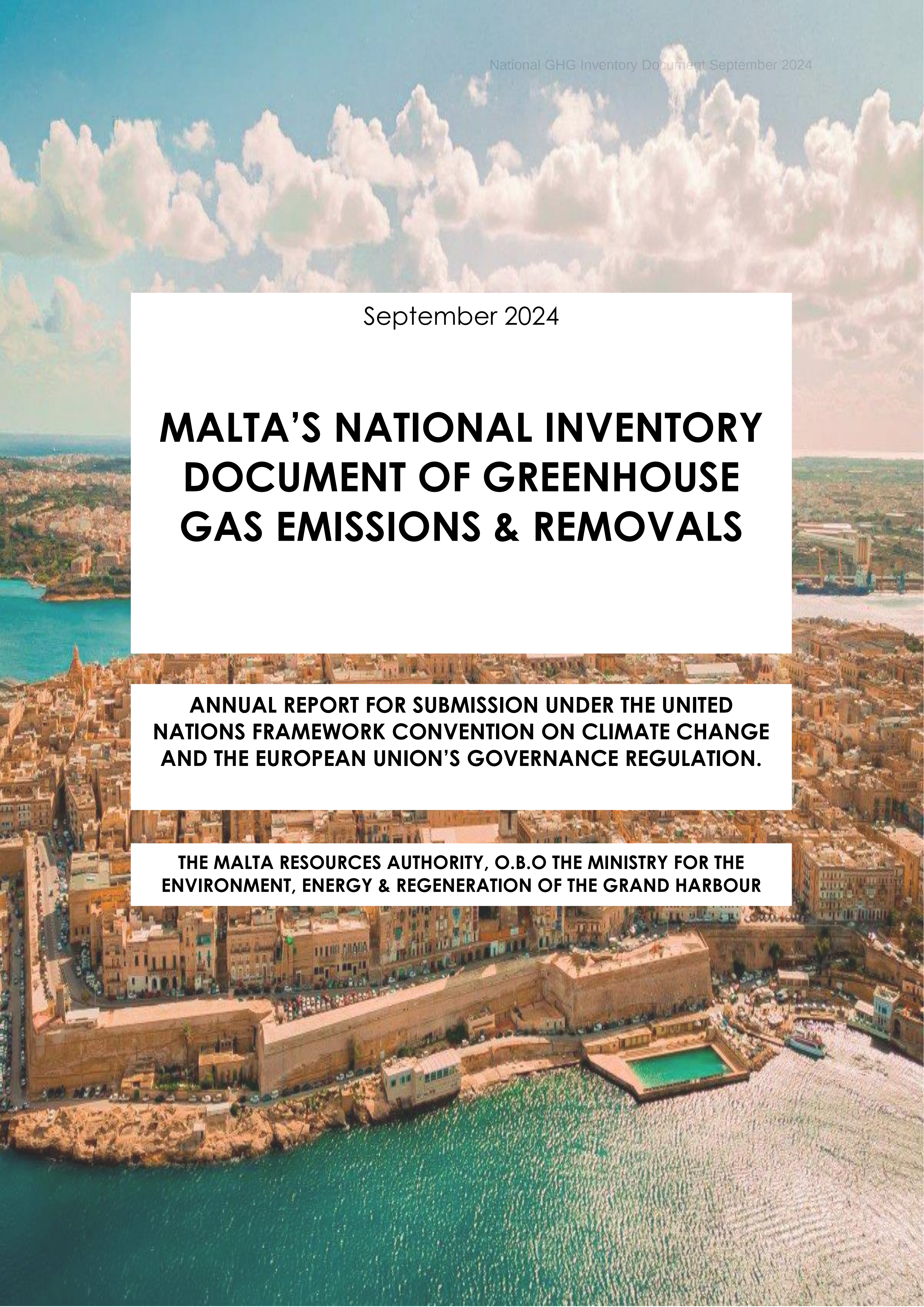


September 2024

MALTA'S NATIONAL INVENTORY DOCUMENT OF GREENHOUSE GAS EMISSIONS & REMOVALS

ANNUAL REPORT FOR SUBMISSION UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE AND THE EUROPEAN UNION'S GOVERNANCE REGULATION.

THE MALTA RESOURCES AUTHORITY, O.B.O THE MINISTRY FOR THE ENVIRONMENT, ENERGY & REGENERATION OF THE GRAND HARBOUR

MALTA'S NATIONAL INVENTORY DOCUMENT OF GREENHOUSE GAS EMISSIONS AND REMOVALS, 2024

REPORT PURSUANT TO

Regulation (EU) 2018/1999 (on the Governance of the Energy Union and Climate Action),

and,

Commission Implementing Regulation (EU) 2020/1208 (on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999).

REFERENCE NUMBER

MRA/03/2024

PREPARED BY THE MALTA RESOURCES AUTHORITY ON BEHALF OF THE MINISTRY FOR THE ENVIRONMENT, ENERGY & REGENERATION OF THE GRAND HARBOUR

THIS VERSION	DATE	NOTES
FINAL	11/09/2024	FINAL

CONTRIBUTORS

Sector compilers and contact points:

Energy: Antonella Apap; Ioanna Thoma

IPPU: Inġ. Maurizio Busuttil

Agriculture: Marija Pia Gatt

LULUCF: Alex Said

Waste: Claudine Pace

Additional material: Louise Attard Refalo; Saviour Vassallo

Coordinators: Antonella Apap; Claudine Pace

Malta Resources Authority

Millennia Building

Aldo Moro Road

Marsa MRS 9065

Malta

Telephone: +356 2122 0720

Email: info@mra.org.mt

[Blank Page]

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

Abbreviations

Gases

CH4	Methane
CO	Carbon monoxide
CO2	Carbon dioxide
F-gases	Fluorinated gases
HFCs	Hydrofluorocarbons
N2O	Nitrous oxide
NF3	Nitrogen trifluoride
NH3	Ammonia
NMVOC	Non-methane volatile organic compound
NOx	Nitrogen oxides
PFCs	Perfluorocarbons
SF6	Sulphur hexafluoride
SO2	Sulphur dioxide

Notation keys

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

Other

AD	Activity Data
AFOLU	Agriculture, Forestry and Other Land Use
C	Carbon
CCC	Climate Change Committee
CO2 eq.	Carbon dioxide equivalent
COP	Conference of the Parties
CRF	Common Reporting Format
CS	Country Specific
D	Default
EC	European Commission
EF	Emission Factor

FOD	First Order Decay
GHG	Greenhouse Gas
GWP	Global Warming Potential
HWP	Harvested Wood Products
IEF	Implied Emission Factor
KC	Key Category
KCA	Key Category Analysis
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
LULUCF	Land-Use Change and Forestry
M	Model
MCF	Methane Correction Factor
NIC	National Inventory Compiler
NIR	National Inventory Report
PS	Plant Specific
QA	Quality Assurance
QC	Quality Control
RA	Reference Approach
T	Tier
UNFCCC	United Nations Framework Convention on Climate Change
WG	Working Group

EXECUTIVE SUMMARY

ES.1 BACKGROUND INFORMATION ON GREENHOUSE GAS INVENTORIES AND CLIMATE CHANGE

Inventories of emissions by sources and removals by sinks of greenhouse gases provide a crucial starting point for policymaking in respect of mitigation of climate change, that is, in respect of limiting or reducing emissions of greenhouse gases from anthropogenic activities and enhancing removals of atmospheric greenhouse gases by sinks. This importance of greenhouse gas inventories arises from the fact that such inventories provide a historic picture of trends of emissions and removals from 1990, thus providing a view of the past and present situation which informs policymakers in assessing the effectiveness of actions taken in the past and a starting point towards assessing what actions need to be taken in future.

The mitigation of climate change as a global and national goal is of primary importance for Malta, being a small island state with particular vulnerability to the impacts of changes in climatic conditions. Indeed, this inventory submission highlights the important, and sustained, gains made by Malta in recent years in reducing overall national greenhouse gas emissions, particularly in the area of electricity generation, for a long time the main contributor to total greenhouse gas emissions in Malta.

(Refer to chapter 2 for an analysis of emission trends).

The preparation of Malta's national greenhouse gas inventory is legally underpinned by national legislation, guided by international and European Union legislation and guidelines, and informed by a thorough data gathering and quality assurance and quality control process. Sector-specific actions are taken by sectoral inventory compilers within the Maltese inventory agency to ensure, to the best extent possible, that Malta's inventory is transparent, accurate, complete, consistent and comparable. This is particularly supported by recent and ongoing efforts to develop a comprehensive quality management system for the greenhouse gas inventory process within the inventory agency.

(Refer to chapter 1 and sector-specific chapters and related annexes for information on the inventory process).

ES.2 SUMMARY OF NATIONAL EMISSION AND REMOVAL TRENDS

(Refer to chapter 2 for a more detailed discussion of trends of national total emissions).

Table ES. 1 presents annual figures for total national greenhouse gas emissions for the years 1990 to 2021. Total national emissions showed a general increase until 2012, followed by a significant reduction in more recent years to the extent that emissions in 2016 were below the level of emissions in the base year. The decrease in total national emissions is a consequence of the decrease in emissions in the Energy sector, resulting from important technical developments in the generation of electricity.

Table ES. 1 Total national greenhouse gas emissions, 1990 – 2022 (AR5)

	Total national emissions with LULUCF (Gg CO2 eq.)	Total national emissions without LULUCF (Gg CO2 eq.)
1990	2616.26	2626.17
1991	2464.73	2479.79
1992	2501.71	2512.83
1993	3104.84	3115.53
1994	2883.78	2893.86
1995	2681.49	2690.78
1996	2772.45	2781.51
1997	2804.18	2813.19
1998	2778.87	2787.36
1999	2835.76	2844.80
2000	2740.59	2749.49
2001	3020.27	3025.75
2002	3066.91	3046.56
2003	3289.14	3268.76
2004	3175.27	3175.80
2005	2989.40	2989.43
2006	3034.93	3035.70
2007	3127.04	3127.10
2008	3054.28	3040.42
2009	2921.76	2908.00
2010	2979.31	2965.32
2011	2971.87	2971.20
2012	3143.30	3142.60
2013	2835.10	2834.49
2014	2846.54	2845.41
2015	2149.73	2148.53
2016	1852.18	1851.27
2017	2019.08	2016.43
2018	2021.43	2019.80
2019	2134.06	2127.94
2020	2094.38	2085.83
2021	2099.35	2098.72

2022	2263.44	2262.67

ES.3 OVERVIEW OF SOURCE AND SINK CATEGORY EMISSIONS ESTIMATES AND TRENDS

(Refer to chapter 2 for a more detailed discussion of emission trends by gas and by sector)

Emissions by gas and by sector are presented in Table ES. 2 and Table ES. 3.

Carbon dioxide emissions by far account for the highest share of total national emissions among all the greenhouse gases covered. Emission of carbon dioxide are primarily the result of combustion of fossil fuels in the Energy sector, particularly from indigenous the generation of electricity and road transport.

Methane emissions and Hydrofluorocarbons account for smaller, albeit important shares respectively. Methane is primarily emitted by activities in the Waste and Agriculture sectors. Important to note is the rapidly increasing trend in emissions of Hydrofluorocarbons, from the sector Industrial Processes and Product Use.

Table ES. 2 Greenhouse gas emissions by gas (AR5)

Note to ES.2: Values denoted ‘0.00’ indicate that emissions have been estimated but the value is of an order of magnitude that cannot be represented at two decimal places. Always refer to CRF tables for exact emissions data.

	CO2 with LULUCF	CO2 without LULUCF	CH4	N2O	HFC	PFC	SF6	NF3	Total with LULUCF	Total without LULUCF
Year	Gg CO2 eq.									
1990	2417.14	2427.40	139.76	59.35	NO,NE,IE,NA	NO,NA	0.01	NA	2616.26	2626.17
1991	2256.43	2271.84	148.83	59.46	NO,NE,IE,NA	NO,NA	0.01	NA	2464.73	2479.79
1992	2282.17	2293.60	157.02	61.05	NO,NE,IE,NA	NO,NA	1.47	NA	2501.71	2512.83
1993	2874.59	2885.59	164.93	63.85	NO,NE,IE,NA	NO,NA	1.47	NA	3104.84	3115.53
1994	2647.95	2658.34	170.98	63.37	0.00	NO,NA	1.48	NA	2883.78	2893.86
1995	2442.53	2452.13	175.68	61.80	0.00	NO,NA	1.48	NA	2681.49	2690.78
1996	2524.59	2533.95	185.33	61.04	0.00	NO,NA	1.49	NA	2772.45	2781.51
1997	2546.94	2556.25	193.36	62.39	0.00	NO,NA	1.49	NA	2804.18	2813.19
1998	2516.14	2524.94	199.12	62.09	0.01	NO,NA	1.51	NA	2778.87	2787.36
1999	2563.57	2572.87	207.86	62.81	0.01	NO,NA	1.51	NA	2835.76	2844.80
2000	2458.99	2468.15	212.93	62.52	4.63	NO,NA	1.51	NA	2740.59	2749.49
2001	2730.86	2736.56	217.41	61.67	8.80	NO,NA	1.54	NA	3020.27	3025.75
2002	2767.36	2747.23	224.85	60.96	12.20	NO,NA	1.54	NA	3066.91	3046.56
2003	2980.98	2960.83	231.87	60.60	13.56	NO,NA	2.12	NA	3289.14	3268.76

2004	2848.29	2849.06	243.54	61.31	20.55	NO,NA	1.59	NA	3175.27	3175.80
2005	2649.49	2649.76	245.51	58.64	34.15	NO,NA	1.61	NA	2989.40	2989.43
2006	2654.30	2655.28	252.16	58.27	68.49	NO,NA	1.72	NA	3034.93	3035.70
2007	2727.45	2727.72	257.59	59.27	81.01	0.00	1.73	NA	3127.04	3127.10
2008	2734.86	2721.19	165.02	57.12	95.38	0.00	1.90	NA	3054.28	3040.42
2009	2574.31	2560.74	180.08	54.99	110.74	0.00	1.64	NA	2921.76	2908.00
2010	2633.00	2619.14	166.09	56.18	122.21	0.00	1.84	NA	2979.31	2965.32
2011	2608.59	2608.05	163.97	50.50	143.98	0.00	4.83	NA	2971.87	2971.20
2012	2749.45	2748.88	168.80	50.32	174.17	0.00	0.56	NA	3143.30	3142.60
2013	2429.93	2429.45	166.84	49.88	185.60	0.00	2.85	NA	2835.10	2834.49
2014	2418.11	2417.10	180.30	50.95	196.50	0.00	0.70	NA	2846.54	2845.41
2015	1700.42	1699.36	193.48	50.89	204.64	0.00	0.29	NA	2149.73	2148.53
2016	1376.39	1375.60	205.69	51.78	218.18	0.00	0.14	NA	1852.18	1851.27
2017	1539.38	1536.87	202.48	51.03	225.18	0.00	1.02	NA	2019.08	2016.43
2018	1548.88	1547.40	210.82	50.00	211.42	0.00	0.31	NA	2021.43	2019.80
2019	1654.53	1648.78	226.31	51.93	200.95	0.00	0.34	NA	2134.06	2127.94
2020	1608.35	1600.39	225.33	53.72	206.56	0.00	0.41	NA	2094.38	2085.83
2021	1610.89	1610.85	226.43	52.79	209.08	0.01	0.14	NA	2099.35	2098.72
2022	1774.18	1773.99	227.37	56.66	204.97	0.01	0.25	NA	2263.44	2262.67

Table ES. 3 Greenhouse gas emissions by sector (AR5)

	Energy	IPPU	Agriculture	LULUCF	Waste	Total with LULUCF	Total without LULUCF
				Gg CO2 eq.			
1990	2434.94	7.50	108.51	-9.91	75.22	2616.26	2626.17
1991	2278.69	7.73	111.24	-15.06	82.13	2464.73	2479.79
1992	2301.39	8.78	113.79	-11.12	88.87	2501.71	2512.83
1993	2895.75	8.82	113.69	-10.69	97.27	3104.84	3115.53
1994	2667.52	9.11	110.88	-10.08	106.35	2883.78	2893.86
1995	2460.35	9.07	107.38	-9.30	113.97	2681.49	2690.78
1996	2542.68	8.86	110.81	-9.05	119.16	2772.45	2781.51
1997	2565.02	9.08	112.63	-9.01	126.47	2804.18	2813.19
1998	2534.04	8.50	107.38	-8.49	137.44	2778.87	2787.36
1999	2582.89	7.90	110.81	-9.04	143.20	2835.76	2844.80

2000	2477.85	12.64	105.01	-8.91	153.99	2740.59	2749.49
2001	2746.41	16.43	101.47	-5.48	161.45	3020.27	3025.75
2002	2757.09	19.96	100.60	20.35	168.91	3066.91	3046.56
2003	2971.50	21.62	97.12	20.38	178.52	3289.14	3268.76
2004	2859.35	27.93	100.73	-0.53	187.80	3175.27	3175.80
2005	2659.91	41.62	91.17	-0.03	196.73	2989.40	2989.43
2006	2664.44	76.42	89.80	-0.76	205.04	3034.93	3035.70
2007	2738.26	88.69	91.24	-0.06	208.91	3127.04	3127.10
2008	2730.53	102.95	88.68	13.86	118.26	3054.28	3040.42
2009	2568.65	117.96	85.93	13.75	135.46	2921.76	2908.00
2010	2628.25	129.03	84.77	13.99	123.28	2979.31	2965.32
2011	2615.90	154.27	82.27	0.67	118.76	2971.87	2971.20
2012	2755.77	181.87	83.97	0.69	120.99	3143.30	3142.60
2013	2429.13	200.93	84.24	0.61	120.20	2835.10	2834.49
2014	2416.81	209.01	84.27	1.13	135.32	2846.54	2845.41
2015	1698.35	215.14	84.43	1.19	150.61	2149.73	2148.53
2016	1375.65	227.60	85.34	0.91	162.68	1852.18	1851.27
2017	1539.39	231.76	84.56	2.65	160.72	2019.08	2016.43
2018	1549.99	217.94	83.31	1.63	168.56	2021.43	2019.80
2019	1652.68	207.24	83.54	6.12	184.48	2134.06	2127.94
2020	1603.37	213.58	86.30	8.54	182.57	2094.38	2085.83
2021	1613.87	215.83	84.82	0.63	184.21	2099.35	2098.72
2022	1777.35	213.13	86.09	0.77	186.09	2263.44	2262.67

CHAPTER 1 INTRODUCTION

1.1 Background information on greenhouse gas inventories and climate change

1.1.1 Background information on climate change

The Earth's climate, acting over long periods of time, is a principal determinant of the landscape and living organisms. It has, for much of humankind's prehistory and history, influenced to a marked extent the relationship between human beings and their surroundings.

It is well known that the Earth's climate has changed over time. For much of the planet's lifetime, such changes were due to natural causes. However, a significantly rapid change in climatic conditions has been observed over the course of the last 200 years or so. An unprecedented global warming trend has been measured. There is now widespread consensus that its main cause is anthropogenic: that is, human activities, such as the combustion of fossil fuels, releasing large quantities of greenhouse gases into the atmosphere, and deforestation, which represents the destruction of an important sink, trees having the faculty of being able to absorb carbon dioxide from the atmosphere, this chemical species being an important greenhouse gas.

The increase in atmospheric temperature brings important effects on weather patterns, with different regions experiencing different impacts. While in certain areas of the world, rates of precipitation may increase, possibly leading even to severe flooding, precipitation in other regions is observed to decrease, even drastically, leading to drought conditions. Both scenarios represent concerns to humans and ecosystems. Sea level rise is caused by thermal expansion of the ocean waters and the melting of glaciers and ice caps. Low lying areas are particularly susceptible to this effect of climate change. Impacts of climate change on agriculture, water resources, health and infrastructure are also cause for concern.

The United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992 with the objective of achieving "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". The Kyoto Protocol to the Convention, adopted in 1997, was intended to make the Convention more effective by setting legally binding quantified emission limitation or reduction targets for several industrialised countries (the so-called Annex I Parties to the Convention, as opposed to the non-Annex I Parties which did not have binding emission related obligations). As the Protocol's first commitment period (2008-2012) elapsed, an extension to the Protocol was adopted until 2020. A new agreement - the Paris

Agreement - was adopted at the 21st Conference of the Parties held in Paris in 2015 and will replace the Kyoto Protocol after 2020.

1.1.2 BACKGROUND INFORMATION ON MALTA

Malta is a group of islands situated in the central Mediterranean, some 90 kilometres to the south of Sicily and 290 kilometres north of the African mainland. The Maltese Islands include Malta, Gozo and Comino, three inhabited islands, Malta being the largest (and most populated), Comino the smallest (and least populated). Smaller uninhabited islands (Cominotto, Filfla and St Paul's Islands) and a few islets are situated close to the coastline. The islands together encompass an area of 316 square kilometres with a total shoreline of 271 kilometres.

The climate is typically Mediterranean, with hot, dry summers and relatively mild winters with fluctuating rain patterns. The general trend for climatic conditions normally sees the highest mean monthly air temperature in July and August, with the lowest monthly mean usually observed in January and February. Average monthly relative humidity typically varies between 60% (in summer months) and 80% (in winter months). Precipitation rates are highest during the November – January period, with minimal rainfall, if any, during the June-August period.

Changes in climatic conditions have been observed in Malta (SOER, 2018). For example, for the period 1981 to 2015, the mean air temperature shows a warming trend of +0.22°C every decade. While the mean maximum air temperature exhibits a relatively low rate of increase, there is stronger trend for the mean minimum temperature, which shows an average increase of +0.38°C per decade. Total yearly precipitation values for the same period of years show a rate of change of -6.3mm per decade, though this may also be attributed to the relatively short time-series under consideration. Oceanographic observations over the short time period of 1992-2006 show that sea level fell by an average rate of 0.5 ± 1.5cm per annum while Mediterranean Sea surface temperature (studies on sea surface temperature within Maltese waters still ongoing) has seen a warming of 0.35°C per decade.

With a population standing at 520,971 in 2021, Malta is one of the most densely populated countries in the world, with a population density of 1,648 persons/km^2. Population has seen a growth of almost 44% over 1990.

Over the past 30 years or so, the islands' small and open economy has transitioned from one originally based primarily on manufacturing activity towards a greater emphasis on high value-added activities such as tourism and services. GDP has grown almost 376% over the period 1990 to 2020. The domestic market is relatively small and the insularity inherent in a small island state offers added challenges; thus, there is a continued need to develop Malta's economy into diverse and new economic activities.

Malta is not immune to the impacts of climate change, and as a small island state it can be considered as being particularly vulnerable to such impacts. Indeed, events of high temperatures in summer, resulting in heat waves, are not a rare occurrence. Precipitation rates are of concern to the country. With no indigenous sources of readily available fresh water such as lakes or rivers, Malta is limited to extraction of water from the water table, replenished through rainfall, or, as has been the case in the recent few decades, desalination of sea water, a process that whilst satisfying more than half of the potable water requirements of the country at present, is also particularly energy intensive. The impact of changing climatic conditions in other areas of the world may also be felt by Malta. Its proximity to the North African coastline could make Malta a point of transit for migrants escaping the devastation that climate change can bring about in Africa. Malta's economy being significantly dependent on trade with other countries, whether it is for imports and exports, or for tourism, the vulnerability of the country to the economic impacts of climate change must be taken into consideration.

1.1.3 Background information on greenhouse gas inventories

Greenhouse gas (GHG) inventories of anthropogenic emissions by sources and removals by sinks are an important tool in climate policy, especially where this relates to greenhouse gas mitigation action. The UNFCCC establishes the basic principles of greenhouse gas inventories.

Article 4 of the Convention states that:

"1. All Parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, shall:

(a) Develop, periodically update, publish and make available to the Conference of the Parties, [...] national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies to be agreed upon by the Conference of the Parties".

Article 12 continues thus:

"1. In accordance with Article 4, paragraph 1, each Party shall communicate to the Conference of the Parties, through the secretariat, the following elements of information:

(a) A national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, to the extent its capacities permit, using comparable methodologies to be promoted and agreed upon by the Conference of the Parties".

The Kyoto Protocol furthermore requires Annex I Parties to:

"have in place [...] a national system for the estimation of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol."

A submission of a greenhouse gas inventory by an Annex I Party incorporates a National Inventory Report (NIR) which includes, among others, a description of the methodologies used, sources of data and the national approach to inventory compilation, accompanied by detailed quantified data on emissions and removals in Common Reporting Format (CRF) tables.

1.1.4 GREENHOUSE GASES REPORTED

Two types of greenhouse gases are reported in national greenhouse gas inventories.

Direct greenhouse gases contribute directly to climate change due to their positive radiative forcing effect; that is, their presence in the atmosphere tends to lead to an increase in atmospheric temperature. Greenhouse gas inventories cover seven categories of such gases, namely:

- Carbon dioxide (CO_2);
- Methane (CH_4);
- Nitrous oxide (N_2O);
- Hydrofluorocarbons (HFCs);
- Perfluorocarbons (PFCs);
- Sulphur hexafluoride (SF_6); and,
- Nitrogen trifluoride (NF_3).

The radiative forcing effect for each greenhouse gas species is usually denoted as the Global Warming Potential (GWP). Global Warming Potentials of the direct greenhouse gases discussed in this inventory report are provided in Annex III to Decision 24/CP.19 '*Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the* Convention' *(Report of the Conference of the Parties on its nineteenth session, held in Warsaw from 11 to 23 November 2013, Addendum; FCCC/CP/2013/10/Add.3.)*. As scientific knowledge on the effect of different gases has grown, the GWPs of many greenhouse gases previously established in the 2nd Assessment Report (2AR) of the Inter-Governmental Panel on Climate Change (IPCC) were updated in the 4th Assessment Report (4AR), published in 2007 and also updated in the 5th Assessment Report (5AR), published in 2014. Inventory submissions up to the 2014 (covering the years 1990 to 2012) used 2AR GWP values. This inventory submission uses 5AR GWP values, in accordance with the applicable decisions taken under the UNFCCC. Historic estimates of emissions and removals for the years up to 2012 have been recalculated to consider the revised GWP values.

For purposes of aggregation of estimated emissions or removals of different greenhouse gases into a single total, and to facilitate comparison between different gases, quantities of greenhouse gases emitted or removed are often also presented in terms of 'CO_2 equivalents', whereby a quantity of a particular gas is multiplied by the GWP of that gas. Thus, 1 tonne of CH_4 can also be represented as 28 tonnes of CO_2 equivalents; 1 tonne of N_2O can be represented as 265 tonnes CO_2 equivalents, and so on.

Table 1-1 Global Warming Potentials (GWP) of direct greenhouse gases covered by this inventory report adapted from the IPCC Fifth Assessment Report, 2014 (AR5).

Chemical species	Chemical formula	GWP (time horizon: 100 years) based on 5th Assessment Report
Carbon dioxide	CO_2	1
Methane	CH_4	28
Nitrous oxide	N_2O	265
Nitrogen trifluoride	NF_3	16,100

Hydrofluorocarbons:		
HFC-23	CHF_3	12,400
HFC-32	CH_2F_2	677
HFC-125	C_2HF_5	3,170
HFC-134a	$C_2H_2F_4(CH_2FCF_3)$	1,300
HFC-143a	$C_2H_3F_3(CF_3CH_3)$	4,800
HFC-227ea	C_3HF_7	3,350
HFC-245fa	$CHF_2CH_2CF_3$	858
HFC-365mfc	$CH_3CF_2CH_2CF_3$	804
Perfluorocarbons:		
Perfluoropropane - PFC-218	C_3F_8	8,900
Sulphur hexafluoride	SF_6	23,500

Precursor greenhouse gases, sometimes also referred to as indirect greenhouse gases, do not directly induce an increase in atmospheric temperature as such; however, their release into the atmosphere results in their chemical conversion into species that have an effect similar to the direct greenhouse gases mentioned above. The indirect greenhouse gases included in national greenhouse gas inventories are:

- Nitrogen oxides (NOx; reported as NO_2);
- Carbon monoxide (CO);
- Non-methane volatile organic compounds (NMVOCs);
- Sulphur dioxide (SO_2).

This latter group of gases, albeit subject to similar reporting requirements as for the direct greenhouse gases, are not however aggregated with the direct greenhouse gases and are usually discussed separately from the direct greenhouse gases.

1.1.5 SECTORS REPORTED

Five main sectors of sources and sinks of greenhouse gases are covered by the national GHG inventory. Each sector is further disaggregated into categories for each of which separate estimations of emissions or removals are carried out in accordance with accepted methodologies and depending on their occurrence in the country. These sectors are:

1. Energy;

2. Industrial Processes and Product Use (IPPU);

3. Agriculture;

4. Land Use, Land-Use Change and Forestry (LULUCF); and,

5. Waste.

Also, forming part of an inventory submission are estimates of emissions from additional categories known as 'Memo Items'. Emission estimates for these categories which include, *inter alia*, emissions from international maritime and aviation bunkering activities, are however not considered as part of 'national totals' of emissions and removals.

1.2 DESCRIPTION OF THE NATIONAL INVENTORY ARRANGEMENTS

1.2.1 INSTITUTIONAL, LEGAL, AND PROCEDURAL ARRANGEMENTS

A first national GHG inventory was compiled as a stand-alone exercise in the context of the preparation of Malta's First National Communication to the UNFCCC, submitted and published in 2004. At the time, Malta was a non-Annex I party to the Convention and reporting obligations were those applicable to such a status. This first inventory was carried out by a team of inventory compilers coordinated by the University of Malta.

In 2004, Malta acceded to full membership of the European Union (EU). Despite retaining the non-Annex I status under the UNFCCC, reporting obligations relating to greenhouse gas emissions and removals became more stringent, and in line with the EU's Monitoring Mechanism *(Formerly Decision No 280/2004/EC of the European Parliament and of the Council of 11 February 2004 concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol; replaced by Regulation (EU) No 525/2013)*, which included the requirement to report a national GHG inventory on an annual frequency with strict timeframes, namely: the submission of a 'provisional' inventory on 15th January of each year to the European Commission, covering the time series from 1990 (as base year) to the year before last (X-2); a 'final' inventory submission by the following 15th March, that may include changes to the January submission; and the submission under the UNFCCC by 15th April.

As of 2010 Malta's status under the UNFCCC changed to that of Annex I Party, which means that reporting obligations relating to such a status became fully applicable to Malta.

The inventory reporting requirements under EU legislation, and then also under Annex I status, made it necessary to establish a process whereby annual inventory reporting could be fulfilled. The Malta Environment and Planning Authority (MEPA) was initially entrusted to take on this obligation, subsequently followed by a migration of this and other climate action responsibilities to the Malta Resources Authority (MRA) as of 2010. Thus, the Climate Change Unit at MRA is currently responsible for the preparation of the national GHG inventory, including this submission.

Political ownership and overall responsibility of the national GHG inventory is vested in the Ministry responsible for climate change policy, this being the Ministry for the Environment, Energy and Regeneration of the Grand Harbour.

Any Annex I Party to the UNFCCC has an obligation to establish a National Greenhouse Gas Inventory System, defined by decision 19/CMP.1 "Guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol" as:

> *"all institutional, legal and procedural arrangements made within a Party included in Annex I for estimating anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, and for reporting and archiving inventory information."*

This obligation has also been transposed into EU law. A first recommendation for the setting up of a national inventory system was made in 2005, following discussions with inventory experts from the Federal Environment Agency of Austria. This led to the recruitment of staff to work on national inventories (greenhouse gases and air quality) and the first steps towards a more structured inventory compilation process. In 2007/2008 MEPA commissioned a more in-depth assessment of inventory compilation practices in place at the time to draw up recommendations for the formal establishment of a national inventory system that would be in accordance with requirements under the Kyoto Protocol; the intention was to integrate inventory reporting relating to both climate change and air quality obligations. Unfortunately, due to several reasons, this assessment and its recommendations could not be followed-up with concrete action. Malta's accession to Annex I status, the ratification requirements of the Doha Amendments to the Kyoto Protocol and the obligations arising from EU law make it imperative that a fully functioning national inventory system that meets the requirements of decision 19/CMP.1 is established. To this effect, the Climate Change Unit at MRA had taken the initiative, in 2013 to submit a report "Establishing a National Greenhouse Gas Inventory System for Malta" (Climate Change Unit-Malta Resources Authority; 30th May 2013) to the relevant local authorities to instigate and inform the decision-making process. As a result of this initiative, the "National System for the Estimation of Anthropogenic Greenhouse Gas Emissions by Sources and Removals by Sinks Regulations of 2015" establish a national system for greenhouse gas inventories *(Legal Notice 259 of 2015, National System for the Estimation of Anthropogenic Greenhouse Gas Emissions by Sources and Removals by Sinks Regulations, 2015 (Subsidiary Legislation 543.01)*.

The legal notice forms part of a wider legislative framework being established specifically for climate action in Malta, with the main underpinning legal instrument being the Climate Action Act, 2015 (Chap. 543). The Act sets the development, updating and publication of national greenhouse gas inventories as an obligation on the Maltese Government (Article 5, sub-article (2), point (a) *("In fulfilling its duties [to protect the climate for the present and future generations] the Government shall, inter alia: (a) develop, periodically update and publish national inventories of anthropogenic emissions by sources and removals by sinks of greenhouse gases in order to monitor progress towards achieving its quantified emission limitation or reduction commitments pursuant to international treaties ad its obligations as a Member State of the European Union […].")*

The national inventory system legal notice, among other aspects, formally identifies the Minister responsible for climate change as the Single National Entity (SNE) in accordance with the relevant UNFCCC requirements. The SNE "*shall have overall responsibility for the national greenhouse gas inventory system*" and shall ensure that the national system is operated in accordance with criteria set out in Schedule 1 to the legal notice and with relevant international and European Union requirements. The SNE shall define and allocate specific responsibilities in the inventory preparation process specifying the roles of, and cooperation between, government agencies and other entities involved in the preparation of the inventory, as well as the institutional, legal and procedural arrangements made to prepare the inventory, shall establish quality objectives for the national system, establish processes for the independent review, official consideration and approval of national greenhouse gas inventory reports and ensure timely submissions.

The legal notice also provides for the formal designation of an inventory agency. The responsibilities of the inventory agency are laid out in regulation 5 of the Legal Notice as follows:

> *"The Inventory Agency shall, annually, and in accordance with deadlines established by the COP and, or the COP/MOP and deadlines set out in Regulation (EU) No 525/2013, prepare a national greenhouse gas inventory report in accordance with relevant decisions of the COP and, or, the COP/MOP, and Regulation (EU) 525/2013."*

Through a Government Notice (No 1036 of 27th October 2015) published pursuant to this same legal notice, the Malta Resources Authority has been designated as Malta's Inventory Agency. Specific functions relating to inventory preparation and management are laid out in Schedule 2 of Legal Notice 259 of 2015.

1.2.2 Overview of inventory planning, preparation, and management

The Climate Change Unit at MRA is responsible for the planning, preparation and management of the national GHG inventory. Staff within the Unit perform duties related to the inventory, including: the preparation of the annual greenhouse gas inventory submission of Malta, performing most of the functions involved, starting from the gathering of data from the relevant data providers, to estimating sectoral emissions or removals of greenhouse gases; drafting of this report and the inputting of data into the CRF Reporter software; and, final submission to the European Commission, the European Environment Agency and the UNFCCC Secretariat. As necessary, the Unit also engages outside contributors to assist in the preparation of submissions.

The preparation of the annual inventory submission is spread over a whole year cycle, starting with initial planning of an inventory cycle and concluding with the last review of that cycle's submission. It is normally the case that each inventory cycle overlaps with the previous and subsequent cycles, especially because the review by the UNFCCC of an inventory submission tends to take place at a time when the next inventory cycle has started. This highlights the importance of looking at the inventory process as a continuous process, linking one submission with the next: indeed, each inventory cycle builds on the previous inventory cycle, and will itself be the starting point of the subsequent inventory cycle.

The work on an inventory submission goes beyond the gathering of data, estimation of emissions and removals, preparation of report text, entry of data into the CRF system and submission. These processes are underpinned by additional steps, including quality assurance and control, the documentation of all actions taken in the preparation of an inventory, and archiving of historic documentation.

An inventory cycle is normally concluded with the peer review of the UNFCCC of that cycle's submission. Peer reviews are not seen solely as an assessment of the work undertaken for the compilation of a submission and a confirmation of the final quantified total national net emissions. Reviews are also an important contributor towards continuous improvement, indicating where existing practices are delivering satisfactory results and highlighting areas where further efforts are required to improve Malta's national greenhouse gas submissions. Findings from reviews provide a basis for the internal evaluation of each submission.

Data gathering is another area where efforts must continue to ensure that reliable data is sourced from the most appropriate sources and in an effective manner. As will be seen in later sections of this report, data is gathered from a diverse range of sources, both public and private. So far, the data gathering process has depended largely either on access to publicly available official data, or on one-to-one relationships built with organisations, or individuals within organisations, in a relatively informal manner. The MRA has identified the need to establish formal channels of data gathering to ensure timely provision of reliable data, including, where appropriate, through formal written agreements with key data providers. Work on this aspect has started. The current approach to greenhouse gas inventory compilation in Malta is pictorially presented in Figure 1-1.

Figure 1-1 Schematic representation of the institutional and procedural arrangements for the preparation and submission of national greenhouse gas inventories of Malta.

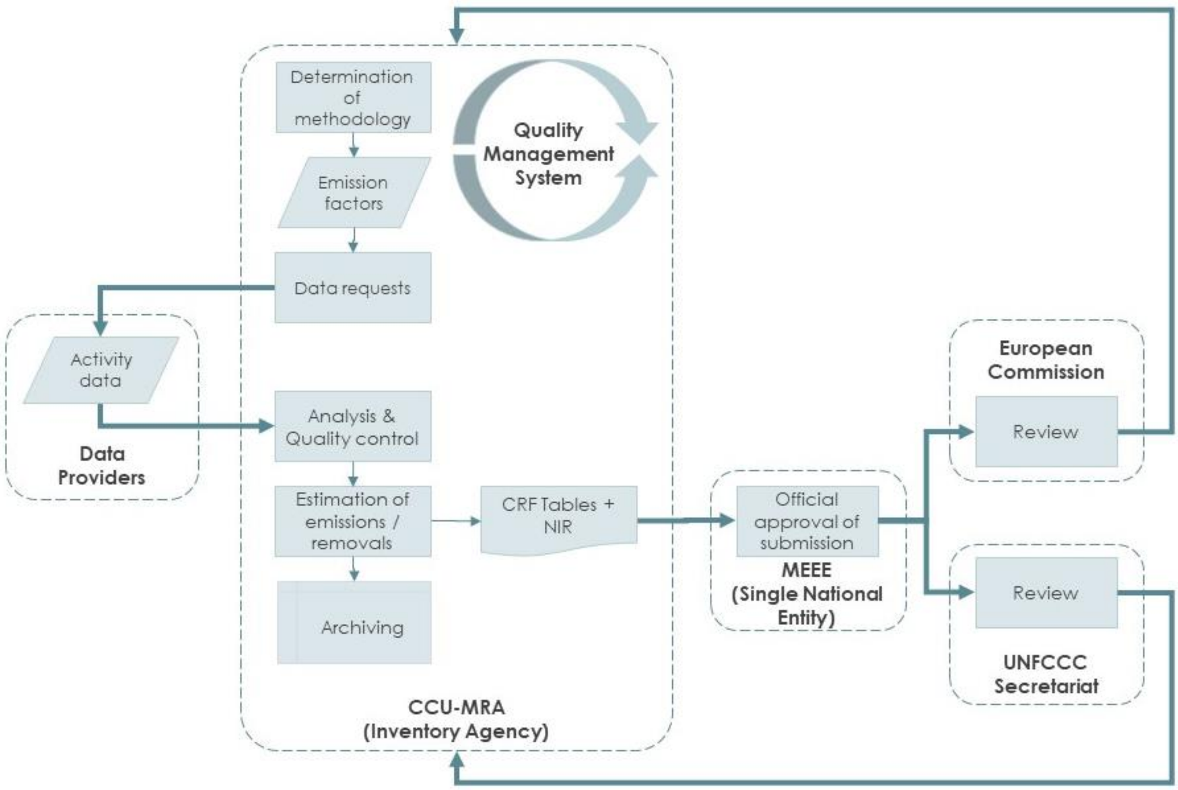


Figure 1-2 GHG inventory annual submissions

1.2.3 QUALITY ASSURANCE, QUALITY CONTROL AND VERIFICATION PLAN

The process of inventory preparation and management aims at ensuring the accuracy, comparability, consistency, completeness, transparency and timeliness of national inventory submissions. "*It is good practice to implement quality assurance and quality control (QA/QC) procedures in the development of national greenhouse gas inventories*" (GPG2000, IPCC, 2000) to meet the listed quality criteria.

