberspace security challenges
f) An integrated and cohesive research and development system amongst various sectors and institutions

1.4. Energy supply and demand

Oil and gas remain the primary revenue sources for Oman, constituting 72.9% of total government revenue in 2017. In 2015, crude oil extraction operations accounted for 49,274 kTOE, most of which was exported – 42,183 kTOE, or 86% of total domestic supply (IEA, 2019). Most of the remaining oil that is consumed in Oman and converted into refined oil products – diesel, gasoline, and jet kerosene – for use in the transport sector. Natural gas production shows far different characteristics, with the extraction of 28,270 kTOE, most of which is consumed within Oman 19,461 kTOE, or 69% of total domestic supply for power generation and industrial applications (i.e., smelters, refineries).

Since the 1970s to the present day, the total primary energy supply has relied exclusively on diesel oil and natural gas (IEA, 2019). There is no coal, biofuel/waste, renewable, or nuclear resources used in Oman. Total energy supply has grown rapidly between 2000 and 2015, from 7.57 to 25.4 kTOE, or 8.4% per year. Most of this growth is attributed to increasing shares of natural gas in the energy system from 2000 to 2015 (IEA, 2019). Currently, there are fourteen (14) power stations in Oman, comprised of open-cycle gas turbines and combined cycle units for the co-production of water and desalinated water. Electricity production from these units is dominated by natural gas at over 97% (IEA, 2019).

Transmission and distribution losses have declined from 20.8 in 2015 to 9.6% over the period 2000-2015. Total net electricity consumption has increased rapidly during this period, from 6,832 GWh in 2000 to 28,912 GWh in 2015, or 10 % per year. The highest growth has been in the industrial sector average 19,4% per year, followed by commercial and public services and residential sector with an annual of 10% and 8.7% respectively (IEA, 2019).

1.5. Administrative divisions

Administratively, Oman is divided into 11 Governorates; Muscat, Al-Batinah North and South, Ad-Dakhiliya, Al-Buraimi, Adh-Dhahirah, Musandam, Ash-Sharqiyyah North and South, Al-Wusta, and Dhofar (see Figure 1-4). These governorates are divided into a further 61 administrative provinces or *wilayat* as follows:

- Muscat governorate: 6 wilayat;
- Al-Batinah North governorate: 6 wilayat;
- Al-Batinah South governorate: 6 wilayat:
- Ad-Dakhiliya governorate: 8 wilayat;
- Al-Buraimi governorate: 3 wilayat;

- Adh-Dhahirah governorate: 3 wilayat;
- Musandam governorate: 4 wilayat;
- Ash-Sharqiyyat North governorate: 6 wilayat;
- Ash-Sharqiyyat South governorate: 5 wilayat;
- Al-Wusta governorate: 4 wilayat; and
- Dhofar governorate: 10 wilayat

1.6. Climate change vulnerability

Oman is already subject to extreme climatic conditions that will likely become only more extreme due to climate change. Over the past several decades, average temperatures have increased by around 0.4°C per decade (1980-2013). In the future, temperatures increase by up to 5.0°C while annual rainfall decreases by up to 20 mm/year by the end of the century and according to the RCP 8.5. Future change in the climate of Oman will adversely affect the following sectors:

- Water resources - in recent years, extreme rainfall frequency has increased. In the future, maximum daily wadi flows may increase up to 1.6 times the historical rate, while sea-level rise poses serious risks to groundwater quality.
- Marine & fisheries - Over the past several decades, the Western Arabian Sea has become warmer and saltier, possibly explaining a decline in annual sardine and yellowfin tuna landings. Future oceanic changes may aggravate these trends.
- Agriculture - by the middle of the century, 64% of cultivated land in southern Al Batinah will be unfit for groundwater irrigation due to seawater intrusion into the Jamma aquifer from sea level rise, leading to a 40% drop in farmer annual incomes.
- Urban areas, tourism, and infrastructure - in recent years, there has been a nearly 10-fold increase in at-risk areas in Muscat. In the future, Al Batinah is the most vulnerable region to a range of coastal threats; and Al Wusta to tropical cyclones
- Health - absent effective adaptive response climate change could increase malaria rates, expose the elderly population to heat stress from increased temperatures, and expose the population to mortality risks from flooding.

2. INSTITUTIONAL ARRANGEMENTS

2.1. Implementation arrangements

The Ministry of Environment and Climate Affairs (MECA) is the government institution mandated to carry out all activities and functions necessary to ensure the protection of the environment and climate system in the country. It was established on 9 September 2007 by Royal Decree No. (90/2007) as one of the government authorities is responsible for formulating plans and programs for protection of the environment and conservation of its natural resources through application of its policy to ensure safety of the environment, combat pollution and maintain the various ecosystems within the framework of the basic objectives of the sustainable development, as well as protection of wildlife, conservation of nature, preservation and sustainable use of resources.

In addition, it is tasked with monitoring and assessment of climate change in coordination with the competent authorities to avoid many of the potential impacts of climate change on the natural, economic and social systems so as to be prepared to manage the risks of climate change by taking necessary actions, preparation of national strategies to mitigate greenhouse gas emissions and to adapt to these effects so as to confront the potential risks in this regard.

The Ministry also contributes to the development of scientific research prospects in the environmental and climate fields, exchange of expertise, collection and use of scientific data. It is responsible for raising awareness and implants the concepts of dealing with the environment and climate affairs among all segments of the community, as well as to consolidate the principles of preservation of the environment and its natural resources and contribute in the support of the exerted efforts in accordance with the objectives of sustainable development. It undertakes the task of issuing environmental laws as may be required by the environmental exigency or upon issuance of Royal Decrees.

Since 2007, The Directorate General of Climate Affairs in MECA is the primary entity that is responsible for administrative and regulatory action in response to national and international requirements regarding climate change management. The organizational chart of MECA, including that of the Directorate General of Climate Affairs, can be seen on MECA's website (https://meca.gov.om/ar/index.php).

As pertains to Oman's Second National Communication (SNC) and its first Biennial Update Report (BUR), the following implementation arrangement was detailed:

- The UNEP Regional Office for West Asia was the implementation agency of the grant support received from GEF and responsible for project execution and technical assistance.
- The Directorate General of Climate Affairs was responsible for coordination and oversight of all aspects of project implementation in collaboration with project partners.
- Sultan Qaboos University was liable for the collection and analysis of comprehensive climate change monitoring data, GHG inventory of the reference years and drafting the SNC and BUR reports.

Overall coordination of the BUR project was overseen by a Project Management & Technical Studies Team composed of the experts of the Directorate General of Climate Affairs and Sultan Qaboos University and experts from relevant public and private entities.

2.2. Global Environment Facility funding support

The First Biannual Update Report of the Sultanate of Oman to The United Nations Framework Convention on Climate Change (UNFCCC) was made possible through the funding support of the Global Environment Facility (GEF) through United Nations Environment Programme, Regional West Asia Office, along with further funding from the Ministry of Environment and Climate Affairs. The funds received allowed the improvement of the emissions inventory, and supported the development of studies on climate change mitigation and adaptation in Oman.

3. GREENHOUSE GAS INVENTORY

3.1. Methodology

This chapter presents estimates of Oman's anthropogenic greenhouse gas emissions (GHG) and sinks for the year 2015. The inventory includes four categories: energy; industrial processes and product use (IPPU); agriculture, forestry and other land use (AFOLU); and waste. The 2006 IPCC Guidelines on National Greenhouse Gas Inventories have been used for reporting GHG inventory for the first BUR of Oman and for the second communication of Oman to the UNFCCC. The methodology used has encompassed only TIER 1, as Tier 2 and 3 methodologies could not be used due to technical and capacity constraints.

3.2. Overall results

In the subsections that follow, GHG emissions are reported at the national level in absolute units of carbon dioxide, methane, nitrogen oxide emissions, high-GWP gasses, as well as in units of CO_2e.

3.2.1. Total GHG emissions

Table 3-1 presents total GHG emissions and sinks for the year 2015. Total GHG emissions in 2015 were 96,072 Gg CO_2e, which includes 61,488 Gg from energy; 29,181 Gg from IPPU; 3,938

Table 3-1: GHG emissions in Oman, 2015 (Gg) (Source: Charabi et al. 2019)

GHG Sources & Sinks	CO2e	CO2	CH4	N2O	PFCs	HFCs	SF6
Energy	61,488	43,405	639	0.72	0	0	0
Industrial processes and product use	29,181	15,123	5.09	0	0.15	1.04	0
Agriculture, forestry and other land use	1,466	37.4	43.4	0.8	0	0	0
Waste	3,938	0	137.4	0.34	0	0	0
Total National Emissions	**96,072**	**58,565**	**824.9**	**1.86**	**0.15**	**1.04**	**0**

Gg from AFOLU and 1,466 Gg from waste. There are no carbon sinks associated with any GHG sources. Perfluorinated compounds (PFCs) and Hydrofluorocarbons (HFCs) emissions are around 0.15 Gg and 1.04 Gg respectively. There are also no emissions of sulfur hexafluoride. Energy-related activities accounted for the dominant portion of GHG emissions in Oman in 2015. Approximately 64% of all GHG emissions are associated with the combustion of fossil fuels or the release of fugitive emissions from oil and gas operations. Industrial processes and product use accounted for about 30.4% of all GHG emissions, followed by the waste sector that accounted for about 4.1% of total emissions. Emissions from agricultural and land use activities are also small, accounting for about 1.5% of total national emissions.

3.2.2. GHG emissions by type

Figure 3-1, provides a breakdown in GHG emissions by gas type and emitting subsector for the year 2015. The following bullets provide an overview of total GHG emissions by all GHG types for the year 2015:

- *CO_2:* Total CO_2 emissions were estimated to be 58,565 Gg or 61% of Oman's total greenhouse emissions on a CO_2e basis. Figure 2-1a summarizes the contribution associated with CO_2 emissions at the source subcategory levels.
- *CH_4:* Methane accounted for the largest share of greenhouse gas emissions. Total CH_4 emissions were estimated to be about 824.9 Gg or about 24% of

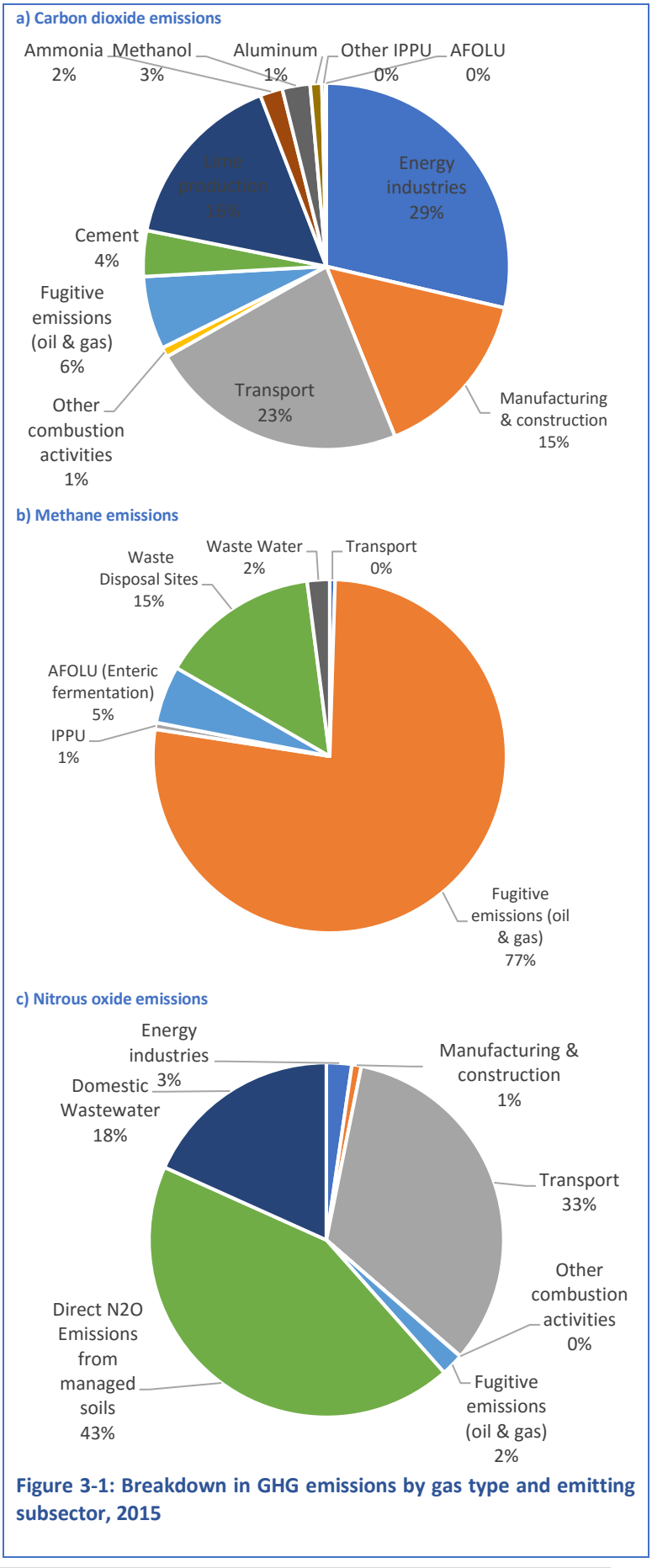
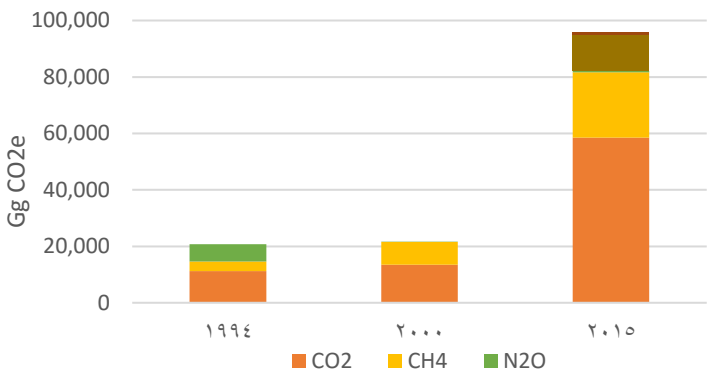


Figure 3-1: Breakdown in GHG emissions by gas type and emitting subsector, 2015

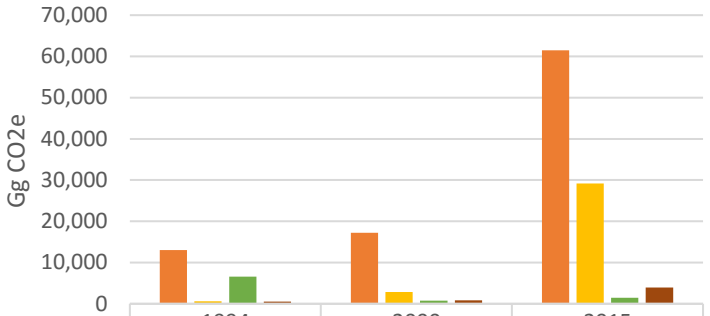
Oman's total greenhouse emissions on a CO_2e basis. Figure 3-1b summarizes the contribution associated with CH_4 emissions at the source subcategory levels.

- *N_2O:* Nitrous oxide emissions were very small compared to other GHGs. Total N_2O emissions were estimated to be only about 1.86 Gg or about 0.5% of Oman's total greenhouse emissions on a CO_2e basis. Figure 3-1c summarizes the contribution associated with N_2O emissions at the source subcategory levels.
- *PFCs:* Perfluorinated compounds estimated for 0.15 Gg or about 1.1% of Oman's total greenhouse emissions on a CO_2e basis. PFCs emission is totally associated with Aluminum industry production.
- *HFCs:* Hydrofluorocarbons estimated for 1.04 Gg or about 13.4% of Oman's total greenhouse emissions on a CO_2e basis. HFCs are totally associated with refrigeration and stationary air conditioning.

a) Net emission trend by gas type, 1994, 2000, 2015



b) Net emission trend by emitting sector, 1994, 2000, 2015



	1994	2000	2015
Energy	13,058	17,196	61,488
IPPU	594	2,865	29,181
AFOLU	6,571	799	1,466
Waste	497	806	3,938

Figure 3-2: Trends in total GHG emissions by gas type and emitting sector

3.2.3. GHG emissions trends

Figure 3-2a presents the trend in total GHG emissions by type of GHG for the years 1994, 2000, and 2015. Over the 1994-2015 period, total emissions have increased by nearly 4.6 times; from 20,719 Gg CO_2e in 1994 to about 96,072 Gg CO_2e in 2015, or roughly 8%/year. Emissions of CH_4 are increasing slightly above this rate, roughly 9% per year. Notably, HFC emissions accounted for about 13.4% of all CO_2e in 2015, compared to no HFC emissions in 1994 and 2000.

Figure 3-2b presents the trend in net GHG emissions by the emitting sector for the Base Year 2006 and projected GHG emissions in 1994, 2000 and 2015. Energy remains the main component responsible for the overall increasing trend in GHG emission levels. Over the 1994-2015 period, CO_2e emissions from energy use have increased over 4 times, or about 8% per year, due primarily to increased energy use for electricity generation, desalinated water

production, and process heat in manufacturing. Notably, CO_2e emissions from IPPU, though less than 31% of total emissions in 2015, increased by nearly 50 times, or about 20% per year.

3.3. Sectoral results

3.3.1. Energy Sector

The energy sector includes electricity generation, water desalination, manufacturing industries and construction, other fossil fuel combustion activities, and fugitive emissions from oil & gas operations.

Table 3-2: GHG emissions from energy use in Oman, 2015 (Gg) (Source: Charabi et al. 2019)

GHG source category	GHG Sources	CO2e	CO2	CH4	N2O	PFCs	HFCs	SF6
Fuel combustion Activities	Energy industries	16,797	16,776	0.3	0.0	0.0	0.0	0.0
	Manufacturing & construction	8,936	8,928	0.2	0.0	0.0	0.0	0.0
	Transport	13,696	13,420	4.0	0.6	0.0	0.0	0.0
	Other combustion activities	505	504	0.0	0.0	0.0	0.0	0.0
Fugitive emissions from fuels	Fugitive emissions (oil & gas)	21,553	3,777	634.5	0.0	0.0	0.0	0.0
Total National Emissions		61,488	43,405	639.1	0.7	0.0	0.0	0.0

Table 3-2 provides a breakdown in energy sector GHG emissions for the year 2015 for these source categories. Relative to overall anthropogenic GHG emissions in Oman, the 61,488 Gg CO_2e represents about 64% of total national emissions.