A properly established QA/QC framework is a crucial element of the National Inventory System. In fact, the Marrakech Accords include minimum requirements for the quality system of a National Inventory System of an Annex I party, stating that Parties shall elaborate an inventory quality plan and implement the quality procedures described in the plan as part of their annual inventory preparations and reporting cycle. The term 'Quality System' is further elaborated upon as follows:

> *"[S]hall include a description of the quality assurance and quality control plan, its implementation and the quality objectives established, as well as information on internal and external evaluation and review process."*

In August of 2017 MRA brought into effect a formally documented Quality Management System (QMS) for the inventory process. The Quality Management System was set up to define the quality assurance and quality control parameters deployed by MRA for the compilation of Malta's national inventory, MRA's mission in this respect being to "*seek to excel in the fulfilment of its obligations as the national Inventory Agency of Malta through the use of Continuous Improvement practices, methods and tools*" (Operations and Quality Manual; Malta Resources Authority; 18th April 2018).

The documented Quality Management System reflects the implementation, by the MRA, of GHG inventory practices as established by IPCC guidelines, and is also in accordance with EN ISO 9001:2015. To this effect, the QMS defines quality objectives, documents the process for the preparation of annual GHG inventory submissions, and provides for overarching functions including regular auditing of the system, treatment of non-conformities and management of competency.

The QMS is made up of an 'Operations and Quality Manual' (OQM), a series of Quality System Procedures (QSP) and Quality Operational Procedures (QOPs), together with supporting documentation such as process maps, forms and logs.

The Operations and Quality Manual establishes how the Climate Change Unit at MRA will plan, compile and submit the national GHG inventory and how QA/QC efforts will be implemented at every stage of the process. It sets out the quality policy of the Climate Change Unit:

"[…] the CCU will strive to ensure that:

- It prepares and submits the National GHG Inventory Report in a timely manner;
- It ensures that each report is as complete as possible in terms of data presented;
- It strives to maintain consistency in terms of operations and data submitted within each report;
- It operates in a way which allows comparability of data;
- It produces reports in the most accurate of manners;
- It upholds values of transparency across its operations; and,
- It ensures that ongoing improvement is implemented further to submission of each report."

The manual also defines roles and responsibilities and quality objectives. It provides the necessary guidance on such aspects as competency, management of knowledge, communication, and the administration of the QMS including with regards to control of documents, management reviews and auditing of the quality system. The OQM is supported by, and refers to, the procedures listed in Table 1-2.

Table 1-2 List of System Procedures and Operational Procedures pertaining to the Quality Management System.

Quality Management System	
System Procedures	Operating Procedures
CCU-QSP-01 Document and Data Control Procedure	CCU-QOP-01 Organization of Work
CCU-QSP-02 Internal Auditing Procedure	CCU-QOP-02 Identification of Key Categories
CCU-QSP-03 Control & Treatment of Non-conformity and Risk	CCU-QOP-03 Methodology, Data collection and Estimation
CCU-QSP-05 Training and Competency Management Procedure	CCU-QOP-04 Completion of Proxy Table and Input of Data into the CRF Reporter
	CCU-QOP-05 Compilation of NIR and consistency procedure
	CCU-QOP-06 Approval from the Single National Entity and Submission
	CCU-QOP-07 EU and UNFCCC Reviews

Figure 1-3 is a schematic representation of how the QSPs and QOPs listed in Table 1-2 fit within the overall context of the GHG inventory process. An important outcome of the development and adoption of a quality management system by the MRA was obtaining certification of the quality system to EN ISO 9001:2015. Certification was issued for the first time by the Malta

Competition and Consumer Affairs Authority in January 2018 and has been successfully renewed since. The implementation of the quality system to the level expected under the certification is monitored through regular internal and external audits and biannual management review meetings chaired by the MRA's management.

The important role of peer reviews of Malta's greenhouse gas inventory submissions has already been referred to above. As a Member State of the European Union, Malta's greenhouse gas inventory data is subject to annual review so as to monitor Malta's greenhouse gas emission reduction or limitation pursuant to the Effort-sharing Decision. These reviews are undertaken by a team of expert reviewers from EU Member States under the auspices of the European Environment Agency and on behalf of the European Commission. A first Step review covers all data for sectors and categories falling within the scope of the Effort-sharing Decision; where significant issues are identified, a second step review is undertaken specifically on those issues. Apart from checks on the information submitted, these reviews may also result in technical corrections, with findings published in an official report.

Malta's greenhouse gas inventory submissions have also undergone individual reviews undertaken by expert review teams in accordance with review guidelines under Article 8 of the Kyoto Protocol. The outcome of such reviews, including detailed findings, are published by the UNFCCC Secretariat. Review reports actively feed into the internal evaluation of inventory submissions performed by the inventory team at the MRA and thus help guide the inventory team in preparing future submission and in identifying and prioritizing elements for further improvement.

The quality process does not stop here. The ongoing investment in enhancing the competency of inventory compilers complements the participation by the national inventory team in capacity building opportunities offered, in particular, through projects run by the European Commission and other projects contracted by the Inventory Agency. The use of IT tools to enhance efficiency of the inventory process, and other best practices, also feature prominently in ongoing projects. Further steps under consideration for possible future implementation include the identification of a pool of independent experts to support the inventory agency through expert advice on sector-specific matters and, or, to review annual inventories prior to submission, and means how to engage a wider range of stakeholders in the greenhouse gas inventory process, especially where it relates to improving accessibility of inventory data to policy-makers, academics and researchers and the general public.

Table 1-3 Capacity building support and knowledge sharing activities in recent years.

Capacity building support	Period
Post-review capacity building support under the 'European Commission Service contract for Annual review of Member States' greenhouse gas inventories under the Effort Sharing Decision'.	2017, 2018, 2019
'Malta National System and QA/QC Improvement', in-country visit and recommendations by inventory expert on behalf of the European Commission.	2017

Bilateral post ESD review support under the auspices of the European Commission: in-country support from Czech Republic on general inventory improvement by expert from Czechia.	2018
Bilateral post ESD review support under the auspices of the European Commission: in-country training from Greece on COPERT5.	2018
European Commission project 'Technical Support for capacity building in Member States to implement Forest Reference Levels and improvements of greenhouse gas inventories' (ICF Ltd. lead): task 1 on preparation of National Forestry Accounting Plan and determination of Forest Reference Level.	2018
Project 'Technical Support for Emission Inventories', contracted by MRA to Aether Ltd (UK).	2018 – 2022
Project 'Technical support on the emission framework for the agriculture sector in Malta', under Structural Reform Support Service (SRSS) programme of the European Commission (Aether Ltd, UK).	2019
European Commission project 'Technical Support for capacity building in Member States to implement Forest Reference Levels and improvements of greenhouse gas inventories' (ICF Ltd. lead): task 2 on assistance for the improvement of land-based reporting under the new LULUCF rules.	2019 ongoing

As part of its capacity building efforts, the Inventory Agency has engaged external consultants (Aether Ltd., UK) to provide, among others, quality assurance of the inventory, in terms of its management system, sectoral compilation, and reporting (through the NIR). As a specific task, the consultants reviewed in detail the NIR, and provided expert feedback on the transparency of the NIR and assessed the completeness and quality of key reporting aspects in line with the IPCC and UNFCCC requirements. This activity has been prioritised in response to reviews (and recommendations) received by Malta during UNFCCC reviews and reviews pursuant to the EU Monitoring Mechanism Regulation (refer to Table 1-4). Work continues by the MRA to develop further the national system, its own internal systems, inventory capacity, methodologies and quality of reporting over the time period 2018-2022. Key to this objective will be the development of effective improvement planning. MRA will continue to work with experts both internally and externally in this regard.

Figure 1-3 QMS process map.

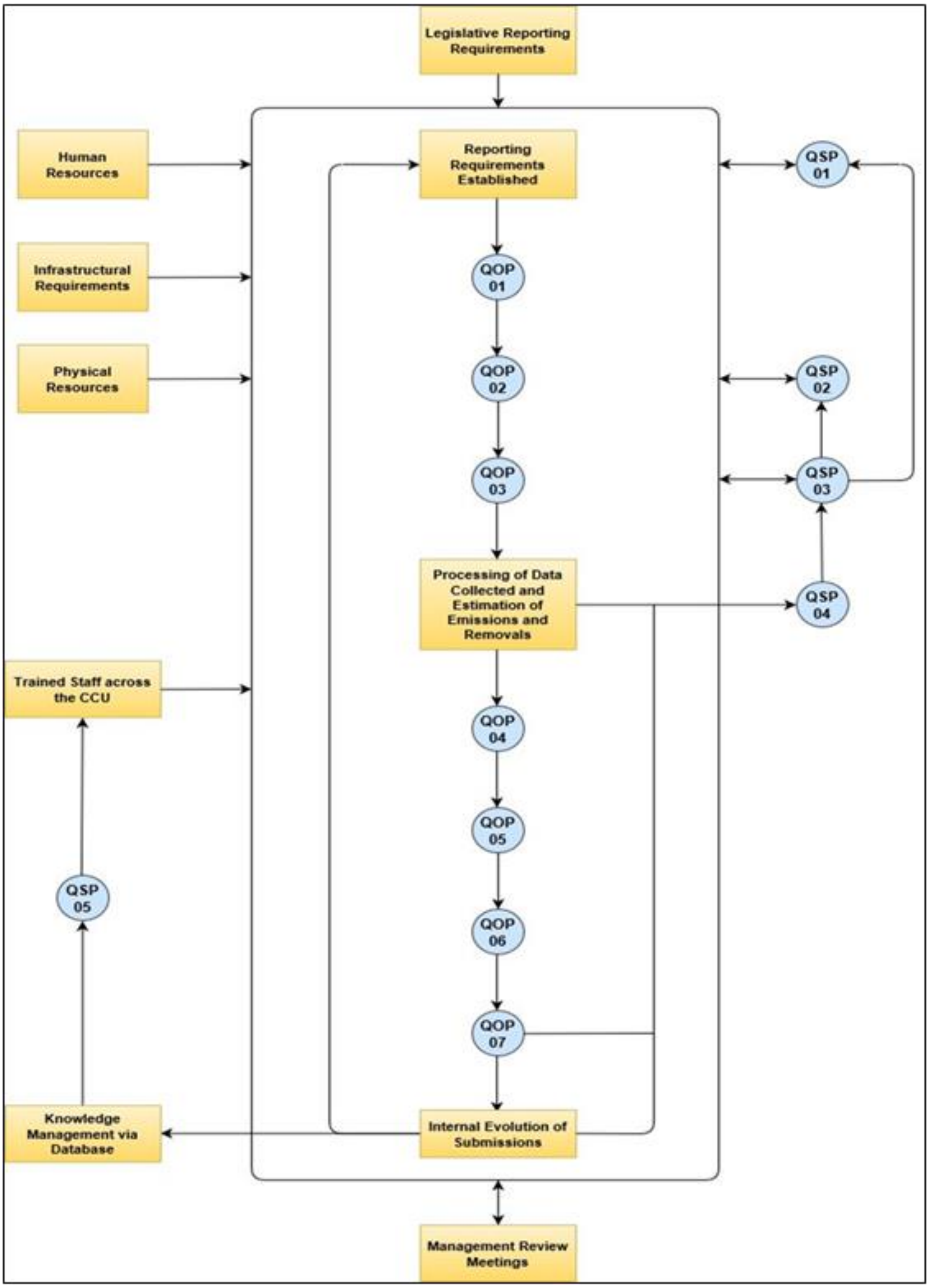


Table 1-4 Expert Reviews of Malta's greenhouse gas inventory submissions.

Type of Review	Year of Review
Annual UNFCCC review (centralized).	2012 – 2013, 2015, 2017, 2019, 2021
Annual UNFCCC review (in-country).	2016
Trial review of the 2015 greenhouse gas inventory under the Effort Sharing Decision.	2015
Comprehensive review of national greenhouse gas inventory pursuant to Article 19(1) of the Monitoring Mechanism Regulation.	2016
Annual review of national greenhouse gas inventory data pursuant to Article 19(2) of the Monitoring Mechanism Regulation.	2017 – 2018, 2019, 2020
Independent expert review of the National Inventory Report forming part of the 2019 submission pursuant to the Monitoring Mechanism Regulation, under project 'Technical Support for Emission Inventories' contracted by MRA to Aether Ltd (UK).	2019

The outcome of the work discussed above is that the overall completeness and quality of reporting is high, and generally in adherence with the reporting guidelines. However, it is acknowledged that there may be a lack of sufficient information at the sector-specific level on QA/QC activities and planned improvements. In addition, the consideration and assessment of uncertainties is a priority weakness that will be addressed across coming submissions. MRA will look to develop its uncertainty assessment in collaboration with sectoral experts, inventory stakeholders and data providers. A summary output from the QA exercise undertaken in the capacity building project with Aether Ltd is included in Chapter 10 to this report.

1.2.4 Changed in the national inventory arrangements since the previous annual GHG inventory submission

There have been no major changes in terms of institutional arrangements since the last annual GHG Inventory Submission (submission of 2021).

1.3 Inventory preparation, and data collection, processing and storage

Inventory preparation starts with planning of the inventory cycle, including allocation of tasks and determining any internal deadlines that may be applicable. Documentary evidence of the allocation of tasks, internal deadlines, and the actual fulfilment of tasks is kept.

Communication with data providers that are the source of the all-important activity data and any country-specific emission factors, on the basis of which sectoral emissions and removals estimates can be performed, then starts. Receipt of activity data and emission factors is logged (activity data log; emissions factor log) to ensure optimal traceability. The activity data received is then assessed for its validity as an input into the emission and removals estimation process. The estimations of emissions and removals are performed using spreadsheets developed internally and specifically for the national greenhouse gas inventory process; these spreadsheets describe the mathematical steps involved in translating activity data and calculation factors (e.g. emissions factors, oxidation factors) into reportable emission and removal values.

Once the quantification of emissions and removals is concluded, the next phase entails the drafting of the national inventory report (this written report) and the inputting of the quantified results of the estimation of emissions and removals into the CRF Reporter software. The written report provides detailed information on the overall set-up of inventory preparation in the country, the approach used to estimate emissions and removals and other information in accordance with requirements of Decision24/CP.19, the Annex to Decision24/CP.19, the appendix to the Annex to Decision 24/CP.19 and Implementing Regulation (EU) No 749/2014. The CRF reporting system serves to bring together, in a sequence of detailed spreadsheets, the relevant quantitative information on emissions and removals as estimated, and activity data and calculation factors as used in the compilation of the inventory, covering the whole time-series, starting from 1990 (as base year) until the last but one year from the year of submission (year X-2).

The data and spreadsheets that form the crucial basis for any inventory submission are held on secure IT systems maintained by MRA. The server handling this material is housed within the MRA offices protected with advanced antivirus and firewall systems that are updated on a regular basis. Backups are performed on a daily basis onto separate backup hard drives. Access to the folder in which the relevant inventory files are held is restricted to relevant staff of the MRA; access by all staff of the MRA to the Authority's servers is restricted by passwords which have to be changed regularly. These features, and the fact that the server system has no direct link with the outside, not only further enhance the security of the inventory compilation process but also ensure confidentiality of inventory-related information, at least where such information is not already available in the public domain. Furthermore, all MRA staff and any contracted external experts (including any external experts contributing to the preparation of the national greenhouse gas inventory) are required to sign up to a confidentiality agreement.

Official approval of reports, CRF tables and any other associated documentation to be submitted is issued by the Single National Entity following which submissions are made to the European Commission, through the EIONET web-system of the European Environment Agency, and the UNFCCC Secretariat, through the submission portal of the Secretariat, in accordance with reporting requirements.

As already indicated above, a first provisional submission to the European Commission is made by not later than mid-January, including both the written national inventory report, the CRF tables and a number of associated templates. It is sometimes the case that revised or previously missing data is found following this provisional submission, which justifies revisions to the estimations previously performed. There may also be instances where a change in the methodological approach is identified after the January submission which could improve the greenhouse gas inventory estimation process and which thus would also warrant an update of the inventory report and the CRF tables. Such updates *(The updates referred to in this instance do not relate to recalculations. Recalculations represent updates in inventory estimations taking place between one year and the other)* are often carried out during the period of weeks leading up to mid-March, when a final submission of the full national inventory report, final CRF tables and final versions of additional documents to the European Commission has to be made.

A final submission is then prepared and submitted to the UNFCCC Secretariat by mid-April. To the extent possible, this submission is maintained the same as that made in the previous March to the European Commission. There may however be rare occasions where some amendments either to the text of the report or even changes to estimations of emissions and removals of greenhouse gases are done to ensure the continued relevance of the submission.

The processes described under this section are all covered by the quality management system of the MRA, as described under section 1.2.3 above, and require the documentation of steps taken.

It is to be noted that the inventory submissions made by the European Union Member States to the European Commission serve as the basis for the latter's compilation and submission of the Union greenhouse gas inventory to the UNFCCC Secretariat, in the context of the European Union's reporting obligations as an Annex I Party in its own right to the UNFCCC and the Kyoto Protocol.

1.4 BRIEF GENERAL DESCRIPTION OF METHODOLOGIES (INCLUDING TIERS USED) AND DATA SOURCES USED

Detailed information on the methodological approaches applied to estimate emissions and removals for the various source and sink categories covered by this inventory can be found in the respective sector-specific chapters.

In general, methodologies are derived from the '2006 IPCC Guidelines for National Greenhouse Gas Inventories' unless otherwise stated in the methodological descriptions. To the extent possible, and in particular where key categories are concerned, efforts are made to apply the highest possible tier levels.

Data sourcing involves a diverse range of data providers. A key data provider is the National Statistics Office (NSO), governed by the Malta Statistics Authority Act, 2000 (Chap. 422) (1st March 2001) and serving as the main body responsible for the collection, compilation, analysis and publications of statistical information related to Malta. NSO data may also be supplemented by data from international statistics organisations such as the statistical office of the European Union, Eurostat, and FAOSTAT, the statistical division of the Food and Agriculture Organization of the United Nations.

Ministries and Government departments, regulatory authorities and agencies, public entities and private establishments and industry organizations also provide important sources of data, and in certain cases, added technical expertise in matters relating to specific sectors.

Reports published by various entities are also sourced in some instances. This is particularly the case for data on fuel consumption in the local electricity generation plants, where data submitted by the operators of such installations under the European Union's Emissions Trading

System (EU ETS) is used directly. EU ETS data covers a major source of national emissions of greenhouse gases and the fact that operators are required to submit duly verified data serves as an important element of quality control for a significant share of national total emissions.

A list of key data providers, by sector, is presented in Table 1-5.

Table 1-5 Key data providers relevant for this inventory submission.

Sector	Data providers
Energy (including 'Memo Items')	National Statistics Office (NSO)
	Operators of electricity generation installations (data reported for EU ETS purposes by Enemalta plc, D3PG Ltd and Electrogas Malta Ltd.)
	Regulator for Energy and Water Services (REWS)
	Transport Malta (TM)
	Armed Forces Malta (AFM)
	Energy and Water Agency
Industrial Processes & Product Use	National Statistics Office
	Enemalta plc
	Transport Malta
	A number of private sector industry enterprises, providing data related to their respective activities
Agriculture	National Statistics Office (NSO)
	Malta Dairy Products (MDP)
	Koperattiva Produtturi tal-Halib (KPH)
	FAOStat
	Koperattiva ta' min irabbi l-majjal (KIM)
	Ghaqda produtturi tal-Fniek
	LULUCF sector
Land Use, Land-use Change and Forestry	Planning Authority (PA)
	National Statistics Office (NSO)
	Environment Resources Authority (ERA)
	Ambjent Malta (AM)
Waste	Environment and Resources Authority (ERA)
	Wasteserv Malta Ltd.
	Water Services Corporation (WSC)
	National Statistics Office (NSO)
	FAOSTAT

	Additional data derived from the Agriculture sector of the Inventory Agency which also serves as an input to the Waste sector inventory

1.5 BRIEF DESCRIPTION OF KEY CATEGORIES

A ‘key category’ is an individual source or sink category that warrants prioritisation within the national inventory system because it has a significant influence on the national inventory concerned, in terms of the absolute level of emissions or removals, the trend in emissions or removals, contribution to uncertainty, or any combination of these.

There are two approaches to identify key categories described in the 2006 IPCC Guidelines (Volume 1, Chapter 4), named “approach 1” and “approach 2”.

Under approach 1, “level” key categories are those which cumulatively account for 95% of the total inventory emissions (in CO_2-eq.) when sorted in descending order of magnitude. “Trend” key categories are those for which the trend over time significantly differs from the trend in total inventory emissions. The with-LULUCF key category assessment includes values relating to estimated removals in the LULUCF sector, taking into consideration the absolute values regardless of the sign (removals can be considered as being equivalent to negative emissions). The without-LULUCF assessment excludes estimates of removals from the LULUCF sector.

Under approach 2, the contributions of each category to the approach 1 level and trend assessments are multiplied by the category’s percentage uncertainty in emissions, and categories sorted in order of their contribution to uncertainty in the level or trend. Key categories are those cumulatively contributing 95% of the total uncertainty across all categories. The robustness of the Approach 2 analysis depends on the quality of uncertainty estimates for emissions from each category, which in turn result from estimates of uncertainty for underlying activity data and emission factors. Indeed, the key category analysis decision tree in the 2006 IPCC Guidelines (Vol 1, Ch 4) only recommends performing Approach 2 assessment when country-specific uncertainty estimates are available for each source category.

At present, Malta does not have country-specific uncertainty estimates for all important source categories, so in this section, Malta presents the results of key category analysis from approach 1 only.

For illustrative purposes, Malta also presents the results of approach 2 key category analysis in Annex 1, using IPCC default uncertainty values where necessary. However, these results are not currently used to determine choice of sectoral methodology or improvement priorities. In future, Malta plans to improve country-specific uncertainty estimates to allow the results of approach 2 key category analysis, although there are currently no concrete timelines for this.

As may be seen in the discussion under subsequent sub-titles, there are a number of categories that consistently appear in the lists of key categories. Their important influence on level and trend of Malta’s national greenhouse gas inventory warrants particular attention in ensuring robustness of the related emission estimates. Sector-specific details on steps being taken to ensure high levels of quality will be discussed in the respective sectoral chapters.

Reference has already been made to the use of verified fuel consumption data from annual reports submitted by operators of the local electricity generation plants under the EU ETS. This data covers all fuel consumption relating to indigenous public electricity generation. Operators of such installations are required to submit to the EU ETS competent authority annual data which has been duly verified as satisfactory by an independent, competent verifier. Verifiers have to be accredited specifically for EU ETS purposes, by a recognized national accreditation body of a Member State of the European Union, in accordance with the appropriate rules and procedures set out in EU law (including the Commission regulation on EU ETS accreditation and verification). Furthermore, the monitoring of activity data and emissions under the EU ETS must be undertaken in accordance with the relevant EU regulations on monitoring and reporting, which includes rules on monitoring methodologies, sampling, analysis of fuel parameters, and assessment of uncertainty. Verified data is available as of 2005, the first year of operation of the EU ETS: in the case of Malta this covers liquid fuels used in public energy industries throughout the period since 2005 and, for 2017, the start of utilisation of natural gas.

The utilisation of COPERT modelling for the determination of emissions from road transport has been an important step towards improving estimations for this category. Efforts will be undertaken in future with the relevant transport regulatory body and with the National Statistics Office and involving the air pollutants inventory team at the Environment and Resources Authority, to analyse in greater depth the national data on the vehicle fleet and find means of formatting this data in a way that makes it more efficient to use for statistical and inventory purposes.

Meanwhile, for other fuel combustion activities, such as those occurring in categories Manufacturing Industries and Construction and Other Sectors, collaboration between several entities is focussing on national surveys so as to obtain a better picture of fuel use in different economic sectors and activities.

In sector Agriculture, for which category Enteric Fermentation has been identified as a level key category, discussions are in course to improve the availability of local data to derive reliable country-specific calculation parameters.

Similar efforts to improve the estimation of emissions of F-gases and emissions from sector Waste have also been undertaken in recent years, focussing on the methodological aspects. Next steps for the future may focus on improving the sourcing of activity data.

One of the recent improvements recently undertaken by the Malta Resources Authority with support from external consultants (Aether Ltd., UK), was the setting up of a tool that provides a detailed Key Category Analysis (KCA) of Malta's national GHG inventory. This KCA tool allows for a more detailed assessment level than the KCA which to-date had been derived directly from the CRF Reporter system. The new tool assesses the key category status of source and sink categories at a more disaggregated level and with a higher confidence level than the KCA provided by the CRF Reporter.

An example of the difference in disaggregation between the KCA tool and the CRF Reporter is the ‘Other sectors’ category of the Energy sector, where the CRF Reporter KCA combines the sub-categories of commercial/industrial, residential and agriculture/forestry/fishing into ‘Other sectors’ while the new KCA tool splits the category ‘Other sectors’ into the respective sub-categories: commercial/industrial, residential or agriculture/forestry/fishing.

Annex 1 to this report provides KCA tables, with Approach 1 methodology for the ‘with’ and the ‘without’ LULUCF data, for the base year and year X-2, and with Approach 2 methodology for year X-2. For each KCA approach, a ‘level’ and ‘trend’ assessment are provided.

1.5.1 KEY CATEGORIES: LEVEL ASSESSMENT

The level assessment of key categories represents the contribution of each source or sink category to the total national inventory.

A detailed level assessment of the key categories, as derived from the KCA tool, is presented in Annex I to this report.

As illustrated in Annex 1, the sub-category with the highest key category for both the base year (1990) and the latest year with and without LULUCF, for approach 1, refers to the public electricity and heat production category from the Energy sector.

The consideration, or not, of LULUCF emissions does not make a difference in the classification of level key categories. More important are the differences that can be seen between 1990 and 2021 (refer to Annex 1). The 1990 classification under the level assessment includes CO_2 emissions from solid fuel use in the energy industries category. However, this does not appear in the level assessment of the latest year (2020), since this type of fuel is no longer being used. Moreover, emissions of F-gases from refrigeration and air-conditioning gain importance, with their inclusion as an important key category in 2020 as opposed to 1990 (when no emissions are reported from this activity).

1.5.2 KEY CATEGORIES: TREND ASSESSMENT

A trend assessment takes into account the trend in emissions or removals of a category over time in addition to the level of emissions or removals for that category. This assessment approach can highlight categories that may not appear to be key categories under a level assessment but whose trend is significantly divergent from that of the overall inventory, thus requiring further attention. As a trend assessment requires an analysis against a previous year’s inventory (usually against the base year), a trend assessment for 1990 cannot of course be presented.

A detailed trend assessment of key categories is presented in Annex 1 to this report.

Similarly, to the level assessment, as illustrated in Annex 1, for the trend assessment, the sub-category with the highest trend key category score for the latest year with and without LULUCF is 'Public electricity and heat production' from Liquid Fuels from the Energy sector.

As for the level assessment, the trend assessment without or with LULUCF emissions does not influence the classification of key categories.

1.5.3 KEY CATEGORIES: WITH LULUCF ASSESSMENT

The below table refers to the key categories with LULUCF both for year 1990 and 2022 including level and trend assessment both from approach 1 and approach 2.

Table 1-6 KCA including Approach 1 for base year (1990) and latest year (2022) with LULUCF both Level and Trend Assessment

CRF Code	Category	Classification	GHG	Identification Criteria	
				1990	2022
1A1	Public electricity and heat production	Gaseous Fuels	CO2		L1
1A1	Public electricity and heat production	Solid Fuels	CO2	L1	T1
1A1	Public electricity and heat production	Liquid Fuels	CO2	L1	L1, T1
1A3b	Road Transportation	Liquid Fuels	CO2	L1	L1, T1
2F1	Product Uses as Substitutes for Ozone Depleting Substances - Refrigeration and Air Conditioning		HFC		L1
5A1	Managed Waste Disposal Sites (Anaerobic)		CH4		L1
1A4a	Commercial/Institutional	Liquid Fuels	CO2	L1	L1, T1
1A4b	Residential	Liquid Fuels	CO2	L1	L1, T1
1A2	Manufacturing industries and construction	Liquid Fuels	CO2	L1	L1
1A3d	Domestic Navigation	Liquid Fuels	CO2		L1, T1
5A2	Unmanaged Waste Disposal Sites		CH4	L1	T1
3A	Enteric Fermentation	Cattle	CH4	L1	L1
5D1	Wastewater Treatment and Discharge - Domestic wastewater		CH4	L1	
3D1	Direct N2O Emissions from Managed soils	Organic N/Manure	N2O	L1	
1A4c	Agriculture/Forestry/Fishing	Liquid Fuels	CO2		L1

L1 = Level Assessment Approach 1, T1 = Trend Assessment Approach 1

1.5.4 KEY CATEGORIES: WITHOUT LULUCF ASSESSMENT

The below table refers to the key categories without LULUCF both for year 1990 and 2022 including level and trend assessment from approach 1.

Table 1-7 KCA including Approach 1 for base year (1990) and latest year (2022) without LULUCF both Level and Trend Assessment

CRF Code	Category	Classification	GHG	Identification Criteria	
				1990	2022
1A1	Public electricity and heat production	Gaseous Fuels	CO2		L1
1A1	Public electricity and heat production	Solid Fuels	CO2	L1	T1
1A1	Public electricity and heat production	Liquid Fuels	CO2	L1	L1, T1
1A3b	Road Transportation	Liquid Fuels	CO2	L1	L1, T1
2F1	Product Uses as Substitutes for Ozone Depleting Substances - Refrigeration and Air Conditioning		HFC		L1
5A1	Managed Waste Disposal Sites (Anaerobic)		CH4		L1
1A4a	Commercial/Institutional	Liquid Fuels	CO2	L1	L1, T1
1A4b	Residential	Liquid Fuels	CO2	L1	L1, T1
1A2	Manufacturing industries and construction	Liquid Fuels	CO2	L1	L1
1A3d	Domestic Navigation	Liquid Fuels	CO2		L1, T1
5A2	Unmanaged Waste Disposal Sites		CH4	L1	T1
3A	Enteric Fermentation	Cattle	CH4	L1	L1
5D1	Wastewater Treatment and Discharge - Domestic wastewater		CH4	L1	
1A4c	Agriculture/Forestry/Fishing	Liquid Fuels	CO2		L1

L1 = Level Assessment Approach 1, T1 = Trend Assessment Approach 1

1.6 GENERAL UNCERTAINTY EVALUATION, INCLUDING DATA ON THE OVERALL UNCERTAINTY FOR THE INVENTORY TOTALS

An Approach 1 assessment of uncertainty is being provided with this submission. Total inventory uncertainty has been determined at 6.07% and trend uncertainty at 6.32%.

As part of its ongoing capacity building project, the inventory agency has recently undertaken support from external consultants (Aether Ltd., UK) by setting up a tool which provides detailed Uncertainty to Malta's national GHG inventory by updating the method to determine sector-specific uncertainties and determining overall inventory and trend uncertainties, for reporting in subsequent submissions.

1.7 GENERAL ASSESSMENT OF COMPLETENESS

A ‘complete’ inventory refers to an inventory which includes estimates for all relevant sources and sinks and gases, and that covers all the applicable geographic area of the country concerned.

Malta’s inventory strives to include all emissions and removals from all known sources and sinks within the whole Maltese territory. To this effect, Malta reports on all known sources of emissions and sinks. No known emissions or removals are left unreported by virtue of being considered to be insignificant. Where, for reasons duly identified, the estimation of emissions or removals was not possible, this is indicated using the appropriate NE (Not Estimated) notation key in the CRF tables.

CHAPTER 2 TRENDS IN GREENHOUSE GAS EMISSIONS

2.1 DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS FOR AGGREGATED GREENHOUSE GAS EMISSIONS

N.B. The emissions given in this chapter are calculated using the AR5 GWPs in accordance with the Governance Regulation where Member States have to report using the Global Warming Potentials (GWP) emanating from the IPCC Fifth Assessment Report (AR5). In view of this, the reporting of estimations will be updated from AR4 GWPs to AR5 GWPs.

The overall profile of total national emissions over the time-series 1990 to 2022 (Figure 2-1) shows a general increase in total national emissions from 1990 (2616.26 Gg CO2 eq. with LULUCF; 2626.17 Gg CO2 eq. without LULUCF) up to the year 2012 (3143.30 Gg with LULUCF CO2 eq.; 3142.60 Gg CO2 eq. without LULUCF), and a subsequent rapid general decrease until 2016 (1852.18 Gg CO2 eq. with LULUCF; 1851.27 Gg CO2 eq. without LULUCF). Total national emissions again showed an increase between 2017 and 2019 (2019.08 Gg CO2 eq.; 2134.06 Gg CO2 eq.), and then decreased slightly in 2020 (2094.38 Gg CO2 eq. with LULUCF; 2085.83 Gg CO2 eq. without LULUCF), the year of the Covid-19 pandemic. In 2022, the with LULUCF was 2263.44 Gg CO2 eq. and the without LULUCF was 2262.67 Gg CO2 eq.

The same trend profile is observed both for net (with LULUCF) and gross (without LULUCF) emissions. The LULUCF sector now reports net negative emissions, thus resulting in total emissions 'with LULUCF' being lower than 'without LULUCF' albeit by a marginal amount. The values for total national emissions are presented in Table 2-1.

As may be observed, the trend profile of total national greenhouse gas emissions follow closely that of the Energy sector. The Energy sector is the highest overall contributor to greenhouse gas emissions, by a significant margin over other sectors, especially towards the beginning of the time-series; thus, its influence on the total emissions profile is decisive. In turn, the Energy sector total is mostly determined by emissions emanating from the two main category contributors, energy generation and transport. Both contribute towards the increase up to 2012. Investment in new generation capacity, fuel switching, and alternative sourcing of electricity all contribute towards the rapid decrease in emissions observed for the years after 2012. This trend is reversed between 2016 and 2017, as there was a shift back towards local electricity generation as opposed to the previous use of the interconnector with mainland Europe's electricity grid.

Year-to-year changes for total national emissions across the period are presented in Figure 2-3.

The period up until 2012 shows a predominance of year-to-year increases, given the overall increasing emissions trend for that period. The decrease in emissions from 2012 to 2016 is reflected in year-to-year reductions, at relatively high rates (24.48% reduction between 2014 and 2015 emissions in particular). A significant increase of 13.34% is observed between 2016 and 2021 followed by an increase of 7.82% in 2022.

Annual percentage changes compared to 1990 emission levels are presented in Figure 2-4.

Especially evident in this graph is the peak in total emissions in 2012 (20.14% higher than 1990 levels), and the fact that 2016 emissions were lower than base year emissions (29.21% lower than 1990 levels). Estimated 2022 emissions were 13.49% lower than 1990 emissions.

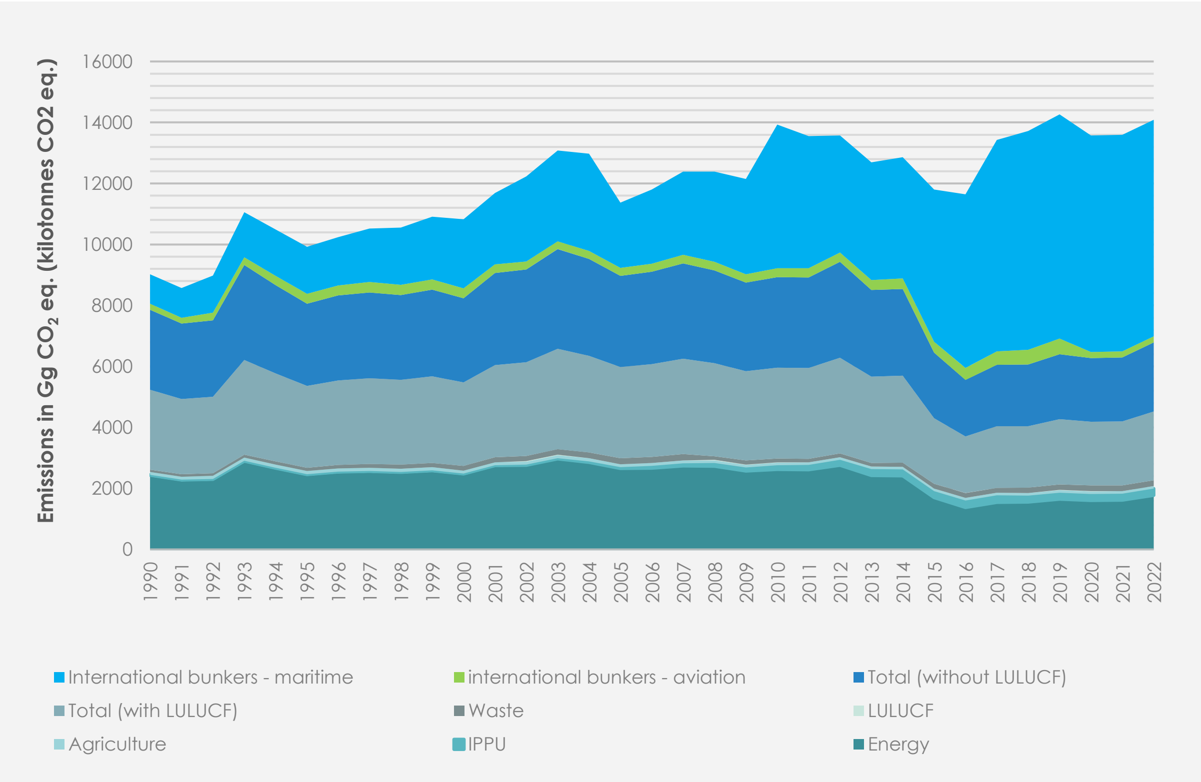


Figure 2-1 Greenhouse gas emission trends, by sector, including international maritime and aviation bunkers.

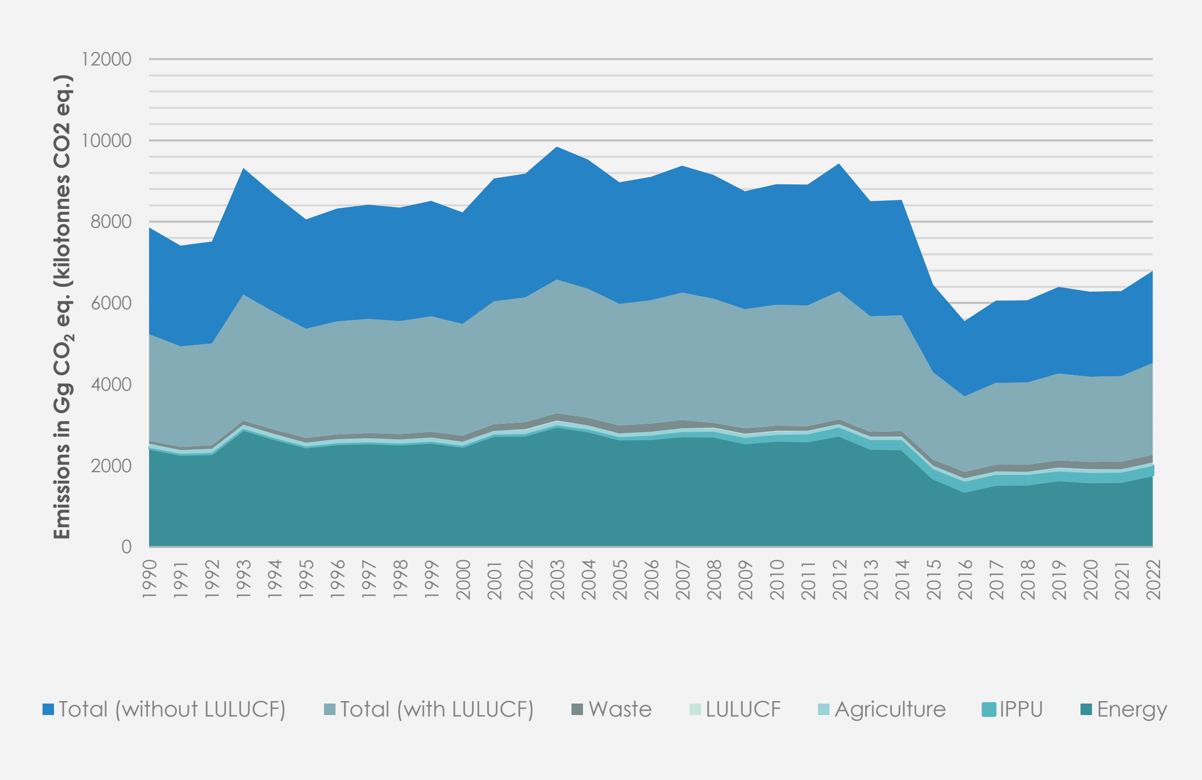


Figure 2-2 National greenhouse gas emission trends (by sector).

Table 2-1 National total greenhouse gas emission trends for select years (with/without LULUCF).