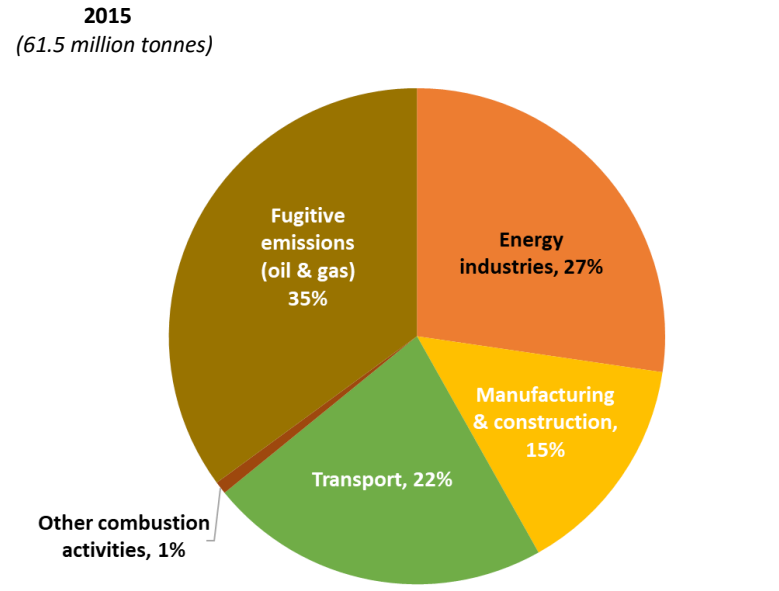


Figure 3-3: Breakdown of CO_2e emissions associated with energy activities in 2015

Figure 3-3 illustrates the breakdown in energy-related GHG emissions in 2015 by activity. Total CO_2e emissions in 2015 accounted for 61,488 Gg. In 2015, fugitive emissions associated with oil and gas production showed the highest share of sectoral GHG emissions, about 35% of total energy sector emissions.

Electricity production at power/desalination plants, as well as electricity-generated onsite at manufacturing and construction enterprises, represents 42% of the total GHG emissions from the energy sector in 2015. Transport activities are based overwhelmingly on the use of gasoline

and diesel oil and accounted for about 22% of total emissions from energy-consuming activities in 2015.

3.3.2. Industrial Processes & Product Use

Table 3-3 summarizes GHG emissions associated with industrial processes and product use in 2015. Industrial processes are the second-largest emitter of anthropogenic GHG emissions in Oman, accounting for 29,181 Gg of CO_2e, or about 30.4% of national CO_2e emissions in 2015.

Table 3-3: GHG emissions from industrial processes and product use in Oman, 2015 (Gg) (Source: Charabi et al. 2019)

GHG source category	GHG Source	CO2e	CO2	CH4	N2O	PFCs	HFCs	SF6
Mineral Industry	Cement	2,366	2,366	0.00	0.00	0.00	0.00	0.00
	Lime production	9,360	9,360	0.00	0.00	0.00	0.00	0.00
	Glass	28	28	0.00	0.00	0.00	0.00	0.00
Chemical Industry	Ammonia	1,162	1,162	0.00	0.00	0.00	0.00	0.00
	Methanol	1,579	1,441	4.95	0.00	0.00	0.00	0.00
Metals Industry	Iron & steel	122	118	0.15	0.00	0.00	0.00	0.00
	Aluminum	1,658	602	0.00	0.00	0.15	0.00	0.00
Non-energy products & solvent use	Lubricant use	46	46	0.00	0.00	0.00	0.00	0.00
Product Uses as Substitutes for Ozone Depleting Substances	Refrigeration and Stationary Air Conditioning	12,859	0	0.00	0.00	0.00	1.04	0.00
Total National Emissions		29,181	15,123	5.09	0.00	0.15	1.04	0.00

Figure 3-4 illustrates the breakdown in industry-related CO_2e emissions in 2015. The product uses as substitutes for Ozone-depleting substances represented the major source of emissions from industrial processes and product use. The use of HFCs in refrigeration and stationary air conditioning accounted for 44% of the total IPPU GHG emissions in 2015. Mineral industries represented the second source of emissions from industrial processes and product use. Together, the production of cement, lime, and glass accounted for about 40.3% of total sectoral GHG emissions in 2015. The shares of industrial emissions from the chemical industry

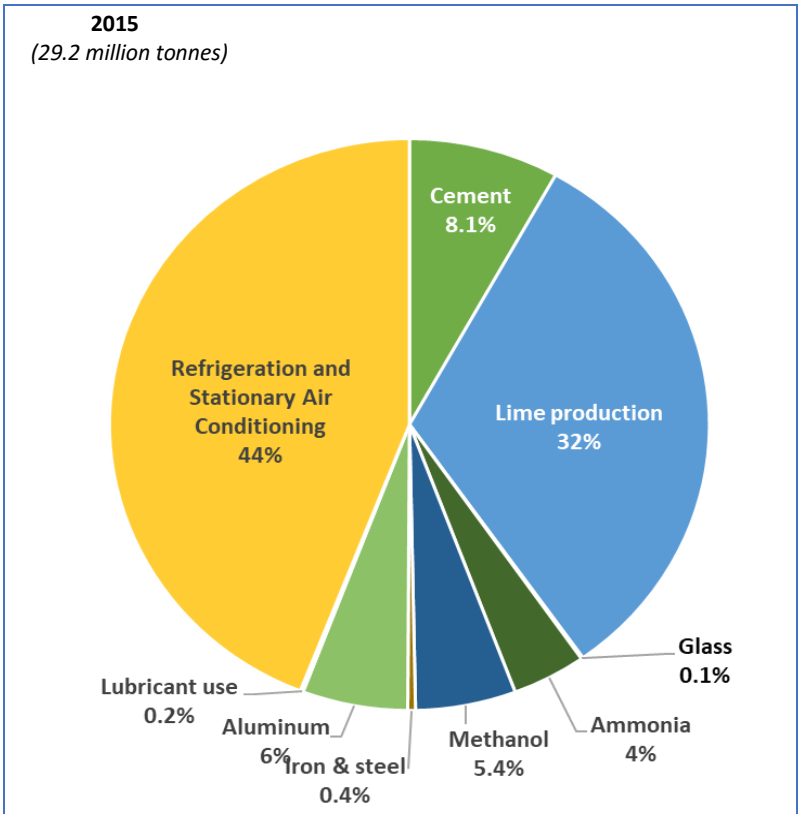


Figure 3-4: Breakdown of CO_2e emissions associated with IPPU activities in 2015

(Ammonia and Methanol production) and metals industry (iron and steel production and Aluminum) are relatively small in comparison, about 9.4% and 6.1%, respectively.

3.3.3. Agriculture, forestry, other land use

Table 3-4 summarizes GHG emissions associated with agriculture, forestry, and other land use in 2015. Agricultural practices are the smallest source of anthropogenic GHG emissions in Oman, accounting for only 1,466 Gg of CO_2e, or about 1.5% of total national CO_2e emissions in 2015. Most of the emissions from AFOLU activities are associated with methane production from livestock.

Table 3-4: GHG emissions and sinks from agriculture, forestry and other land use in Oman, 2015 (Gg) (Source: Charabi et al. 2019)

GHG source category	GHG Source	CO_2e	CO_2	CH_4	N_2O	PFCs	HFCs	SF6
Livestock	Enteric fermentation	1,216	0	43.4	0.000	0	0	0
Land	Cropland	0.026	0.026	0.0	0.000			
Aggregate sources and non-CO2 emissions sources on land	Urea	37	37.4	0.0	0.000	0.0	0.0	0.0
	Direct N2O Emissions from managed soils	212	0.0	0.0	0.801	0.0	0.0	0.0
Total National Emissions		**1,465.738**	**37.4**	**43.4**	**0.801**	**0.000**	**0.000**	**0.000**

Figure 3-5 illustrates the breakdown in AFOLU-related total CO_2e emissions in 2015 by activity. Total CO_2e emissions in 2015 accounted for 1,466 Gg. While enteric fermentation associated with livestock dominates emissions of 2015, its share of AFOLU emissions represents 83%. On the other hand, the share of aggregate sources and non-CO_2 emissions on land (i.e., urea and direct N_2O Emissions from managed soils) are relatively small, about 17%.

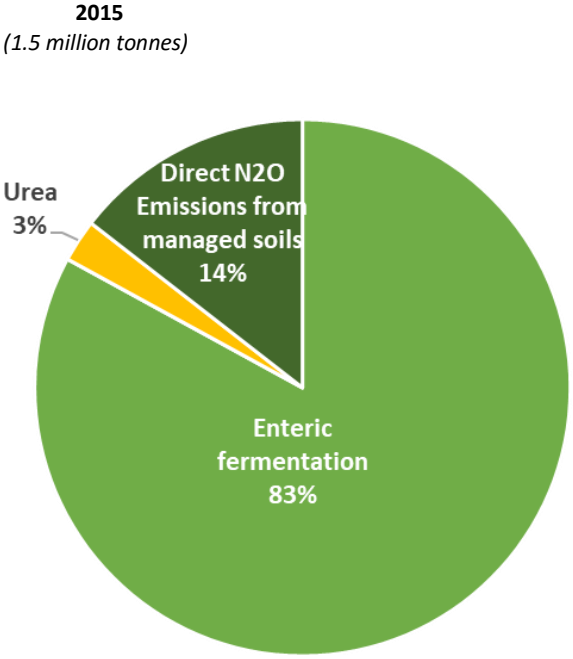


Figure 3-5: Breakdown of total CO_2e emissions associated with AFOLU activities in 2015

3.3.4. *Waste*

Table 3-5 summarizes GHG emissions associated with waste management activity in 2015. Relative to overall anthropogenic GHG emissions, the 3,937.6 Gg of CO_2e represented about 4.1% of total national emissions. Waste-related GHG emissions are associated with solid waste disposal, as well as wastewater treatment and discharge from domestic and industrial sources.

Table 3-5: GHG emissions from waste in Oman, 2015 (Gg) (Source: Charabi et al. 2019)

GHG source category	GHG Source	CO2e	CO2	CH4	N_2O	PFCs	HFCs	SF6
Solid waste (Managed Waste Disposal Sites)	Managed Waste Disposal Sites	909	0.0	32.5	0.0	0.0	0.0	0.0
	Unmanaged Waste Disposal Sites	1,862	0	66	0	0.0	0.0	0.0
	Uncategorised Waste Disposal Sites	606	0	22	0	0.0	0.0	0.0
Wastewater Treatment and Discharge	Domestic Wastewater	552	0.0	16.5	0.3	0.0	0.0	0.0
	Industrial Wastewater	10	0.0	0.3	0.00	0.0	0.0	0.0
Total National Emissions		**3,937.6**	**0.0**	**137.4**	**0.3**	**0.0**	**0.0**	**0.0**

Figure 3-6 illustrates the breakdown in waste-related total CO_2e emissions in 2015 by activity. Solid waste is the major source of GHG emissions, about 86%, followed by domestic wastewater which represents 14%. While the share of emissions associated with industrial wastewater treatment is small.

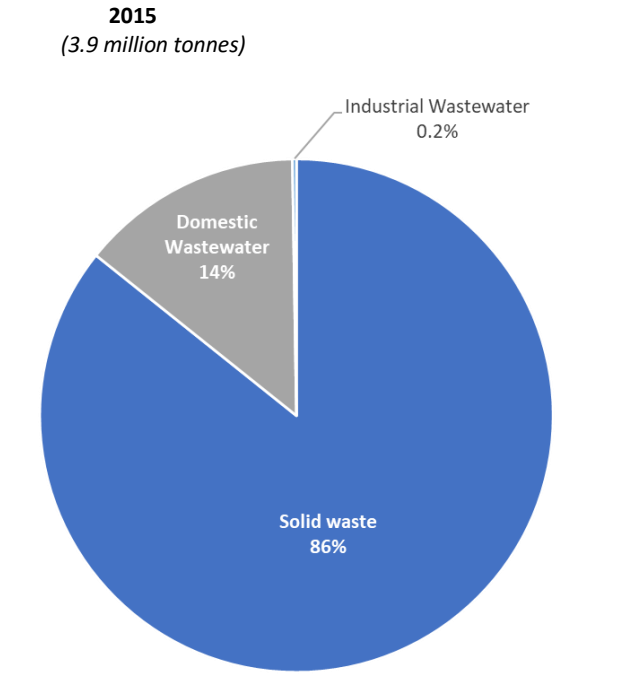


Figure 3-6: Breakdown of total CO_2e emissions associated with waste management activities, 2000 and 2015

3.4. Quality assessment and quality control

The 2006 IPCC Guidelines on National Greenhouse Gas Inventories have been used for reporting GHG inventory for the second communication of Oman to the UNFCCC. Quality Assurance (QA), Quality Control (QC) and verification procedure were developed according to the 2006 IPCC Guidelines. The national expert team from MECA and SQU engaged in the GHG inventory were provided a QC checklist in line with Table 6.1 and Annex 6A.1 QC checklists of 2006 IPCC guidelines which were duly followed. Data cross-checking and verification for accuracy, consistency, completeness, and integrity of the database after data entry in 2006 IPCC software were carried out by UNE-ROWA experts.

3.4.1. *Uncertainty assessment*

Uncertainty information is intended to help priorities efforts to improve the accuracy of the GHG inventory in the future and guide decisions on methodological choices. A tier 1

uncertainly analysis across the sectors was carried out in line with IPCC Good Practice Guidelines (2000, 2003). IPCC defaults conversion sector was used for all sectors. The activity data were mainly from nationally published sources, such as the Statistical Year Book, published by the National Center for Statistics and Information. This publication, provides a an integrated statistical tables to the following: climate, population, housing, public sector, private sector, Agriculture and Livestock, Fisheries, oil and gas, electricity, water, internal industry and commerce, foreign trade, transport, communications, public national accounts, finance, financial institutions, price indices, health care, education, social services, security and safety, media and tourism. Sectoral specific activity data were collected from relevant public entities as follows:

- Energy: The Fuel combustion activities are a well-documented sector and the activity data related to energy industries and manufacturing industries construction were mainly collected from published sources, for example, the annual report of the Authority for Electricity Regulation. This report details the electricity generation and consumption in Oman. Fugitive emissions from fuels activity data were based on a nonpublished technical report from the Ministry of Oil and Gas. In the energy sector, the only assumption is related to the transport sector. The available data is only related to the quantities of fuel categories sold at the pump stations for road transportation. The developed assumption is related to the ratio between international and domestic aviation, the share between road transport categories and the ratio between international water-born navigation and domestic water-born navigation. Overall, the transport sector will require evaluation and revision to reduce current high uncertainty levels.
- Industrial Processes and Product use: Data related to the IPPU activity data was collected mainly from the annual report of the manufacturing companies. Then, aggregated according to the IPCC subcategories. The level of confidence for this data is too low since it is not verified and published by official sources. For example, there is no information about the ratio of the imported clinker in the annual production of the Cement. The annual report of the Ministry of Commerce and Industry provides detailed data about the industry sector in terms of monetary values, not as a produced amount as required for the inventory. It will be important to account for industrial production in terms of produced quantities in the annual report of the Ministry of Commerce and Industry to reduce current high uncertainties.
- Agriculture: Nitrous oxide from soils represents the overwhelming majority of emissions from agricultural activities. However, high uncertainties exist regarding the type and the quantities of nitrogen inputs to the soils. In addition, some assumptions used in the current inventory (I.e., the ratio between dairy and nondairy cattle), will require evaluation and revision to reduce current high uncertainty levels.
- Waste: There is limited data on the waste composition, and the population/GDP activity data were used to estimate the amount of waste deposited to Solid Waste Disposal Services (SWDS). This approach encompasses high uncertainties, due to the ratio assumption for municipal solid waste and industrial waste disposed on unmanaged shallow, unmanaged deep, managed anaerobic, managed semi aerobic and uncategorized SWDS. In addition, domestic Wastewater treatment and discharge were assumed collected. These assumptions will require security and vetting.

3.4.2. Key category analysis

Given Oman's is a hydrocarbon-based economy, the major GHG emissions are coming from energy sector, precisely from fugitive emission from oil and gas industries, followed by energy industries. The cumulative contribution from these two sectors is 70.3% of CO2e in the year 2000. Other key category emissions contributing to threshold level of 95% are detailed in Table 3-6.

Table 3-6 : Key Source Analysis of Greenhouse Gas Emissions for 2015 (Source: Charabi et al. 2019)

Sector	GHG Category/Source	GHG type	Emissions (Gg)		Level assessment (%)	
			Per type	CO2e	Per category	Cumulative
Energy	Fugitive emissions (oil & gas)	CH_4	634.5	17,765.9	18.5%	18.5%
Energy	Energy industries	CO_2	16,775.9	16,775.9	17.5%	36.0%
Energy	Transport	CO_2	13,419.9	13,419.9	14.0%	49.9%
IPPU	Refrigeration and Stationary Air Conditioning	HFCs	1.04	12,859	13.4%	63.3%
IPPU	Lime production	CO_2	9,360	9,360	9.7%	73.1%
Energy	Manufacturing & construction	CH_2	8,927.5	8,927.5	9.3%	82.4%
Energy	Fugitive emissions (oil & gas)	CO_2	3,777.4	3,777.4	3.9%	86.3%
IPPU	Mineral Industry-Cement	CO_2	2,366	2,366	2.5%	88.7%
Waste	Solid waste- Unmanaged Waste Disposal	CH_4	66	1,862	1.9%	90.7%
IPPU	Methanol	CO_2	1,441	1,441	1.5%	92.2
AFOLU	Enteric fermentation	CH_4	43.4	1,216	1.3%	93.4
IPPU	Ammonia	CO_2	1,162	1,162	1.2%	94.7
IPPU	Aluminum	PFCs	0.15	1,056	1.1%	95.7
Subtotal - key categories				**91,988.6**	**95.7%**	
Total national emissions				**96,072**	**100%**	

3.6. Constraints, Gaps, and improvements

For the preparation of its first SNC and BUR, MECA received financial support from the Global Environment Facility on May 2, 2014. The GEF grant was managed by UNE-ROWA as an implementing agency for the SNC and BUR. On May 27, 2015, UNE-ROWA signed a contract with Sultan Qaboos University to carry out all the project activities of the SNC and BUR. The implementation of the project activities started in February 2016. This delay in the project implementation is mainly due to the migration of UNE-ROWA to a new financial management system. MECA, after these financial constraints, has prepared this BUR well from 2016 to 2019.