	Total national emissions with LULUCF (Gg CO2 eq.)	Total national emissions without LULUCF (Gg CO2 eq.)
1990	2616.26	2626.17
1995	2681.49	2690.78
2000	2740.59	2749.49
2005	2989.40	2989.43
2010	2979.31	2965.32
2015	2149.73	2148.53
2020	2094.38	2085.83
2022	2263.44	2262.67

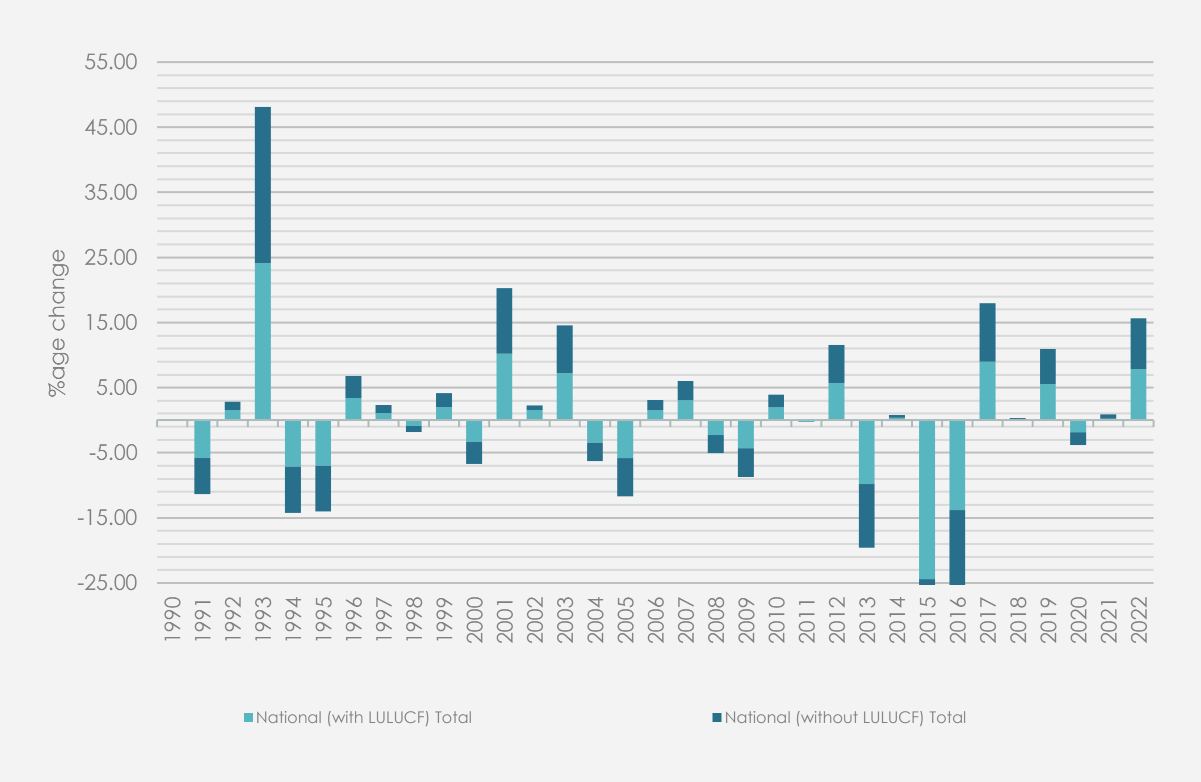


Figure 2-3 Annual year-to-year percentage change in total national emissions.

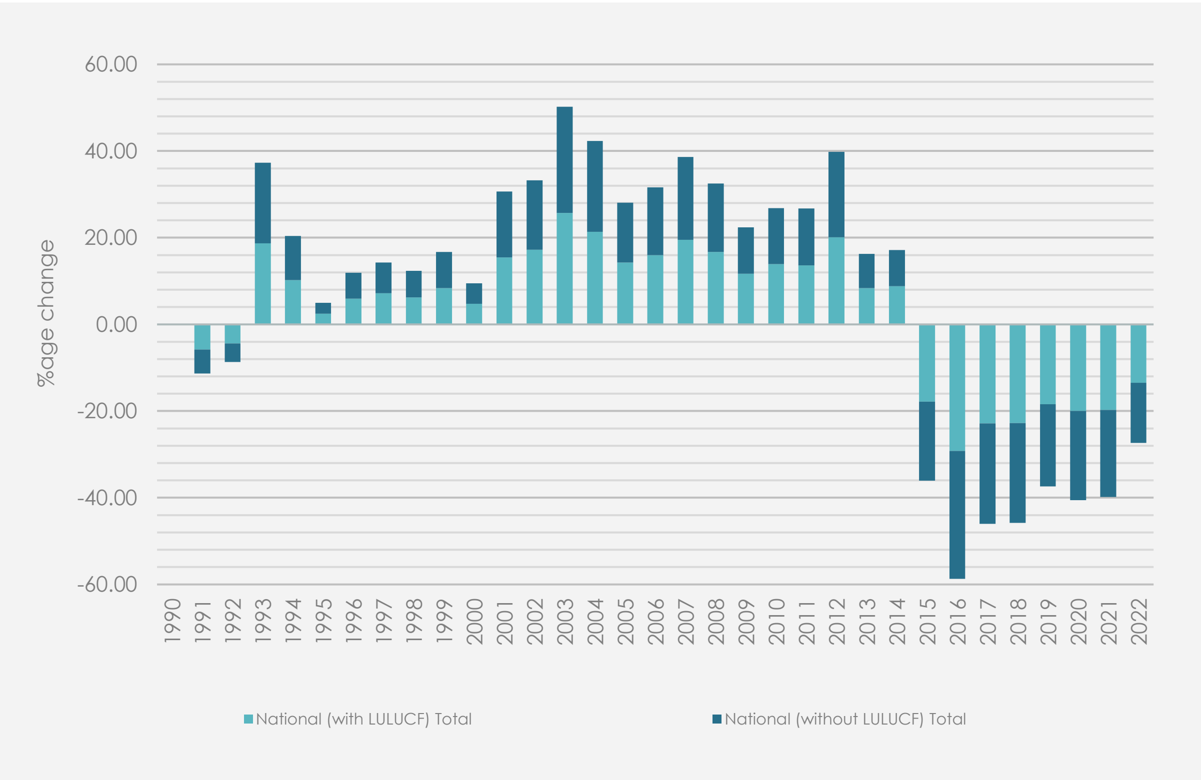


Figure 2-4 Annual percentage change from base year in total national emissions.

The figure below depicts the trend in total national emissions per capita alongside the population trend of the Maltese Islands. Historical data shows that there was a correlation between population and national total greenhouse gas emissions until 2012, following which a decoupling of these two parameters can be observed. The fact that total emissions have decreased over the time-period looked at means that population increases have not translated into emissions increases up to this point, due to emissions reduction efforts and technological improvements.

Population has grown steadily over the years. GHG emissions per capita remain fairly stable for the most part from 1990 until 2012, after which there is a significant drop-off. This is the result of the general decrease in emissions, which proves more significant than the high level of population growth seen in this period. Emissions per capita in 1990 stood at 7.23 tonnes CO2 eq. per capita, reaching their highest level in 1993 at 8.32 tonnes CO2 eq. per capita and a low of 4.02 tonnes CO2 per capita in 2016, with 4.18 tonnes CO2 eq. per capita being produced in 2022.

The decoupling between GHG emission trends and population trends for Malta in the latter years implies that population has not been a limiting factor in achieving emissions reductions up to this point. It is likely that greater demand for major emitting activities in Malta, particularly energy generation and mobility, resulting from population growth, could help to explain the increases in emissions seen until 2012, with substantial emission reductions due to major technical developments in the electricity generation sector counteracting any further increases after this point. So targeted measures in one sector or activity category have the potential to majorly impact overall emissions, in spite of continued population growth.

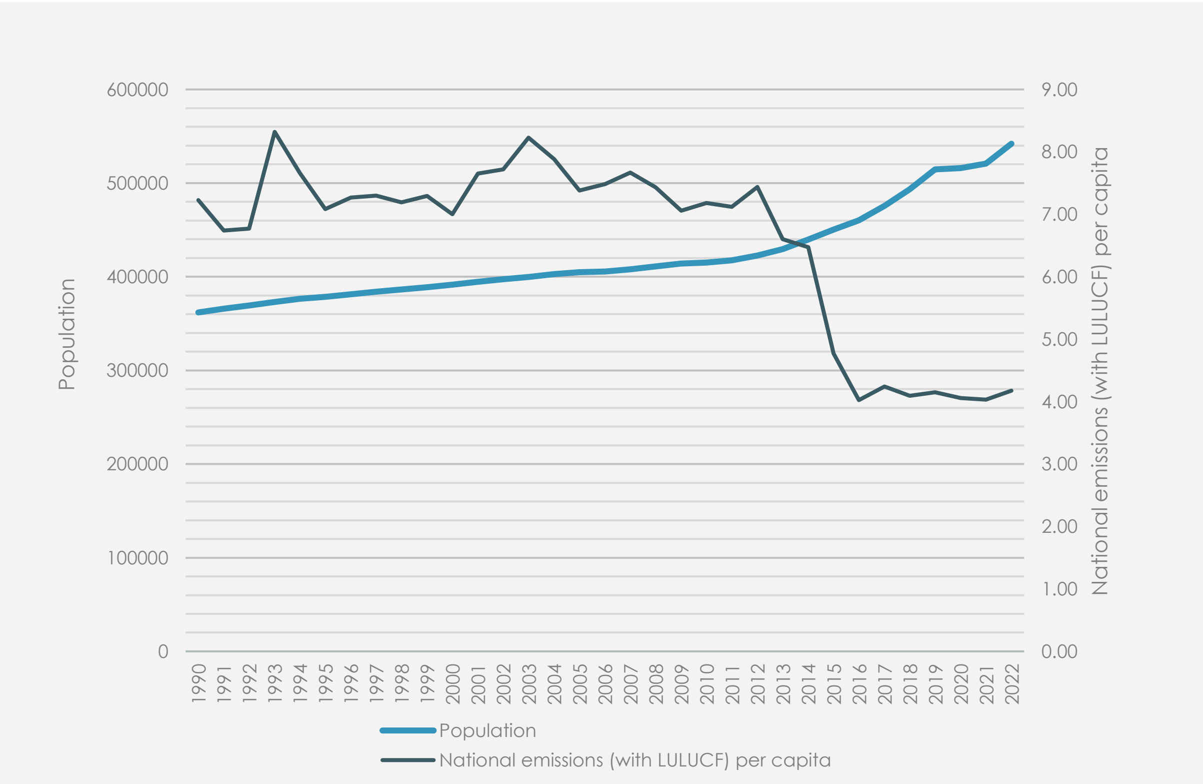


Figure 2-5 Trend in emissions per capita compared to population trend (end-of-year population figures).

2.1.1 TRENDS IN GREENHOUSE GAS EMISSIONS COMPARED TO GROSS DOMESTIC PRODUCT

The emission intensity of Malta's economic development can be described in terms of the relationship between the trend in national GHG emissions and the trend in Gross Domestic Product (GDP).

Figure 2-6, together with Table 2-2, shows how GHG emissions per unit million GDP changes over the time-series. The figure below also gives the trend for GDP. Overall, apart from the years 1990 to 1995, the trend is a continuous decrease in the emissions intensity of Malta's economy. Between 1990 and 2022, Malta's GDP saw an overall increase of 513.59%, while GHG emissions per unit million GDP in 2022 were 85.84% lower than in 1990.

Table 2-2 GHG emissions per unit of GDP (tCO2 eq./GDP) at 5-year intervals (with/without LULUCF).

	1990	1995	2000	2005	2010	2015	2020	2022
Emissions/GDP (with LULUCF)	951.56	876.40	704.71	579.43	437.12	215.04	160.37	134.17
Emissions/GDP (without LULUCF)	955.17	879.44	705.99	579.43	435.07	214.92	159.71	134.12

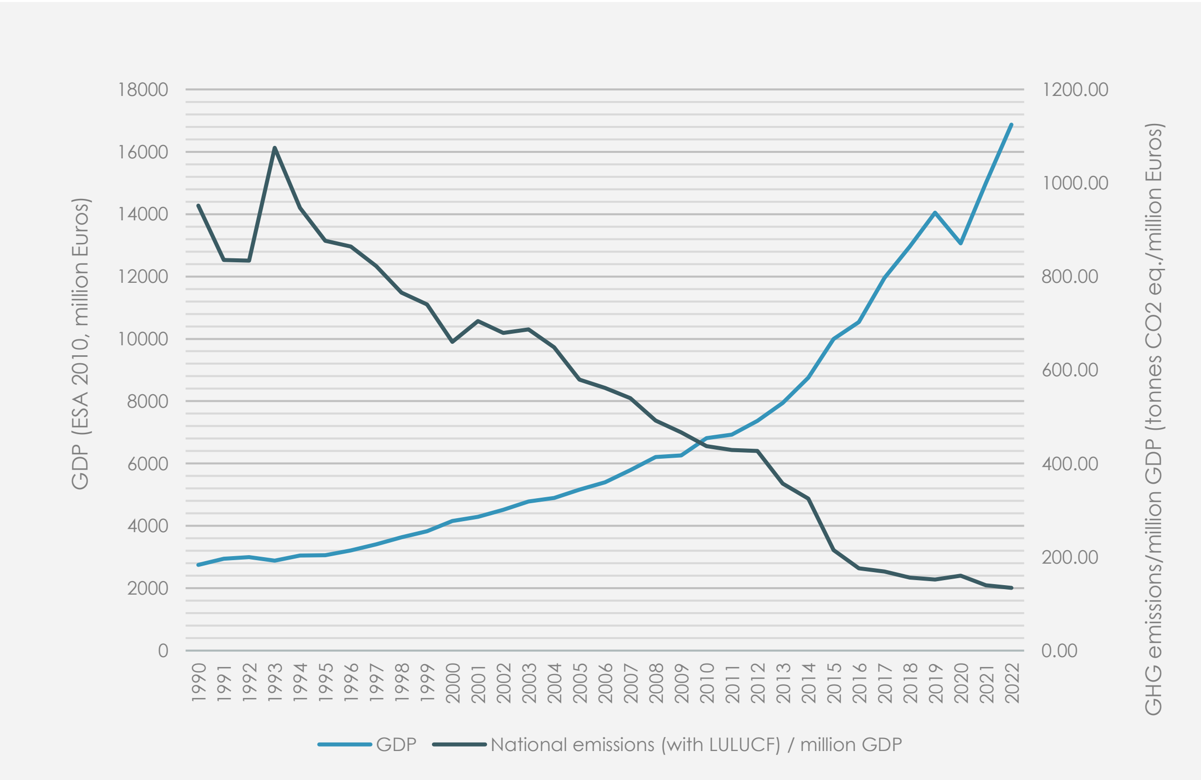


Figure 2-6 Trend in emissions per GDP compared to GDP trend.

The fact that emissions have fallen over the time-period looked at while GDP has increased means that economic growth has been decoupled from overall national emissions over this period. However, there are some further considerations to this point. The first is that not all sectors have been decoupled uniformly, as is shown in the below figure. What we see here is that the Transport, IPPU and Waste sectors have grown alongside GDP, while Energy Industries also did to some extent up until 2012. In the same way that population increases probably contributed to emissions being higher than they otherwise would have been, but these increases were counteracted by policy improvements, the same can be said about GDP (or GDP/capita).

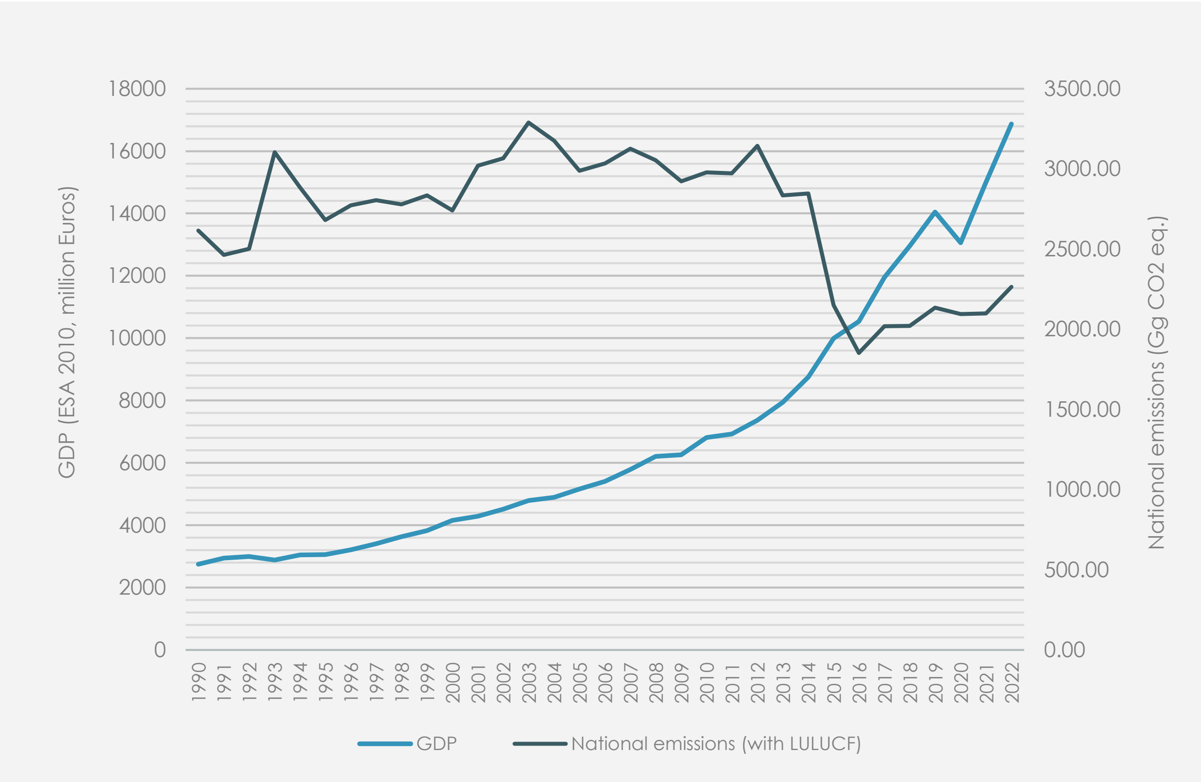


Figure 2-7 Trend in emissions of some high-emitting sectors compared to GDP trend.

A further consideration is the fact that a de-couplement has been achieved through policy intervention, meaning that such interventions will need to continue into the future to maintain this state.

2.2 DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS BY GAS

2.2.1 GENERAL DISCUSSION OF EMISSION TRENDS BY GAS

Carbon dioxide emission have by far the highest influence on total national emissions among all greenhouse gases reported (figure and table below). In fact, the trend for total national emissions closely follows a profile which is very similar to that of carbon dioxide emissions. It is important to also note the significant rate of increase in emissions of hydrofluorocarbons, particularly during the second half of the time-series, which contrasts with the trends of the other greenhouse gases reported. No emissions of nitrogen trifluoride are reported to occur in Malta.

Across the whole time-series, carbon dioxide emissions have always accounted for more than 70% of total national greenhouse gas emissions, surpassing 90% until 2003. This reflects primarily the influence of emissions from the Energy sector in total national emissions in comparison with emissions from other sectors, especially IPPU. As Energy sector emissions have decreased in recent years, coupled with the increase in emissions of HFCs in particular, the relative share of carbon dioxide emissions has decreased. On the other hand, the increase in emissions of HFCs from activities in the IPPU sector is represented by an increase in the share of HFCs in total national emissions (Figure 2-8).

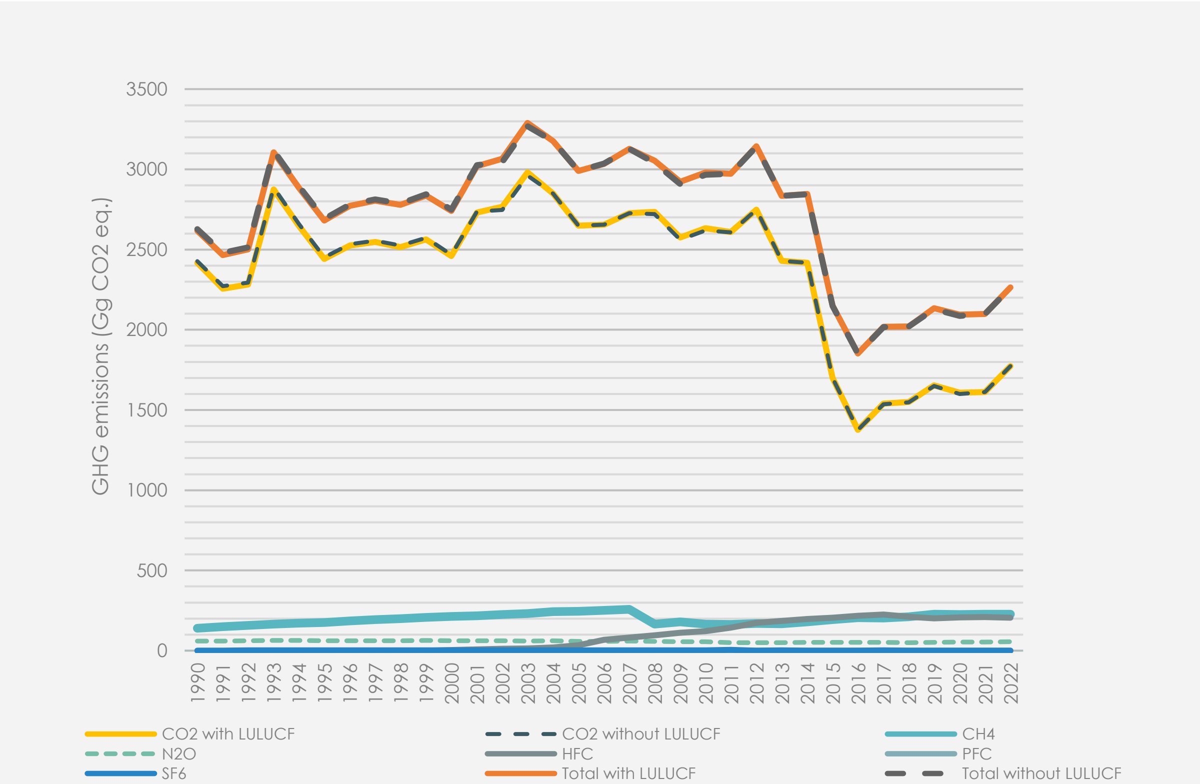


Figure 2-8 Greenhouse gas emission trends by gas

Table 2-3 Greenhouse gas emissions by gas for select years.

	CO2 with LULUCF	CO2 without LULUCF	CH4	N2O	HFC	PFC	SF6	NF3	Total with LULUCF	Total without LULUCF
					Gg CO2 eq.					
1990	2417.14	2427.40	139.76	59.35	NO,NE,IE,NA	NO,NA	0.01	NA	2616.26	2626.17
1995	2442.53	2452.13	175.68	61.80	0.00	NO,NA	1.48	NA	2681.49	2690.78
2000	2458.99	2468.15	212.93	62.52	4.63	NO,NA	1.51	NA	2740.59	2749.49
2005	2649.49	2649.76	245.51	58.64	34.15	NO,NA	1.61	NA	2989.40	2989.43
2010	2633.00	2619.14	166.09	56.18	122.21	0.00	1.84	NA	2979.31	2965.32
2015	1700.42	1699.36	193.48	50.89	204.64	0.00	0.29	NA	2149.73	2148.53
2020	1608.35	1600.39	225.33	53.72	206.56	0.00	0.41	NA	2094.38	2085.83

2022	1774.18	1773.99	227.37	56.66	204.97	0.01	0.25	NA	2263.44	2262.67

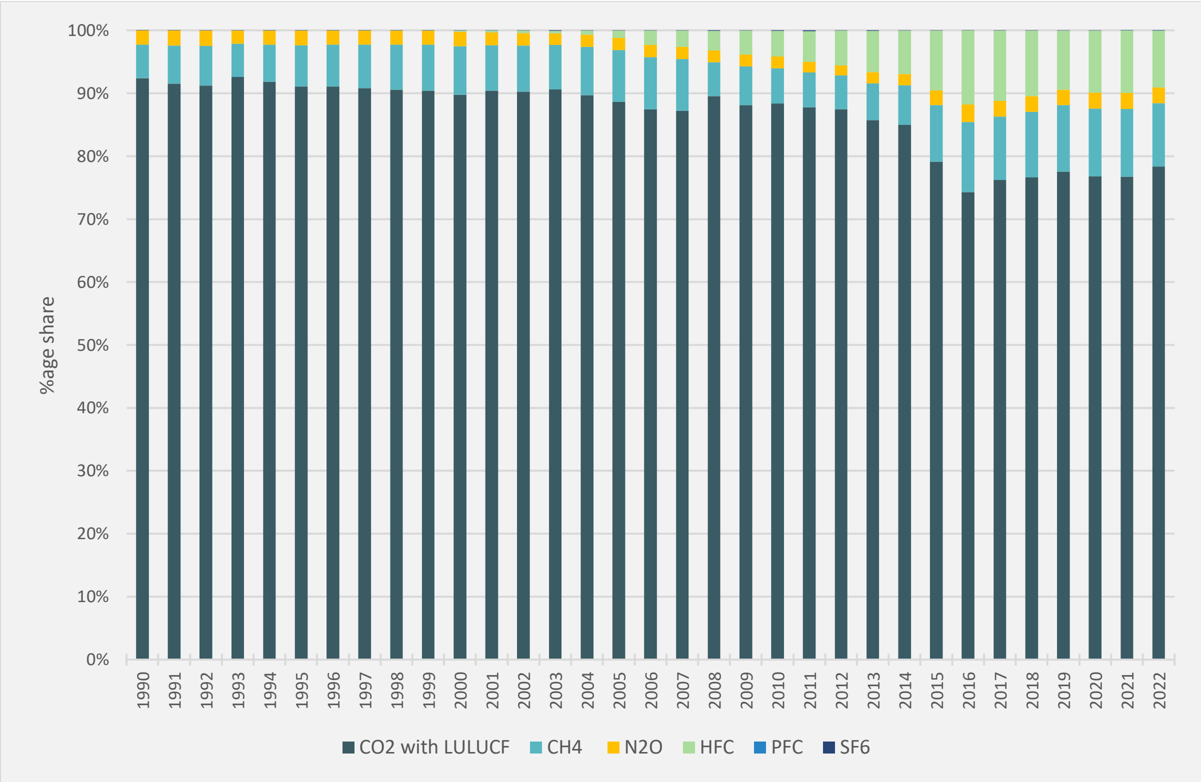


Figure 2-9 Annual percentage share of total national emissions for each GHG

The table below provides a summary of the percentage contribution of Malta's total GHG emissions by sector and by gas for the reporting year.

Table 2-4 The contribution (%) of Malta's total GHG emissions by sector and by gas in 2022.

Sector	GHG emissions (%)			
	CO2	CH4	N2O	F-Gases
Energy	99.66	1.12	11.90	NO
IPPU	0.32	NO	3.92	96.17
Agriculture	NO	20.07	71.40	NO
LULUCF	0.01	NO	1.02	NO
Waste	0.01	78.81	11.76	NO

NO refers to Not Occurring.

2.2.2 *CARBON DIOXIDE*

As already noted, carbon dioxide emissions account for the largest share in total national emissions among all the greenhouse gases reported here. The sector that has the highest contribution towards total CO2 emissions is Energy, being responsible for more than 99% of total carbon dioxide emissions in all years between 1990 and 2022 (1990 share (excluding LULUCF): 100.2%; 2022 share (excluding LULUCF): 99.66%). Very small contributions are given by sectors IPPU (0.32%), LULUCF and Waste (<0.1%).

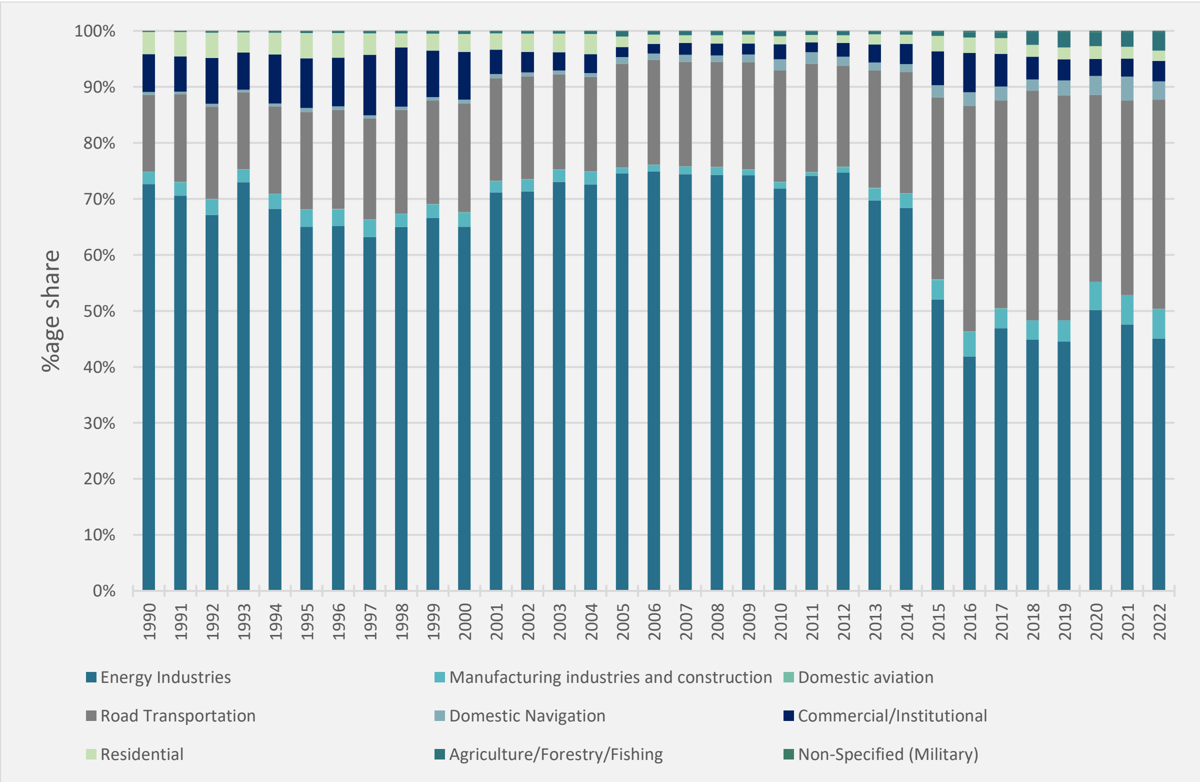


Figure 2-10 Annual percentage share in total carbon dioxide emissions in sector Energy, for activity categories in this sector.

2.2.3 *METHANE*

Sectors Waste and Agriculture are the two main contributors towards total national methane emissions (figure below). In 2022, sector Waste accounted for 78.81% of total national methane emissions, with a 20.07% contribution by sector Agriculture. A much smaller share is provided by the Energy sector (1.12%).

In the Waste sector, methane emissions are predominantly the result of activities in the category Solid Waste Disposal. Enteric fermentation in cattle is the main source of methane emissions in the Agriculture sector, making it the second highest contributor at the level of categories.

No methane emissions are reported for sectors IPPU and LULUCF.

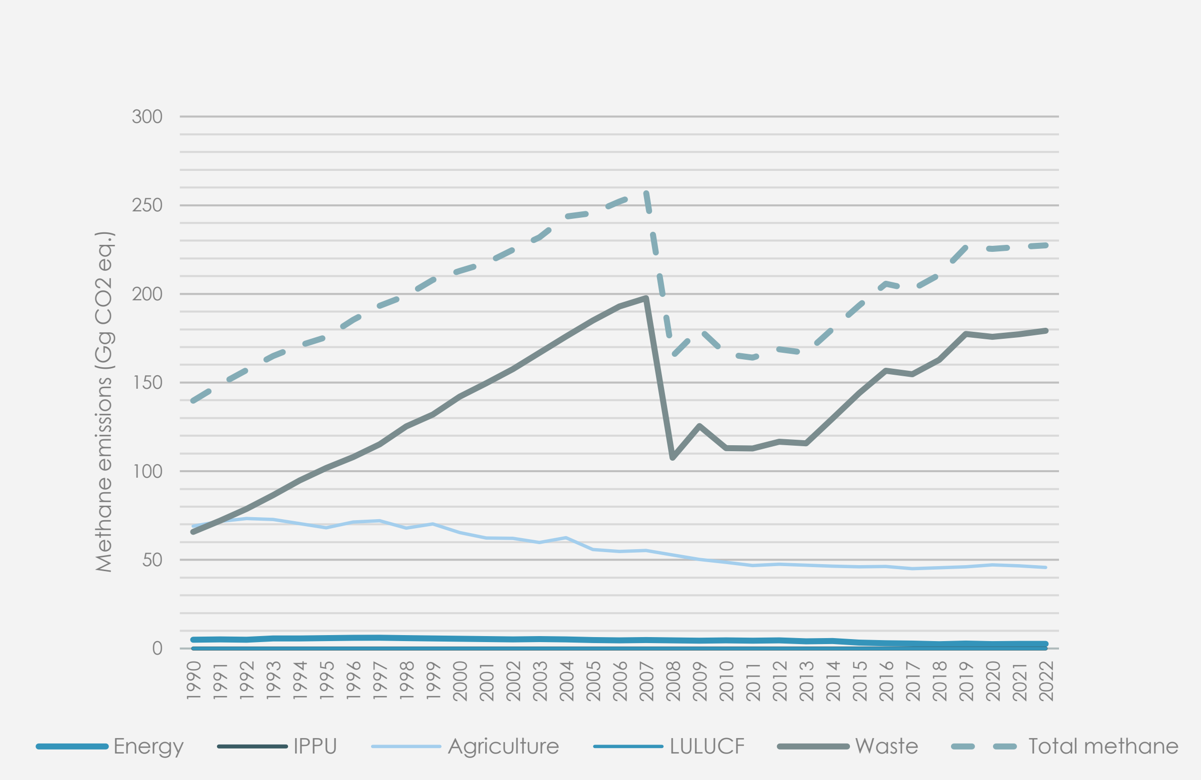


Figure 2-11 Emission trends: methane, total and by sector.

2.2.4 NITROUS OXIDE

The main source of emissions of nitrous oxide in Malta is the Agricultural sector, with smaller, but still relatively important contributions by sectors Waste and Energy, and an even lower share for IPPU and LULUCF (figure below).

The relative share of sector Agriculture in total national nitrous oxide emissions in 2022 was 71.40%, not much higher than it was in 1990 (66.70%). The relative share of sector Energy had been increasing over time, while that of sector Waste was decreasing, but this trend has reversed recently.

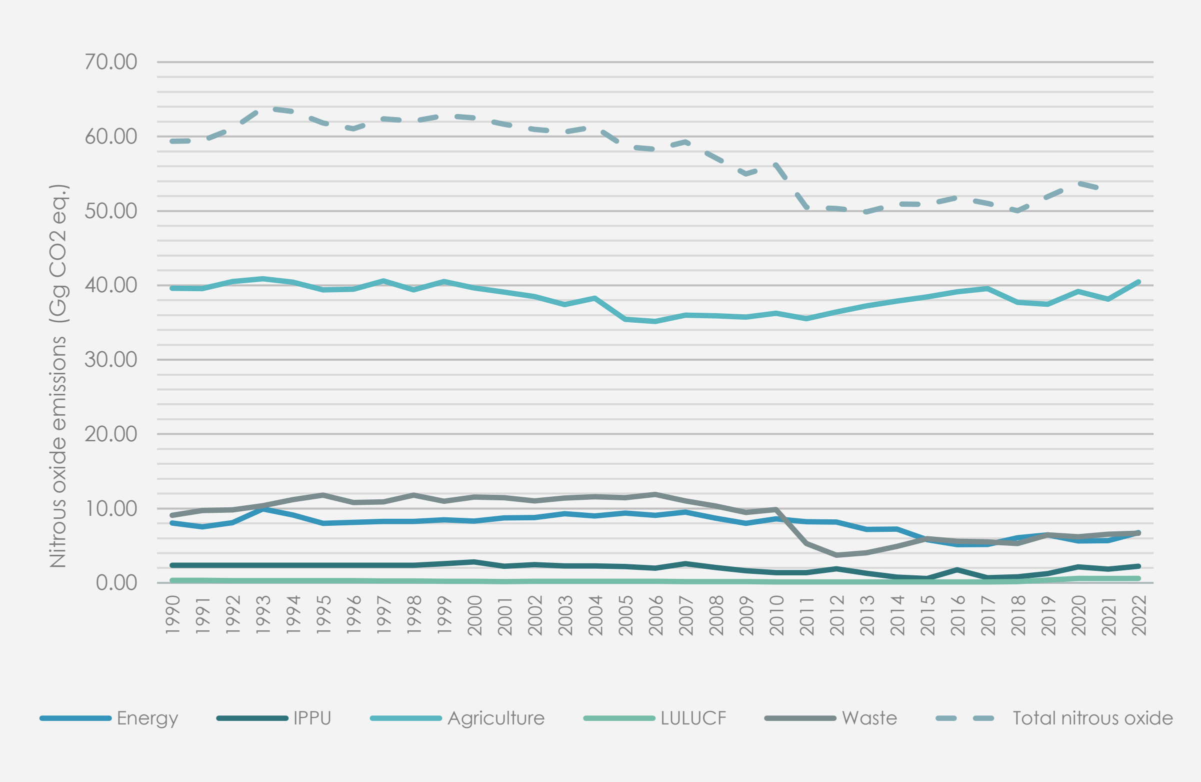


Figure 2-12 Emission trends: nitrous oxide, total and by sector.

2.2.5 *FLUORINATED GASES*

Fluorinated greenhouse gases encompass hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride (no emissions of nitrogen trifluoride are reported in Malta), emissions of which are reported under sector IPPU. HFCs are by far the most important class of fluorinated gases reported by Malta, in terms of overall emissions. The rapid increase in emissions of HFCs, especially since the early 2000's when their emissions start making a contribution to national total emissions, is clearly evident from Figure 2-13.

The importance of emissions of HFCs is also reflected in the fact that this class of gases accounts for a very high share of total sector IPPU emissions. Suffice to say that in 2022, emissions of HFCs account to 96.17% of total emissions, of all gases, in sector IPPU.

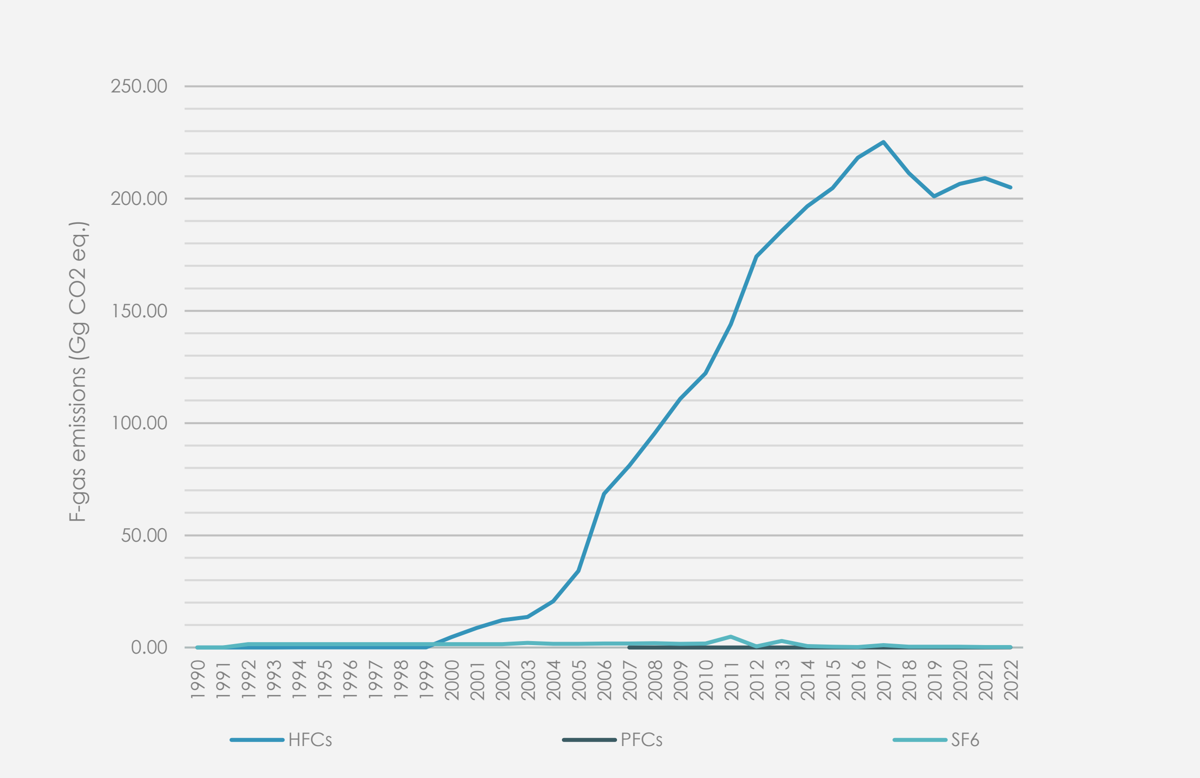


Figure 2-13 Emission trends: fluorinated gases.