The main challenges in the BUR-SNC project's activities were related to data collection and data accessibility for the GHG inventory. Table 3-7 depicts gaps and constraints in GHG inventory for SNC and BUR. GHG inventory requires a large volume of data in order to define appropriate mitigation actions. However, the collection, analysis, and verification of such a huge scattered volume of data and information is a big challenge. In 2019, MECA created a National Greenhouse Gas Inventory System (NIS) to support national reporting under the UNFCCC and its Paris Agreement – i.e. the National Communication and BURs under the UNFCCC, and the Biennial Transparency Report under the Paris Agreement (Figure 3-7). The NIS would require continuous capacity building for a large number of stakeholders and financial support from international organizations.

Table 3-7 : Key Source Analysis of Greenhouse Gas Emissions for 2015

Gaps and constraints	Description	Improvements
Data organization	Data not available in IPCC format for inventory reporting	In 2019, MECA implemented the National Greenhouse Gas Inventory System (NIS) to facilitate data collection and aggregation according to IPCC format from different public and private entities.
	Scattered data with different public and private entities	
	Inconsistency in reporting data from year to year	
Data collection and accessibility	Data not available in electronic format	
	Time-consuming process to access to data	
	Requires official communication at a higher level to access to data	
	Security concerns	
Non-availability of relevant data	Time series data not available for some specific sub-categories e.g. Municipal solid waste, wastewater treatment, land, and urea application.	

Figure 3-7: Oman's National GHG inventory system

4. MITIGATION ACTIONS

The Sultanate of Oman made great strides over the last two years (2017-2018) to roll out regulations and projects to harness the potential of solar and wind resources. In 2018, the Sultanate of Oman adopted a firm policy aimed at reaching a minimum level of renewable energy penetration of 10% of the electrical generation by 2025. Oman's renewable energy development plan encompasses solar, wind and waste-to-energy. The Omani renewable energy plan aims to secure more than 2,600 MW by 2025, under the independent power producer (IPP) model (Table 4-1). This will reduce approximately 5,737.55 Gg CO2 eq., which represent an abatement of about 6% of the total GHG emission of 2015, and 26.5% of the total GHG emission of 2000.

The first large scale solar photovoltaic farm with a planned installed capacity of up to 500 MW in underdevelopment in Ibri 300 km west of the capital Muscat, with an expected commercial operation date of 2021. This project will reduce about 1103.37 Gg CO2 eq. For wind energy, the first wind farm of 50 MW in the Sultanate of Oman and the Gulf region is currently under development near Harweel in Dhofar region (South of Oman). The project is expected to be commercially operational in 2020, to generate power for 16,000 homes, representing 7% of Dhofar's installed power generation capacity.

The Sultanate of Oman is on track to improve the waste management infrastructure, by moving more than 300 dumpsites to well-conceived engineered landfills. The aim of the government is to divert 60% of waste from landfills to sorting facilities by 2022 and this target is expected to reach 80% by 2040. After this important step, the first Omani waste-to-energy power plant will be operational in 2023 with an expected capacity of 50 MW.

Table 4-1 : Oman's Renewable Energy Development Plan (Source : Electricity Authority Regulation)

	2019	2020	2021	2022	2023	2024
			MW			
Ibri II Solar IPP	*	*	500	500	500	500
Solar IPP 2022	*	*	*	500	500	500
Solar IPP 2023	*	*	*	*	500	500
Solar IPP 2024	*	*	*	*	*	500
Wind IPP 2023	*	*	*	*	200	200
Wind IPP 2024	*	*	*	*	*	200
Waste to Energy 1	*	*	*		50	50
Dhofar I Wind IPP	*	50	50	50	50	50
Dhofar II Wind IPP	*				150	150
Total Capacity	*	**50**	**550**	**1050**	**1900**	**2600**

5. FINANCIAL RESOURCES, TECHNOLOGY TRANSFER, CAPACITY BUILDING, AND TECHNICAL SUPPORT RECEIVED

5.1. Finance resources

Over the last decade, the Sultanate of Oman has provided considerable national funding for adaptation and mitigation actions related to climate change. Recently, MECA has allocated important financial resources to develop its National Strategy for Adaptation and Mitigation to Climate Change 2020-2040. Public spending on climate resilience has dramatically increased over the last decade due to the damage of extreme events. Several cities in the Sultanate of Oman were protected from the exacerbated risk of flash flooding by the construction of dams and water drainage infrastructures.

The National Strategy for Adaptation and Mitigation to Climate Change 2020-2040, which was adopted by the government of the Sultanate of Oman on October 2019, highlights current and future risks and vulnerabilities in surface resources, agriculture and livestock, marine environment and fisheries, urban area, Tourism and infrastructures, and urban health. The implementation of the adaptation and resilience measures related to the above sectors will require important public funding and international climate finance. The Omani renewable energy plan aims to secure more than 2,600 MW by 2025 and implies considerable domestic and international funding resources.

The Sultanate of Oman has received funds from GEF to prepare the initial communication of Oman to UNFCCC (US$ 300,000), and for SNC-BUR (US$ 852,000). To implement this project, technical assistance was received from UNEP-ROWA. In 2018, MECA received U$S 300,000 from Green Climate Fund to prepare the Readiness climate support. This project was successfully completed in April 2019. Aside from the support received from the GEF and UNEP-ROWA in relation to the preparation of the SNC and the BUR, no other support from other sources was received by the Sultanate of Oman.

5.2. Technical and capacity building needs

MECA needs the following technical and building capacity to sustain GHG inventory and accounting mitigation measures:

- MRV of GHG reductions by implementing Nationally Appropriate Mitigation Actions (NAMAs). NAMAs are important components for the implementation of Oman's Intended Nationally Determined Contributions (INDCs) under the UNFCCC and its Paris Agreement. In fact, NAMAs will help the country to encompass concrete mitigation actions and can serve as the main channel for delivering emission reductions pledged through Oman's NDCs. Also, learned experiences from developing countries that have implemented NAMAs show the co-benefit of this tool for sectorial and sub-sector policy-based emission reductions and driving national sustainable development goals and priorities. In the light of the great potential of NAMAs to support GHG mitigation, sustainable development objectives, pathways to low carbon-intense future and as powerful tools to access to climate finance, the Sultanate of Oman underlines its interest for obtaining technical support for the implementation of its NAMAs as a component of its NDC.

- GHG inventory Tier 2 and 3. The Tier 1 method for calculating CO2 emissions from stationary combustion uses default emission factors for each fuel type, whereas the Tier 2 method requires each country to develop and use country-specific emission factors for each fuel type. The Tier 3 method uses emission factors that are not only country-specific but also differentiated by technology and operating conditions. The energy sector in the Sultanate of Oman, which is the main emitter of GHG, utilizes different technology and operating conditions and consequently requires inventory according to Tier 2 and Tier 3.

6. MEASUREMENT, REPORTING, AND VERIFICATION

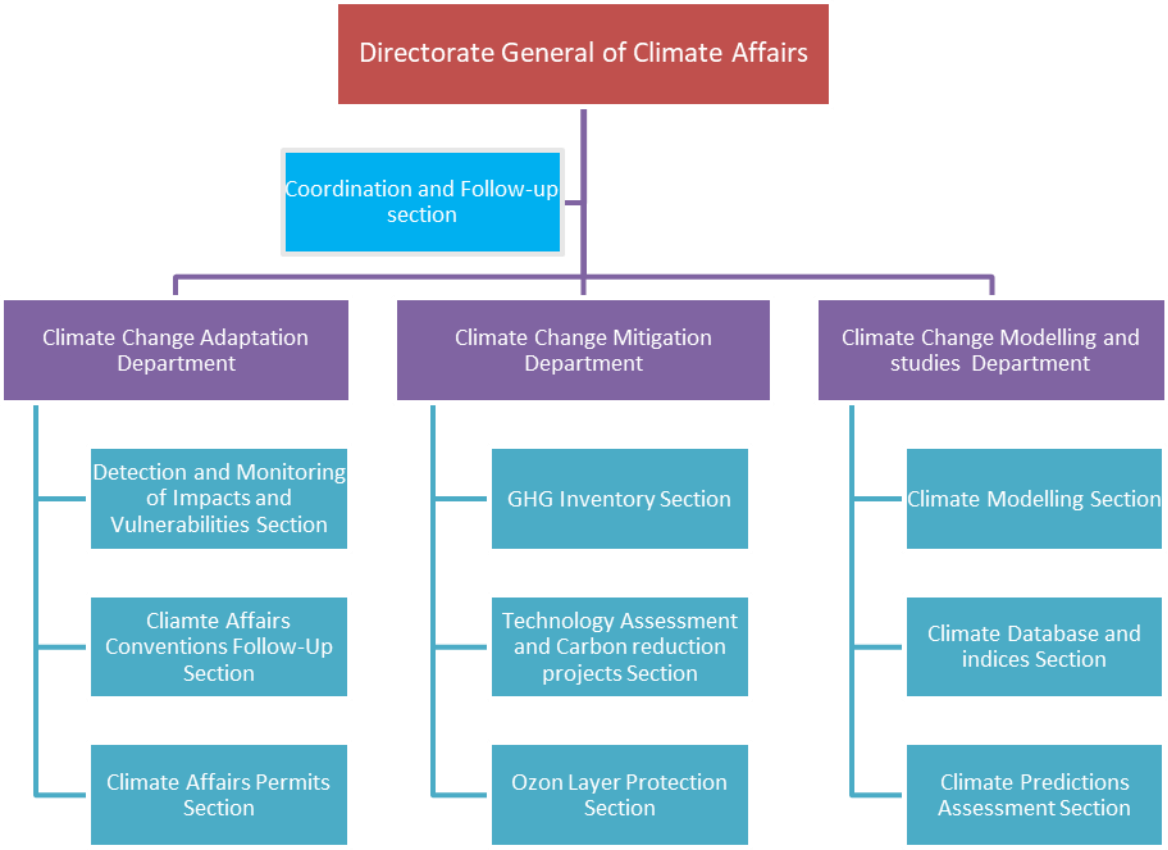
6.1. Key elements of the national MRV system

In line with the international climate commitments of the Sultanate of Oman under the UNFCCC and the recently established universal system of reliable, transparent and comprehensive information on GHG emissions under the Paris Agreement, the Ministry of Environment and Climate Affairs started in 2015 the development of a national strategy for adaptation and mitigation to climate change. One of the major compounds of the national strategy for adaptation and mitigation to climate change was to establish a national climate Measurement, Reporting and Verification (MRV) system according to UNFCCC requirements and guidelines. As legal frameworks for enabling the implementation of the Omani MRV required institutional strengthening and regulatory enforcement, the following significant steps were taken in this direction:

- ***Official set-up***: In 2016, the Ministry of Environment and Climate Affairs started the official set-up of the MRV. Therefore, a new climate affairs regulation is issued to control GHG emission, measurement, and reporting (Ministerial Decision 20/2016). The new Climate Affairs regulation also defines the role and responsibilities of the Directorate General of Climate Affairs and regulates the flow of information and data collection, frequency of reporting and reporting modalities among different stakeholders.

- ***Institutional set-up:*** Currently, the Directorate General of Climate Affairs is the primary entity that is responsible for administrative and regulatory action in response to national and international requirements regarding climate change. In recent years, the Directorate has prioritized national capacity building in adapting to climate change by supporting programs to monitor and limit the adverse impacts of climate change among vital sectors. In 2016, the new structure of the Directorate General of Climate Affairs was legally issued. The new structure expands the focus of the Directorate to GHG inventory and mitigation activities. Specifically, the new organizational structure introduces specialized programs to track GHG emissions, increase energy efficiency, support the integration of renewable energy into the energy mix, and monitor the implementation of the ozone layer protection program in the industrial, agricultural and recycling sectors. Such activities would be operationalized within new specialized departments of the Directorate General of Climate Affairs (Table 6-1).

Table 6-1 : Organizational structure of the Directorate General of Climate Affairs



More specifically, under Article 3 of Ministerial Decision 20/2016, the Directorate General of Climate Affairs has the following tasks that are relevant to MRV:

- Prepare and implement the regulations and decisions related to the management of climate change adaptation and mitigation of its impacts, reduction of greenhouse gases emissions, and the protection of the ozone layer,
- Develop emissions measurement methods and tools, and samples of periodic reports to be provided by the establishments
- Establish and operate networks and systems for monitoring and control of emissions and climate affairs
- Conduct surveys of greenhouse gas emissions as per the requirements of the UNFCCC
- Contribute to the development of climate affairs mitigation plans in line with the Sultanate's comprehensive development plans and policies
- Conduct feasibility studies for the development of techniques for climate change adaptation and mitigation of its impacts

- Participate in the preparation of studies on energy efficiency and renewable energy projects for the reduction of emissions
- Conduction emissions reduction measures in line with national conditions
- Prepare and review models of future climate prediction and projections, and review their impacts on the Sultanate
- Prepare research and studies on assessment of impacts and risks resulting from climate change
- Collect and keep data of the projects and establishments subject to the provisions of the Regulation in a database.

- ***Procedural set-up:*** This step refers to the predefined, standardized templates and procedures for data collection reporting and monitoring. In these, regards two procedural set-ups were successfully implemented:

    - MRV of GHG emissions at the organization level: This type of MRV system is targeting factories, facilities, and companies. In these regards, the new climate affairs regulation of 2016 regulates carbon reporting from the biggest stationary sources of GHG in the country. Overall, only the big suppliers of GHG emitting products or facilities that emit more than 2000 CO_2 eq per year are required to report their annual GHG emissions. A technical guideline and calculation tools for reporting and measuring GHG emission according to Scope 1, 2 and 3 were designed to harmonize GHG emission reporting. Under this regulatory framework, the big suppliers of GHG emissions from energy and industrial sectors should submit their GHG mitigation actions and their plan. In 2019, the Ministry of Environment and Climate Affairs is in a process to develop a GHG emission web inventory and reporting platform.

    - MRV of GHG emissions at the national level: This type of MRV focus on the inventory of GHG emissions at the national level where the total amount of aggregated GHG emissions is monitored and reported to the UNFCCC. This type has been well-established and satisfactorily implemented in the Sultanate of Oman. In 2019, The Directorate General of Climate Affairs in MECA adopted the National Greenhouse Gas Inventory System (NIS) of Oman. It incorporates all the elements necessary to estimate greenhouse gas (GHG) emissions and removals, including institutional arrangements, calculation tools, and methodologies, to facilitate data collection and aggregation according to IPPC format from different public and private entities, to facilitate data collection and aggregation according to IPPC format from different public and private entities. The NIS will enable Oman to produce transparent, consistent, comparable, complete and accurate inventories, and standard quality results, using methodologies, parameters, software, and institutional arrangements that are tailor-made for Oman, developed with the technical expertise of Dubai Carbon Centre of Excellence (DCCE) in collaboration with UNE Regional Office for West Asia (ROWA), to serve as a sustainable system that will support MECA in the collection and reporting of GHG inventories on a regular basis. The NIS includes the development of tailor-made NIS software in line with the

methodologies and tools described in the 2006 IPCC Guidelines for National GHG Inventories. This software online will be handy for future national climate reporting under the UNFCCC and its Paris Agreement, mainly in shortening the time for data collection in electronic format. (NIS-Oman User Manual, 2018). The NIS was not used and applied for this BUR but, following further coordination with relevant national stakeholders, will be used for Oman's future GHG inventories and national reports under the Paris Agreement's Enhanced Transparency Framework.

7. LIST OF REFERENCES

- Annual report, Central Bank of Oman, 2019 (www. https://cbo.gov.om/).
- Charabi, Y., Al-Rawas, G., Al-Wardy, M., Al-Maskari, J., Al-Sarmi, S., and Al-Yahyai, S. 2015. "Observed and projected changes in climate of Oman", Sultan Qaboos University.
- Charabi, Y., Al-Rawas, G., Al-Wardy, M., 2019. "Inventory of Greenhouses Gas Emission in Auuthe Sultanate of Oman for the reference year 2015", Sultan Qaboos University.
- Food Agriculture Organisation statistics, 2014. (http://www.fao.org/statistics/en/).
- National Center for Statistics and Information, 2019 (www. https://www.ncsi.gov.om/Pages/AllIndicators.aspx).
- National Strategy for Adaptation and Mitigation to Climate Change: 2020-2040. Ministry of Environmant and Climate Affairs. Sultanate of Oman, 2019.
- International Energy Agency, 2019 (www. iea.org).
- IPCC, 2000. Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.
- IPCC, 2006. Guidelines for National Greenhouse Gas Inventories.
- World Bank Statistics, 2019 (www. https://data.worldbank.org/)

8. ANNEX – NATIONAL GREENHOUSE GAS INVENTORY TABLES (INVENTORY YEAR 2015)

Table 7-1 : National greenhouse gas inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol and greenhouse gas precursors (Decision 17/CP.8, Table 1) (Source: Charabi et al. 2019)

Greenhouse Gas source and sink categories	CO2 emissions (Gg)	CO2 removals (Gg)	CH4 (Gg)	N2O (Gg)	NOX (Gg)	CO (Gg)	NMVOCs (Gg)	SO2 (Gg)
Total National Emissions and Removals	**58564.72**	**0.00**	**825**	**1.85**	**0.00**	**0.00**	**0.00**	**0.00**
1 - Energy	**43404.78**	**0.00**	**639**	**0.71**	**0.00**	**0.00**	**0.00**	**0.00**
1.A - Fuel Combustion Activities	39627.33	0.00	4.58	0.67	0.00	0.00	0.00	0.00
1.A.1 - Energy Industries	16775.90	0.00	0.34	0.04	0.00	0.00	0.00	0.00
1.A.2 - Manufacturing Industries and Construction	8927.53	0.00	0.16	0.02	0.00	0.00	0.00	0.00
1.A.3 - Transport	13419.93	0.00	4.04	0.61	0.00	0.00	0.00	0.00
1.A.4 - Other Sectors	503.97	0.00	0.04	0.00	0.00	0.00	0.00	0.00
1.A.5 - Non-Specified	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.B - Fugitive emissions from fuels	3777.45	0.00	634.50	0.04	0.00	0.00	0.00	0.00
1.B.1 - Solid Fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.B.2 - Oil and Natural Gas	3777.45	0.00	634.50	0.04	0.00	0.00	0.00	0.00
1.B.3 - Other emissions from Energy Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.C - Carbon dioxide Transport and Storage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.C.1 - Transport of CO2	0.00	0.00			0.00	0.00	0.00	0.00
1.C.2 - Injection and Storage	0.00	0.00			0.00	0.00	0.00	0.00
1.C.3 - Other	0.00	0.00			0.00	0.00	0.00	0.00
2 - Industrial Processes and Product Use	**15122.51**	**0.00**	**5.09**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
2.A - Mineral Industry	11753.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.A.1 - Cement production	2365.77	0.00			0.00	0.00	0.00	0.00
2.A.2 - Lime production	9360.12	0.00			0.00	0.00	0.00	0.00
2.A.3 - Glass Production	28.09	0.00			0.00	0.00	0.00	0.00
2.A.4 - Other Process Uses of Carbonates	0.00	0.00			0.00	0.00	0.00	0.00
2.A.5 - Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.B - Chemical Industry	2602.85	0.00	4.95	0.00	0.00	0.00	0.00	0.00
2.B.1 - Ammonia Production	1162.35	0.00			0.00	0.00	0.00	0.00
2.B.2 - Nitric Acid Production		0.00		0.00	0.00	0.00	0.00	0.00
` 2.B.3 - Adipic Acid Production		0.00		0.00	0.00	0.00	0.00	0.00
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production		0.00		0.00	0.00	0.00	0.00	0.00
2.B.5 - Carbide Production	0.00	0.00	0.00		0.00	0.00	0.00	0.00
2.B.6 - Titanium Dioxide Production	0.00	0.00			0.00	0.00	0.00	0.00
2.B.7 - Soda Ash Production	0.00	0.00			0.00	0.00	0.00	0.00
2.B.8 - Petrochemical and Carbon Black Production	1440.50	0.00	4.95		0.00	0.00	0.00	0.00
2.B.9 - Fluorochemical Production		0.00			0.00	0.00	0.00	0.00