2.3 DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS BY SECTOR

2.3.1 GENERAL DISCUSSION OF EMISSION TRENDS BY SECTOR

Table 2-5 gives a summary of emissions by sector totals for the time-series covered by this report. The trends in emissions changes for each sector are presented in the below figure.

Greenhouse gas emissions by sector for select years.

Table 2-5 Greenhouse gas emissions by sector for select years.

	Energy	IPPU	Agriculture	LULUCF	Waste	Total with LULUCF	Total without LULUCF
				Gg CO2 eq.			
1990	2434.94	7.50	108.51	-9.91	75.22	2616.26	2626.17
1995	2460.35	9.07	107.38	-9.30	113.97	2681.49	2690.78
2000	2477.85	12.64	105.01	-8.91	153.99	2740.59	2749.49
2005	2659.91	41.62	91.17	-0.03	196.73	2989.40	2989.43
2010	2628.25	129.03	84.77	13.99	123.28	2979.31	2965.32
2015	1698.35	215.14	84.43	1.19	150.61	2149.73	2148.53

2020	1603.37	213.58	86.30	8.54	182.57	2094.38	2085.83
2022	1777.35	213.13	86.09	0.77	186.09	2263.44	2262.67

The overall impact that the Energy sector has on total national emissions has already been mentioned. In recent years, emissions of this sector have started to decrease in general. On the other hand, emissions from the IPPU sector, strongly represented by emissions of HFCs, are showing a substantial rate of increase, particularly since 2000. The relative share of emissions of IPPU has therefore grown compared to those of the Energy sector as shown in Figure 2-14.

The table below provides a summary of the percentage contribution of Malta's total GHG emissions by sector for the reporting year 2022.

Table 2-6 Contribution (%) of Malta's total GHG emissions by sector in 2022.

Sector	% Contribution of Malta's total GHG emissions
Energy	78.52
IPPU	9.42
Agriculture	3.80
LULUCF	0.03
Waste	8.22

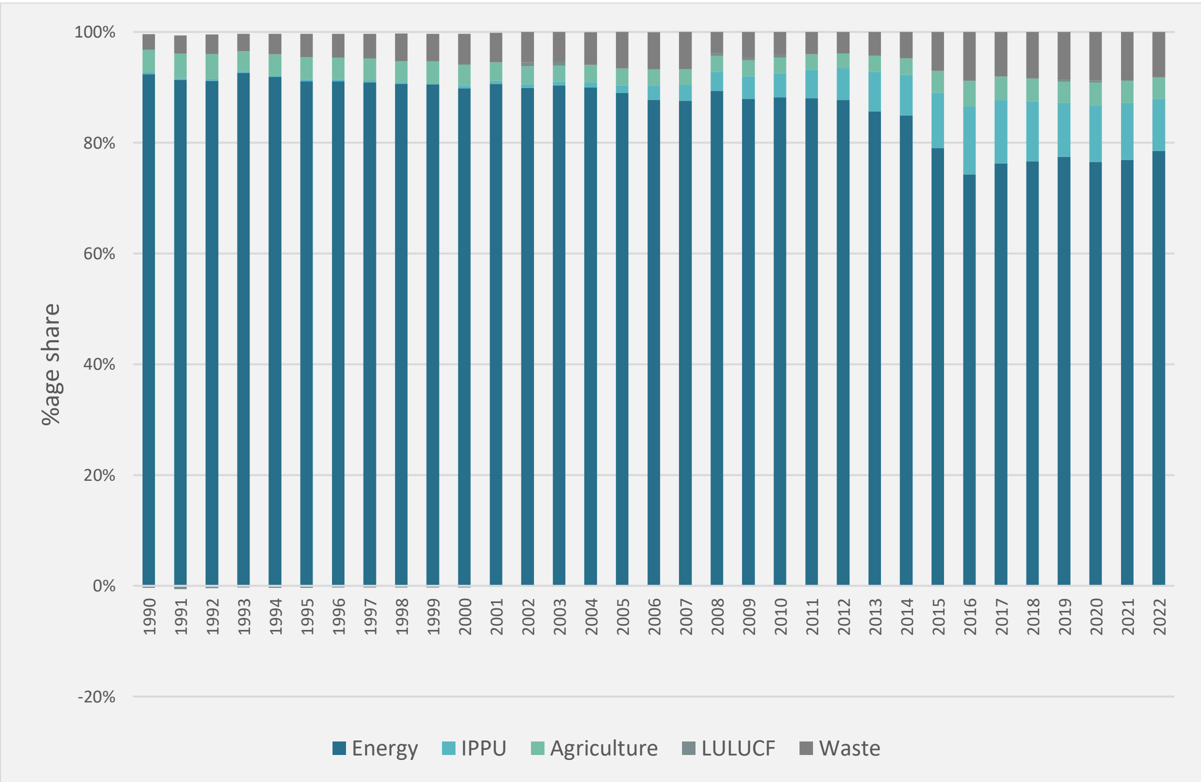


Figure 2-14 Annual percentage share of national emissions for sector.

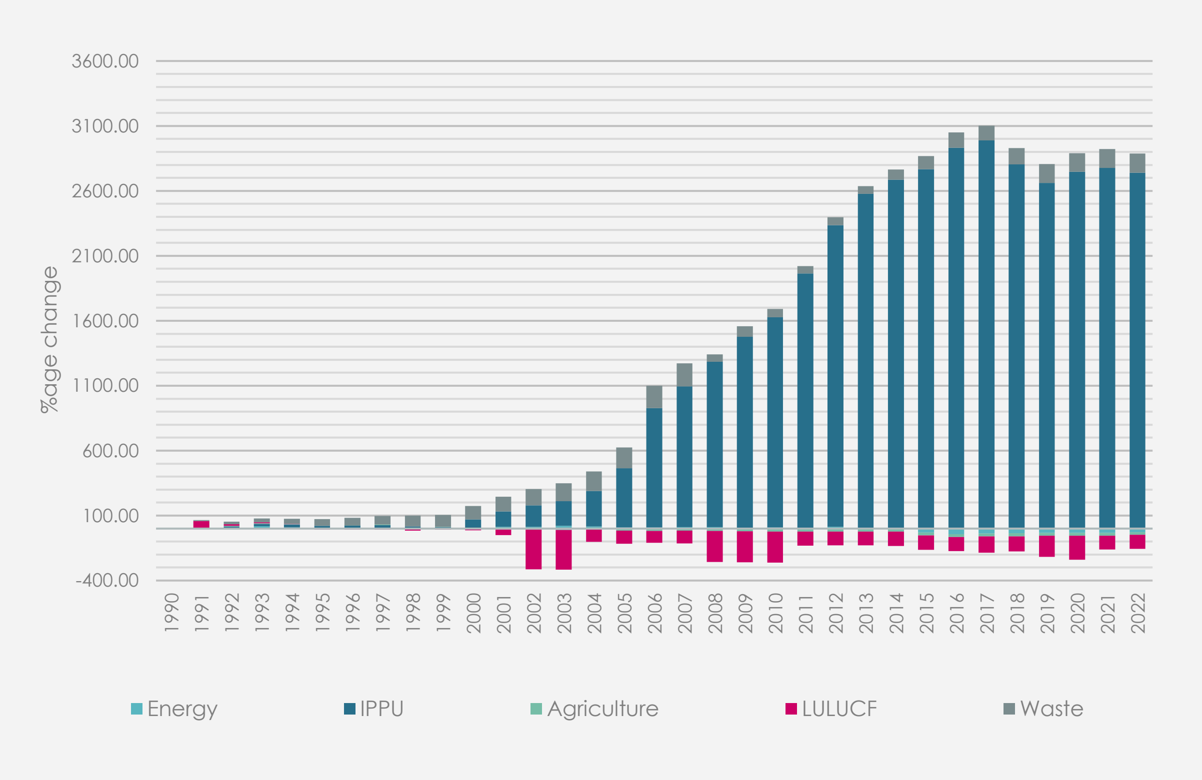


Figure 2-15 Annual percentage change compared to 1990, by sector.

2.3.2 SECTOR ENERGY EMISSIONS

The trend profile for the Energy sector can be split into two main sub-trends, namely a general increase in emissions up to 2012, followed by a rapid decrease over the space of the subsequent few years until 2016, with emissions growing again in 2017. As estimated for year 2022, the energy sector contributes to 78.52% of Malta's total GHG emissions.

Up to 2012, the growth in emissions reflects growing demand for energy, especially electricity generation and transport. The significant efficiency gains achieved in the energy generation sector post-2012 have then impacted on the overall sector emissions in recent years: these gains have been achieved primarily through technical developments taking place in recent years, including investment in new, more efficient local generation capacity, the sourcing of electricity through an interconnector with mainland Europe, and fuel switches including the discontinuation of use of heavy fuel oil. The increase in emissions observed in 2017 compared to 2016 is mainly due to a renewed shift towards indigenous electricity generation, as opposed to outside sourcing, though the impact is markedly subdued because of the shift to natural gas as the main generation fuel.

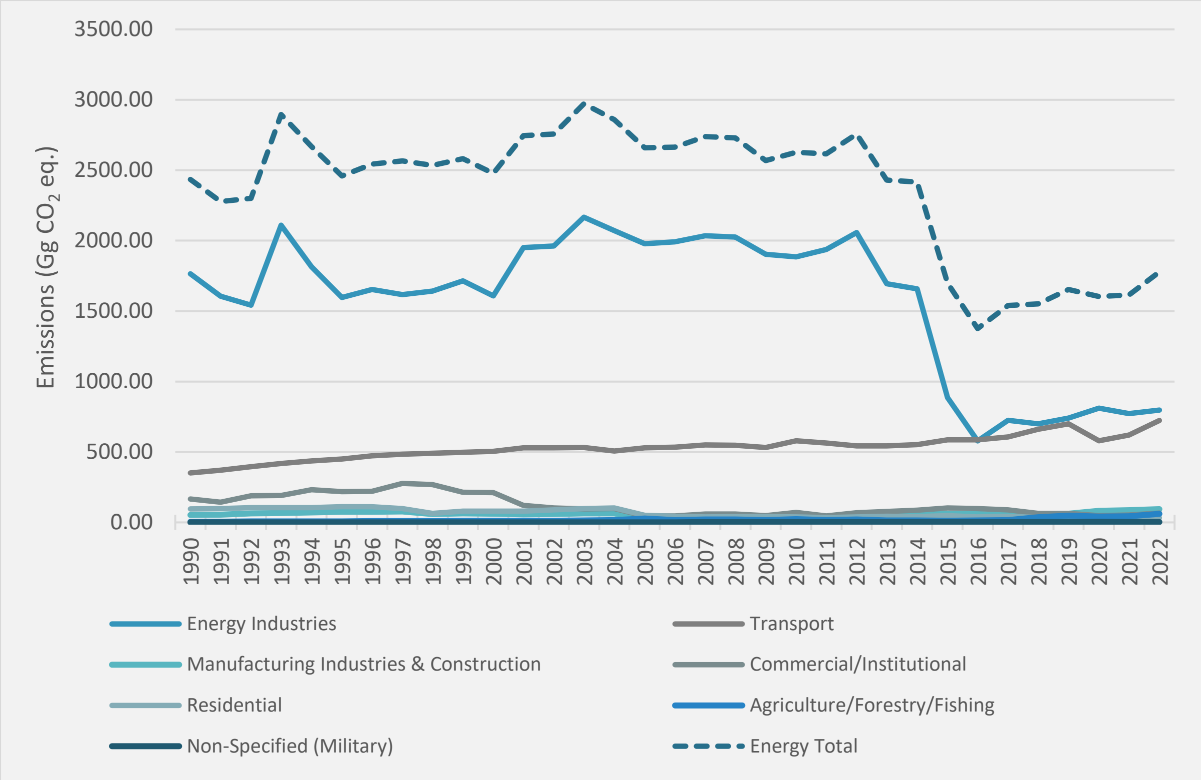


Figure 2-16 Emission trends for sector Energy, by category

The sharp change in the trend for emissions from category Energy Industries (1A1) clearly shows the potentially high impact of focussed policies and measures targeted towards an activity which is defined by a relatively small number of clearly identifiable point sources, especially in the context of a small country such as Malta. It is to note that up to 2016, Public Electricity Production was concentrated in two power generation plants, the Marsa Power Station and what was formerly called the Delimara Power Station. In 2017, the latter was split into two separate commercial enterprises with a fourth new installation built adjacent. Thus, Malta now has four distinct electricity generation plants, with the Marsa plant operating in a much-reduced form and only run on stand-by basis for emergency use.

Emissions from the category Transport (1A3; includes road transport, civil aviation and national navigation within the Maltese Islands; does not include international aviation and navigation activities, which are considered as memo items and not included in national totals) account for a contribution towards total national emissions that in recent years is comparable to that of category Energy Industries. In general, Transport emissions show a sustained gradual increase over the whole time series, with emissions in 2016 estimated to be highest for any category, including surpassing emissions from category Energy Industries.

Sub-category Road Transport (1A3b) is by far the biggest contributor to national total emissions among the three Transport sub-categories mentioned above. This reflects primarily the continued growth in the number of road vehicles.

The bulk of emissions from the Energy sector are carbon dioxide; in 2022, emissions of methane and nitrous oxide for this sector accounted for 0.14% and 0.38% respectively.

The trend of road transport emissions has increased proportionally with the increase in Malta's car fleet. The stock of licenced vehicles in Malta stood at 424,904 by Q4 of 2022. According to a National Statistics Office News Release entitled 'Motor Vehicles: Q4/2022', a total of 4,992 newly licensed vehicles were added to Maltese roads in 2022 with the majority or 60% being passenger cars. This figure was followed by 1,601 newly licensed motorcycles and e-bikes or 33% of all the newly licenced vehicles.

2.3.3 SECTOR IPPU EMISSIONS

The trend profile for sector IPPU (figure below) is clearly dominated by the emissions trend of HFCs, particularly from category Refrigeration and Air-conditioning (CRF 2.F.1). Emissions of HFCs, and, consequently, IPPU emissions, have increased from the early 2000s. Category Refrigeration and Air Conditioning, accounted for 94.51% of all direct greenhouse gas emissions estimated for the IPPU sector in 2022. Emissions from other industrial processes are minimal or even non-existent, considering the nature of the industrial sector in Malta, where industrial activities found in other countries either do not exist or only take place at very small scales.

The emissions contribution from the IPPU sector to the total national GHG emissions in Malta amounted to 9.42% in 2022.

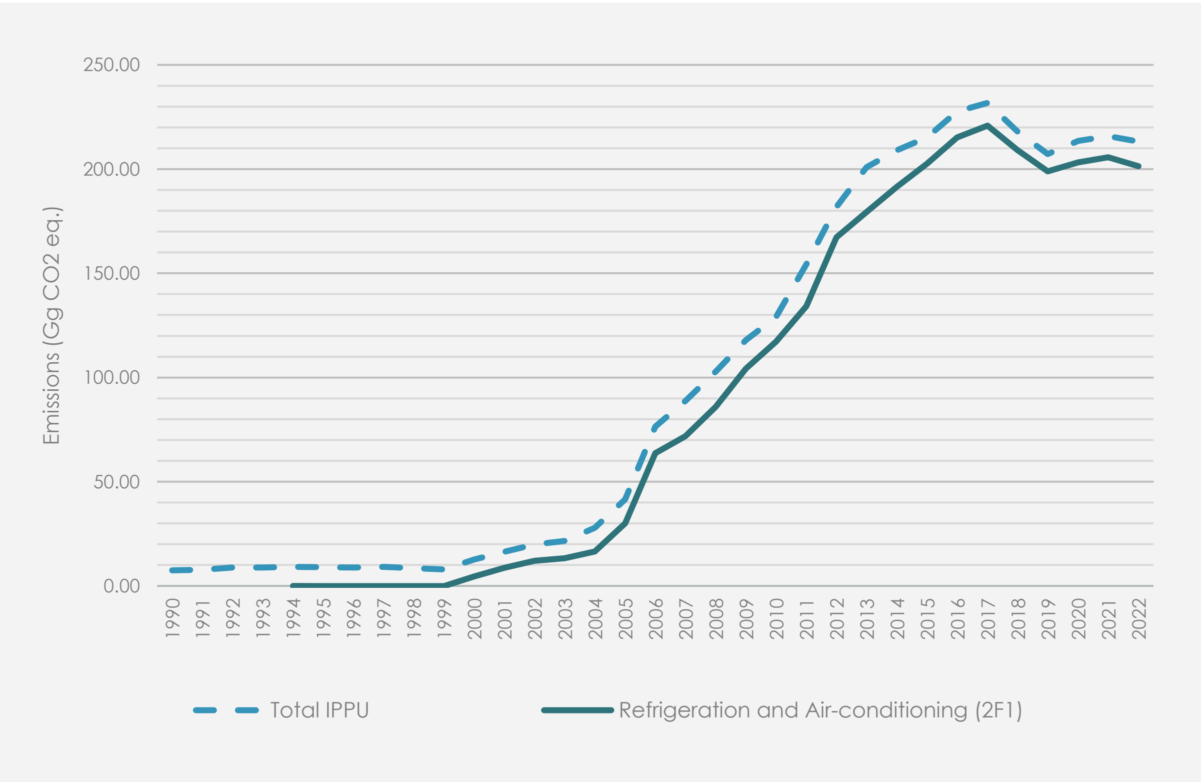


Figure 2-17 Emission trends for sector IPPU.

2.3.4 SECTOR AGRICULTURE EMISSIONS

In general, the agriculture sector is certainly not a major contributor towards total national emissions, as has already been discussed above. The sector has seen a decrease in emissions of around 20% over the 1990 and 2022 period. Within this sector (figure below) the category Enteric Fermentation (3A) has always had the highest share of total sector emissions. In 2022, Enteric Fermentation accounted for around half of the agriculture emissions (45.67%) (figure below), while manure management accounted for 20.59% and agricultural soils accounted for 33.74% of total emissions. In agriculture only two gases are being reported, Nitrous oxide and methane. Methane emissions originate from enteric fermentation and manure management, while nitrous oxide emissions are emitted from manure management and agricultural soils.

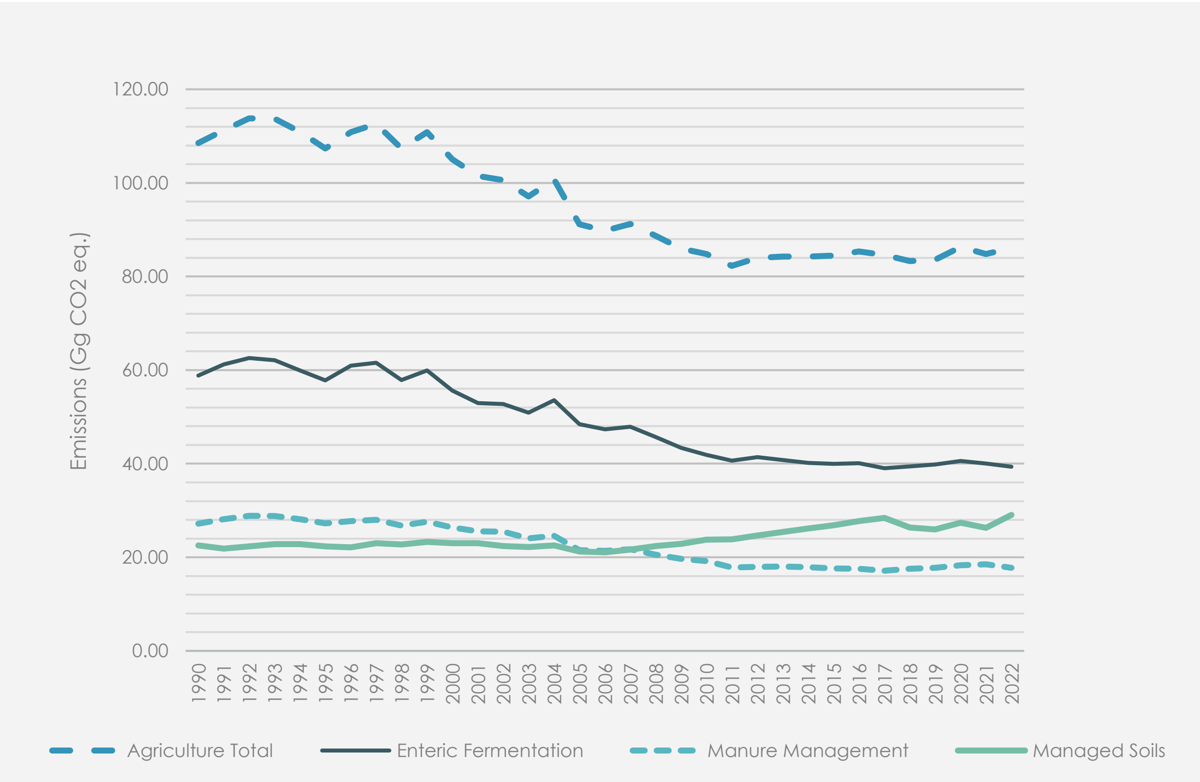


Figure 2-18 Emission trends for sector Agriculture

Livestock populations have decreased significantly compared to 1990 levels. These changes could be attributed to the rise in the import of meat and dairy products. As a result of these changes in livestock populations and manure management systems, methane emissions from Enteric Fermentation and Manure Management have also declined. The total agricultural area, UAA and fodder crop land, have also decreased; consequently, so have the nitrogen application rates and the Nitrous Oxide emissions.

Methane emissions accounted for 53% of total agriculture emissions, while nitrous oxide accounted for 47% respectively. Enteric fermentation accounted for 86% of total methane emissions, whereas those coming from the management of manure accounted for 14%. Manure management was responsible for 17.67% of nitrous oxide emissions, while 72% of N2O emissions originated from Agricultural soils.

GHGs from manure management and agricultural soils are emitted both directly and indirectly, the latter of which occurs through atmospheric deposition and through leaching and runoff. During 2022, indirect emissions from atmospheric deposition and leaching/runoff totalled to 7.26 GgCO2eq, while direct emissions amounted to 21.79 GgCO2eq. Although in the Maltese agricultural sector both inorganic (synthetic fertilizer) and organic fertilizer (animal manure) is applied to soils, animal manure is applied for the most part. In 2022, it estimated that around 1,987,927 KgN of animal manure were applied per hectare, while 2,054,448 KgN of synthetic fertilizer and 396,035 KgN of organic fertiliser were applied per hectare.

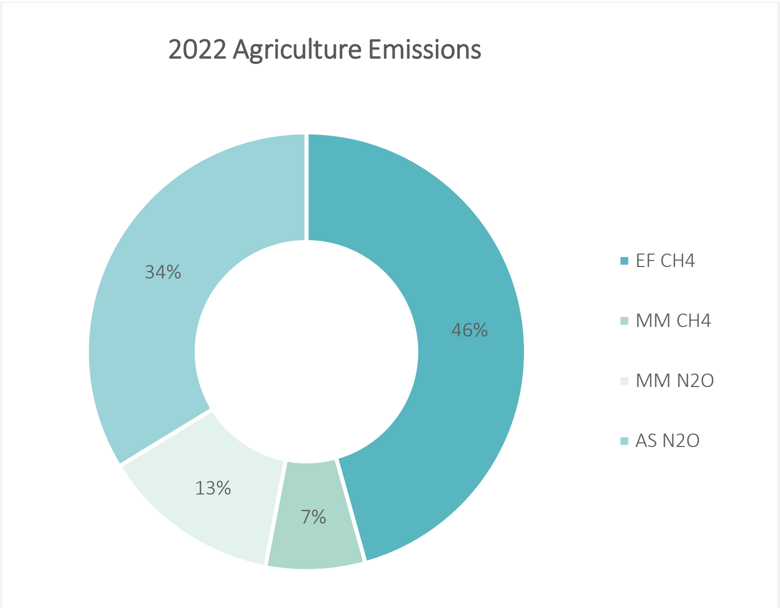


Figure 2-19 Percentage share of agriculture emissions by gas and category for the year 2022

2.3.5 SECTOR LULUCF EMISSIONS

The LULUCF sector has undergone updates with regards to the land use matrix. The LUM was developed to better represent the land use representation, in view of the implementation of the new updates, based on the land use imagery developed during the project in collaboration with MCAST. As a result, noting the revision in the land use matrix to better represent the different land use categories of Malta and the conversion within the years, some estimations were recalculated for certain years as relevant.

In this inventory, calculations from the categories Forest Land (CRF 4.A), Cropland (CRF 4.B), Grassland (CRF 4.C), Wetlands (CRF 4.D), Settlements (CRF 4.D) and Other Land (4.E) were estimated (more details on the estimations for the categories are given in the corresponding category sections of the LULUCF chapter). CO2 is the main greenhouse gas emission source and sink from the various categories. Non- CO2 emissions also occur in the sector including N2O and CH4. As of the latest inventory, the sector in Malta represents a net removal of -9.91 ktCO2 eq. in 1990, decreasing to 0.77 ktCO2 eq. by 2022. The sector accounted for less than 1% of Malta's total GHG emissions in 2022.

The main source of emissions throughout the whole time-series was represented by the land transitioning to Cropland. Land transitioning to Grassland represents the main sink in the time-series. One can instantly notice the sharp shifts in the emission and removal profile of Cropland. The spikes that are occurring in the estimations in the sector, to the category Land Converted to Cropland in some of the years, are due to the big annual changes occurring in Annual Cropland, where in some of the years, national statistics for 2001, 2003, 2005, 2007 and 2010 etc. are present, while assuming a linear interpolation for the years without data. Unfortunately, this presents an issue and is very challenging to solve, since getting rid of these spikes would mean changing national statistics data. Work is currently ongoing on the collaboration project with MCAST to acquire an improved land use representation data, and thus update the land use time series as necessary.

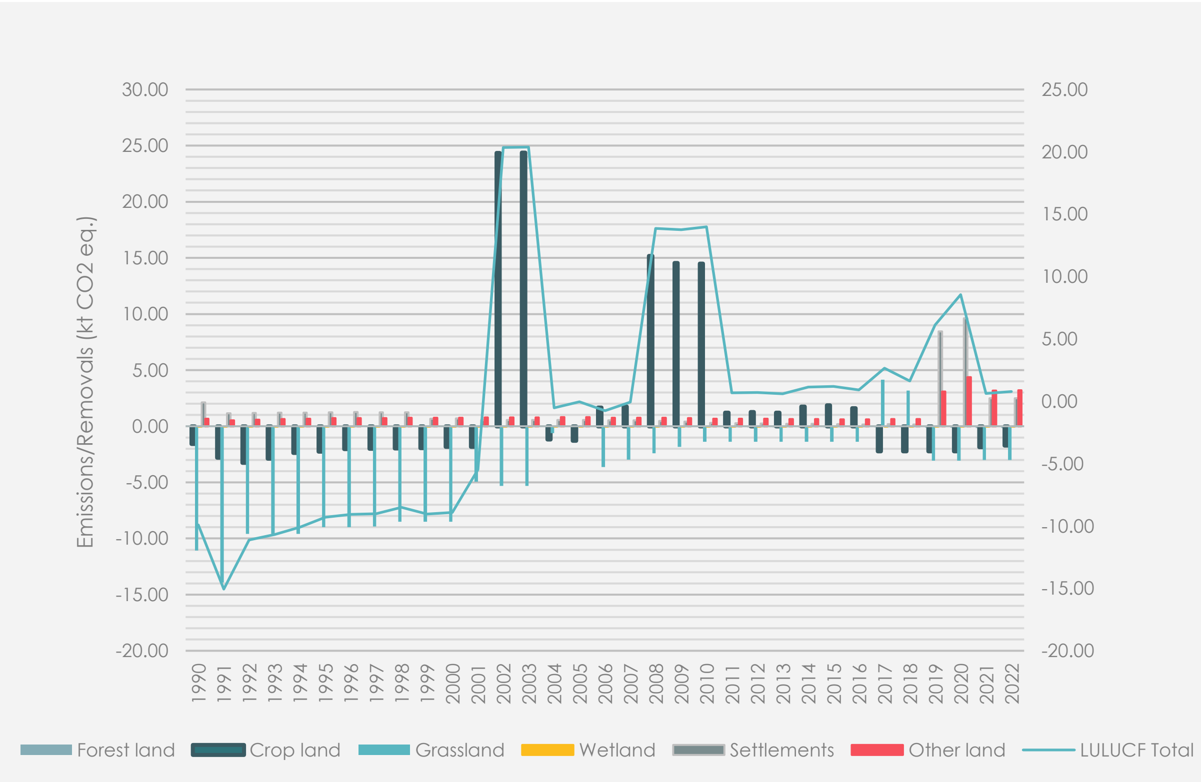


Figure 2-20 Emission trends for sector LULUCF.

2.3.6 SECTOR WASTE EMISSIONS

The general profile of the trend of emissions from sector Waste is evidently greatly influenced by the profile of emissions for category Solid Waste Disposal (5A), this also being the category with the highest share of emissions in this sector. Until the upsurge in IPPU emissions, Waste was the second highest contributing sector towards total national emissions in Malta.

In 2022, 90.59% of all sector Waste emissions were generated by the category Solid Waste Disposal (figure below). Methane emissions from this category are also the predominantly emitted greenhouse gas in this sector; emissions of nitrous oxide and carbon dioxide have relatively small shares of total sector emissions. In fact, a relatively large proportion of emissions reported are emitted from landfill operations.

As estimated for year 2022, the Waste sector contributes to 8.22% of Malta's total GHG emissions.

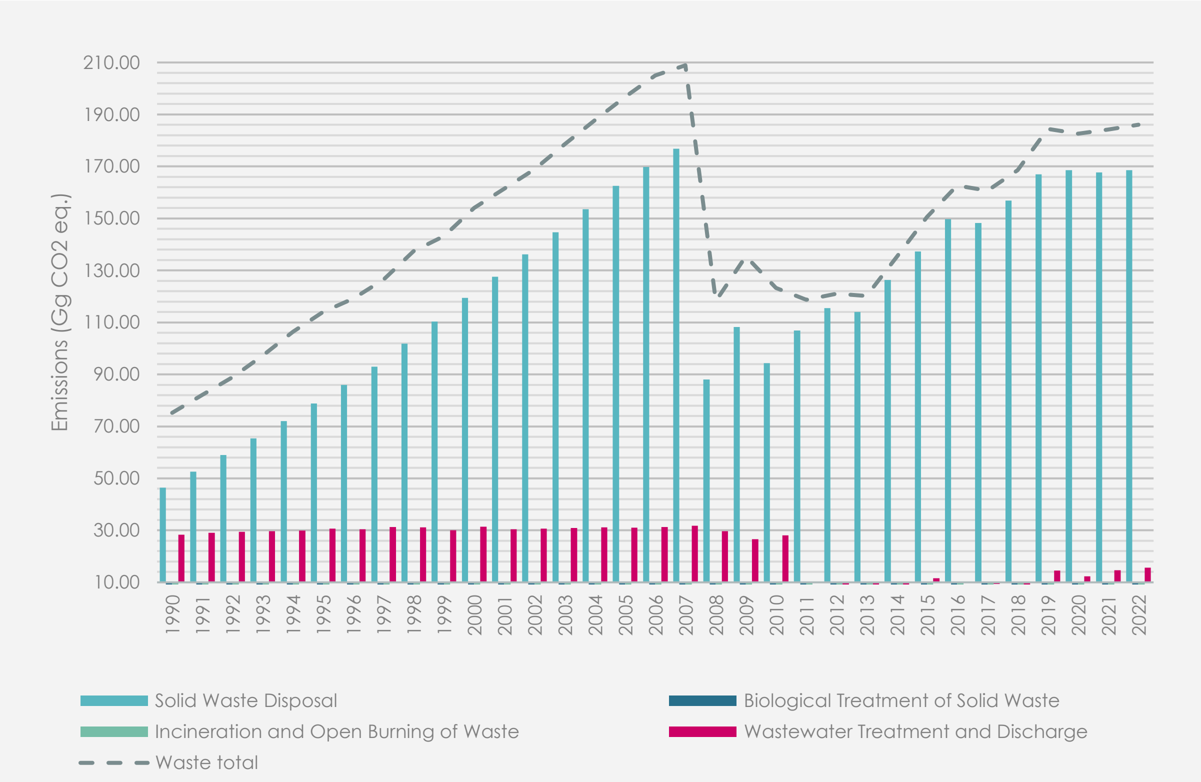


Figure 2-21 Emission trends for sector Waste.

As presented in the figure below, the trend in the waste sector displays a growth of emissions throughout the period up to year 2007. However, a drastic decrease in emissions is manifest in year 2008, mainly in the Solid Waste Disposal on Land category (5.A). The reasons behind this abrupt change of trends are further explained in detail in the sector-specific sections describing the respective categories (refer to section 7.2). However, the reason for the significant reduction in year 2008 from the Solid Waste Disposal category was due to the commencement of operations at the Material Recovery Facility in the Sant Antnin Waste Treatment Plant. The aim of this facility was to reduce emissions from the Waste sector. Nonetheless, and despite showing a number of year-to-year fluctuations, emissions from the waste sector continue to show a general increase over the years following 2009, mainly due to the continuation of landfilling practices.

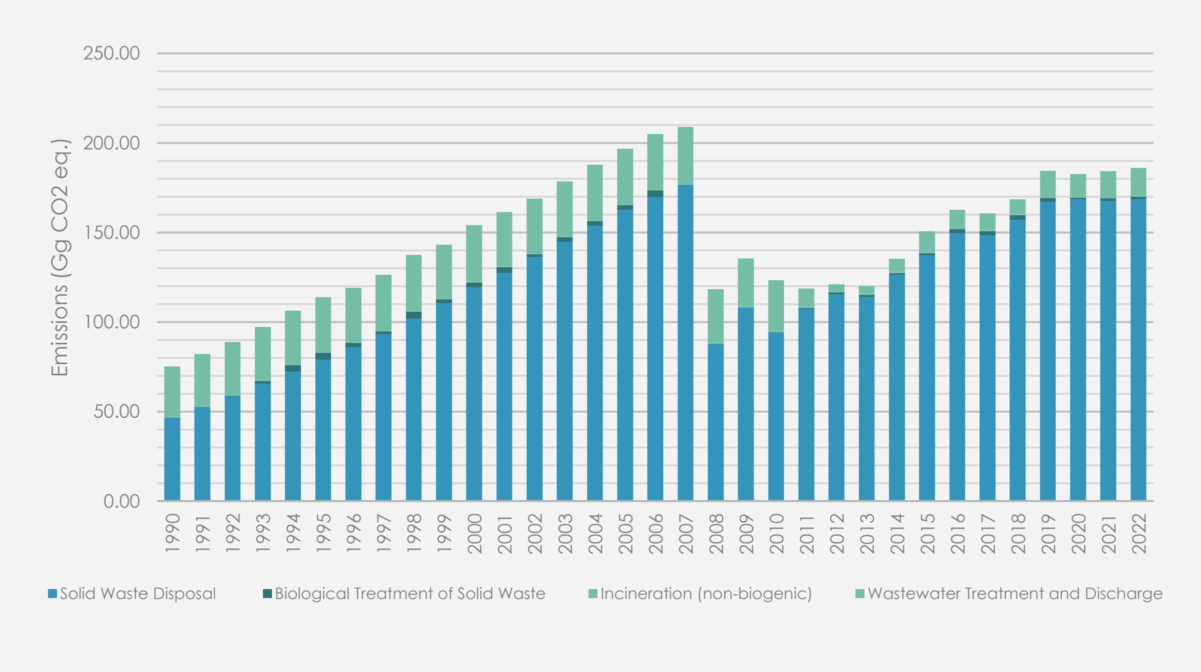


Figure 2-22 Total GHG emissions from waste management overview by activity for sector Waste

Furthermore, the below figure shows the contribution in carbon dioxide equivalents (CO2 eq.) of carbon dioxide, methane and nitrous oxide emissions in the latest inventory year. As shown, a large proportion of percentage share is from CH4 emissions resulting mostly from solid waste disposal on land category. SWD on land is then followed by methane emissions in wastewater treatment and discharge category, biological treatment of solid waste, and incineration. The second percentage share of emissions are N2O from wastewater treatment and discharge category and incineration, and then followed by CO2 emissions from incineration.

However, waste management practices are continuously being improved with newer technologies being planned and implemented mainly in the solid waste treatment sector, with an increased amount of organic fraction being directed to alternative processes (such as bio-digestion), increased recycling and material recovery and aerobic treatment of liquid waste. The need to divert organics in general from solid waste disposal is the main reason behind such trends. Please refer to the sector-specific sector section 7.1 regarding waste facilities in Malta.

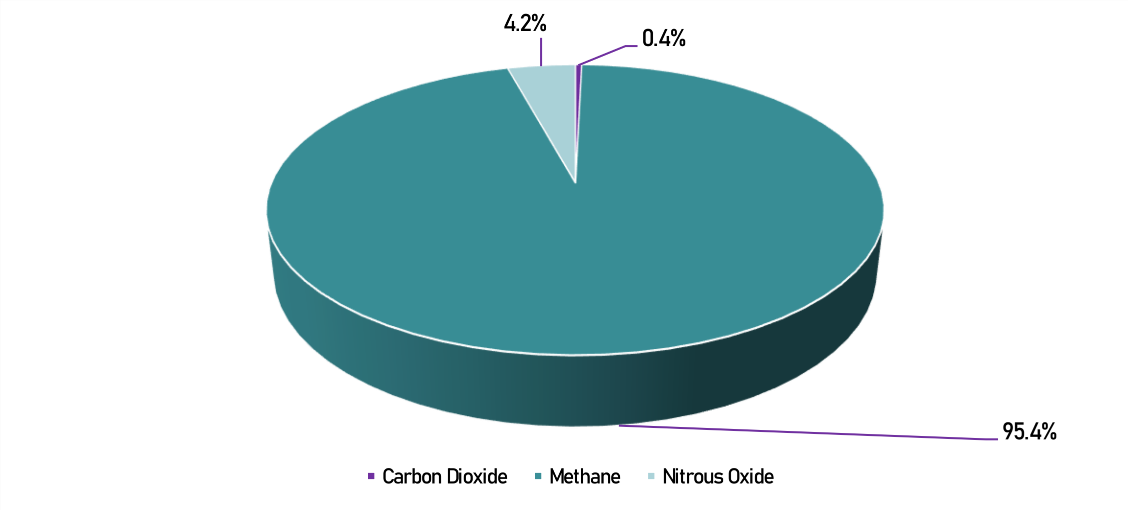


Figure 2-23 Share of emissions, by gas, for sector Waste (% share by gas, based on CO2 equivalents).

The direct greenhouse gases estimated for the waste sector, as presented in the inventory, are illustrated in Table 2-7, below, including the base year (1990) and the reporting year (2022), according to the GHG emissions and the source category or sub-sector, as applicable.

Table 2-7 GHG emissions from the Waste sector (in AR5).

		Year							
		1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2022**
		Gg							
GHG	**CO2**	0.37	0.37	0.35	0.32	0.52	0.57	0.65	0.25
	CH4	2.35	3.64	5.08	6.61	4.03	5.15	6.28	6.40
	N2O	0.03	0.04	0.04	0.04	0.04	0.02	0.02	0.03
	Total	**2.75**	**4.05**	**5.46**	**6.97**	**4.59**	**5.74**	**6.94**	**6.67**
		Gg CO2 eq.							
Waste sector category	**Solid Waste Disposal**	46.48	78.86	119.46	162.54	94.33	137.34	168.52	168.57
	Biological Treatment of Solid Waste	0.00	4.01	2.72	2.81	0.17	0.93	0.91	1.48
	Incineration and Open Burning of Waste	0.43	0.43	0.41	0.32	0.71	0.71	0.79	0.39
	Wastewater Treatment and Discharge	28.31	30.67	31.41	31.07	28.07	11.62	12.35	15.65
	Total	**75.22**	**113.97**	**153.99**	**196.73**	**123.28**	**150.61**	**182.57**	**186.09**

2.4 EMISSION TRENDS FOR INDIRECT GREENHOUSE GASES

The below table presents emissions of the four indirect greenhouse gases (NOx, CO, NMVOC and SO2) included in this submission. Trends for each of these gases are shown in the below figures. There are varying trends between the four gases.

In 1990, CO and SO2 were respectively the highest and second highest in terms of absolute emissions, followed by NOx. In 2022, the highest estimated indirect greenhouse gas emissions were for NOx, followed by NMVOC and CO respectively.

As illustrated in the below figures, all indirect emissions of NOx, CO, SO2 and NMVOC have decreased between the timeseries.

Table 2-8 Emissions of indirect greenhouse gases.