2.B.10 - Other (Please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.C - Metal Industry	719.40	0.00	0.15	0.00	0.00	0.00	0.00	0.00
2.C.1 - Iron and Steel Production	117.60	0.00	0.15		0.00	0.00	0.00	0.00
2.C.2 - Ferroalloys Production	0.00	0.00	0.00		0.00	0.00	0.00	0.00
2.C.3 - Aluminium production	601.80	0.00			0.00	0.00	0.00	0.00
2.C.4 - Magnesium production	0.00	0.00			0.00	0.00	0.00	0.00
2.C.5 - Lead Production	0.00	0.00			0.00	0.00	0.00	0.00
2.C.6 - Zinc Production	0.00	0.00			0.00	0.00	0.00	0.00
2.C.7 - Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.D - Non-Energy Products from Fuels and Solvent Use	46.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.D.1 - Lubricant Use	46.29	0.00			0.00	0.00	0.00	0.00
2.D.2 - Paraffin Wax Use	0.00	0.00			0.00	0.00	0.00	0.00
2.D.3 - Solvent Use		0.00			0.00	0.00	0.00	0.00
2.D.4 - Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.E - Electronics Industry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.E.1 - Integrated Circuit or Semiconductor		0.00			0.00	0.00	0.00	0.00
2.E.2 - TFT Flat Panel Display		0.00			0.00	0.00	0.00	0.00
2.E.3 - Photovoltaics		0.00			0.00	0.00	0.00	0.00
2.E.4 - Heat Transfer Fluid		0.00			0.00	0.00	0.00	0.00
2.E.5 - Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.F - Product Uses as Substitutes for Ozone Depleting Substances	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.F.1 - Refrigeration and Air Conditioning		0.00			0.00	0.00	0.00	0.00
2.F.2 - Foam Blowing Agents		0.00			0.00	0.00	0.00	0.00
2.F.3 - Fire Protection		0.00			0.00	0.00	0.00	0.00
2.F.4 - Aerosols		0.00			0.00	0.00	0.00	0.00
2.F.5 - Solvents		0.00			0.00	0.00	0.00	0.00
2.F.6 - Other Applications (please specify)		0.00			0.00	0.00	0.00	0.00
2.G - Other Product Manufacture and Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.G.1 - Electrical Equipment		0.00			0.00	0.00	0.00	0.00
2.G.2 - SF6 and PFCs from Other Product Uses		0.00			0.00	0.00	0.00	0.00
2.G.3 - N2O from Product Uses		0.00		0.00	0.00	0.00	0.00	0.00
2.G.4 - Other (Please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.H - Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.H.1 - Pulp and Paper Industry	0.00	0.00	0.00		0.00	0.00	0.00	0.00
2.H.2 - Food and Beverages Industry	0.00	0.00	0.00		0.00	0.00	0.00	0.00
2.H.3 - Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 - Agriculture, Forestry, and Other Land Use	37.43	0.00	43.43	0.80	0.00	0.00	0.00	0.00
3.A - Livestock	0.00	0.00	43.43	0.00	0.00	0.00	0.00	0.00
3.A.1 - Enteric Fermentation		0.00	43.43		0.00	0.00	0.00	0.00
3.A.2 - Manure Management		0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B - Land	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.1 - Forest land	0.00	0.00			0.00	0.00	0.00	0.00
3.B.2 - Cropland	0.03	0.00			0.00	0.00	0.00	0.00
3.B.3 - Grassland	0.00	0.00			0.00	0.00	0.00	0.00

Table 8-1 : National greenhouse gas inventory of anthropogenic emissions of HFCs, PFCs, and SF6 (decision 17/CP.8, Table 2) (Source: Charabi et al. 2019)

3.B.4 - Wetlands	0.00	0.00		0.00	0.00	0.00	0.00	0.00
3.B.5 - Settlements	0.00	0.00			0.00	0.00	0.00	0.00
3.B.6 - Other Land	0.00	0.00			0.00	0.00	0.00	0.00
3.C - Aggregate sources and non-CO2 emissions sources on land	37.40	0.00	0.00	0.80	0.00	0.00	0.00	0.00
3.C.1 - Emissions from biomass burning		0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.C.2 - Liming	0.00	0.00			0.00	0.00	0.00	0.00
3.C.3 - Urea application	37.40	0.00			0.00	0.00	0.00	0.00
3.C.4 - Direct N2O Emissions from managed soils		0.00		0.80	0.00	0.00	0.00	0.00
3.C.5 - Indirect N2O Emissions from managed soils		0.00		0.00	0.00	0.00	0.00	0.00
3.C.6 - Indirect N2O Emissions from manure management		0.00		0.00	0.00	0.00	0.00	0.00
3.C.7 - Rice cultivations		0.00	0.00		0.00	0.00	0.00	0.00
3.C.8 - Other (please specify)		0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.D - Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.D.1 - Harvested Wood Products	0.00	0.00			0.00	0.00	0.00	0.00
3.D.2 - Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4 - Waste	**0.00**	**0.00**	**137.43**	**0.34**	**0.00**	**0.00**	**0.00**	**0.00**
4.A - Solid Waste Disposal	0.00	0.00	120.57	0.00	0.00	0.00	0.00	0.00
4.B - Biological Treatment of Solid Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.C - Incineration and Open Burning of Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.D - Wastewater Treatment and Discharge	0.00	0.00	16.85	0.34	0.00	0.00	0.00	0.00
4.E - Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5 - Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.B - Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Memo Items (5)								
International Bunkers	3994.68	0.00	0.27	0.11	0.00	0.00	0.00	0.00
1.A.3.a.i - International Aviation (International Bunkers)	1133.51	0.00	0.01	0.03	0.00	0.00	0.00	0.00
1.A.3.d.i - International water-borne navigation (International bunkers)	2861.17	0.00	0.26	0.07	0.00	0.00	0.00	0.00
1.A.5.c - Multilateral Operations	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Greenhouse Gas source and sink categories	HFCs	PFCs	

	HFC-23 (Gg)	HFC-134 (Gg)	Other	CF4 (Gg)	C2F6 (Gg)	Other	SF6 (Gg)
Total National Emissions and Removals	**1.04**	**0.00**	**NA**	**0.15**	**0.00**	**NA**	**0.00**
1 - Energy	**0.00**	**0.00**	**NA**	**0.00**	**0.00**	**NA**	**0.00**
1.A - Fuel Combustion Activities	0.00	0.00	NA	0.00	0.00	NA	0.00
1.A.1 - Energy Industries	0.00	0.00	NA	0.00	0.00	NA	0.00
1.A.2 - Manufacturing Industries and Construction	0.00	0.00	NA	0.00	0.00	NA	0.00
1.A.3 - Transport	0.00	0.00	NA	0.00	0.00	NA	0.00
1.A.4 - Other Sectors	0.00	0.00	NA	0.00	0.00	NA	0.00
1.A.5 - Non-Specified	0.00	0.00	NA	0.00	0.00	NA	0.00
1.B - Fugitive emissions from fuels	0.00	0.00	NA	0.00	0.00	NA	0.00
1.B.1 - Solid Fuels	0.00	0.00	NA	0.00	0.00	NA	0.00
1.B.2 - Oil and Natural Gas	0.00	0.00	NA	0.00	0.00	NA	0.00
1.B.3 - Other emissions from Energy Production	0.00	0.00	NA	0.00	0.00	NA	0.00
1.C - Carbon dioxide Transport and Storage	0.00	0.00	NA	0.00	0.00	NA	0.00
1.C.1 - Transport of CO2	0.00	0.00	NA	0.00	0.00	NA	0.00
1.C.2 - Injection and Storage	0.00	0.00	NA	0.00	0.00	NA	0.00
1.C.3 - Other	0.00	0.00	NA	0.00	0.00	NA	0.00
2 - Industrial Processes and Product Use	**1.04**	**0.00**	**NA**	**0.15**	**0.00**	**NA**	**0.00**
2.A - Mineral Industry	0.00	0.00	NA	0.00	0.00	NA	0.00
2.A.1 - Cement production	0.00	0.00	NA	0.00	0.00	NA	0.00
2.A.2 - Lime production	0.00	0.00	NA	0.00	0.00	NA	0.00
2.A.3 - Glass Production	0.00	0.00	NA	0.00	0.00	NA	0.00
2.A.4 - Other Process Uses of Carbonates	0.00	0.00	NA	0.00	0.00	NA	0.00
2.A.5 - Other (please specify)	0.00	0.00	NA	0.00	0.00	NA	0.00
2.B - Chemical Industry	0.00	0.00	NA	0.00	0.00	NA	0.00
2.B.1 - Ammonia Production	0.00	0.00	NA	0.00	0.00	NA	0.00
2.B.2 - Nitric Acid Production	0.00	0.00	NA	0.00	0.00	NA	0.00
2.B.3 - Adipic Acid Production	0.00	0.00	NA	0.00	0.00	NA	0.00
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production	0.00	0.00	NA	0.00	0.00	NA	0.00
2.B.5 - Carbide Production	0.00	0.00	NA	0.00	0.00	NA	0.00
2.B.6 - Titanium Dioxide Production	0.00	0.00	NA	0.00	0.00	NA	0.00
2.B.7 - Soda Ash Production	0.00	0.00	NA	0.00	0.00	NA	0.00
2.B.8 - Petrochemical and Carbon Black Production	0.00	0.00	NA	0.00	0.00	NA	0.00
2.B.9 - Fluorochemical Production	0.00	0.00	NA	0.00	0.00	NA	0.00
2.B.10 - Other (Please specify)	0.00	0.00	NA	0.00	0.00	NA	0.00
2.C - Metal Industry	0.00	0.00	NA	0.15	0.00	NA	0.00
2.C.1 - Iron and Steel Production	0.00	0.00	NA	0.00	0.00	NA	0.00
2.C.2 - Ferroalloys Production	0.00	0.00	NA	0.00	0.00	NA	0.00
2.C.3 - Aluminium production	0.00	0.00	NA	0.15	0.00	NA	0.00
2.C.4 - Magnesium production	0.00	0.00	NA	0.00	0.00	NA	0.00
2.C.5 - Lead Production	0.00	0.00	NA	0.00	0.00	NA	0.00
2.C.6 - Zinc Production	0.00	0.00	NA	0.00	0.00	NA	0.00
2.C.7 - Other (please specify)	0.00	0.00	NA	0.00	0.00	NA	0.00

2.D - Non-Energy Products from Fuels and Solvent Use	0.00	0.00	NA	0.00	0.00	NA	0.00
2.D.1 - Lubricant Use	0.00	0.00	NA	0.00	0.00	NA	0.00
2.D.2 - Paraffin Wax Use	0.00	0.00	NA	0.00	0.00	NA	0.00
2.D.3 - Solvent Use	0.00	0.00	NA	0.00	0.00	NA	0.00
2.D.4 - Other (please specify)	0.00	0.00	NA	0.00	0.00	NA	0.00
2.E - Electronics Industry	0.00	0.00	NA	0.00	0.00	NA	0.00
2.E.1 - Integrated Circuit or Semiconductor	0.00	0.00	NA	0.00	0.00	NA	0.00
2.E.2 - TFT Flat Panel Display	0.00	0.00	NA	0.00	0.00	NA	0.00
2.E.3 - Photovoltaics	0.00	0.00	NA	0.00	0.00	NA	0.00
2.E.4 - Heat Transfer Fluid	0.00	0.00	NA	0.00	0.00	NA	0.00
2.E.5 - Other (please specify)	0.00	0.00	NA	0.00	0.00	NA	0.00
2.F - Product Uses as Substitutes for Ozone Depleting Substances	1.04	0.00	NA	0.00	0.00	NA	0.00
2.F.1 - Refrigeration and Air Conditioning	1.04	0.00	NA	0.00	0.00	NA	0.00
2.F.2 - Foam Blowing Agents	0.00	0.00	NA	0.00	0.00	NA	0.00
2.F.3 - Fire Protection	0.00	0.00	NA	0.00	0.00	NA	0.00
2.F.4 - Aerosols	0.00	0.00	NA	0.00	0.00	NA	0.00
2.F.5 - Solvents	0.00	0.00	NA	0.00	0.00	NA	0.00
2.F.6 - Other Applications (please specify)	0.00	0.00	NA	0.00	0.00	NA	0.00
2.G - Other Product Manufacture and Use	0.00	0.00	NA	0.00	0.00	NA	0.00
2.G.1 - Electrical Equipment	0.00	0.00	NA	0.00	0.00	NA	0.00
2.G.2 - SF6 and PFCs from Other Product Uses	0.00	0.00	NA	0.00	0.00	NA	0.00
2.G.3 - N2O from Product Uses	0.00	0.00	NA	0.00	0.00	NA	0.00
2.G.4 - Other (Please specify)	0.00	0.00	NA	0.00	0.00	NA	0.00
2.H - Other	0.00	0.00	NA	0.00	0.00	NA	0.00
2.H.1 - Pulp and Paper Industry	0.00	0.00	NA	0.00	0.00	NA	0.00
2.H.2 - Food and Beverages Industry	0.00	0.00	NA	0.00	0.00	NA	0.00
2.H.3 - Other (please specify)	0.00	0.00	NA	0.00	0.00	NA	0.00
3 - Agriculture, Forestry, and Other Land Use	**0.00**	**0.00**	**NA**	**0.00**	**0.00**	**NA**	**0.00**
3.A - Livestock	0.00	0.00	NA	0.00	0.00	NA	0.00
3.A.1 - Enteric Fermentation	0.00	0.00	NA	0.00	0.00	NA	0.00
3.A.2 - Manure Management	0.00	0.00	NA	0.00	0.00	NA	0.00
3.B - Land	0.00	0.00	NA	0.00	0.00	NA	0.00
3.B.1 - Forest land	0.00	0.00	NA	0.00	0.00	NA	0.00
3.B.2 - Cropland	0.00	0.00	NA	0.00	0.00	NA	0.00
3.B.3 - Grassland	0.00	0.00	NA	0.00	0.00	NA	0.00
3.B.4 - Wetlands	0.00	0.00	NA	0.00	0.00	NA	0.00
3.B.5 - Settlements	0.00	0.00	NA	0.00	0.00	NA	0.00
3.B.6 - Other Land	0.00	0.00	NA	0.00	0.00	NA	0.00
3.C - Aggregate sources and non-CO2 emissions sources on land	0.00	0.00	NA	0.00	0.00	NA	0.00
3.C.1 - Emissions from biomass burning	0.00	0.00	NA	0.00	0.00	NA	0.00
3.C.2 - Liming	0.00	0.00	NA	0.00	0.00	NA	0.00
3.C.3 - Urea application	0.00	0.00	NA	0.00	0.00	NA	0.00
3.C.4 - Direct N2O Emissions from managed soils	0.00	0.00	NA	0.00	0.00	NA	0.00

3.C.5 - Indirect N2O Emissions from managed soils	0.00	0.00	NA	0.00	0.00	NA	0.00
3.C.6 - Indirect N2O Emissions from manure management	0.00	0.00	NA	0.00	0.00	NA	0.00
3.C.7 - Rice cultivations	0.00	0.00	NA	0.00	0.00	NA	0.00
3.C.8 - Other (please specify)	0.00	0.00	NA	0.00	0.00	NA	0.00
3.D - Other	0.00	0.00	NA	0.00	0.00	NA	0.00
3.D.1 - Harvested Wood Products	0.00	0.00	NA	0.00	0.00	NA	0.00
3.D.2 - Other (please specify)	0.00	0.00	NA	0.00	0.00	NA	0.00
4 - Waste	**0.00**	**0.00**	**NA**	**0.00**	**0.00**	**NA**	**0.00**
4.A - Solid Waste Disposal	0.00	0.00	NA	0.00	0.00	NA	0.00
4.B - Biological Treatment of Solid Waste	0.00	0.00	NA	0.00	0.00	NA	0.00
4.C - Incineration and Open Burning of Waste	0.00	0.00	NA	0.00	0.00	NA	0.00
4.D - Wastewater Treatment and Discharge	0.00	0.00	NA	0.00	0.00	NA	0.00
4.E - Other (please specify)	0.00	0.00	NA	0.00	0.00	NA	0.00
5 - Other	0.00	0.00	NA	0.00	0.00	NA	0.00
5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3	0.00	0.00	NA	0.00	0.00	NA	0.00
5.B - Other (please specify)	0.00	0.00	NA	0.00	0.00	NA	0.00
Memo Items (5)	**0.00**	**0.00**	**NA**	**0.00**	**0.00**	**NA**	**0.00**
International Bunkers	0.00	0.00	NA	0.00	0.00	NA	0.00
1.A.3.a.i - International Aviation (International Bunkers)	0.00	0.00	NA	0.00	0.00	NA	0.00
1.A.3.d.i - International water-borne navigation (International bunkers)	0.00	0.00	NA	0.00	0.00	NA	0.00
1.A.5.c - Multilateral Operations	0.00	0.00	NA	0.00	0.00	NA	0.00