	National totals			
	NOx	CO	NMVOC	SO2
1990	7.44	21.59	4.65	10.23
1995	9.04	24.90	5.08	11.35
2000	8.68	18.15	4.26	9.88
2005	9.88	12.98	3.78	12.34
2010	9.71	9.70	3.51	8.33
2015	5.90	5.83	4.10	2.19
2020	5.57	3.69	4.06	0.14
2022	5.19	3.44	4.41	1.00

In 2022, the sector that contributed the most to emissions from CO, NOx, and SO2 was the sector Energy, category 'Transport'. The IPPU sector contributed the most to NMVOC emissions, from category 'non-energy products from fuels and solvent used'. The sectors Agriculture and Waste contributed minimally to emissions of all the four indirect gases mentioned above.

Moreover, no emissions of indirect gases were reported from the sector LULUCF. These contributions from the different sectors follow the trends observed throughout the time series. This can be observed in the figures below.

Finally, it should be noted that no emissions of NF3 are reported in Malta.

The below charts represent the indirect greenhouse gases.

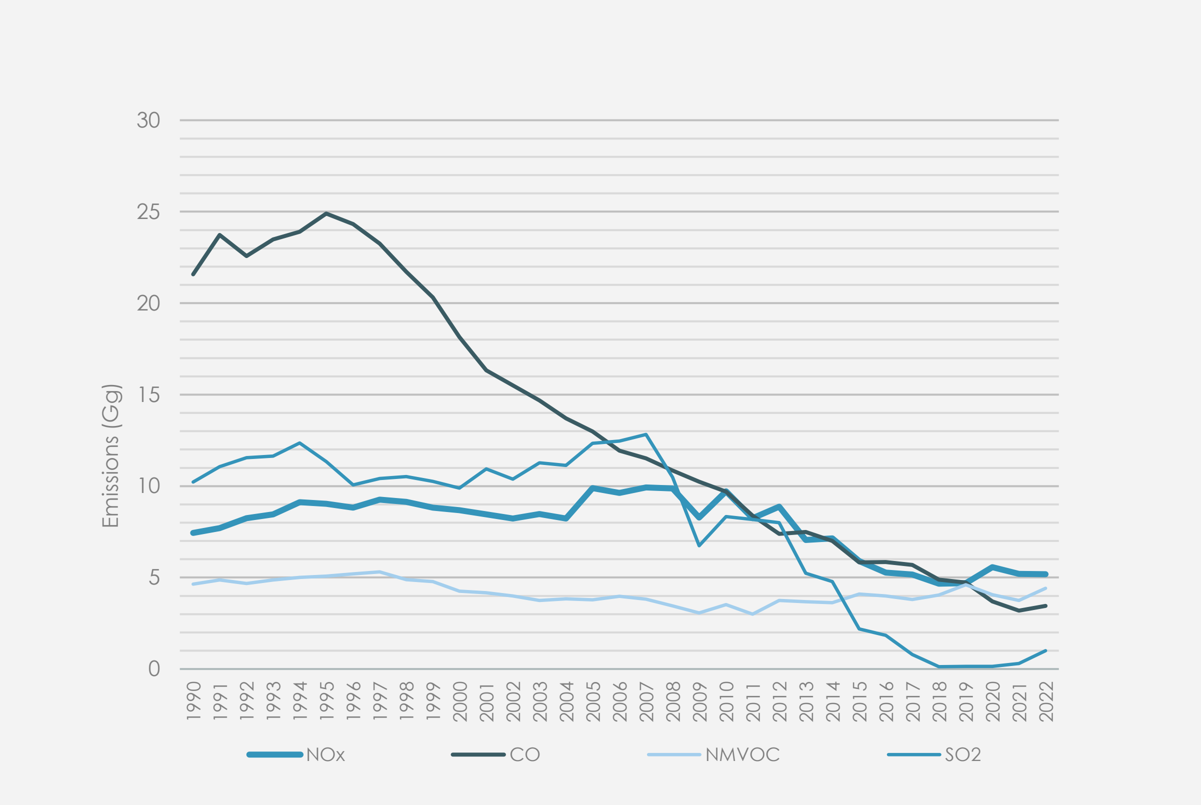


Figure 2-24 Trends in emissions of indirect greenhouse gases.

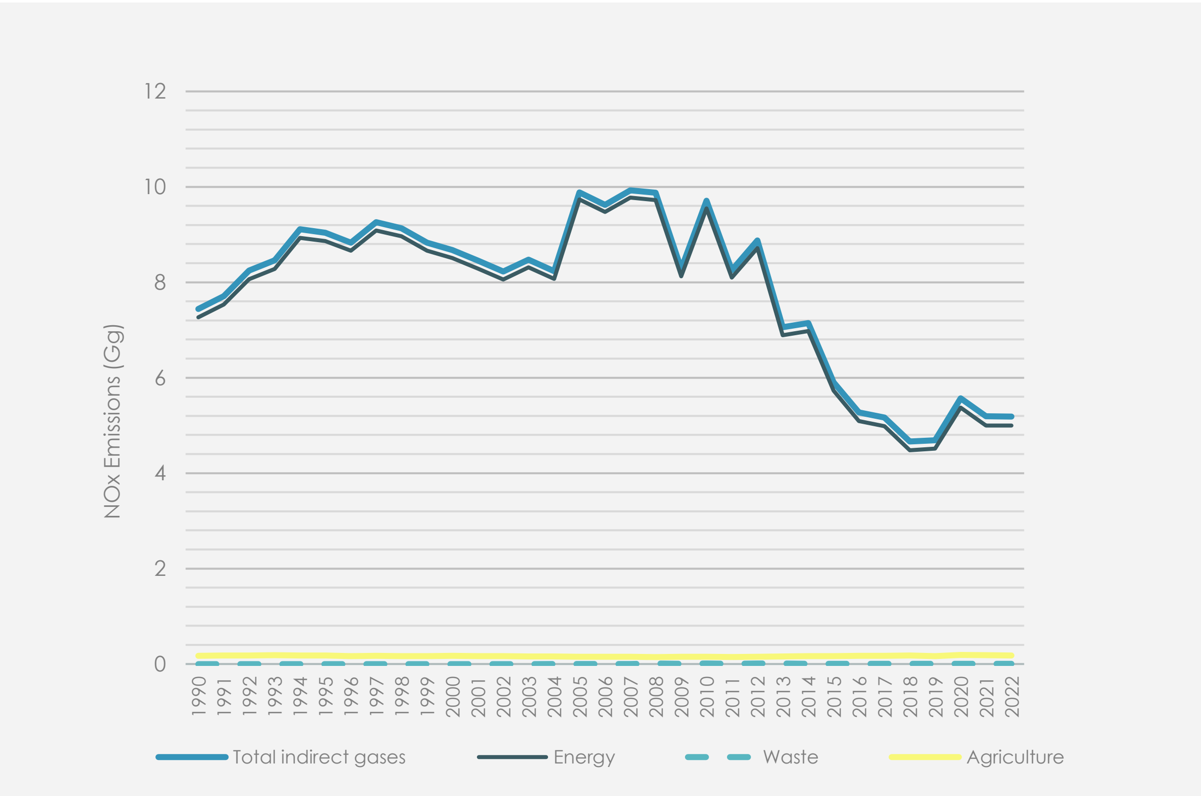


Figure 2-25 NOx emissions by sector.

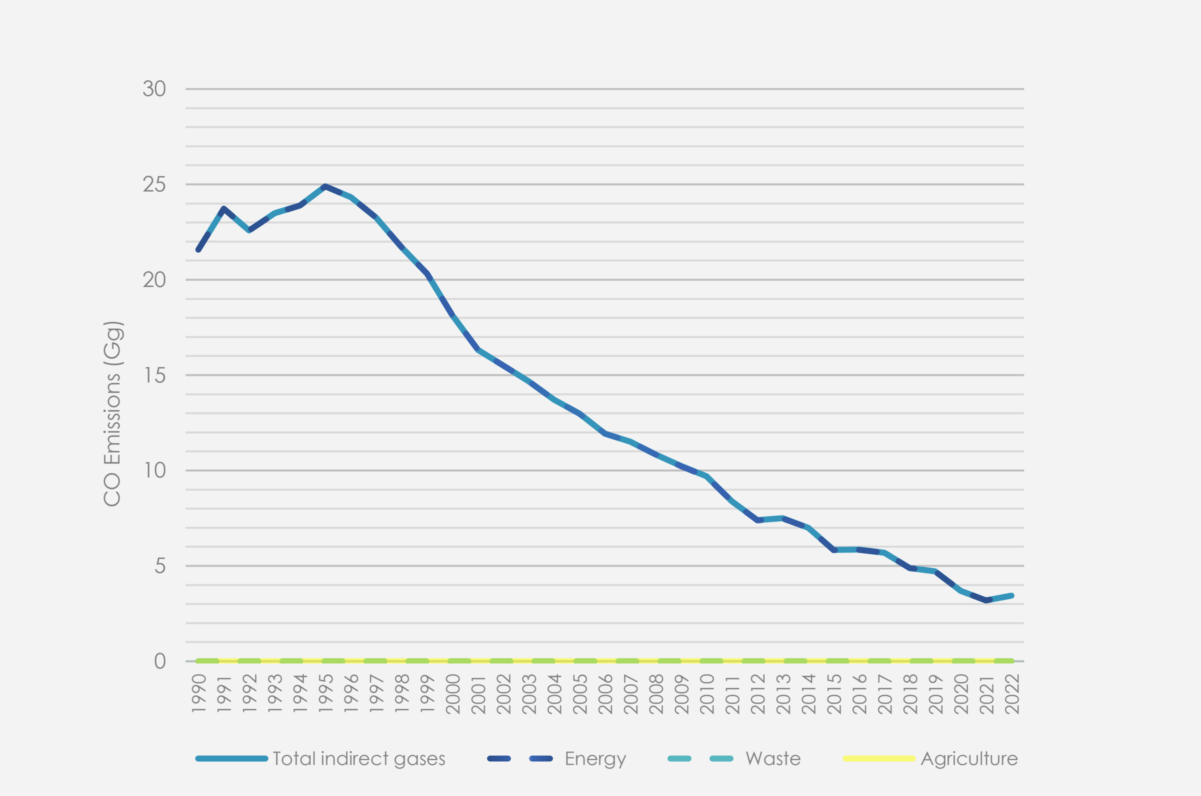


Figure 2-26 CO emissions by sector.

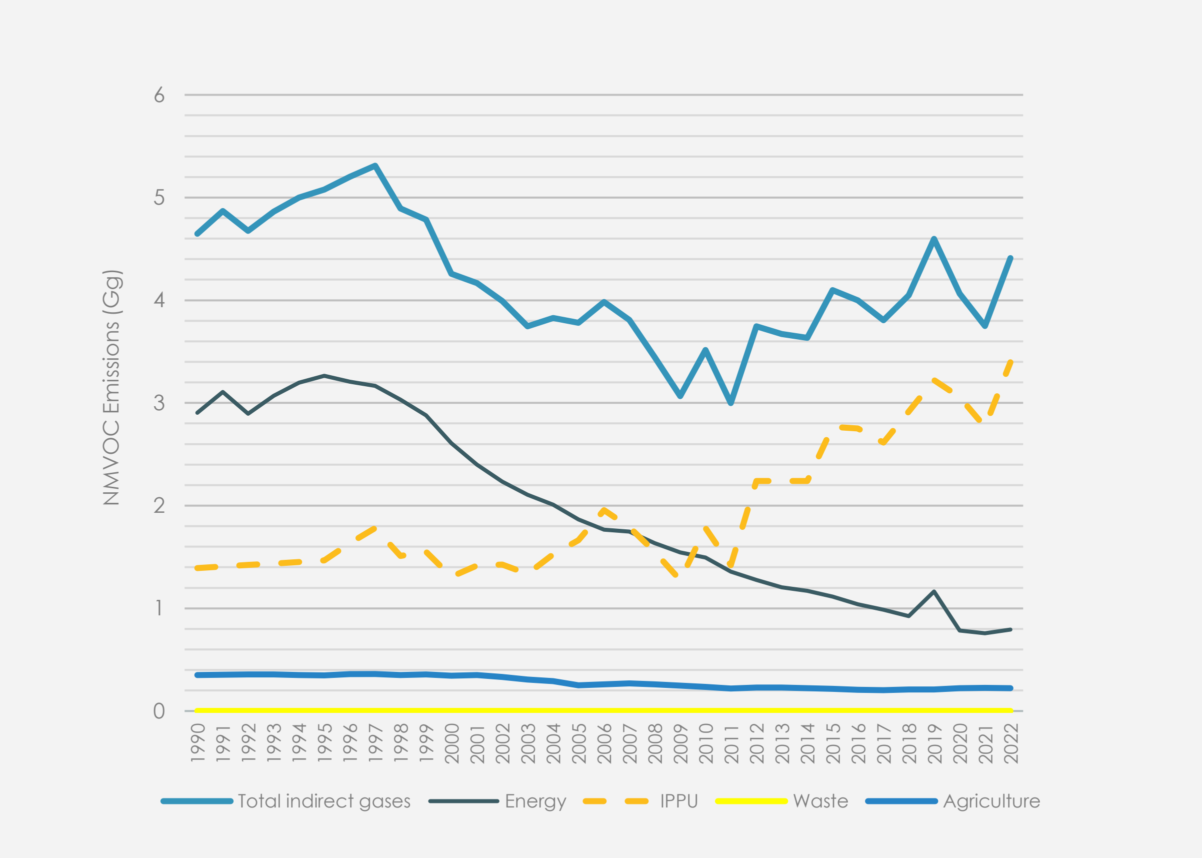


Figure 2-27 NMVOC emissions by sector.

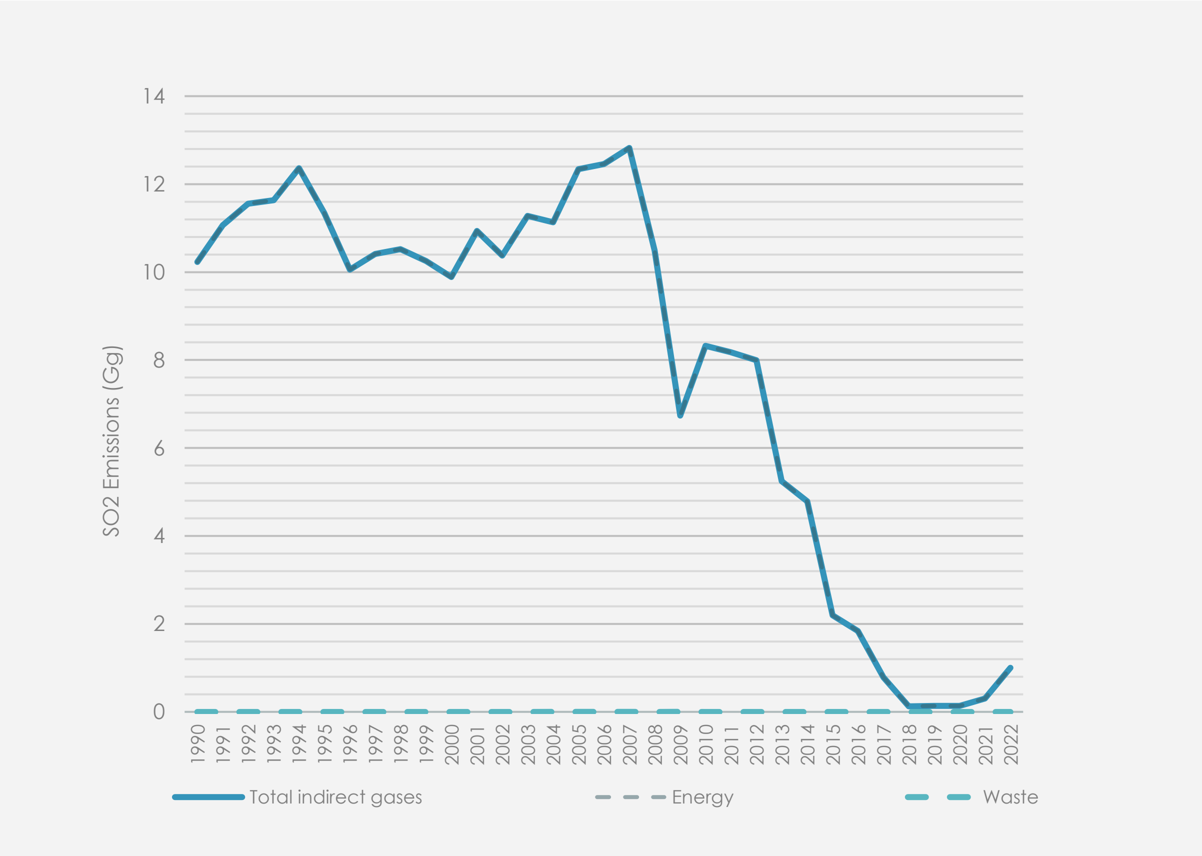


Figure 2-28 SO2 emissions by sector.

CHAPTER 3 ENERGY

ENERGY INDUSTRIES & TRANSPORT

3.1 OVERVIEW OF SECTOR

In Malta, greenhouse gas emissions estimated for the purposes of the inventory for the Energy sector result from the combustion of fuels in:

- Energy industries for the production of public electricity,
- several manufacturing industries and construction activities,
- transport (road, maritime and aviation),
- commercial, institutional, residential, agriculture, forestry, fishing and,
- military.

Energy supply in Malta is largely dependent on imports, either in the form of fuels or as electricity through an interconnector with mainland Europe. Emissions relating to the latter are not within the scope of this inventory as they do not occur within Malta's national territory. Furthermore, there is a small share of energy derived from renewable sources, in particular the use of solar energy in photovoltaic systems and solar water heating; these sources do not contribute to the national greenhouse gas emissions inventory. Malta does not have indigenous fossil fuel sources.

Local electricity generation has seen several changes over the years. Until the early to mid-1990's, a single power plant, mainly fired by coal, met all local electricity demand. In subsequent years, a new plant was commissioned to improve Malta's generation capacity, while a switch from coal to oil-based generation was also undertaken. In recent years, further development of the country's generation capacity, by the setting up of additional power plants, the commissioning of an electricity interconnector with Italy and a shift to natural gas as the primary fossil fuel use for electricity generation, complemented by a smaller amount of diesel (also known as gas oil), has been undertaken. These changes have important implications for the historic trend of greenhouse gas emissions from this activity.

Road mobility is largely dependent on diesel and petrol, with recent years also seeing the introduction of alternative fuels and energy sources such as biodiesel, LPG and electricity, albeit to a significantly lower level. Civil aviation is dominated by international flights with purely local aviation activities being limited (Malta has only one airport). Similarly, maritime activities are primarily international in nature, with national navigation activities mainly including ferry services between the Maltese islands, and between a number of towns around the main harbours, pleasure boating and fishing activities.

Electricity demands of local industry, commercial and residential sectors are largely met by the local power plants, the interconnector (in recent years) and a contribution from renewable sources. Own generation, besides renewables, is limited mainly to steam and heat generation systems in industry.

The compilation of the annual national greenhouse gas inventory of emissions for the Energy sector is dependent on a good number of key data providers including the National Statistics Office (NSO), regular bodies (e.g. the Regulator for Energy and Water Services (REWS); The Malta Resources Authority (MRA), Transport Malta (TM), Eurostat, and operators of local power generation plants. A detailed list of data used in the compilation of emissions from the energy sector and the respective data provider is provided in Table 3-1

Table 3-1 Source of Activity Data used in the compilation of the Energy inventory

Source	Data
Eurostat	Annual Energy Balance (1990 – 2022)
NSO	Oil Balance Reports covering 2022 Survey Results on Fuels used in the Economic Sectors 2021 Coal used in the Power Stations covering 1990-1995; Net Calorific Value of fuels used in the Power Stations covering 1990-2004; COPERT 5 Input Parameter – min_temperature [℃], max_temperature [℃], humidity [% 2005-2020. COPERT 5 Input Parameter stock [n], mean_activity [km], and energy_content [MJ/kg] covering 2005-2017.
Operators of electricity / generation plants **(Enelmalta Corporation now Enemalta plc;** **D3 Power Generation LTD;** **Electrogas.**	For years 1990 – 2004: Enemalta Annual Reports covering 1990-2005 (Enemalta Corporation was the sole operator of power plants in Malta in this period); For years 2005 – 2021: Enemalta reports in accordance with the European Union Emissions Trading System Directive (Enemalta Corporation was the sole operator of power plants in Malta in this period; and, For years 2017 – 2021: Enemalta Corporation, D3 PG Ltd. and Electrogas Malta Ltd reports in accordance with the European Union Emissions Trading System Directive; Fuel oil used in the Power Stations covering 2005-2022; Gasoil used in the Power Stations covering 2005-2022; Natural Gas used in the Power Stations covering 2005-2022; Urea used in the Power Stations covering 2005-2022; Bicarbonate used in the Power Stations covering 2005-2022; Net Calorific Value of fuels used in the Power Stations covering 2005-2022; Emission Factors of fuels used in the Power Stations covering 2005-2022; Sulphur content of fuels used in the Power Stations covering 2010-2022.

IPCC Guidelines	Emission Factors of fuels used in the Power Stations covering 1990-2004. Emission Factors of fuels used in Manufacturing Industries 2017-2022; Emission Factors of fuels used in Commercial/Institutional 2017-2022; Emission Factors of fuels used in Residential 2017-2022; Emission Factors of fuels used in Agriculture/Forestry/Fishing 2017-2022; Emission Factors of fuels used in Domestic & International Navigation 1990-2022; Emission Factors of fuels used in Road Transportation 2019-2022; Emission Factors of fuels used in Domestic Aviation 1990-2022; Net Calorific Values of fuels used in all sectors 2017-2022;
EU Commission	Biodiesel reports submitted to fulfil requirements of Article 4 of Directive 2003-30-EC covering 2003-2016.
REWS	Oil Balance Reports 2022; COPERT 5 Input Parameter - s_content [ppm wt] covering 2012-2020; COPERT 5 Input Parameter - reid_vapor_pressure [kPa] covering 2019-2020; Fuel used for National Navigation & Fishing purposes covering 2015-2022; Fuels used for international aviation purposes covering 2015-2022; Fuels used for international navigation purposes covering 2015-2022; Sulphur content of fuels used in for International Marine Bunkers and International Aviation covering 2012-2020.
ERA	COPERT 5 Input Parameter - s_content [ppm wt] covering 2017; Sulphur content of fuels used for transport purposes.
MRA	Survey Results on Fuels used in the Economic Sectors covering 2010-2013; COPERT 5 Input Parameter - total_fuel_sales [TJ] covering 2005-2016.
Emisia S.A.	COPERT 5 Input Parameters –], fuel_tank_size [l], canister_size [l], fuel_injection [%], evaporation_control[%], urban_off_peak_evaporation_sha [%], urban_peak_evaporation_share [%], rural_evap_share [%], highway_evap_share [%], urban_off_peak_load [%], rural_load [%, highway_load [%], urban_off_peak_road_slope [%], urban_peak_road_slope [%], rural_road_slope [%], highway_road_slope [%], no_of_axels [n], primary_fuel_bifuel_share [%], secondary_fuel_bifuel_share [%], first_blend, second_blend, first_blend_energy_share [%], second_blend_energy_share [%], first_technology_share [%], second_technology_share [%], third_technology_share [%], hc_ratio [-], oc_ratio [-], pb_content [ppm wt], cd_content [ppm wt], cu_content [ppm wt], cr_content [ppm wt], ni_content [ppm wt], se_content [ppm wt], zn_content [ppm wt], hg_content [ppm wt], as_content [ppm wt], and total_fuel_sales [TJ] covering 2005-2020.

	COPERT 5 Input Parameters - vehicles_with_ac [%] and ac_usage [%] covering 2019-2020;
Transport Malta	Fuel used for National Navigation & Fishing purposes covering 1990-2014; Fuels used for international navigation purposes covering 1990-2014; COPERT 5 Input Parameters – trip_length [km], trip_duration [hour], urban_off_peak_speed [km/h], urban_peak_speed [km/h], rural_speed [km/h], highway_speed [km/h], urban_off_peak_share [%], urban_peak_share [%], rural_share [%], and highway_share [%] covering 2005-2016. Vehicles_with_AC and AC_Usage 2017-2020 Vehicles fleet covering 2019-2020;
Working Group on Transport Statistics	COPERT 5 Input Parameters - vehicles_with_ac [%] and ac_usage [%] covering 2005-2016.
International Energy Agency	COPERT 5 Input Parameter - density [kg/m3] covering 2005-2016.
EWA	Survey Results on fuels used in the Economic Sector covering 2014-2019; COPERT 5 Input Parameter – mean activity [km], cumulative activity [km], vehicles fleet covering 2019-2020;
Armed Forces Malta (AFM)	Fuels used for Military Purposes covering 2017-2019

Enemalta plc was, for a long time, the sole electricity services provider in Malta. Since 2017, two new operators have entered the electricity supply market. Enemalta plc retains responsibility for distribution of electricity, the operation of the interconnector and development of the national electricity distribution network.

The National Statistics Office (NSO) provides a substantial quantity of data required to compile the National Inventory Report. For the Energy sector, NSO provides the Oil Balance Report inclusive of all liquid fuels used namely; LPG, Petrol, Jet Kerosene, Aviation Gasoline, Kerosene, Diesel, Biodiesel, Gasoil, Fuel Oil, Crude Oil and Hydrotreated Vegetable Oil. After gathering this data from the Regulator for Energy and Water Services, NSO checks and verifies the information and make available for the National Inventory Report.

The Energy and Water Agency (EWA) provides the Malta Resources Authority with the Fuel Use Survey. This survey is a joint exercise between NSO and EWA whereby data from fuel consumption in the economic and household sectors is collected. This survey is conducted every four years. In-between each survey, data on total oil uses reported by REWS and NSO from the Oil Balance are used to produce a disaggregation of fuel use in the various relevant sectors, using percentage splits by NACE and end-use as determined according to the most recent survey held. The stock of licensed vehicles and annual environmental conditions are also collected from NSO which are used for COPERT to generate Malta's annual greenhouse gas emissions. Data from the EUROCONTROL model that is generated by EUROCONTROL is used to report domestic and international aviation emissions.

3.1.1 METHODOLOGICAL OVERVIEW

The calculation of GHG emissions for the Energy sector is based on the methodologies and emission factors provided in the IPCC 2006 Guidelines with some country specific emission factors. Tier 1 methodologies, with default emission factors (T1/D), are used for calculating emissions from the Manufacturing Industries and Construction sector (1A2), from Other Sectors (1A4) and Military (1A5). Emissions resulting from the Energy Industries (1A1) are based on Tier 2 methodologies, having a plant/country specific emission factor (T2/CS). Emissions from cars and aviation in the Transport sector (1A3) use a Tier 3 methodology and Country Specific emission factors (T3/CS), the rest of the sector 1A3 uses a Tier 1 with a default emission factor (T1/D). Similarly, emissions from International Bunkers and International Aviation included in Memo Items (1D) share a Tier 1 and Tier 3 methodologies with default and country specific emission factors (T1/D, T3/CS) respectively. The methodologies and emission factors are summarized in

Table 3-2 A summary of tier methodologies and emission factors used in the Energy sector for year 2020

	CO_2		N_2O		CH_4	
	Method	EF	Method	EF	Method	EF
1A1. Energy Industries	T2	CS	T1	D	T1	D
1A2. Manufacturing Industries and Construction	T1	D	T1	D	T1	D
1A3. Transport	T1	D	T1/T3	D	T1/T3	D
1A4. Other Sectors	T1	D	T1	D	T1	D
1A5. Other (military)	T1	D	T1	D	T1	D
1AB. Reference Approach	NO	NO	NO	NO	NO	NO
1AD. Feedstocks & non-Energy use	NO	NO	NO	NO	NO	NO
1C. CO2 transport and storage	NO	NO	NO	NO	NO	NO
1D. Memo Items	T1	D	T1	D	T1	D

3.1.2 Sector Specific QA/QC Verification

Table 3-3 QA/QC checks performed for the Energy Inventory

Item		Yes/No
EMISSION DATA QUALITY CHECKS		
1	Are emission comparisons for historical data source performed	Yes
2	Are emission comparisons for significant sub-source categories performed	Yes
3	If applicable, are checks against independent estimates or estimates based on alternative methods performed	n.a.
4	Are reference calculations performed	Yes
5	Is completeness check performed	Yes
6	Other (detailed checks)	Yes
EMISSION FACTOR QUALITY CHECKS		
IPCC default emission factors		
7	Are the national conditions comparable to the context of the IPCC default emission factors study	Yes
8	Are default IPCC factors compared with site or plant-level factors	Yes
Country-specific emission factors		
QC on models		
9	Are the model assumptions appropriate and applicable to the GHG inventory methods and national circumstances	Yes
10	Are the extrapolations/interpolations appropriate and applicable to the GHG inventory methods and national circumstances	Yes
11	Are the calibration-based modifications appropriate and applicable to the GHG inventory methods and national circumstances	Yes
12	Are the data characteristics appropriate and applicable to the GHG inventory methods and national circumstances	Yes
13	Are the model documentation (including descriptions, assumptions, rationale, and scientific evidence and references supporting the approach and parameters used for modelling) available	No
14	Are model validation steps performed by model developers and data suppliers	Yes
15	Are QA/QC procedures performed by model developers and data suppliers	Yes
16	Are the responses to these results documented	Yes

17	Are plans to periodically evaluate and update or replace assumptions with appropriate new measurements prepared	Yes
18	Is there completeness in relation to the IPCC source/sink categories	Yes
Comparisons		
19	Are country-specific factors compared with IPCC default factors	Yes
20	Is comparison between countries, including historical trends, min and max value, base and most recent year value, IEF performed	No
21	If applicable, is comparison to plant-level emission factors performed	Yes
22	Other (detailed checks)	No
ACTIVITY DATA QUALITY CHECKS		
National level activity data		
23	Are alternative activity data sets based on independent data available	Will be investigated
24	Were comparisons with independently compiled data sets performed	Independently compiled data is difficult to find
25	Were the national data compared with extrapolated samples or partial data at sub-national level	Yes
26	Was a historical trend check performed	Yes
27	Are any sharp increases/decreases detected and checked for calculation errors	Yes
28	Are any sharp increases/decreases explained and documented	Yes
Site-specific activity data		
29	Are there any inconsistencies between the sites	No
30	If yes, was a QC check performed to identify the cause of the inconsistency (errors, different measurement techniques or real differences in emissions, operating conditions or technology)	NA
31	Are the activity data compared between different reference sources and geographic scales (national production statistics vs. aggregated activity data)	Yes
32	Are the differences explained	Yes
33	If applicable, is a comparison between bottom up (site-specific) and top down (national level) account balance performed	Yes
34	Are large differences explained	Yes
35	Other (please specify)	No
CALCULATION RELATED QUALITY CHECKS		

36	Are checks of the calculation algorithm (duplications, unit conversion, calculation errors) performed	Yes
37	Are the calculations reproducible	Yes, however please see comments in the presentation
38	Are all calculation procedures recorded	Yes, however please see comments in the presentation
39	Other (please specify)	No

3.1.3 Sector-Specific Recalculation & Planned Improvements

A number of revisions in data and methodologies have been taken into consideration following reviews of Malta's greenhouse gas inventory under the requirements of the EU's Effort Sharing Decision and under UNFCCC requirement, as well as non-conformities identified during the compilation of the inventory and other QA/QC checks. Moreover, through recent capacity building support (see Chapter 1 for more details), a sector-specific improvement and QA/QC plan was developed. These improvement plans are included in their respective categories and sub-categories further below.

Table 3-4 Summary of UNFCCC provisional views on the issues raised in the previous review report (2021) and their status according to this submission

ID#	Previous recommendation for the issue identified	MS response / status of implementation	Chapter/section in the NIR
E.1	Allocate AD and emissions to the appropriate subcategories in order to improve the comparability of the emission estimates with those of other Parties included in Annex I to the Convention.	During the review, the Party clarified that no energy intensive manufacturing industries occur in Malta and the data provision regarding manufacturing industries in Malta is reported under "other industries" by Eurostat. For these reasons the Party reported all emissions from 1.A.2 under subcategory 1.A.2.g Other in CRF table 1.A(a)s2 and AD and emissions from the other subcategories of 1.A.2 as NO.	NIR 3.2.5.6
E.2	Improve the description in the NIR of the category-specific QA/QC activities performed on the AD, with the objective of better understanding the links between the EU ETS,	Detailed information on QA/QC activities regarding links to the EU ETS, energy balances and the data reported in the CRF tables was not provided in the NIR. During the review, the Party indicated that it is	N/A

	the energy balances and the data reported in the CRF tables.	making efforts to address this issue for its reporting in future submissions.	
E.3	Estimate CO_2 emissions using the reference approach for all years of the time series.	The Party reported CO_2 emissions using both the reference and sectoral approach for the whole time series. For gaseous fuels, the reference approach covers 2017 onward. The reference approach for biomass fuels covers 2010 onward. During the review, the Party indicated that efforts were being made to cover the other years in the time series.	CRF Table1.A(a) till Table 1.A(d)
E.4	Explain differences in CO_2 emissions that are above 2 percent.	The Party did not provide any explanations for the difference between liquid fuels reported using the reference and sectoral approaches in the NIR. The Party cited a lack of data as one of the challenges resulting in the differences between the reference and sectoral approaches in its NIR (section 3.2.1.2.). During the review, the Party indicated that it is making efforts to identify the source of the discrepancies between both approaches.	N/A
E.5	Review whether the same fuels are reported in the IEA data and in the CRF tables and investigate the emissions from other bituminous coal for the whole time series and report the related information transparently in the NIR, or revise the calculations.	The Party reported apparent energy consumption for other bituminous coal as “NE” compared to “NO” in the previous submission for the entire time series in CRF table 1.A(b). The ERT noted that apparent energy consumption (excluding non-energy use, reductants and feedstocks) reported in the IEA data is greater than the apparent energy consumption reported in CRF table 1.A(b) for solid fuels and other fossil fuels. The ERT also noted that the difference is almost entirely caused by the imports of bituminous coal, which is reported in the IEA data but not in the CRF tables. During the review, the Party has not undertaken any investigation within this regard since any activity data used for the purposes of the NIR is acquired from the National Statistics Office of Malta and from Eurostat. The Party indicated that it is making efforts to investigate the comparability of data sourced from the sources mentioned and data published by the IEA and could then report on the differences in future submissions.	N/A

E.6	Investigate and address the inconsistences identified between the IEA data and the reference approach data, in particular those related to stock changes and imports and exports of liquid fuels, correct the values reported under the reference approach and provide related explanations in the NIR, if appropriate.	No explanations have been provided in the NIR on inconsistences identified between the IEA data and the reference approach data. During the review, the Party stated that it has not undertaken any investigation in this regard since any activity data used for the purposes of the NIR is acquired from the National Statistics Office of Malta and from Eurostat. The Party indicated that it is making efforts to investigate the comparability of data sourced from the sources mentioned and data published by the IEA and will report on this in future submissions.	N/A
E.7	Investigate and address the inconsistences identified between the IEA data and the aviation gasoline data reported in CRF tables, correct the values reported and provide related explanations in the NIR, if appropriate.	Efforts are being made to investigate the comparability of data sourced from the sources mentioned and data published by the IEA to explain the differences in aviation gasoline in future submissions.	N/A
E.8	Report in CRF table 1.A(d) CO2 emissions from the non-energy use of fuels for bitumen and lubricants.	The Party reported the CO2 emissions from the non-energy use of fuels for lubricants and bitumen under the IPPU sector and reported as "IE" in the CRF table1.A.(d). During the review, the Party confirmed that there are no combustion activities of Lubricants and Bitumen in Malta, as explained in the NIR (section 3.2.3.).	NIR Chapter 3.2.3
E.9	Obtain data on the NCVs and carbon content from the fuel suppliers in order to develop and use a more accurate EF when estimating CO_2 emissions from gasoline; if such data are not available, use the default CO_2 EF from the 2006 IPCC Guidelines that is applicable to European gasoline passenger cars.	Addressing. The Party reported in its NIR section 3.2.6.8 that emissions factors for road transport are sourced from the COPERT V and European Monitoring and Evaluation Programme/ European Environmental Agency (EMEP/EEA) Emissions Inventory Guidebook. During the review, the Party clarified that hydrogen/carbon ratios from EMEP/EEA are used by COPERT V to generate an EF. Malta confirmed that it is in discussions with the COPERT V on how to	An updated methodology and justification for any EF or NCVs used are presented in the NIR, section: 3.2.6.2.1

		change the ratio to match the 2006 IPCC Guideline EF. The Party indicated that a detailed methodology for the category will be provided in the next submission. The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet obtained data on NCVs and carbon content from fuel suppliers or used the default factor from the 2006 IPCC Guidelines.	
E.10	Report estimates, including any relevant information such as country-specific NCVs, oxidation factors, EFs and AD used for the estimation of emissions for the whole time series, in the NIR.	The Party indicated that it has used the most reliable information available in different periods. For 1990-2004, the calculation of emissions was carried out using a country-specific calorific value for each of the fuels used in the power stations and an oxidation factor of 1 in accordance with the 2006 IPCC Guidelines. For the years 2005 onwards, the calorific values and oxidation factor identified in the verified emission reports submitted by the operators of public electricity generators operating in Malta and that fall within the scope of the European Union Emissions Trading System (EU ETS) Directive (2003/87/EC) were used and NCVs, oxidation factors, EFs and AD were reported in the NIR for 2020 (section 3.2.4.2, pp. 77-78).	NIR Chapter 3.2.4.2
E.11	Review the CO_2 and N_2O IEFs for cars for gasoline, diesel oil and liquefied petroleum gas and explain any significant inter-annual changes and how the consistency of the time series is ensured.	Addressing. NIR section 3.2.6.8 does not provide detailed information on how the consistency of the road transport is maintained following a data source change between 1990–2004 and 2005–2019. NIR table3-4 also reports that time series consistency of the road transport subcategory will be addressed in the coming years by developing emissions estimates for 1990 to 2017 using the COPERT V model. During the review, the Party	Addressing

		indicated that it would review the CO_2 and N_2O IEFs for gasoline, diesel oil and liquefied petroleum gas and would report additional information in its next submission. The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet provided detail on the drivers for significant inter-annual changes in its NIR.	
E.12	Calculate CO_2 emissions from fuel sold in accordance with the 2006 IPCC Guidelines and apply the procedure for validating vehicle-kilometres travelled with fuel statistics data, and correct the data if necessary, before estimating CH_4 and N_2O emissions using the COPERT V model, and describe this procedure and the results in the NIR.	Addressing. The Part did not report using the 2006 IPCC guidelines tier 1 method to verify emissions calculated using the COPERT V model. During the review, the Party clarified that it planned to estimate CO_2 emissions using the 2006 IPCC guidelines tier 1 method to verify estimates calculated using the COPERT V model and will report results in the next submission.	A detailed methodology for CO_2 emissions estimates for 2020 is included in section 3.2.6.2.1. Malta is using the default 2006 IPCC guidelines CO_2 EF for 2019 and 2020 and is planning to updated the timeseries using the same methodology. In addition, a comparison of the two approaches is presented in the same chapter, for 2020.
E.13	Correct the discrepancies between the NIR and the CRF tables and add a description in the NIR of the treatment of biodiesel in the COPERT V model.	Addressing. CO_2 and CH_4 emissions reported in the NIR section 3.2.6.11 are consistent with emissions reported in CRF table 1.A(a)s3. The Party has not provided a description of the treatment of biodiesel in the COPERT V model. During the review, the Party clarified that it intends to provide a description of the treatment of biodiesel in the COPERT V model in its next submission.	A description of the treatment of biodiesel in COPERT is included in section 3.2.6.2.1

E.14	Justify in the NIR the use of the country-specific N_2O EF for biodiesel.	Not resolved. NIR section 3.2.6.8 does not include a justification of a country-specific emission factor for N_2O for biodiesel. During the review, the Party indicated that it is currently updating its methodology and will report more detail on the N2O emissions factor in its next submission. The ERT considers that the recommendation has not yet been addressed because the Party has not yet justified the use of a country-specific N_2O EF for biodiesel in its NIR.	A description of the treatment of biodiesel in COPERT is included in section 3.2.6.2.1 Malta is using COPERT to calculate N2O emissions from biodiesel using the EF provided by the model.
E.15	Document the changes in data sources and methodology in the NIR and also describe in the NIR how the consistency of the time series is maintained.	Addressing. The Party reported in its NIR section 3.2.6.17 that no changes were made to data sources in the 2021 submission. In NIR section 3.2.6.15 the Party noted there were small inconsistencies in fuel sales data, specifically that residual fuel oil sales data was not available for 2017 and 2018. In NIR section 3.2.6.15, the Party also confirmed with their National Statistics Office and the Regulator for Energy and Water that no residual fuel oil was sold in 2017 but no confirmation was reported for 2018. During the review, the Party indicated that they are investigating potential new data providers to acquire more reliable and accurate data.	Documentation on the timeseries consistency and any changes in data sources is included in section: 3.2.6.4
E.16	Describe in the NIR the factors contributing to the significant inter-annual variation in the consumption of residual fuel oil.	Not resolved. The Party has not reported on contributing factors to interannual variation in the consumption of residual fuel oil in NIR section 3.2.6. During the review, the Party clarified that it was undertaking an investigation to identify contributing factors for annual variation and will report new findings in the next submission.	Documentation on the timeseries consistency and any changes in data sources is included in sections : 3.2.6.4
E.17	Explain in the NIR the methodology, assumptions and sources of AD and EFs used to	Addressing. The Party reported in its NIR Table 3-1 that Armed Forces Malta was the data source for fuels used for military purposes	Category 1.A.5 has been revised in the current submission .In

	estimate and report CO2, CH4 and N2O emissions from fuel use in the military (both stationary and mobile combustion) for the entire time series since 1990.	covering 2017–2019, however AD for the remainder of the time series is not detailed. NIR section 3.2.8.3 reports that for the 2019 inventory year emissions from military have been allocated to 1.A.3.B Road Transport and 1.A.3.d Domestic Navigation, and emissions from military for 1990-2018 are allocated to 1.A.5. During the review, the Party clarified that the allocations for 2019 will be applied to the time series in the next submission, additionally aviation from military will be allocated to 1.A.3.a Domestic Aviation.	addition. More information can be found in section 3.2.8
E.18	Review whether the same fuels are reported in the IEA data and in the CRF tables and investigate the emissions from other bituminous coal for the whole time series and report the related information transparently in the NIR, or revise the calculations.	Not resolved. The Party assigned the indicator 'NO' for Other Bituminous Coal in its NIR CRF Table1.A(b) across the time series. During the review, the Party clarified that Other Bituminous was used between 1990 and 1995 for electricity generation, with Eurostat's Annual Energy Balance reflects the use of other bituminous coal used during this timeframe. The ERT considers that the recommendation has not yet been addressed because the Party has not yet reported data on Other Bituminous Coal used between 1990–1995 in its reference approach.	CRF Table1.A(b)
E.19	Investigate and address the inconsistences identified between the IEA data and the reference approach data, in particular those related to stock changes and imports and exports of liquid fuels, correct the values reported under the reference approach and provide related explanations in the NIR, if appropriate.	\` Not resolved. The Party has not provided explanations on identified inconsistencies between IEA and the reference approach data. During the review, the Party clarified that for the purpose of the NIR, sectoral and reference approach data is acquired either from national statistics or from Eurostat's Annual Energy Balance.	Addressing

E.20	Investigate and address the inconsistences identified between the IEA data and the reference approach data, in particular those related to stock changes and imports and exports of liquid fuels, correct the values reported under the reference approach and provide related explanations in the NIR, if appropriate.	Not resolved. The Party has not provided explanations on identified inconsistencies between IEA and the reference approach data. During the review, the Party clarified that for the purpose of the NIR, sectoral and reference approach data is acquired either from national statistics or from Eurostat's Annual Energy Balance.	Addressing
E.21	Report in CRF table 1.A(d) CO_2 emissions from the non-energy use of fuels for bitumen and lubricants.	Not resolved. The Party has not reported CO_2 emissions from the non-energy use of fuels for bitumen and lubricants in CRF table 1.A(d). During the review, the Party indicated that the energy sector expert would work with the IPPU expert to report CO2 emissions from bitumen and lubricants in CRF table 1.A(d).	Addressing
E.22	Investigate and address the differences in the reporting of jet kerosene, residual fuel oil and gas and diesel oil used in international aviation and navigation in CRF tables 1.A(b) and 1.D.	Not resolved. The Party has reported discrepancies between jet kerosene reported in CRF Table 1.A(b) and Table1.D, for example 6,899.78 TJ and 7,198.88 TJ respectively in 2019. During the review, the Party clarified that data for international aviation are being revised and any inconsistencies are to be reported as recalculations in the next submission.	Addressing
E.23	Provide in the NIR verification information on the COPERT V model used to estimate GHG emissions from cars under category 1.A.3.b.i (see decision 24/CP.19, para. 41).	Addressing. The Party did not provide information on methods to verify emissions calculated using the COPERT V model in its NIR. During the review, the Party clarified that COPERT V calculates emissions following a methodology which is very similar to the one provided in the 2006 IPCC guidelines, which is based on vehicle kilometres rather than fuel sold. The Party indicated that it planned on using the 2006 IPCC guidelines tier 1 methodology to	A detailed methodology for the emission estimates from category 1.A.3.b is included in section 3.2.6.2.1 to ensure the consistency of the timeseries, Malta is planning to recalculate emissions for the period 1990-2009

		verify its estimates with those calculated using COPERT V and report results in the next submission.	using the updated methodology, which was used for 2010 - 2020 in the present submission.
E.24	Transparently explain in the NIR how it reported CO_2 emissions from lubricants used as fuel in two-stroke engines.	Addressing. The Party reported in its NIR 3.2.2 that emissions from lube oil used in motorcycle 2-stroke engines are calculated and reported under sub-category 1.A.3.b Road transportation. During the review, the Party clarified that CO_2 emissions from lubricants by 2-stroke engines (motorcycles) are calculated using the COPERT V model and additional information on the method would be provided in the next submission in NIR section 3.2.6.	An explanation is included under section 3.2.6.2.1
E.25	Transparently report the type of fuel constituting the biomass used in the commercial/institutional sector and the quantities of each fuel type used over the time series, and refer to table 1.1 in chapter 1, volume 2, of the 2006 IPCC Guidelines for information on fuel classification.	Addressing. The Party reported in its NIR section 3.2.7.1 that biodiesel and biogas are used in the commercial/institutional category. During the review, the Party clarified that biomass types used in the commercial/institutional sector have been updated according to the 2006 IPCC guidelines for year 2019, with similar updates to be reported in future submissions for the remainder of the time series. The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet reported the quantities of biodiesel and biogas in its NIR or applied the 2006 IPCC guidelines classifications to biomass across the time series.	Addressing
E.26	Transparently report the CH_4 EFs applied for each biomass type and any recalculations for this category.	Not resolved. The NIR does not report CH4 EFs applied for each biomass type. During the review, the Party clarified that CH4 EFs for each biomass type will be reported in the 2022 submission.	NIR Chapter 3

3.2 FUEL COMBUSTION (CRF 1A)

3.2.1 COMPARISON OF THE SECTORAL APPROACH WITH THE REFERENCE APPROACH (CRF 1AC)

3.2.1.1 Category Description

The Sectoral Approach is a ‘bottom-up’ methodological approach to estimate emissions for individual categories based on activity statistics pertaining to end-users’ consumption. This activity data thus presented reflects the activity of the various economic sectors, residential households and other end-users operating within their respective sub-category.

On the other hand, the Reference Approach is a ‘top-down’ methodological approach to estimate emissions. The activity data used represents total national consumptions, by fuel type, using the national oil balance. Eurostat data was used for compiling the reference approach.

Table 3-5 shows the comparison between the Reference Approach and the Sectoral Approach for 2022. The total aggregated difference in energy consumption between both approaches is –2.15 and -0.62% difference in CO2 emissions.

Table 3-5 Differences between the Reference and Sectoral Approach

FUEL TYPES	REFERENCE APPROACH			SECTORAL APPROACH		DIFFERENCE	
	Apparent energy consumption	Apparent energy consumption (excluding non-energy use, reductants and feedstocks)	CO2 emissions	Energy consumption	CO2 emissions	Energy consumption	CO2 emissions
	(PJ)	(PJ)	(kt)	(PJ)	(kt)	(%)	(%)
Liquid fuels (excluding international bunkers)	14.17	13.72	1020.82	14.17	1020.23	-3.16	0.06
Solid fuels (excluding international bunkers)	NO	NO	NO	NO	NO	NO	NO
Gaseous fuels	13.51	13.51	758.17	13.65	747.47	-1.02	1.43
Other fossil fuels	NO,NE	NO	NO,NE	0.01	0.36	-100.00	-100.00
Peat	NO	NO	NO	NO	NO	NO	NO
Total	27.69	27.23	1778.99	27.83	1768.06	-2.15	0.62

The difference in energy consumption, hence CO2 emissions emerges from the different data sources used to compile the sectoral approach. Data from Eurocontrol was used to report emissions from international aviation. In addition, the amount of fuels consumed by military was obtained from the Armed Forces of Malta. These amounts (except fuels for automotive purposes) are subtracted from the totals and are reported under category 1.A.5.

Furthermore, biomass data from Eurostat regarding the road transport category is being used. The percentage of FAME in biomass is obtained by the national oil balance or the Fuel Quality Directive and is inputted into the COPERT model which estimates the fossil part of biomass for road transportation. Then this fossil part is ultimately reported under other fossil fuels in category 1A3, (refer to chapter 3.2.6). Unfortunately, biomass is reported as a total number in the Energy Balance from Eurostat, including both the biogenic and fossil part of biomass. Therefore, the discrepancy between both approaches for other fossil fuels is 100%.

Ultimately, gaseous fuels reported under the reference approach are derived from Eurostat. In the sectoral approach, gaseous fuels are taken from reporting by electricity generation plants under the scope of the EU ETS. This is data that is duly verified by independent and competent verifiers in accordance with the rules of the EU ETS. There are two plants that operate on natural gas. These plants use in-line equipment that calculates CO2 directly from analysis of the flowing natural gas.

3.2.1.2 Methodological Issues

The data is obtained directly from importers/wholesalers and reflects the activities involved during the importations, [primary] storage and wholesaling of petroleum products. The Regulator for Energy and Water Services collects, collates, analyses and verifies (via third-party external consultants), the data obtained from all the importers/wholesalers (including those operating in the marine bunkering industry) and subsequently provides the 'oil balance report' to the National Statistics Office.

Following Eurostat's updated version of the methodology for calculating annual energy balances (2018), an adaptation to the present methodology for calculating the apparent consumption of primary fuel has taken place. The equation used is that of the Energy Balance Guide published by the European Commission in January, page 12;

Total energy supply = + Primary production + Recovered & Recycled products + Imports – Export + Stock changes – International maritime bunkers – International aviation.

In Malta's case, there is no production of fuel: all fuel is imported. Therefore, the total energy supply is calculated by subtracting the fuel exported and the fuel used in international bunkers, from the fuel imported and adding the change in stock.

Eurostat's Energy balance data was used for the compilation of the reference approach.

In addition, activity data and emissions for Propane are included under fuel type LPG in the CRF tables since this fuel is primarily in liquid form.

3.2.1.3 Uncertainties and time-series consistency

The oil balance reporting system as undertaken by Regulator for Energy and Water Services covers the period 2010 – 2022. For the preceding years (1990-2009), the type and quantities of petroleum products released in the inland market were published by Enemalta in its annual reports. During this time-period, Enemalta was the sole importer and wholesaler of petroleum products in the inland market.

In theory, the Sectoral Approach and the Reference Approach should equate, since the quantity of fuels released in the inland market (the gross inland consumption) cannot be different from the quantity that is consumed by the end-users in a particular period. Put differently, the consumption of fuels by end-users cannot exceed the quantity that is released from the primary storages.

However, in practice, one can never obtain perfect information for both approaches and hence, a margin of statistical discrepancy will always be present. A margin of +/-5% between the Sectoral Approach and the Reference Approach is deemed to be acceptable for the purposes of emissions estimation.

3.2.1.4 Category-specific planned improvements

The use of Eurostat's data has significantly improved the discrepancies between both approaches and no planned improvements are envisaged for this category. The development of a Sankey diagram provided in Annex 4 of also shows the comparison between both approaches.

3.2.2 MEMO ITEMS (CRF 1D)

Emissions estimated from International Bunker activities are considered as "Memo Items" and are not considered in terms of Malta's emissions of greenhouse gases. These memo items refer to fuels used for international marine navigation and for international aviation purposes that are combusted outside of Maltese territory, territorial waters, or airspace respectively. This category also includes CO2 emitted from biofuel used for 1.A.3.b.i Cars, 1.A.3.b.ii Light-Commercial Vehicles, 1.A.3.b.iii Heavy Duty Vehicles and buses and for 1.A.3.d Domestic Navigation.

3.2.2.1 International Bunkers (1.D.1)

3.2.2.1.1 Category Description

This category includes emissions from internatinal Aviation activities and International Marine Bunkers.

Table 3-6 Total GHG emissions in kt CO_2 eq from category 1.D.1-International Bunkers

Memo Items: GHG Emissions									
GHG Source Category	Greenhouse Gas Emissions (in kt CO_2 eq)								
	1990	1995	2000	2005	2010	2015	2020	2021	2022
1.D.1 International Bunkers	1163.08	1875.31	2591.95	2402.55	5001.88	5353.18	6091.9	7377.58	7655.52

a. International Aviation*	198.17	331.74	327.29	268.43	294.00	360.33	195.25	249.07	385.05
b. International Navigation	903.34	1542.72	2263.39	2132.65	4704.89	4989.64	7093.68	6289.73	6890.74

Notes:* Any emissions arising from International Aviation ,from 2005 onwards,are estimated by EUROCONTROL.

3.2.2.1.2 *Methodological Issues*

International Aviation (CRF Category 1.D.1.a)

GHG emissions from international aviation, for the period 1990-2004, were calculated according to the IPCC 2006 guidelines, following a Tier 1 approach. For the years 2005 onwards, estimates for this category are provided by EUROCONTROL model which uses a combination of Tier 3A & Tier 3B approach. The fuel used for international aviation includes aviation gasoline and jet kerosene which is also known as jet A1 or aviation turbine fuel. Figure 3-1 shows the fuel consumption by fuel type: Aviation gasoline (black) and Jet kerosene (grey).

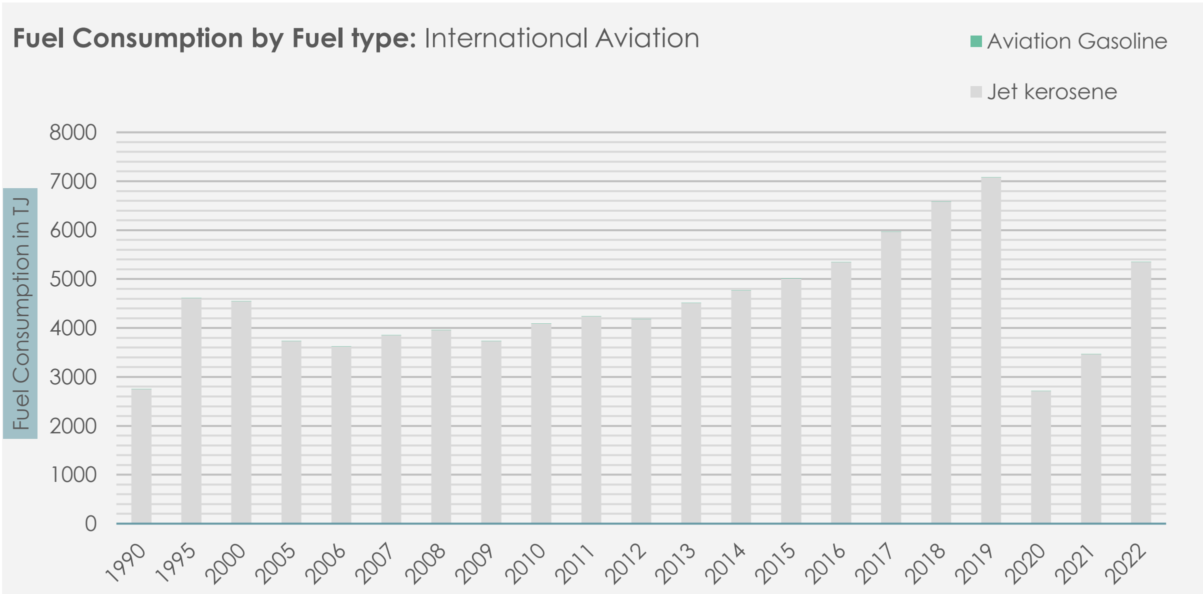


Figure 3-1 Fuel consumption by fuel type for category 1.D.1.a: International Aviation.

Implied Emission Factors

The implied emission factors for CO_2, CH_4 and N_2O emissions, for 2020, from this category can be found in Table 3-7.

Table 3-7 Implied emission factors (IEF) for category 1.D.1.a: International Aviation, for 2020.

Implied Emission Factors & NCVs: International Aviation (CRF: Year 2022)					
	Jet Kerosene	Unit	Aviation Gasoline	Unit	Source
CO_2	71.43	t/TJ	68.85	t/TJ	CRF
CH_4	0.61	kg/TJ	0.69	kg/TJ	CRF
N_2O	1.94	kg/TJ	1.93	kg/TJ	CRF
Notes: Fuel consumption and GHG emissions for this category were estimated by EUROCONTROL (from 2005 onwards)					

International Navigation (CRF Category 1.D.1.b)

GHG emissions from international navigation were calculated following the same method listed in the Domestic Navigation section (see section 3.2.6.13), using a Tier 1 approach. Emissions from international marine bunkering, for CO_2, CH_4 and N_2O have been estimated based on the IPCC 2006 default emission factors (Figure 3-9) and default net calorific values. The EMEP/EEA 2019 Guidelines are used for indirect emissions (Table 3-9). An analysis of the fuel consumption for all fuel types used in this category, including multiple data sources, was performed to ensure the accuracy and consistency of the timeseries. Emissions were recalculated, for the period 1990-2019, based on the results of the analysis (Figure 3-5).

Activity Data

For the period 1990-2001, it was decided to use national historical inventory data, for Residual Fuel Oil consumption, over EUROSTAT data to eliminate any inconsistencies, as there were a lot of discrepancies between the two sources. From 2002 onwards and until 2019 EUROSTAT data was used. Figure 3-2 shows the discrepancies between the two datasets, for Residual Fuel Oil consumption.

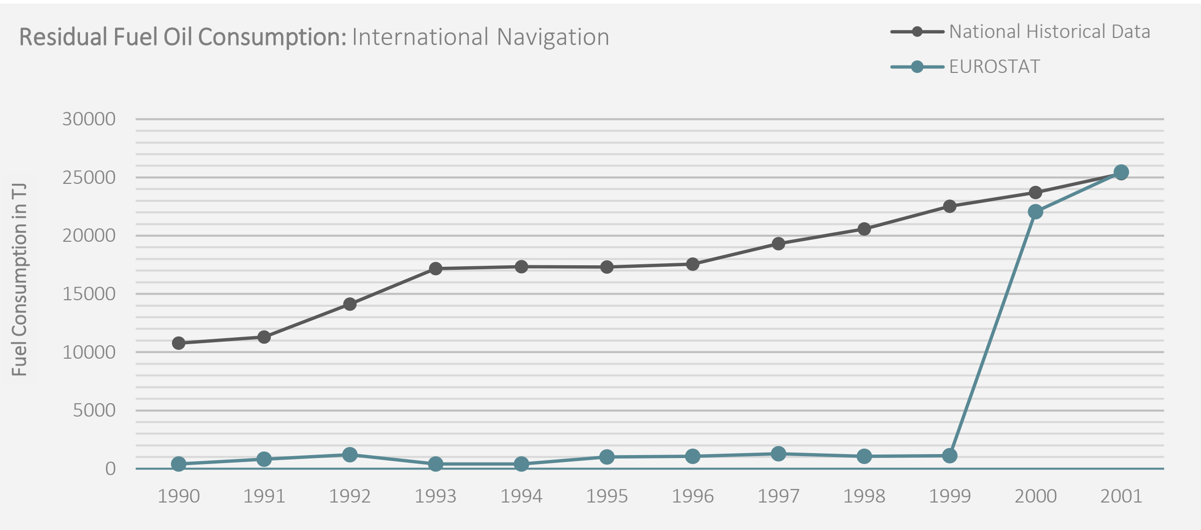


Figure 3-2 Residual Fuel Oil consumption, for the period 1990-2001, as reported in 2021 and 2022 submissions for category 1.D.1.b: International Navigation.

Similarly, for the period 1990-1999 the dataset used for Gas/Diesel Oil consumption was the national one while for the period 2000-2019 data was obtained from EUROSTAT. Figure 3-3 shows the discrepancies between the two datasets, for Gas/Diesel oil consumption. In addition, as it can be seen in Figure 3-4 , there is a sudden increase in Fuel Oil for 2009(red) that does not agree with the reported historical data, and it was decided to take the average RFO consumption in 2008 and 2010 (shown in blue).

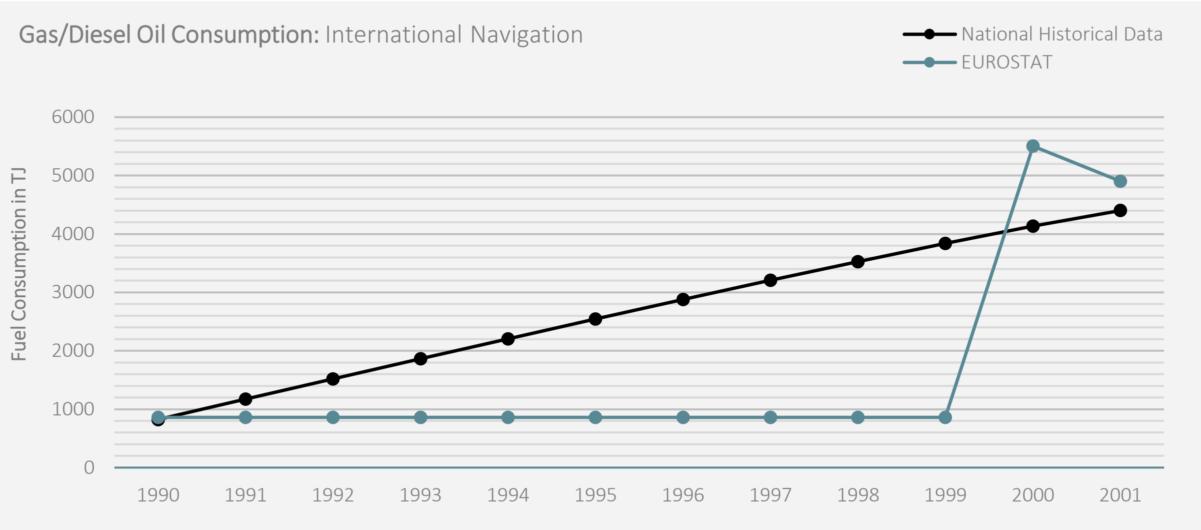


Figure 3-3 Gas/Diesel Oil consumption, for the period 1990-2001, as reported in 2021 and 2022 submissions for category 1.D.1.b: International Navigation.

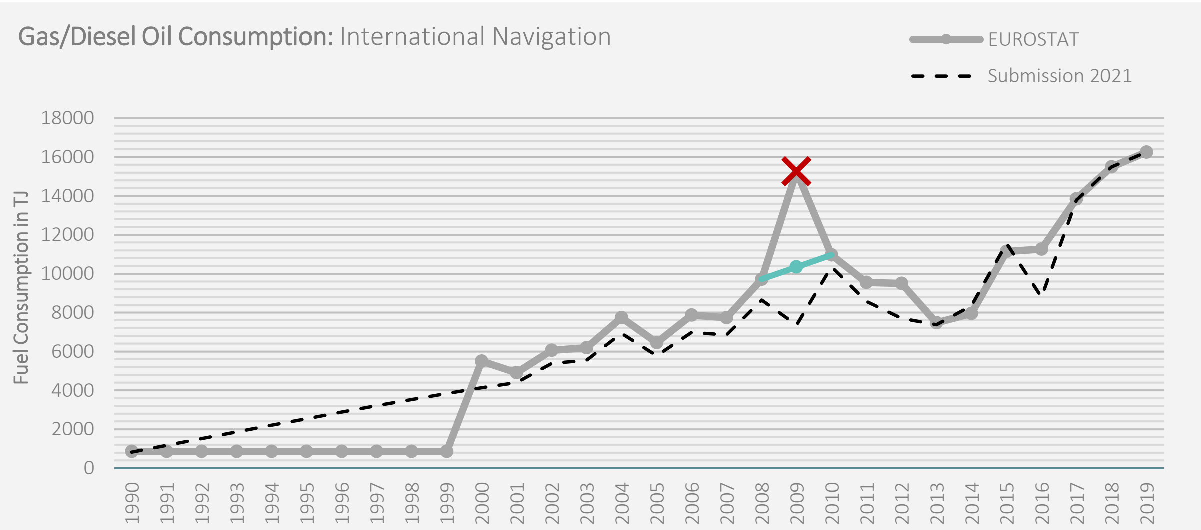


Figure 3-4 Gas/Diesel Oil consumption, for the period 1990-2019, as reported in 2021 submission compared to EUROSTAT data. Category 1.D.1.b: International Navigation.

Fuel consumption data, for the present submission is obtained from the Regulatory for Energy and Water Services (REWS) (Table 3-8). Fuels used under this category include Diesel EN 590, Gasoil and Residual Fuel Oil with the former making up the greater share of the total fuels used for this purpose within this sector. Figure 3-5 shows the total fuel consumption and consumption by fuel type since 1990.

Table 3-8 Statistical fuel consumption by fuel type for category 1.D.1.b: International Navigation, year 2022.

Statistical Fuel Consumption: International Navigation (2022)		
Fuel Type	Fuel Consumption	Unit
Gas and Diesel Oil	18047.23	TJ
Residual Fuel Oil	70915.48	TJ

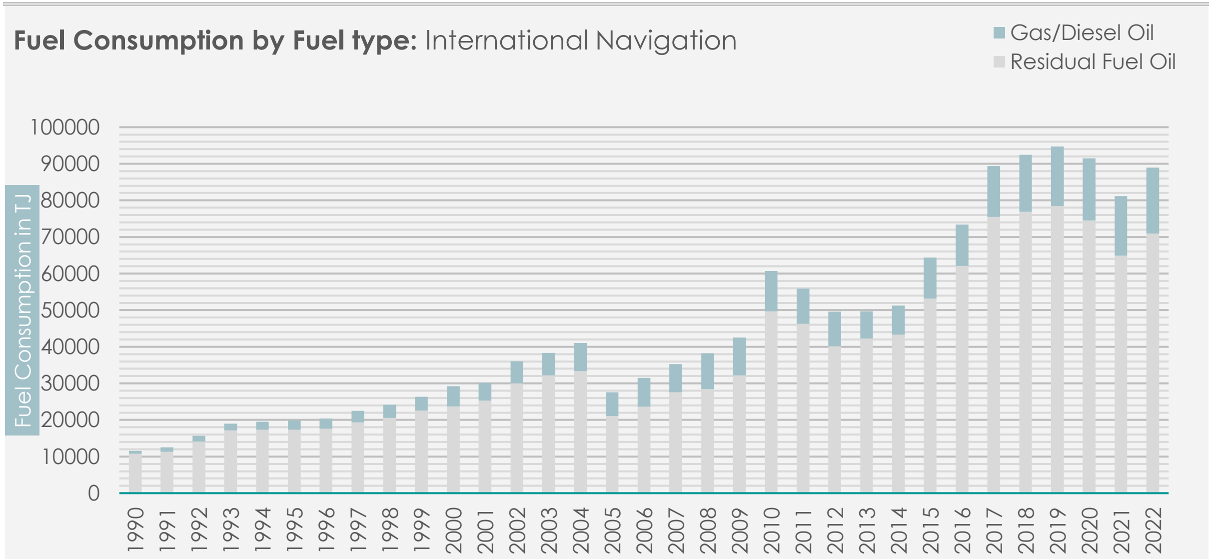


Figure 3-5 Fuel consumption by fuel type for category 1.D.1.a: International Navigation

Emission Factors and Net Calorific Values

Table 3-9 Emission factors and net calorific values used for category 1.D.1.b: International Navigation.

Default Emission Factors & NCVs: International Navigation					
	Gas/Diesel Oil	Unit	Residual Fuel Oil	Unit	Source
CO_2	74100	kg/TJ	77400	kg/TJ	IPCC Guidelines-Volume 2: Energy, Table 3.5.2 p.3.50
CH_4	7	kg/TJ	7	kg/TJ	IPCC Guidelines-Volume 2: Energy, Table 3.5.3 p.3.50
N_2O	2	kg/TJ	2	kg/TJ	IPCC Guidelines-Volume 2: Energy, Table 3.5.3 p.3.50
NO_x	78.5	kg/t	79.30	kg/t	EMEP/EEA 2019. Navigation Chapter. Table 3-1 & Table 3-2, p.13-15

CO	7.4	kg/t	7.40	kg/t	EMEP/EEA 2019. Navigation Chapter. Table 3-1 & Table 3-2, p.13-15
NMVCOs	2.8	kg/t	2.7	kg/t	EMEP/EEA 2019. Navigation Chapter. Table 3-1 & Table 3-2, p.13-15
NCV	43	TJ/Gg	40.4	TJ/Gg	IPCC Guidelines-Volume 2: Energy, Table 1.2 p.1.18

Emissions of sulphur dioxide were also calculated following the methodology presented in 3.2.6.4. Sulphur content and calculated SO_2 emission factors for this submission are presented in Table 3-10.

Table 3-10 Sulphur content and SO_2 emission factors for category 1.D.1.b: International Navigation, year 2022.

Sulphur Content & SO_2 Emission factors: International Navigation (2022)				
	Sulphur Content (%)	SO_2	Unit	Equation
Diesel EN 590	0.000714	0.33	kg/TJ	$EF_{SO_2} = 2\left(\frac{S}{100}\right)\cdot\left(\frac{1}{NCV\frac{[TJ]}{[Gg]}}\right)\cdot 10^6\left[\frac{kg}{TJ}\right]$
Gas Oil	0.070000	32.56	kg/TJ	
Residual Fuel Oil (Grade 1)	0.440000	217.82	kg/TJ	
Residual Fuel Oil (Grade 2)	0.500000	247.52	kg/TJ	

3.2.2.1.3 Uncertainties and time-series consistency

The updated activity data and emissions factors ensures the consistency of the timeseries. In addition, the same methodology was used to estimate emissions for the entire period (1990-2020) to further ensure the consistency of the timeseries.

3.2.2.1.4 Category-specific QA/QC and verification

As presented in the section above, an analysis was performed in the activity data to ensure the consistency and accuracy of the timeseries.

3.2.2.1.5 Category-specific recalculations

Recalculations were performed (Table 3-11) for the category 1.D.1.a-International Aviation, for the period 2016-2021, due to updates in the activity data (provided by EUROCONTROL).

Table 3-11 of recalculations for 1.D.1.a International Aviation

1.D.1.a International Aviation									
Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage Change in reported emissions	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage Change in reported emissions	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage Change in reported emissions
	(Gg CO2 eq.) CO_2	(Gg CO2 eq.) CO_2	(%)	(Gg CO2 eq.) CH_4	(Gg CO2 eq.) CH_4	(%)	(Gg CO2 eq.) N_2O	(Gg CO2 eq.) N_2O	(%)
1990	196.960	196.960	0.0%	0.7713	0.7713	0%	0.4380	0.438	0.0%
1991	186.110	186.110	0.0%	0.7288	0.7288	0%	0.4139	0.414	0.0%
1992	244.150	244.150	0.0%	0.9561	0.9561	0%	0.5429	0.543	0.0%
1993	250.280	250.280	0.0%	0.9801	0.9801	0%	0.5566	0.557	0.0%
1994	308.370	308.370	0.0%	1.2076	1.2076	0%	0.6857	0.686	0.0%
1995	329.720	329.720	0.0%	1.2912	1.2912	0%	0.7332	0.733	0.0%
1996	326.620	326.620	0.0%	1.2791	1.2791	0%	0.7263	0.726	0.0%
1997	342.970	342.970	0.0%	1.3431	1.3431	0%	0.7627	0.763	0.0%
1998	329.560	329.560	0.0%	1.2906	1.2906	0%	0.7329	0.733	0.0%
1999	338.170	338.170	0.0%	1.3243	1.3243	0%	0.7520	0.752	0.0%
2000	325.290	325.290	0.0%	1.2739	1.2739	0%	0.7234	0.723	0.0%
2001	274.650	274.650	0.0%	1.0756	1.0756	0%	0.6108	0.611	0.0%
2002	254.370	254.370	0.0%	0.9962	0.9962	0%	0.5657	0.566	0.0%
2003	255.450	255.450	0.0%	1.0004	1.0004	0%	0.5681	0.568	0.0%
2004	260.970	260.970	0.0%	1.0220	1.0220	0%	0.5803	0.580	0.0%
2005	266.450	266.450	0.0%	0.0574	0.0574	0%	1.9188	1.919	0.0%
2006	258.900	258.900	0.0%	0.0542	0.0542	0%	1.8644	1.864	0.0%
2007	274.970	274.970	0.0%	0.0594	0.0594	0%	1.9802	1.980	0.0%
2008	282.670	282.670	0.0%	0.0581	0.0581	0%	2.0356	2.036	0.0%
2009	266.480	266.480	0.0%	0.0562	0.0562	0%	1.9190	1.919	0.0%
2010	291.840	291.840	0.0%	0.0610	0.0610	0%	2.1016	2.102	0.0%
2011	302.880	302.880	0.0%	0.0610	0.0610	0%	2.1811	2.181	0.0%
2012	298.510	298.510	0.0%	0.0622	0.0622	0%	2.1497	2.150	0.0%
2013	322.150	322.150	0.0%	0.0673	0.0673	0%	2.3199	2.320	0.0%
2014	340.420	340.420	0.0%	0.0717	0.0717	0%	2.4515	2.451	0.0%
2015	357.680	357.680	0.0%	0.0753	0.0753	0%	2.5758	2.576	0.0%
2016	**392.300**	**381.870**	**-2.7%**	**0.0816**	**0.0815**	**0%**	**2.8250**	**2.750**	**-2.7%**
2017	**426.280**	**426.140**	**0.0%**	**0.0953**	**0.0952**	**0%**	**3.0698**	**3.069**	**0.0%**
2018	**470.550**	**470.170**	**-0.1%**	**0.1091**	**0.1091**	**0%**	**3.3885**	**3.386**	**-0.1%**
2019	**506.990**	**505.560**	**-0.3%**	**0.1156**	**0.1155**	**0%**	**3.6510**	**3.641**	**-0.3%**
2020	**194.220**	**193.810**	**-0.2%**	**0.0425**	**0.0425**	**0%**	**1.3986**	**1.396**	**-0.2%**
2021	**247.510**	**247.230**	**-0.1%**	**0.0572**	**0.0578**	**1%**	**1.7824**	**1.780**	**-0.1%**

No recalculations were performed for category 1.D.1.b. However, the value for CO_2 emissions reported for 1990 was updated as there was an error in the calculations.

Table 3-12 Table of recalculations for 1.D.1.b International Navigation

Year	1.D.1.a International Navigation								
	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage Change in reported emissions	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage Change in reported emissions	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage Change in reported emissions
	(Gg CO2 eq.) CO_2	(Gg CO2 eq.) CO_2	(%)	(Gg CO2 eq.) CH_4	(Gg CO2 eq.) CH_4	(%)	(Gg CO2 eq.) N_2O	(Gg CO2 eq.) N_2O	(%)
1990	**956**	**894.92**	**-6.40%**	2.273	2.273	0%	6.147	6.147	0.00%
1991	962.43	962.43	0.00%	2.447	2.447	0%	6.617	6.617	0.00%
1992	1205.71	1205.71	0.00%	3.066	3.066	0%	8.29	8.29	0.00%
1993	1466.67	1466.67	0.00%	3.73	3.73	0%	10.085	10.085	0.00%
1994	1504.59	1504.59	0.00%	3.828	3.828	0%	10.353	10.353	0.00%
1995	1528.31	1528.31	0.00%	3.891	3.891	0%	10.523	10.523	0.00%
1996	1571.63	1571.63	0.00%	4.004	4.004	0%	10.827	10.827	0.00%
1997	1732.64	1732.64	0.00%	4.414	4.414	0%	11.937	11.937	0.00%
1998	1854.7	1854.7	0.00%	4.726	4.726	0%	12.78	12.78	0.00%
1999	2028.83	2028.83	0.00%	5.17	5.17	0%	13.979	13.979	0.00%
2000	2242.19	2242.19	0.00%	5.724	5.724	0%	15.478	15.478	0.00%
2001	2322.31	2322.31	0.00%	5.922	5.922	0%	16.013	16.013	0.00%
2002	2772.48	2772.48	0.00%	7.071	7.071	0%	19.122	19.122	0.00%
2003	2947.89	2947.89	0.00%	7.517	7.517	0%	20.326	20.326	0.00%
2004	3153.28	3153.28	0.00%	8.05	8.05	0%	21.767	21.767	0.00%
2005	2112.64	2112.64	0.00%	5.404	5.404	0%	14.612	14.612	0.00%
2006	2412.83	2412.83	0.00%	6.176	6.176	0%	16.7	16.7	0.00%
2007	2703.58	2703.58	0.00%	6.911	6.911	0%	18.688	18.688	0.00%
2008	2924.45	2924.45	0.00%	7.487	7.487	0%	20.245	20.245	0.00%
2009	3097.52	3255.49	5.10%	7.912	8.33	5%	21.396	22.526	5.30%
2010	4660.84	4660.84	0.00%	11.894	11.894	0%	32.163	32.163	0.00%
2011	4292.53	4292.53	0.00%	10.95	10.95	0%	29.609	29.609	0.00%
2012	3809.46	3809.46	0.00%	9.726	9.726	0%	26.3	26.3	0.00%
2013	3822.09	3822.09	0.00%	9.741	9.741	0%	26.341	26.341	0.00%
2014	3938.44	3938.44	0.00%	10.04	10.04	0%	27.148	27.148	0.00%
2015	4942.93	4942.93	0.00%	12.61	12.61	0%	34.099	34.099	0.00%
2016	5639.8	5639.8	0.00%	14.376	14.376	0%	38.873	38.873	0.00%
2017	6871.07	6871.07	0.00%	17.515	17.515	0%	47.363	47.363	0.00%
2018	7101.38	7101.38	0.00%	18.112	18.112	0%	48.977	48.977	0.00%
2019	7277.74	7277.74	0.00%	18.565	18.565	0%	50.202	50.202	0.00%
2020	7027.24	7027.24	0.00%	17.937	17.937	0%	48.503	48.503	0.00%
2021	6230.78	6230.78	0.00%	15.914	15.914	0%	43.034	43.034	0.00%

3.2.2.1.6 Category-specific planned improvements

There is some room for improvement regarding emissions from international navigation, as emissions from international aviation are already estimated using a high tier 3 methodology. However, there are no planned improvements for this category.

3.2.3 MULTILATERAL OPERATIONS (1.D.2)

This category does not occur.

3.2.3.1.1 Methodological issues

Not applicable

3.2.3.1.2 Uncertainties and time-series consistency

Not applicable

3.2.3.1.3 Category-specific QA/QC and verification

Not applicable

3.2.3.1.4 Category-specific recalculations

Not applicable

3.2.3.1.5 Category-specific planned improvements

Not applicable

3.2.3.2 Emissions from Biomass (1.D.3)

This category includes CO_2 emissions from the combustion of pure or blended biomass from all Energy sub-categories, excluding Energy Industries which does not make any use of biomass.

3.2.3.2.1 Methodological issues

For sub-categories1.A.3.b and 1.A.3d, emissions from the fossil part of biomass are removed and reported under the respective categories. Details on the methodology can be found in sections 3.1.8.2-Road Transport and 3.1.8.4-Domestic Navigation. Biofuel used for automotive military purposes was also included in category 1.A.3.b. CO2 emissions from the fossil part of biomass in category 1.A.2 and 1.A.4 are also included under memo items section.

3.2.3.2.2 Uncertainties and time-series consistency

Malta is planning to do an exercise to ensure the consistency and accuracy of the timeseries.

3.2.3.2.3 Category-specific QA/QC and verification

QA/QC methods for this category follow the same procedure as 1.A.2, 1.A.3 and 1.A.4 categories.

3.2.3.2.4 Category-specific recalculations

Recalculations for biomass and blended biodiesel used in the categories mentioned are presented in the table below.

3.2.3.2.5 Category-specific planned improvements

It is planned to estimate CO_2 emissions separately for the fossil and biogenic part for all categories. The methodology will be similar to the one explained in section 1.A.3.b-Domestic navigation. Thus, CO_2 emissions from the fossil part of biofuels that are still included under this category will be reported under the respective categories in future submissions.

3.2.3.3 CO_2 Captured (1.D.4)

This category does not occur.

3.2.3.3.1 Methodological issues

Not applicable

3.2.3.3.2 Uncertainties and time-series consistency

Not applicable

3.2.3.3.3 Category-specific QA/QC and verification

Not applicable

3.2.3.3.4 Category-specific recalculations

Not applicable

3.2.3.3.5 Category-specific planned improvements

Not applicable

3.2.4 FEEDSTOCKS AND NON-ENERGY USE OF FUELS

Activity data on feedstocks and non-energy use of fuels has been obtained from the Annual Energy Balance published by Eurostat in mid-January. The non-energy fuels used locally are bitumen and lubricants, which are used for asphalting and to minimise friction between moving surfaces, respectively. Since there is no combustion of bitumen, emissions are calculated and reported under IPPU. Emissions from lube oil used in motorcycle 2-stroke engines are calculated and reported under sub-category 1A3b Road Transportation.

The methodology for reporting CO_2 emissions for non-energy lubricant use and for energy was revised after findings reported in the TERT review that took place in 2018, concerning inconsistencies between the two sectors. It was concluded that emissions from lubricants used in 2-stroke engines in the L-Category (1A3biv) are included in the IPPU sector. Category 1AD namely Feedstocks and Other Non-Energy Use in this sector also includes information regarding lubricants. This information includes the amount of lubricants sold (TJ) in Malta and the carbon content of these lubricants which was obtained from the IPPU sector. Data regarding lubricants added to petrol for motorcycles was added in the CRF sector *1.A.3.b.iv Motorcycles* Other Liquid Fuels. These values are equal to those included under IPPU to ensure consistency and avoid double counting.

3.2.5 SECTORAL APPROACH - ENERGY INDUSTRIES (CRF 1A1)

3.2.5.1 Category Description

This section is limited to emissions from the Public Electricity Generation sub-category (1A1a) since both sub-categories Petroleum Refining (1A1b) and Manufacture of Solid Fuels and Other Energy Industries (1A1c) do not occur in Malta.

Public Electricity Generation sub-category (1A1a) includes four installations: Marsa Power Station (operating since before 1990 and now largely decommissioned except for one generating unit kept in stand-by mode for emergency purposes), Delimara Power Station (operational since the 1990's), D3 Power Plant (previously part of the Delimara Power Station) and Electrogas power plant (operational since 2017) Together with the electricity interconnector between Malta and Sicily, and electricity generated though renewables, these plants cater for the current electricity demands of the country.

The use of fossil fuels in this sub-category have seen a decrease in recent years, compared to earlier years. This is due to the sourcing of electricity through the electricity interconnector, the gradual phasing out of fuel oil and replacement by other fuels and investment in more efficient generation turbines installed. Moreover, LNG has started to be used from 2017 resulting in more efficient thermal generation capacity and, hence a lower reliance on gasoil for power generation purposes. It is worth noting that until the shift to oil-fired electricity generation in the early to mid-1990's, coal was also used. Emissions from coal-based electricity generation are reported for the relevant years.

Apart from emissions generated from the combustion of fossil fuels, greenhouse gas emissions are also reported from flue gas treatment through desulphurisation and denoxification (deNOx) processes using bicarbonate and urea respectively. These abatement measures were originally implemented in Delimara Power Station in conjunction with the generation units that eventually formed the basis of the present D3 Power Plant. During an expert visit organised in the context of the EU's *Effort Sharing Decision Review capacity building project* in August 2018, it was recommended that the emissions from urea used in denoxification in energy generation should be reported under the Industrial Processes and other Product Use (IPPU) sector.

3.2.5.2 Methodological Issues

The estimation of emissions for the sub-category Public Electricity and Heat Production benefits from fuel use data reported by the operators of public electricity generators operating in Malta and that fall within the scope of the European Union Emissions Trading System (EU ETS) Directive (2003/87/EC)15[1]. The EU ETS in Malta covers all currently operational public electricity generation installations. The EU ETS Directive requires that data reported by operators of stationary installations that fall within the scope of the Directive is duly verified by accredited

[1] Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC.

and independent verification bodies in accordance with rules established under the Directive. The data obtained from annual emissions reports under the EU ETS covers the period 2005-2019.

The calculation of emissions for the years until 2004 is carried out using a country-specific calorific value for each of the fuels used in the power stations and an oxidation factor of 1 in accordance with the 2006 IPCC Guidelines. For the years 2005 onwards, the calorific values and oxidation factor identified in the verified emission reports submitted pursuant to Directive 2003/87/EC have been used for estimating greenhouse gas inventory emissions. Table 3-13 below includes power plant data used for estimating emissions for the last year covered by the present submission.

Table 3-13 Plant Specific information used for Energy Industries

Power Plant	Actvity Data (t)	Emission Factor (tCO2/TJ)	NCV (TJ/kt)	Oxidation Factor (%)
Marsa				
Diesel	93.29	73.99	42.98	100.00
Delimara				
HFO	NA	NA	NA	NA
Diesel	6831.86	73.47	42.92	100.00
D3PG				
Natural Gas	56124.10	2.76	49.90	100.00
Diesel	8581.40	3.15	42.92	100.00
Electrogas (D4)				
Natural Gas	2593863.33	56.10	48.00	100.00
Diesel	18.54	74.10	43.00	100.00

3.2.5.3 Uncertainties and time-series consistency

As stated below, time-series consistency was improved due to the use of consistent data sources throughout the period 1990-2021, namely Enemalta plc.

3.2.5.4 Category-specific QA/QC and verification

Pursuant to Directive 2003/87/EC, internal data quality assurance and control procedures by the operator of the plants, and independent verification processes by accredited verifiers are applied at a plant level, complemented by review and formal acceptance of emission reports by the competent authority. It is to be noted that all plants falling within the scope of this inventory category also fall within the scope of the said Directive.

3.2.5.5 Category-specific recalculations

Recalculations were necessary for 1.A.1 Energy Industries due to updates in activity data. The updated values for these recalculations are provided in the corresponding Annex.

3.2.5.6 Category-specific planned improvements

No category specific improvements are envisaged since the present data collection sources and methodology are in-line with the IPCC guidelines for a Tier 2 approach.

3.2.6 *SECTORAL APPROACH - MANUFACTURING INDUSTRIES AND CONSTRUCTION (CRF 1A2)*

3.2.6.1 Category Description

This category comprises of emissions from fuel combustion in the manufacturing industries and construction. The fuel types used in this sector are petrol, diesel, gas oil, fuel oil, liquified petroleum gas (LPG), propane, kerosene and biodiesel. Biodiesel was first used in this sector in 2003 and is still being used to-date.

3.2.6.2 Methodological Issues

Fuel data for the source category ‘Manufacturing Industries and Construction’ was, up until 2009, provided by the Petroleum Division of the then Enemalta Corporation, which was the sole importer of fuels used in this sub-category. Following the liberalisation of the inland fuel market and the entry of new operators into the inland fuel market, the Regulator for Energy and Water Services implemented a reporting system to collect, collate, audit and report fuel-related data to the National Statistics Office. This led to an overhaul of the activity data used for inventory purposes.

Furthermore, in recognition of the need to have a better picture of fuel use in Malta, the Malta Resources Authority, in conjunction with the National Statistics Office, carried out a detailed survey on the types of fuels used, and for which purpose(s), split according to the classification of the economic sectors, for the period 2010 - 2013. The results of the survey thus distinguished the fuel usage for each NACE Section. Following the completion of the survey, the Malta Resources Authority carried out a statistical normalization exercise whereby the survey results were ‘back-casted’ over the period 1990-2009.

In the case of fuel oil and gasoil, end-use data for the period 2005 – 2014 was obtained from the Customs Department, who compiles the quantities released in the inland market on the basis of the excise duty rate levied upon them. For the years 2015 and 2016, a 4-year moving average starting from 2010-2013 [the period covered by the survey] was used to estimate the use of fuel oil and gasoil.

Additional to the above, a second survey on the fuels used in the economic sectors was carried out in 2017 by the Energy & Water Agency covering the period 2014-2016. The results of this survey were made available during the compilation of this year’s submission and values were updated accordingly. A new set of data was compiled by the Energy and Water Agency for 2019 which was also made available during the compilation of this year’s NIR.

During a capacity building visit organised in the context of the EU’s Effort Sharing Decision Review capacity building project, in December 2019, a thorough examination of the values provided by the fuels use survey and the data published by Eurostat identified inconsistencies between the two data sources. In order to eliminate such inconsistencies, it was decided that for the March submission, Eurostat’s data is to be used instead of that provided in the Fuel Use Survey. In addition, however, data for 1990 till 2004 is shown as 0 TJ in the Eurostat’s Energy Balance and it was decided that back-casted data is to be used for the said period for completeness purposes.

NSO data verification and validation was completed during the compilation of the current NIR. IPCC 2006 Guidelines default emission factors and calorific values have been used for the whole time-series as shown in Table 3-14 since these are comparable to data provided by the National Statistics Office.

Table 3-14 Emission factors for category Manufacturing Industries and Construction

Fuel Type	CO_2	CH_4	N_2O
	(kg/TJ)	(kg/TJ)	(kg/TJ)
Diesel Oil	74,100.0	3	0.6
Fuel Oil	77,100.0	3	0.6
Gasoil	74,100.0	3	0.6
Kerosene	71,900.0	3	0.6
Liquified Petroleum Gas	63,100.0	1	0.1
Petrol	69,300.0	3	0.6

3.2.6.3 Uncertainties and time-series consistency

The survey results for years 2017- 2020 enhanced the time-series consistency. However, the sample population size quote for the survey was not reached and this led to uncertainties in quality of the final results. Moreover, uncertainties and inconsistences between Eurostat and Fuel Use Survey data needs to be verified with the fuel use survey data provider in order to identify reasons for inconsistencies and resolve issues.

3.2.6.4 Category-specific QA/QC and verification

Internal QA/QC and verification was possible throughout the processes of compiling the NIR since all data is made available to all inventory compilers who can also check the data. Furthermore, support provided by external experts through capacity building in-country visits over recent years has also addressed QA/QC and verification procedures.

3.2.6.5 Category-specific recalculations

Recalculations were necessary for 1.A.2 Manufacturing Industries and Construction due to updates in activity data. The updated values for these recalculations are provided in the corresponding Annex.

3.2.6.6 Category-specific planned improvements

An improvement measure carried out in this category was the disaggregation of data for the category manufacturing industries, for years 2018 till 2022.

3.2.7 *SECTORAL APPROACH - TRANSPORT (CRF 1A3)*

The Transport category comprises the combustion of fuel by all forms of transportation in the Maltese islands. The category is divided into three distinct subcategories:

• Domestic Aviation

- Road Transportation
- Domestic Navigation

In 2021, transport-related GHG emissions total 609 kt, accounting for about 29% of Malta's total GHG emissions (Table 3-15The most significant emission growth since 1990 has been observed in Domestic Navigation, with growth of 329% (40 kt) in 2019. There was no particular long-term decrease in emissions in any of the subcategories up to 2021. Results of the key categories analysis for the transport category can be found in Table 3-16.

Table 3-15 Total GHG emissions in kt CO_2 eq from category 1.A.3-Tranport

1.A.3 Transport									
GHG Source Category	Greenhouse Gas Emissions (in kt CO_2 eq)								
	1990	1995	2000	2005	2010	2015	2020	2021	2022
1.A.3. Transport	351.09	450.19	503.49	529.91	578.68	585.96	579.12	620.62	723.53
a. Domestic Aviation [a]	1.20	2.04	2.08	1.87	2.71	1.44	0.15	0.16	0.31
b. Road Transportation [a,c]	337.98	430.67	484.73	495.23	522.18	545.65	523.90	550.91	665.05
c. Railways	NA	NA	NA	NA	NA	NA	NA	NA	NA
d. Domestic Navigation [a,b]	11.91	11.96	11.95	12.11	12.31	12.16	12.33	12.47	12.36
e. Other Transportation (Off-Road)	IE	IE	IE	IE	IE	IE	IE	IE	IE

Notes:

a.) Excludes emissions from military equipment, which are reported under sub-category 1.A.5-Other (Not Specified Elsewhere)

b.) Excludes emissions from fishing vessels which are reported under sub-category 1.A.4.c.iii-Fishing

c.) Includes off-road emissions

Table 3-16 Key Categories

Key Categories						
Sub Category	Without LULUCF			With LULUCF		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
1.A.3. Transport						
a.Domestic Aviation	x	x	x	x	x	x
b. Road Transportation	✓	x	x	✓	x	x
c. Railways	NA	NA	NA	NA	NA	NA
d. Domestic Navigation	✓	x	x	✓	x	x
e.Other Transportation (Off-Road)	IE	IE	IE	IE	IE	IE

3.2.7.1 Civil Aviation 1.A.3.a

This sub-category includes all GHG emissions from domestic air transport, excluding military air transportation. In accordance with the 2006 IPCC Guidelines (IPCC 2006), military air transportation emissions are reported in the Other (Not specified elsewhere)—Mobile subcategory (CRF category 1.A.5.b). It is important to note that there is only one national airport on the Maltese islands and thus domestic flights mainly include flights from small aircrafts used by training schools, helicopters for search and rescue operations and emergency medical transport between the two main islands. Small aircraft recreational flights are also included. Emissions from transport fuels used at airports for ground transport are included under the Road Transport category (1.A.3.b). Emissions arising from flights that have their origin in Malta and destination in any other country are considered international in nature and are reported separately under Memo Items—International Bunkers (CRF category 1.D.1.a). The methodology for the Domestic Aviation subcategory follows a Tier 1 approach.

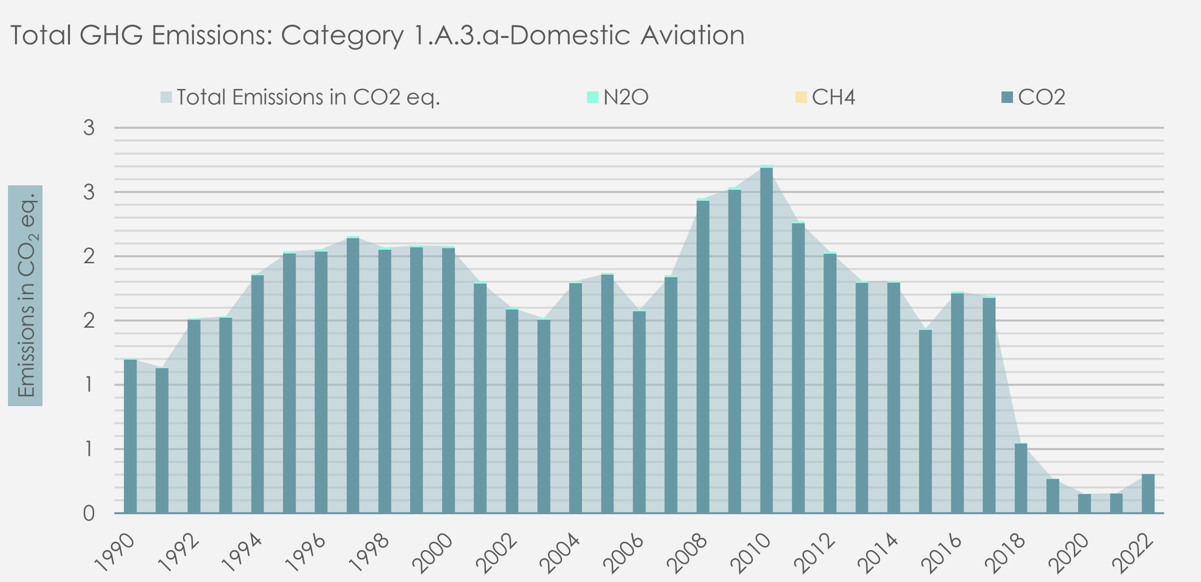


Figure 3-6 Total GHG emissions and emissions by gas. Category 1.A.3.a-Domestic Aviation.

Methodological Issues

Following the IPCC good practice guide, emissions from any fuel listed in the national energy balance on domestic aviation is reported in the National Inventory Report. For the period 1990-2022, the methodology for estimating greenhouse gas emissions from civil aviation follows a Tier 1 approach using the following formula:

$$Emissions = \sum_{j} (Fuel\ Consumption_j \cdot Emission\ Factor_j)$$

Activity Data

The fuel used for domestic aviation in Malta includes Jet kerosene and aviation gasoline. Historical data on fuel consumption for the period 1990-2006 was collected through the Malta Resources Authority from the relevant Aviation Fuel Suppliers. Throughout this period there was only one active supplier on the Maltese islands. After analysing the data for the period 1990-2021, it was concluded that this data was not consistent throughout the timeseries and different sources were used for certain periods. Annex 3 provides more details, regarding the different data sources and any gap filling or interpolation methods used. Since 2015, data regarding domestic aviation were available through the National Oil Balance by EUROSTAT.

Fuel consumption data, for the present submission was obtained from the National Statistics Office (NSO), which is the entity responsible of submitting such data to EUROSTAT. Fuel used for any aviation activities by the military is subtracted and reported under category 1.A.5.b.

Table 3-17 Statistical fuel consumption. Category 1.A.3.a: Domestic Aviation

Statistical Fuel Consumption: Domestic aviation (2022)		
Fuel Type	**Fuel Consumption**	**Unit**
Jet Kerosene	2.96	TJ
Aviation Gasoline	1.33	TJ

Emission Factors & Net Calorific Values

The emission factors used for Domestic aviation and for CO_2, CH_4 and N_2O were the IPCC default emission factors as presented in the guidelines. For NOx, CO and NMVCOs the IPCC Emission Factors Database and the EMEP/EEA guidebook were used. Table 3-18 and Table 3-19 summarize the sources regarding Emission Factors and Net Calorific Values used for this category.

Table 3-18 Default emissions factors and net calorific values used for category 1.A.3.a: Domestic Aviation-Jet kerosene

Default Emission Factors & NCVs: Domestic Aviation (Jet kerosene)			
	Jet Kerosene	Unit	Source
CO_2	71500	kg/TJ	IPCC Guidelines-Volume 2: Energy, Table 3.6.4 p.3.64
CH_4	0.5	kg/TJ	IPCC Guidelines-Volume 2: Energy, Table 3.6.4 p.3.64
N_2O	2	kg/TJ	IPCC Guidelines-Volume 2: Energy, Table 3.6.4 p.3.64
NOx	11*	kg/tonne of fuel	IPCC Emission Factors Database
CO	7*	kg/tonne of fuel	IPCC Emission Factors Database
NMVCOs	0.7*	kg/tonne of fuel	IPCC Emission Factors Database
NCV	44.1	TJ/Gg	IPCC Guidelines-Volume 2: Energy, Table 1.2 p.1.18

Table 3-19 Default emissions factors and net calorific values used for category 1.A.3.a: Domestic Aviation-Aviation Gasoline

Default Emission Factors & NCVs: Domestic Aviation (Aviation Gasoline)			
	Aviation Gasoline	Unit	Source
CO_2	70000	kg/TJ	IPCC Guidelines-Volume 2: Energy, Table 3.6.4 p.3.64
CH_4	0.5	kg/TJ	IPCC Guidelines-Volume 2: Energy, Table 3.6.4 p.3.64
N_2O	2	kg/TJ	IPCC Guidelines-Volume 2: Energy, Table 3.6.4 p.3.64

NOx	4	kg/t	EMEP/EEA 2019. Navigation Chapter. Table 3-2 & Table 3-3, p.20
CO	1200	kg/t	EMEP/EEA 2019. Navigation Chapter. Table 3-2 & Table 3-3, p.20
NMVCOs	19	kg/t	EMEP/EEA 2019. Navigation Chapter. Table 3-2 & Table 3-3, p.20
NCV	44.3	TJ/Gg	IPCC Guidelines-Volume 2: Energy, Table 1.2 p.1.18

The SO_2 emission factor for Jet kerosene was calculated assuming 0.005% of sulphur content, following the IPCC 2006 guidelines. For aviation gasoline the SO_2 emission factor used was obtained from the EEA/EMEP CORINAIR 2019 guidebook.

Table 3-20 SO_2 emissions factors used for category 1.A.3.a: Domestic Aviation.

Sulphur Content & SO2 Emission factors: Domestic Aviation				
	Sulphur Content (%)	SO_2	Unit	Source
Aviation Gasoline	-	1.00	kg/tonne of fuel	EEA/EMEP CORINAIR 2019 Guidebook, Table 3.3, p.20
Jet Kerosene	0.005	2.268	t/TJ	Calculated based on 0.005% of S content according to IPCC 2006 guidelines p371, footnote 10

3.2.7.1.1 *Uncertainties and time-series consistency*

The same methodology and Emission Factors are used for the emissions estimated throughout the whole period (1990-2022). However, as a tier 1 methodology is used, emissions are directly proportional to the fuel consumption. Figure 3-7 illustrates the Fuel consumption in domestic aviation (stacked columns) and the CO_2 emissions (green line) for the period 1990-2022.

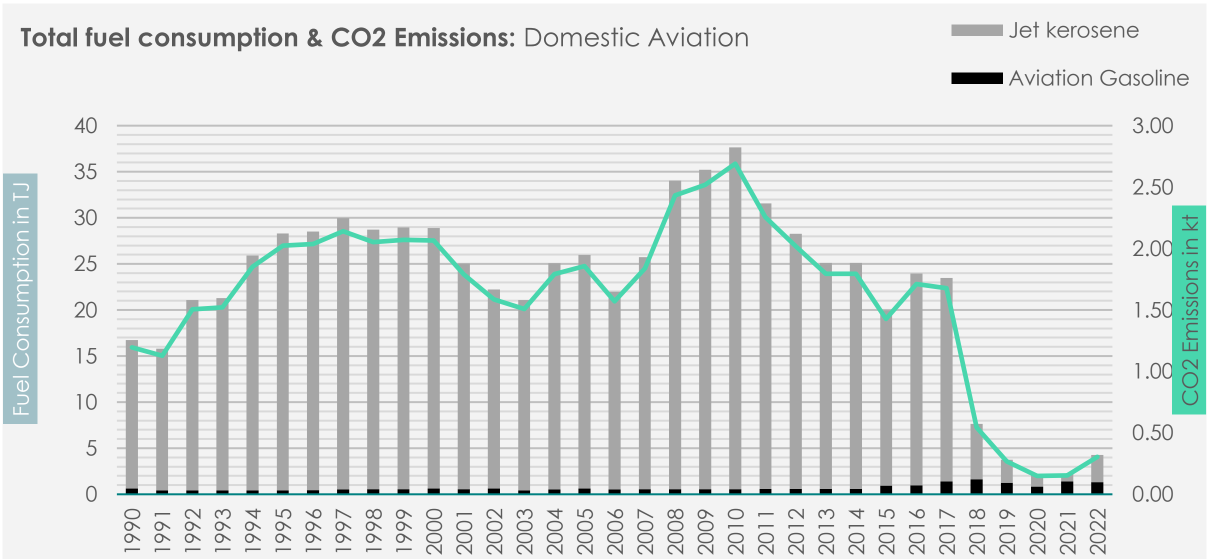


Figure 3-7 Total fuel consumption (stacked columns) and GHG emissions (green line). Category 1.A.3.a-Domestic Aviation.

It is important to highlight that domestic aviation is a very small contributor, for 2010 which was the year of higher emissions from this category, it was still less than 0.5% of total transport emissions. There is only one airport in the Maltese Islands and domestic flights are mainly flights from training schools, recreational flights by small aircrafts and test flights. The total fuel consumption is also affected by the military consumption, which is deducted from the total amount present in the national energy balance (not included in this category).

3.2.7.1.2 Category-specific QA/QC and verification

Domestic aviation has undergone Tier 1 QA/QC checks as outlined in the IPCC Guidelines. The activity data, methods and changes are documented within the domestic aviation worksheets, in electronic form. In addition, information on data sources and any interpolation or extrapolation methods used for the activity data are provided in Annex 3.

3.2.7.1.3 Category-specific recalculations

Recalculations were performed for the year 2021, due to in activity data (fuel consumption).

Table 3-21: of recalculations for category 1.A.3.a Domestic aviation.

1.A.3.a Domestic Aviation									
Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	% Change in reported emissions	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	% Change in reported emissions	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	% Change in reported emissions
	(Gg CO2 eq.) CO_2	(Gg CO2 eq.) CO_2	(%)	(Gg CO2 eq.) CH_4	(Gg CO2 eq.) CH_4	(%)	(Gg CO2 eq.) N_2O	(Gg CO2 eq.) N_2O	(%)
1990	1.20	1.20	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
1991	1.13	1.13	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
1992	1.51	1.51	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
1993	1.52	1.52	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
1994	1.85	1.85	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
1995	2.02	2.02	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
1996	2.04	2.04	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
1997	2.14	2.14	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
1998	2.05	2.05	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
1999	2.07	2.07	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
2000	2.06	2.06	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
2001	1.79	1.79	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
2002	1.59	1.59	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
2003	1.51	1.51	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
2004	1.79	1.79	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
2005	1.86	1.86	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
2006	1.57	1.57	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%

2007	1.84	1.84	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
2008	2.43	2.43	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
2009	2.52	2.52	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
2010	2.69	2.69	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
2011	2.26	2.26	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
2012	2.02	2.02	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
2013	1.79	1.79	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
2014	1.79	1.79	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
2015	1.43	1.43	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
2016	1.71	1.71	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
2017	1.68	1.68	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
2018	0.54	0.54	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
2019	0.27	0.27	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
2020	0.15	0.15	0.0%	0.000	0.000	0.0%	0.000	0.000	0.0%
2021	0.15	0.15	**1.1%**	0.000	0.000	**1.1%**	0.000	0.000	**1.1%**

3.2.7.1.4 Category-specific planned improvements

There are no planned improvements for this category.

3.2.7.2 Road Transport (CRF 1.A.3.b)

This section addresses the estimation of emission related to category 1.A.3.b-Road transportation. All combustion and evaporative emissions arising from fuel use in any automotive purposes, including off-road activities, ground activities in airports and harbours, military automotive purposes, are reported under this category. Military vehicles, which are mainly troop carrying trucks, could not be excluded from the total stock, thus any fuel consumed by military for automotive purposes is not deducted from national totals and is included in this category. Figure 3-8 illustrates the total GHG emissions from road transportation, by vehicle type. Figure 3-9 presents the share of emissions by vehicle type and share of fuel by fuel type, in 2022. The fuels used for road transport include Diesel oil, Motor Gasoline, LPG, and biodiesel, with the latter being sold pre-blended with diesel following the implementation of EN590 (diesel) and EN228 (petrol) in 2010.

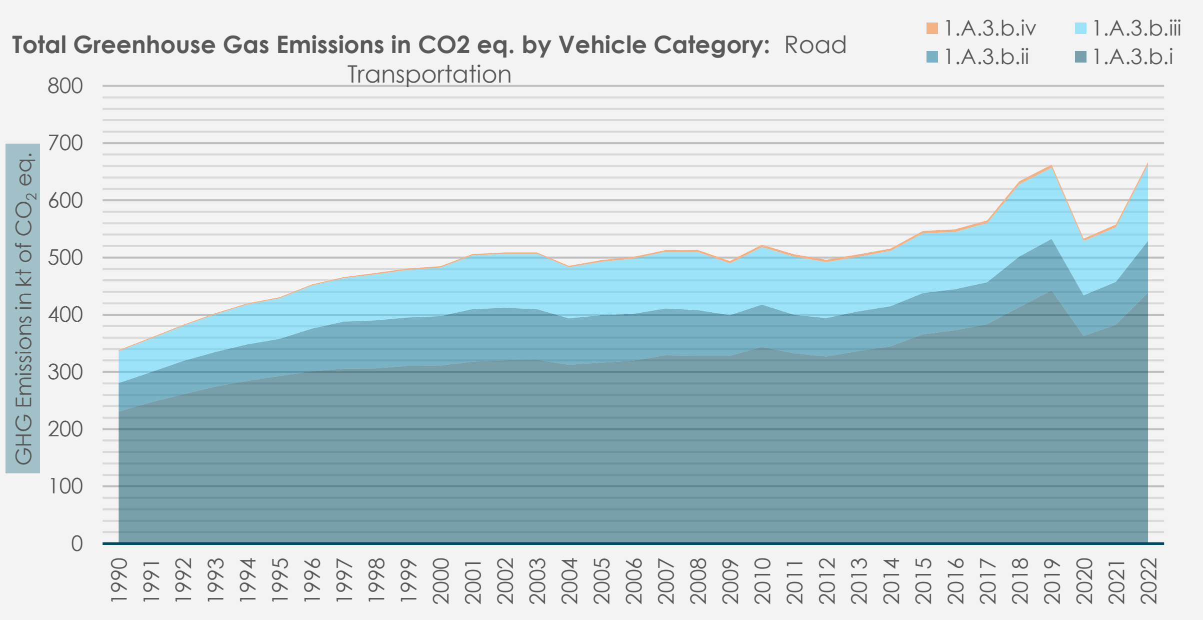
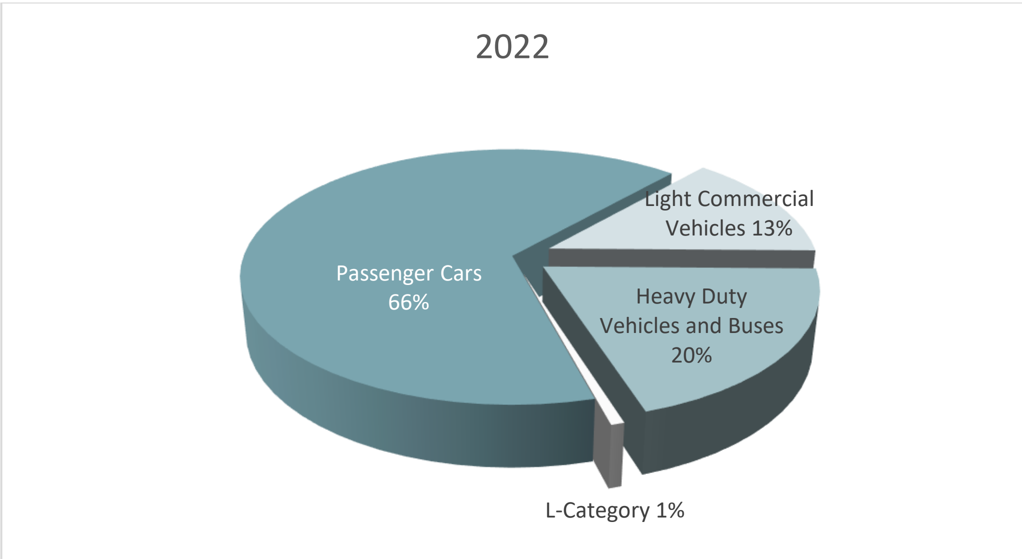


Figure 3-8 Total GHG Emissions in kt CO_2 eq. by vehicle category (1990-2022).

Category 1.A.3.b-Road Transport



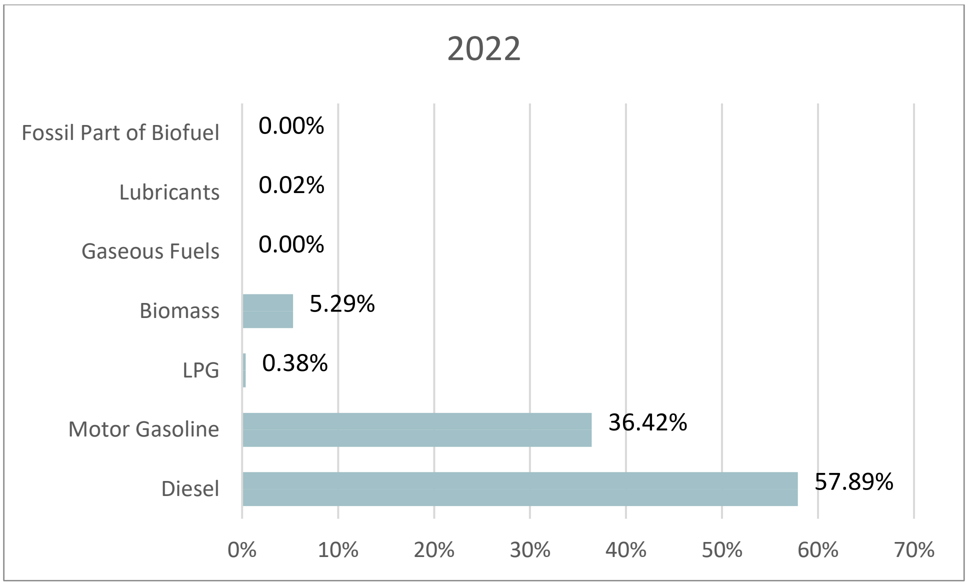


Figure 3-9 Emissions share by vehicle type and Fuel share by fuel type Category 1.A.3.b-Road Transport (2022).

3.2.7.2.1 Methodological issues

Carbon dioxide emissions are estimated following the IPCC 2006 Tier 1 methodology. Since fuel consumption disaggregated by vehicle type (cars, light duty vehicles, heavy duty vehicles, buses, and L-category) is not available, the amount of fuel allocated to each category is estimated by the COPERT V model. The energy consumption for each sub-category is extracted and used as activity data following the 2006 IPCC guidelines Tier 1 approach and using the default CO_2 emission factors and default net calorific values provided by the 2006 IPCC guidelines(Table 3-22).Please note that country specific EF for CO_2 are not available as the carbon content of fuels used in road transportation is not available. Due to the many different types of vehicles, activities and fuels, the emission factors are numerous and complex. In order to cope with this complexity, road transport Methane and nitrous oxide emission estimates are calculated using the COPERT V model, which follows a detailed Tier 3 method. Implied Emission Factors for CH_4 and N_2O can be found in Table 3-23. NOx ,SO_2, CO and NMVOCs emissions are also estimated by COPERT.

The model calculates emissions following a methodology which is very similar to the one provided in the IPCC 2006 guidelines, which is based on vehicle kilometres rather than fuel sold. In order to balance the statistical and the calculated energy consumption, the user can input data regarding total fuel sales, per fuel type and enable the 'Energy Balance' function. The software follows a two-step approach. First, it matches the fossil/bio energy consumption ratio defined in the statistical values by modifying the blend type and blend share . Once this is achieved a second modification to the mileage is applied in the form of a correction factor in order to match the total statistical energy consumption level. These updated values for both the fuel blend characteristics and the annual mileage are then used to calculate the total emissions.

Table 3-22 CO_2 Emission Factors and Net Calorific Values for category 1.A.3.b-Road Transport.

CO_2 Emission Factors and Net Calorific Values : Road Transport				
Fuel Type	CO_2 EF (kg/TJ)	source	NCV	source
Petrol	69 300	IPCC Guidelines/Volume 2/Chapter 3- Mobile Combustion, Table 3.5.2, p 3.50	44.3	IPCC Guidelines/Volume 2/Chapter 1- Introduction, table 1.2, p. 1.18
Diesel	74 100		43.0	
LPG	63100		47.3	

Table 3-23 CH_4 and N_2O Implied Emission Factors for category 1.A.3.b-Road Transport (2022)

CH_4 and N_2O Implied Emission Factors Values : Road Transport (2022)			
Fuel Type	CH_4 IEF (kg/TJ)	N_2O IEF (kg/TJ)	source
Petrol	7.53	0.66	CRF tables
Diesel	1.19	1.88	
LPG	7.78	1.00	
Biomass	1.34	2.17	

COPERT input parameters

Environmental Information:

This form requires the values for monthly average minimum and maximum temperatures. Data related to the relative humidity per month, which is also provided in this form, is used to calculate the load of air-conditioning (A/C) and estimate emissions from fuel evaporation. These parameters are obtained annually(Table 3-24), from the National Statistics Office (NSO).

Table 3-24 Environmental Information for 2022. Category 1.A.3.b-Road Transport.

Environmental Information: Road Transport (2022)			
Month	Minimum Temperature (°C)	Maximum Temperature (°C)	Humidity (%)
January	8.7	14.7	76.1%
February	9.3	15.8	74.9%
March	9.2	15.6	73.3%
April	12.4	19.2	71.7%
May	16.1	24.9	66.9%
June	21.5	32.5	51.6%
July	23.8	33.5	63.5%
August	24.1	32.4	70%

September	22.7	29.5	72%
October	17.9	25.4	75.4%
November	14.9	21.4	77.3%
December	12.9	19.5	84.2%

Trip Characteristics:

The average Trip Length (km) and Trip Duration (hour) are provided by Transport Malta (TM) which is the national authority for Transport in Malta. The provided values are outputs of the National Transport Model, a mathematical model which simulates network conditions during peak period (AM and PM) across the Maltese transport network (though with a focus on upper hierarchy roads). The model is a typical four-stage traffic model which takes into consideration: Trip Generation, Trip Distribution, Mode Choice and Trip Assignment. Trip length has an effect on the cold start emission factors and energy consumption, while the trip duration affects the evaporative emissions factors.

Table 3-25 Trip Length (km) and Trip Duration (h). Category 1.A.3.b-Road Transport.

Trip Characteristics: Road Transport		
2022	Trip Length (km)	Trip Duration (h)
Passenger Cars	12	0.25
Light Commercial Vehicles	12	0.25
Heavy Duty Trucks	44	0.85
Buses	44	0.85
L-Category	12	0.25

Fuel Specifications:

COPERT default values are used for most of the Fuel Specifications, such as the Hydrogen to Carbon ratio and density. Sulphur content is provided annually by the Regulator for Energy and Water Services (REWS). Please note that SO_2 emissions from LPG are not estimated, as sulphur content for liquified petroleum gas is not available. Fuel specifications such as H:C ratio or O:C ratio will affect any CO_2 emissions. The density of fuel is used to estimate the total fuel consumed and the Energy balance. Heavy metal content and advanced fuel specification have an effect on the heavy metal emissions and CO, VOC, Nox,MP emissions of older vehicles. Table 3-26 presents the values used for the current submission.

Table 3-26 Fuel specifications for category 1.A.3.b-Road Transport.

Fuel Specifications: Road Transport							
Fuel Type	**Energy [MJ/kg]**	**Content**	**H:C Ratio**	**O:C Ratio**	**source**	**S Content* [ppm wt]**	**source**

Petrol	43.774	1.86	0	COPERT V	3.24	Country Specific (REWS)
Diesel	42.695	1.86	0	COPERT V	6.35	Country Specific (REWS)
LPG	46.565	2.525	0	COPERT V	-	-

Notes:
* S content refers to 2022 only.

Statistical Consumption

COPERT V calculates emissions following a methodology which is very similar to the one provided in the IPCC 2006 guidelines, and which is based on vehicle kilometres rather than fuel sold. To balance the statistical and the calculated energy consumption, fuel sales per fuel type, are fed into the model. This data is available in the Eurostat oil Balance. Statistical fuel consumption for 2021 is presented in Table 3-27. An inbuilt COPERT function (Energy Balance) assists in balancing statistical and calculated energy consumption. To do so, the software has a two-step approach. First, it matches the fossil/bio energy consumption ratio defined in the statistical values by modifying the blend type. Once this is achieved a second modification to the mileage and blend share is applied in the form of a correction factor to match the total statistical energy consumption level. These updated values for both the fuel blend characteristics and the annual mileage are then used to calculate the total emissions. The statistical energy consumption is taking into account by the model while estimating the Blend share, bi-fuel share and the mean activity. All these paramaters will affect the final energy consumption and emissions.

Table 3-27 Statistical fuel consumption for category 1.A.3.b-Road Transport.

Statistical Fuel Consumption: Road Transport (2022)*		
Fuel Type	Fuel Consumption	Unit
Diesel	5,590.11	TJ
Petrol	3,516.51	TJ
LPG	36.84	TJ
Blended biodiesel	522.58	TJ

Reid Vapor Pressure

The monthly Reid Vapor Pressure is provided by REWS (Table 3-28).

Table 3-28 Reid Vapor Pressure of for category 1.A.3.b-Road Transport.

Reid Vapor Pressure: Road Transport (2022)		
Month	RVP	Unit
January	71.04	kPa

February	71.04	kPa
March	71.04	kPa
April	70.97	kPa
May	58.28	kPa
June	58.28	kPa
July	58.56	kPa
August	59.36	kPa
September	59.53	kPa
October	57.71	kPa
November	56.91	kPa
December	58.03	kPa

Share of ETBE in Bioethanol

According to the Regulatory of Energy and Water Services, there is no ETBE use in Malta, thus the percentage in COPERT is set to 0%. We confirm this statement with the agency annually.

Share of FAME in biodiesel

The share of FAME in biodiesel is usually calculated based on the article 7a of the Fuel Quality Directive (FQD). Since the FQD is only available from 2017 onwards, for the period 2010-2016 the default value for the Share of FAME in Biodiesel (80%) provided by COPERT was used. In 2022 the only type of blended biofuel used was HVO and thus there is 0% of FAME.

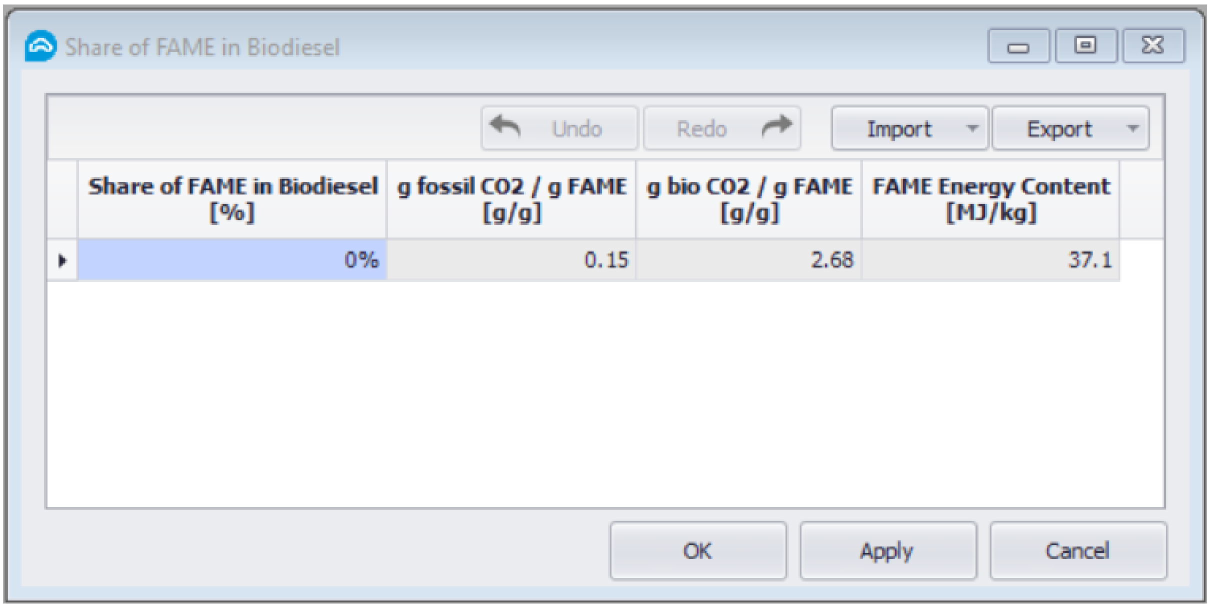


Figure 3-10 FAME specifications for category 1.A.3.b: Road Transport (2022)

Stock Configuration and Activity Data

This data is one of the necessary forms required as input by the user in COPERT. The Lifetime Cumulative Mileage is relevant for both the calculation of evaporative emissions and the estimation of mileage degradation parameters. This value is the mean distance travelled by each vehicle of a specific technology level since their introduction in the market. The value is also used to provide an emission degradation factor depending on vehicle age (or total mileage driven).

In the case of the automatic energy balance, in order for the calculated consumption to match the statistical consumption, COPERT calculates a new Mean Activity. This new mean activity is used to calculate both energy consumption and emissions

For the period 1995-2005 was extracted from the national Vehicle Registration and Administrative Systeme Database (VERA), provided by Transport Malta (TM) (the Authority responsible for transport in the country). VERA database is the only register that contains the complete details of all vehicles registered and licensed in Malta. Data for total vehicle fleet categorisation in Malta is only available for 1995 onwards. In order to have a consistent timeseries, an exercise has been carried out to categorise the vehicle fleet according to euro standards, for years 1990 to 1994. The vehicle fleet of year 1995 was used to calculate backwords such categorisations (please check Annex 3 for more information). illustrates the

The mean and lifetime cumulative activity, for each category, were provided by the same model. According to the documentation of the transport model EWA developed, estimates of the annual VKM driven, were provided by NSO and are based on a sample of vehicles which carried out a Vehicle Roadworthiness Test (VRT) in that year. The VRT data include information of the vehicle type, engine size/ vehicle weight, fuel type, year of manufacture, and sample of vehicles feeding into the annual VKM estimate. In the same documentation, provided by EWA the following is stated:

"The NSO noted that the annual average VKM was calculated as follows:

- VRT Mileage difference = VRT2 – VRT1 = A
- VRT Days = VRT Date 2 – VRT Date 1 = B
- VKM average / day = A/B = C
- Annual Ave. VKM = C x 365 days = D

Only vehicles with an annual average VKM between 500KM<=D<=150,000KM were considered (NSO, 2018) to remove the effect of data anomalies."

Circulation Data

The average Speed and the mileage percentage driven by each vehicle technology per driving mode is provided by Transport Malta. Speeds affect hot and cold emission and energy consumption factors. Road share parameters affect emissions and energy consumption split in different driving modes.

Table 3-29 Circulation data for category 1.A.3.b-Road Transport.

Trip Characteristics: Road Transport (2020)				
	Urban Peak	Urban Off Peak	Rural	Highway
Road share	2.55%	34.94%	28.70%	33.82%
Speed	15.97	16.55	14.81	55.44

Other Parameters

Parameters where country specific data were not available, the default COPERT V parameters were used. A few examples are, the Fuel Evaporation Data, the A/C usage, Technology share and Driving conditions.

Emissions

The type of emissions includes:

Hot exhaust emissions: emissions from the vehicle exhaust when the engine has warmed up to its normal operating temperature.

Cold start emissions: the excess emissions that occur when a vehicle is started with its engine below its normal operating temperature.

Emissions are calculated for vehicles of the following types:

• Passenger Cars: Petrol, Diesel, Petrol Hybrid, LPG Biofuel

• Light Commercial Vehicles (Petrol, Diesel

• Heavy Duty Trucks (Petrol, Diesel)

• Buses and coaches (Diesel)

• Motorcycles (Petrol)

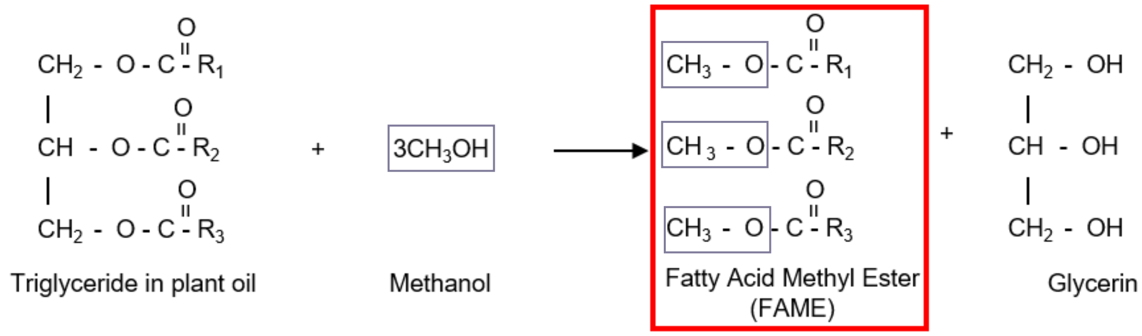
Carbon dioxide emissions

CO_2 from fossil fuels

CO_2 from fossil fuels, are estimated following a fuel-based Tier 1 approach.

CO_2 from biofuels

Biodiesel in Malta is sold preblended. Most of the blended biodiesel is of biogenic origin (Hydrotreated Vegetable Oil-HVO), thus CO_2 emissions from HVO are not included in the national totals but are estimated and reported separately as memo item. Biodiesel includes an amount of Fatty Acid Methyl Esters (FAME) which contains methanol (fossil origin-Figure below). Emissions from this fossil part of FAME is included in national totals and is reported in category 1.A.3.b-Road transportation under “other fossil fuels”, for each sub-category.



CO_2 emissions from both the biogenic and fossil part of biodiesel are estimated using the COPERT V model. COPERT requires the share of FAME in total biodiesel, which was calculated based on the National Oil Balance, provided by REWS.

Emissions from Lubricants

Due to unavailability of disaggregated data on lubricant use, total importation data is used to calculate emissions from lubricants in road transportation. The assumption is that lubricants imported in one year are used throughout that same year and as a result emissions are attributed in whole to that year. In addition, it is assumed that lubricants in road transport are consumed only by 2-strokes motorcycles. Total lubricant consumption in Malta is provided by the national statistics office.

Gasoline consumption for 2-stroke motorcycles is obtained from COPERT. According to the 2006 IPCC Guidelines, Volume 2 Chapter 3 Box 3.2.4, the common mixture of lubrication oil and gasoline are 1:25, 1:33 and 1.50 depending on the engine type. The median value of 1.33 is chosen to calculate the amount of lubricant used in category 1.A.3.b.iv-Road Transportation: Motorcycles. The CO_2 emissions from lubricants using the Tier 1 methodology and the default CO_2 EF from the IPPC guidelines (73300 kg/TJ). Lubricant specifications are not available and the default specifications by COPERT are used.

Non-CO_2 Emissions

Methane (CH_4) and Nitrous Oxide (N_2O) for any fuel type (except lubricants) are calculated with COPERT V, based on specific emission factors (Tier 3 approach). All Emission factors for these gases are provided by the model. For CH_4 emissions, four values (mg/km) are provided :Cold Urban, Hot Urban, Rural, and Highway CH_4 emissions. The cold and hot urban part are estimated on the basis of cold-start distance. For N_2O emissions and in particular for petrol passenger cars and light commercial vehicles the following equation is used:

$$EF_{N_2O} = (a \times M_{cumulative} + b) \times Emission\ Factor_{BASE}$$

Where:

- A,b, EF_{BASE} depend on the technology level
- A,b, depend on fuel sulphur content
- Different factors for cold urban, hot urban, rural and highway are used.

The approach is much simpler when it comes to diesel cars, heavy duty vehicles and motorcycles.

Sulphur dioxide (SO_2) emissions are also estimated with COPERT, using a country specific emission factor (Sulphur content is provided by REWS) and a Tier 1 approach. Carbon monoxide (CO), Nitrogen oxides (NOx) and Non-methane VOCs (NMVOCs) are calculated by COPERT following a detailed methodology, based on specific emission factors.

Non-CO_2 Emissions from Lubricants

As mentioned above, for Category 1.A.3.b.iv Motorcycles, Malta reports only emissions arising from the use of Lubricants in motorcycles.CO_2 emissions from lubricants are estimated using the Tier 1 methodology and the default CO_2 EF from the IPCC guidelines (73300 kg/TJ). Although emissions of CH_4 and N_2O do arise from lubricant combustion in 2-stroke engines, these are assumed to be included in the hot exhaust emission factors for gasoline consumption in 2-stroke vehicles, thus such emissions are not estimated separately, and they are reported as “IE”."

3.2.7.2.2 Uncertainties and time-series consistency

Although fleet information was revised to ensure the accuracy and timeseries consistency, vehicle fleet information is only available from 1995 onwards hence years prior required a back-casting exercise which could have led to some timeseries uncertainties. Data regarding mean activity needs to be revised to ensure the time series consistency, especially for the period 1990-2009. This can lead to uncertainties in the classification of all sub-categories. It is also important to point out that the category 1A3biii Heavy-Duty trucks includes emissions from heavy duty trucks, buses and coaches. In addition, for the current submission, a more recent version of the COPERT model was used, which may have slightly different emission factors for certain categories.

3.2.7.2.3 Category-specific QA/QC and verification

Most of the parameters that are used to estimate emissions from road transportation were analysed and revised, including fuel consumption, to ensure the consistency and accuracy of the time series. Please see Annex 3 for more information.

3.2.7.2.4 Category-specific recalculations

Recalculations were performed for the period 1990-2021, as an updated version of the model was available. In addition, there were updates in the fuel consumption for 2018-2021.

Table 3-30: of recalculations for category 1.A.3.b Road Transportation.

	1.A.3.b Road Transportation								
Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	% Change in reported emissions	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	% Change in reported emissions	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	% Change in reported emissions
	(Gg CO2 eq.) CO_2	(Gg CO2 eq.) CO_2	(%)	(Gg CO2 eq.) CH_4	(Gg CO2 eq.) CH_4	(%)	(Gg CO2 eq.) N_2O	(Gg CO2 eq.) N_2O	(%)

1990	333.23	333.23	0.0%	2.672	2.672	0.0%	2.078	2.078	0.0%
1991	355.00	355.00	0.0%	2.857	2.857	0.0%	2.226	2.211	-0.7%
1992	376.76	376.76	0.0%	2.608	2.608	0.0%	2.950	2.946	-0.2%
1993	396.57	396.57	0.0%	2.720	2.720	0.0%	3.120	3.120	0.0%
1994	413.94	413.94	0.0%	2.821	2.821	0.0%	3.255	3.255	0.0%
1995	424.45	424.45	0.0%	2.885	2.885	0.0%	3.340	3.340	0.0%
1996	446.79	446.79	0.0%	2.875	2.875	0.0%	3.536	3.536	0.0%
1997	459.50	459.50	0.0%	2.844	2.844	0.0%	3.672	3.672	0.0%
1998	466.62	466.62	0.0%	2.753	2.753	0.0%	3.744	3.744	0.0%
1999	474.21	474.21	0.0%	2.676	2.676	0.0%	3.848	3.848	0.0%
2000	478.41	478.41	0.0%	2.508	2.508	0.0%	3.820	3.820	0.0%
2001	500.06	500.06	0.0%	2.393	2.393	0.0%	3.844	3.844	0.0%
2002	503.02	503.02	0.0%	2.286	2.286	0.0%	3.835	3.835	0.0%
2003	503.05	503.05	0.0%	2.194	2.194	0.0%	3.823	3.823	0.0%
2004	479.71	479.71	0.0%	2.067	2.067	0.0%	3.711	3.711	0.0%
2005	489.50	489.50	0.0%	1.993	1.993	0.0%	3.731	3.731	0.0%
2006	495.47	495.47	0.0%	1.919	1.919	0.0%	3.718	3.718	0.0%
2007	507.24	507.24	0.0%	1.898	1.898	0.0%	3.778	3.778	0.0%
2008	508.48	508.48	0.0%	1.821	1.821	0.0%	2.989	2.989	0.0%
2009	489.09	489.09	0.0%	1.713	1.713	0.0%	2.848	2.848	0.0%
2010	517.56	517.56	0.0%	1.661	1.661	0.0%	2.954	2.955	0.0%
2011	501.02	501.02	0.0%	1.501	1.501	0.0%	2.816	2.817	0.0%
2012	491.43	491.43	0.0%	1.357	1.357	0.0%	2.748	2.749	0.0%
2013	500.85	500.85	0.0%	1.323	1.323	0.1%	2.846	2.848	0.1%
2014	510.44	510.44	0.0%	1.261	1.261	0.1%	2.913	2.916	0.1%
2015	541.40	541.40	0.0%	1.245	1.245	0.0%	3.005	3.008	0.1%
2016	544.29	544.29	0.0%	1.178	1.178	0.0%	3.008	3.010	0.0%
2017	560.34	560.34	0.0%	1.123	1.123	0.0%	3.093	3.094	0.0%
2018	627.77	622.79	-0.8%	1.107	1.105	-0.1%	3.543	3.509	-1.0%
2019	657.01	650.35	-1.0%	1.093	1.089	-0.4%	3.706	3.663	-1.2%
2020	529.05	520.02	-1.7%	0.869	0.865	-0.4%	3.064	3.011	-1.7%
2021	553.35	547.04	-1.1%	0.865	0.862	-0.3%	3.044	3.006	-1.3%

3.2.7.2.5 Category-specific planned improvements

According to the IPCC guidelines, the category 1.A.3.b-Road Transport should include only road vehicles. Construction vehicles and agricultural vehicles should be reported under other categories. The values for gas/diesel oil, petrol and LPG for road transport that are taken from Eurostat, includes the fuel used in those other categories, since they are not categorised. Therefore, one of the planned improvements is to start calculating emissions for the non-road transport vehicles under their respective categories, instead of including them under Road transport. Moreover, emissions from transport fuels used at airports and harbours for ground transport are currently being reported under the Road Transport category (1.A.3.b). Efforts are being made to estimate such emissions separately and to include them under the category 1.A.3.e -Other Transportation.

Refinements are required for COPERT input data including average mileage, trip duration and trip length. These refinements are currently being discussed in consultation with Transport Malta, ERA, EWA and NSO, to make this data available for future submissions.

In addition, as it was mentioned above, a more recent version of the model was used for the estimation of 2022 data. It is planned (for the submission of March 2024) to recalculate emissions for the period 1990-2022 using the most updated version of the model.

3.2.7.3 Railways (CRF 1.A.3.c)

This category does not occur.

3.2.7.3.1 Methodological Issues

Not applicable.

3.2.7.3.2 Uncertainties and Time-Series Consistency

Not applicable.

3.2.7.3.3 Category-specific QA/QC and verification

Not applicable.

3.2.7.3.4 Category-specific Recalculations

Not applicable.

3.2.7.3.5 Category-specific planned Improvements

Not applicable.

3.2.7.4 Domestic (Water-Borne) Navigation (CRF 1.A.3.d)

3.2.7.4.1 Category Description

This subcategory includes all GHG emissions from domestic marine transport including boats, yachts, pleasure craft, jet skis and passenger ferries. In accordance with the 2006 IPCC Guidelines (IPCC 2006), emissions from fuel consumed by military vessels are reported in the Other (Not specified elsewhere)—Mobile subcategory (CRF category 1.A.5.b). Emissions arising from fuel used for international voyages are designated as "bunker" emissions and are not included in national totals but are estimated and reported as international bunkers under Memo Items— International Bunkers (CRF Category 1.D.1.b). Emissions from fuel consumed by fishing vessels are reported under Agriculture/Forestry/Fishing—CRF Category 1.A.4.c.

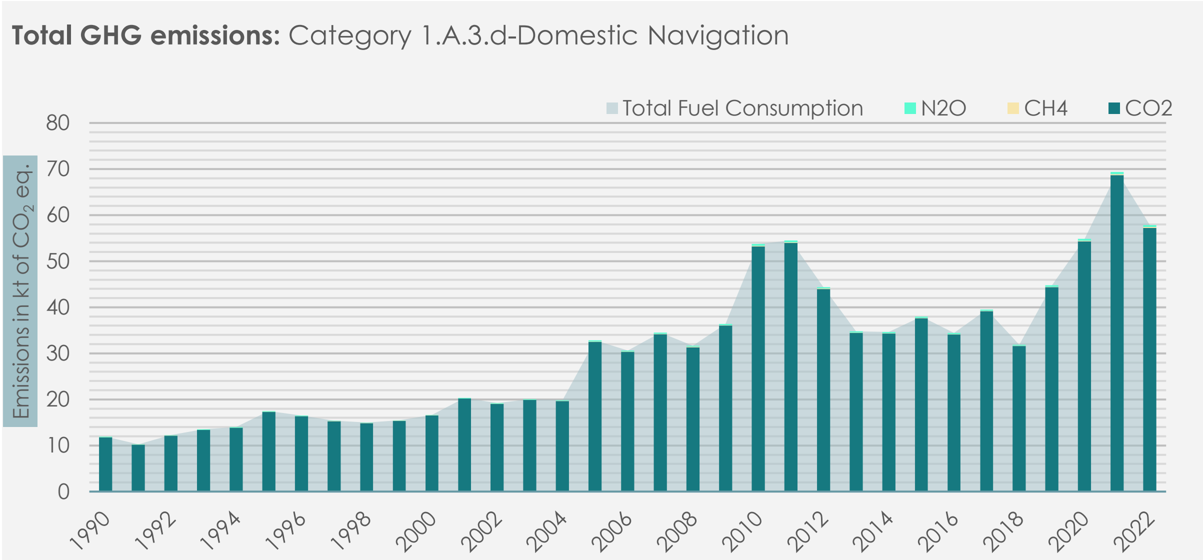


Figure 3-11 Total GHG emissions and emissions by gas. Category 1.A.3.d-Domestic Navigation

3.2.7.4.2 Methodological Issues

The methodology complies with an IPCC Tier 1 technique for GHG emissions, which is based on the relative consumption of energy per fuel and default emission factors from the 2006 IPCC Guidelines. The methodology used to estimate SO_2 emissions is considered an IPCC Tier 1 approach using a country specific emission factor, calculated based on the sulphur content of fuel. CO, NOx and NMVOCs emissions are estimated according to the default methodology of EEA/EMEP CORINAIR (Guidebook 2019), which is based on the relative consumption of energy per fuel and default emission factors.

Activity Data (Fuel Consumption)

Fuel consumption data, for the present submission is obtained from the National Statistics Office. This data is also submitted to EUROSTAT and other international statistics agencies. Hence, the data is verified and accepted as reliable. Fuels used nationally include Gas/Diesel oil (Diesel EN 590, Gasoil and High-Performance Diesel), Gasoline (Motor Gasoline RON 95 EN 228) and biomass. The use of fuel oil for domestic navigation was stopped in 2012, however during the pandemic (2020-2021)fuel oil was used again. As in road transport, the CO_2 emissions from the biogenic part of biofuel were not included in this category but reported under category 1.D Memo Items. Only CH_4 and N_2O and CO_2 from the fossil part of biofuels were added to the national total. The consumption fluctuations are affected by the existing national economic conditions, international circumstances, weather conditions and tourism.

Statistical Fuel Consumption

An analysis of the fuel consumption for all fuel types used in this category, including multiple data sources, was performed to ensure the accuracy and consistency of the timeseries and to validate the results of the previous analysis. Results are presented in Annex 3.

Table 3-31 Statistical fuel consumption by fuel type for category 1.A.3.d-Domestic Navigation, year 2022.

Statistical Fuel Consumption: Domestic Navigation (2022)		
Fuel Type	Fuel Consumption	Unit
Gas/Diesel Oil	758.475	TJ
Motor Gasoline	15.190	TJ
Blended biodiesel	0.000	TJ

Emission Factors & Net Calorific Values

The emission factors used for Domestic Navigation and for CO_2, CH_4 and N_2O were the IPCC default emission factors as presented in the guidelines. For NOx, CO and NMVCOs EMEP/EEA guidebook was used. Table 3-32 Summarize the sources regarding Emission Factors and Net Calorific Values used for this category.

Table 3-32 Default emission factors and net calorific values used in category 1.A.3.d-Domestic Navigation.

Default Emission Factors & NCVs: Domestic Navigation					
	Gas/Diesel Oil	Residual Fuel Oil	Motor Gasoline	Unit	Source
CO_2	74100	77400	69300	kg/TJ	IPCC Guidelines-Volume 2: Energy, Table 3.5.2 p.3.50
CH4	7	7	7	kg/TJ	IPCC Guidelines-Volume 2: Energy, Table 3.5.3 p.3.50
N_2O	2	2	2	kg/TJ	IPCC Guidelines-Volume 2: Energy, Table 3.5.3 p.3.50
NOx	78.5	79.3	9.4	kg/t	EMEP/EEA 2019. Navigation Chapter. Table 3-2 & Table 3-3, p.13-17
CO	7.4	7.4	573.9	kg/t	EMEP/EEA 2019. Navigation Chapter. Table 3-2 & Table 3-3, p.13-17
NMVCOs	2.8	2.7	181.5	kg/t	EMEP/EEA 2019. Navigation Chapter. Table 3-2 & Table 3-3, p.13-17
NCV	43	40.4	44.3	TJ/Gg	IPCC Guidelines-Volume 2: Energy, Table 1.2 p.1.18

Emissions of sulphur dioxide are primarily a function of the sulphur content of the fuel. The Tier 1 approach for SO_2 emissions does require fuel type specificity because of the dependence of emissions upon the sulphur content of the fuel, which can vary significantly. The sulphur content of fuels used in Malta is obtained by the Regulator for Energy and Water Services

(REWS). To estimate an emission factor for SO_2 the following equation is recommended (IPCC good practice guide):

$$EF_{SO_2}\left[\frac{kg}{TJ}\right] = \frac{[SO_2][Kg]}{[S][kg]}\cdot\left(\frac{S}{100}\right)\cdot\left(\frac{1}{NCV\,\frac{[TJ]}{[Gg]}}\right)\cdot 10^6\cdot\left(\frac{100-n}{100}\right)\leftrightarrow$$

$$EF_{SO_2}\left[\frac{kg}{TJ}\right] = 2\left(\frac{S}{100}\right)\cdot\left(\frac{1}{NCV\,\frac{[TJ]}{[Gg]}}\right)\cdot 10^6\cdot\left(\frac{100-n}{100}\right)$$

Where:

EF: Emission Factor (g SO_2/TJ)

2: [SO_2/S] (kg/kg)

S: Sulphur content in fuel (% by mass)

Q: Net calorific value (TJ/Gg)

n: Efficiency of abatement technology and/or reduction efficiency (%)

For the present submission, we assume that there is no retention in Ash (100-S retention ash)/100=1. We also assume that there is no abatement technology, meaning that n=0. Note that SO_2 emission from biomass are not estimated.

Table 3-33 Sulphur content and calculated SO_2 emission factors by fuel type for category 1.A.3.d-Domestic Navigation.

Sulphur Content & SO_2 Emission factors: Domestic Navigation (2022)				
	Sulphur Content (%)	SO_2	Unit	Equation
Diesel EN 590	0.001	0.332	kg/TJ	$EF_{SO_2} = 2\left(\frac{S}{100}\right)\cdot\left(\frac{1}{NCV\,\frac{[TJ]}{[Gg]}}\right)\cdot 10^6\left[\frac{kg}{TJ}\right]$
Gas Oil	0.07	32.558	kg/TJ	
Residual Fuel Oil	0.001	0.307	kg/TJ	

Emissions:

CO_2 Emissions

CO_2 for any fuel type are calculated following a Tier 1 approach and emissions factors as presented in Table 3-32.

CO_2 Emissions from Biomass

Blended biodiesel used in Malta is mixture of Hydrotreated vegetable oil (HVO) and Fatty acid methyl esters (FAME). There is no ETBE (bio gasoline) used in Malta As mentioned in the IPCC Guidelines (volume 2, Chapter 3,p.3.17) "it is important to assess the biofuel origin so as to identify and separate fossil from biogenic feedstocks". However, for the present submission we do not dissadragate emissions from blended biofuels used for domestic navigation and we are planning to update our methology, following the methodology proposed by Sempos, I. (Note on fossil carbon content in biofuels).

Non CO_2 emissions

Methane (CH_4) and Nitrous Oxide (N_2O) for any fuel type are calculated following a Tier 1 approach and emissions factors as presented in Table 3-32.

3.2.7.4.3 Uncertainties and time-series consistency

The Tier 1 calculation implemented for domestic navigation leaves few uncertainties and timeseries inconsistencies as it is based on fuel sold data. Uncertainty is mostly connected to the general lack of data concerning the type of the engines of the ships as well as their use (fuel consumption for vessel categories) and ship movement information. There is still some room for improvement by implementing a Tier 2 or Tier 3 approach. One small inconsistency in the data is the use of residual fuel oil which is no longer used for Domestic Navigation, since 2013. Previous years all included sales of residual fuel oil. Another incosistency may arise for the year of 2020 onwards, as the National Oil balance includes a separate row for “own use” fuel which was previously included under the respective categories. The “own use” fuel is defined as “*the quantities of fuel that are used by the authorised provider to carry out it's operations in the reporting month from own stocks e.g. fuelling of company vehicles, generators, heating of fuel tanks, barges*”. “Own use” fuel is included under domestic navigation on EUROSTAT and this data is used for the current submission.

3.2.7.4.4 Category-specific QA/QC and verification

Domestic aviation has undergone Tier 1 QA/QC checks as outlined in the IPCC Guidelines. The activity data, methods and changes are documented within the domestic aviation worksheets, in electronic form. In addition, information on data sources and any interpolation or extrapolation methods used for the activity data are provided in Annex 3.

3.2.7.4.5 Category-specific recalculations

Recalculations for all emissions were performed for the period 2018-2021, due to revised activity data (fuel consumption).

Table 3-34 of recalculations for 1.A.3.d Domestic Navigation, GWP (AR5).

1.A.3.d - Domestic Navigation									
Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	% Change in reported emissions	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	% Change in reported emissions	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	% Change in reported emissions
	(Gg CO2 eq.) CO_2	(Gg CO2 eq.) CO_2	(%)	(Gg CO2 eq.) CH_4	(Gg CO2 eq.) CH_4	(%)	(Gg CO2 eq.) N_2O	(Gg CO2 eq.) N_2O	(%)
1990	11.80	11.80	0.0%	0.031	0.031	0.0%	0.083	0.083	0.0%
1991	10.20	10.20	0.0%	0.026	0.026	0.0%	0.071	0.071	0.0%
1992	12.17	12.17	0.0%	0.031	0.031	0.0%	0.085	0.085	0.0%
1993	13.39	13.39	0.0%	0.035	0.035	0.0%	0.093	0.093	0.0%

1994	13.87	13.87	0.0%	0.036	0.036	0.0%	0.097	0.097	0.0%
1995	17.31	17.31	0.0%	0.045	0.045	0.0%	0.121	0.121	0.0%
1996	16.35	16.35	0.0%	0.042	0.042	0.0%	0.114	0.114	0.0%
1997	15.29	15.29	0.0%	0.039	0.039	0.0%	0.106	0.106	0.0%
1998	14.86	14.86	0.0%	0.038	0.038	0.0%	0.103	0.103	0.0%
1999	15.33	15.33	0.0%	0.040	0.040	0.0%	0.107	0.107	0.0%
2000	16.52	16.52	0.0%	0.043	0.043	0.0%	0.116	0.116	0.0%
2001	20.17	20.17	0.0%	0.052	0.052	0.0%	0.141	0.141	0.0%
2002	19.04	19.04	0.0%	0.049	0.049	0.0%	0.133	0.133	0.0%
2003	19.90	19.90	0.0%	0.051	0.051	0.0%	0.139	0.139	0.0%
2004	19.65	19.65	0.0%	0.051	0.051	0.0%	0.137	0.137	0.0%
2005	32.50	32.50	0.0%	0.085	0.085	0.0%	0.229	0.229	0.0%
2006	30.33	30.33	0.0%	0.079	0.079	0.0%	0.214	0.214	0.0%
2007	34.14	34.14	0.0%	0.089	0.089	0.0%	0.241	0.241	0.0%
2008	31.34	31.34	0.0%	0.082	0.082	0.0%	0.221	0.221	0.0%
2009	36.02	36.02	0.0%	0.094	0.094	0.0%	0.255	0.255	0.0%
2010	53.20	53.20	0.0%	0.140	0.140	0.0%	0.378	0.378	0.0%
2011	53.96	53.96	0.0%	0.142	0.142	0.0%	0.384	0.384	0.0%
2012	43.95	43.95	0.0%	0.116	0.116	0.0%	0.313	0.313	0.0%
2013	34.43	34.43	0.0%	0.091	0.091	0.0%	0.247	0.247	0.0%
2014	34.29	34.29	0.0%	0.091	0.091	0.0%	0.246	0.246	0.0%
2015	37.60	37.60	0.0%	0.100	0.100	0.0%	0.269	0.270	0.0%
2016	34.09	34.09	0.0%	0.090	0.090	0.0%	0.244	0.244	0.0%
2017	39.13	39.13	0.0%	0.104	0.104	0.0%	0.280	0.281	0.0%
2018	37.63	31.58	**-16.1%**	0.100	0.084	**-16.1%**	0.270	0.226	**-16.1%**
2019	51.08	44.35	**-13.2%**	0.135	0.117	**-13.2%**	0.366	0.318	**-13.2%**
2020	54.06	54.33	**0.5%**	0.143	0.144	**0.4%**	0.387	0.389	**0.4%**
2021	68.18	68.70	**0.8%**	0.181	0.182	**0.8%**	0.488	0.492	**0.8%**

3.2.7.4.6 Category-specific planned improvements

At present, there are no scheduled improvements for this category. However, future plans include the potential transition of this sub-category to Tier 2 or Tier 3 depending on the availability of required data. This transition could be done using AIS data to highlight the country specific situation. A lot still needs to be concluded however, such as an assurance for the provision of AIS data from a Maltese entity and the proper examination of this data.

3.2.7.5 Other Transportation (CRF 1.A.3.e)

Emissions for this category are Included Elsewhere.

3.2.7.5.1 Methodological Issues

Not applicable

3.2.7.5.2 Uncertainties and Time-Series Consistency

Not applicable.

3.2.7.5.3 Category-specific QA/QC and verification

Not applicable.

3.2.7.5.4 Category-specific Recalculations

Not applicable.

3.2.7.5.5 Category-specific planned Improvements

Efforts are being made to identify the best methodology in order to disaggregate the total fuel consumption at the necessary level in order to report emissions from on-road and 0ff-road categories separately.

3.2.8 SECTORAL APPROACH - OTHER SECTORS (CRF 1A4)

3.2.8.1 Category Description

Source category 1A4 comprises of emissions from fuel combustion in the categories Commercial/Institutional (1A4a), Residential (1A4b) and Agriculture/Forestry/Fisheries (1A4c).

The fuels used in the Commercial & Institutional sector are diesel, biodiesel, biogas, gasoil, fuel oil, kerosene, and LPG. Up until 2004, kerosene was prominently used but this has gradually declined following a marked increase in excise duty levied on this product.

Fuels used in the residential sector are LPG, gasoil, kerosene and biomass. LPG makes up the greater bulk of fuel consumption within the residential sector. This fuel type is used for heating and cooking purposes while gasoil is used for heating purposes and to power small generators. Fuels used in the Agriculture/Forestry/Fisheries sector are petrol, diesel, residual fuel oil, biodiesel and LPG.

3.2.8.2 Methodological Issues

Activity data for this source category was previously being obtained from the Petroleum Division of the Enemalta Corporation. However, from 2010 onwards, the data started to be collected from the National Statistics Office, as reflected in the oil balance reports. The sectoral breakdown of fuel consumption was expected to follow methodological approach described in sub-section 3.2.2.2, except for the residential sector. Eurostat's data published in February was used for the compilation of this GHG inventory due to inconsistencies between the Fuel Use Survey data and Eurostat's data.

Unless otherwise stated, an oxidation factor of 1.00 is used across the whole Energy sector for the estimation of emissions from fuel combustion.The default emission factors, and calorific values provided in the IPCC 2006 Guidelines have been used for the whole time-series.

This category includes emissions from fuel combustion in the agriculture, forestry and fishing industries. Fuels used in the Agriculture/Forestry/Fisheries sector are petrol, diesel, residual fuel oil, biodiesel and LPG.

The methodology complies with an IPCC Tier 1 technique for GHG emissions, which is based on the relative consumption of energy per fuel and default emission factors from the 2006 IPCC Guidelines. Estimates for SO_2, CO, NOx and NMVOCs emissions were provided from the Environment and Resources Agency (ERA), the entity responsible for the national Air Pollutants Report.

Activity data, disaggregated at the necessary level to report stationary and mobile consumption for agriculture and forestry are not available in the national oil balance. However, this desegregation was made possible with the help of the Fuel Use Survey (provided by EWA). The Fuel use survey is available from 2017 onwards. For the period 1990-2016 an average of the ratios for 2017-2022 was used to split the data. Any LPG present in the national oil balance it was assumed that was used for stationary combustion. Although LPG for fisheries is assumed that is used for stationary combustion is still included under 1.A.4.c.iii. Emission factors for pure and blended biofuels for mobile combustion were assumed the same as those for stationary combustion as no other data was available.

3.2.8.3 Uncertainties and time-series consistency

The survey results for years 2017- 2020 enhanced the time-series consistency. However, the sample population size quote for the survey was not reached and this led to uncertainties in quality of the finalized results. Moreover, even though uncertainties and inconsistences between Eurostat and Fuel Use Survey still persist, the discrepancies have minimized. A thorough exercise has been conducted by the data provider which enhanced the activity data for years 2018-2022.

3.2.8.4 Category-specific QA/QC and verification

Cross-checks are carried out with the oil balance report and the sectoral balance reports, which both provide a level of confidence when compiling and aggregating the activity data. Like previous categories, internal and external QA/QC and verification procedures were also carried out throughout the process of compiling the NIR. In addition, shadowing of the energy sector's data is possible with a second inventory compiler.

3.2.8.5 Category-specific recalculations

No recalculations were performed for this category, as there were no updates in the activity data or emission factors.

3.2.8.6 Category-specific planned improvements

Liaising with data providers for an effective and efficient data collection has already started and the continuation of periodic surveys was assured to obtain statistically significant end-user data.

An analysis to ensure the timeseries accuracy and consistency in terms of the activity data is planned for this category. In addition, once is clarified that LPG is used for stationary purposes, emissions arising from the use of LPG will be removed from 1.A.4.c.iii and will be included under 1.A.4.c.i Updates will be reported in future submissions. In addition, efforts are being made to identify the best emission factors, especially for biomass and blended biofuels used for mobile combustion.

3.2.9 SECTORAL APPROACH – OTHER MOBILE (CRF 1A5B)

3.2.9.1 Category Description

The UNFCCC reporting guidelines assign military fuel combustion to this CRF category. Any Fuel used for military purposes is subtracted from the respective categories and emissions generated by military aviation, navigation, x or any other military purposes are reported here. Emissions from military automotive operations are included in category 1.A.3.b-Road transportation. In addition, any other fuel present in the national oil balance that is not specified elsewhere is also included under this category.

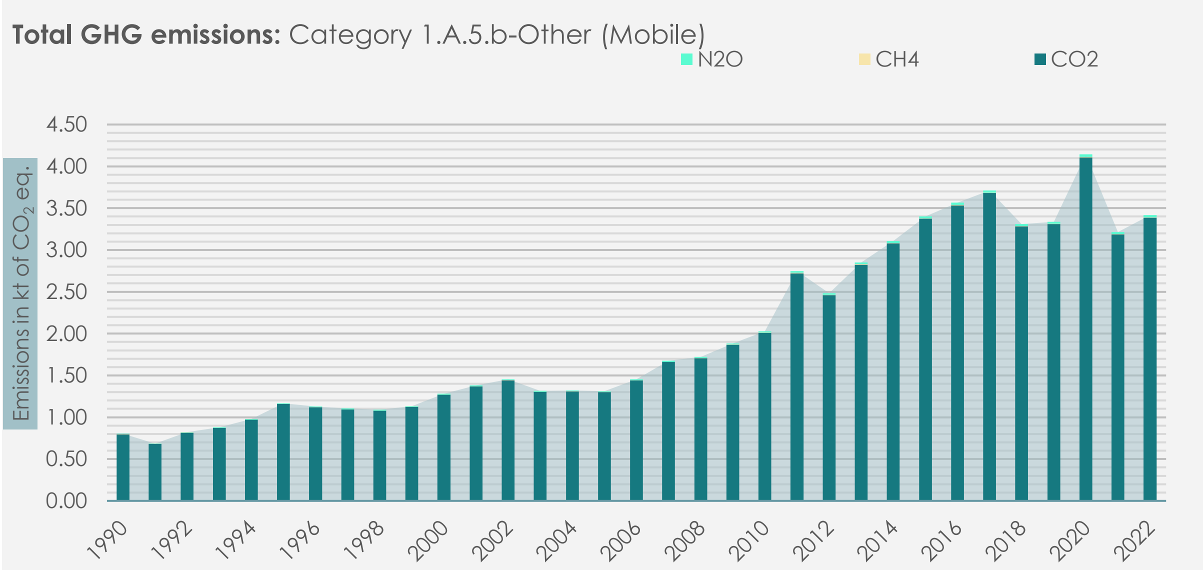


Figure 3-12 Total GHG emissions and emissions by gas. Category 1.A.3.5

3.2.9.2 Methodological issues

Updated Fuel consumption for military purposes was provided by the Armed Forces of Malta (AFM) for the period 2013-2020. As no data was available for past years, an exercise was carried out to identify the best activity data. This exercise was based on historical data of previous submissions as well as the ratios of the provided data of AFM over the total fuel consumption as present in the national oil balance. The methodology followed to estimate emissions for category 1.A.5.b derived from marine purposes is similar to the one used for domestic navigation. Emissions from aviation purposes follow the tier 1 methodology us described in the domestic aviation section. Any emissions arising from automotive purposes are included under category 1.A.3.b-Road transportation, as it was not possible to exclude military vehicles form the national fleet.. NOx, SO_2, NMVOC and CO emissions from marine purposes are included in Domestic Navigation, while those arising for automotive purposes are included in Road Transport.

Table 3-35 Statistical fuel consumption for category 1.A.5.b Other (Mobile)

Statistical Fuel Consumption: Category 1.A.5-Other (2022)		
Fuel Type	**Fuel Consumption**	**Unit**
Liquid Fuels	52.095	TJ

3.2.9.3 Sector specific QA/QC & Verification

Cross-checks are carried out with the oil balance report and the sectoral balance reports, which both provide a level of confidence when compiling and aggregating the activity data. Like previous categories, internal and external QA/QC and verification procedures were also carried out throughout the process of compiling the NIR.

3.2.9.4 Category-specific Recalculations

No recalculations were performed for this category.

3.2.9.5 Category-specific planned improvements

There are no planned improvements for this category.

3.3 FUGITIVE EMISSIONS FROM SOLID FUELS, OIL AND NATURAL GAS AND OTHER EMISSIONS FROM ENERGY PRODUCTION (CRF 1B)

This category does not occur.

3.4 CO2 TRANSPORT AND STORAGE (CRF 1C)

This category does not occur.

CHAPTER 4 IPPU

INDUSTRIAL PROCESSES & PRODUCT USE

4.1 OVERVIEW OF SECTOR

Emissions within the sector *Industrial Processes and Other Product Use* (IPPU) comprise direct and indirect greenhouse gas emissions arising from various industrial activities. In Malta, the most relevant sub-sector is the use of fluorinated fluids. In terms of carbon dioxide equivalent, fluorinated gases are the main contributor to the direct GHG emissions in this sector, especially due to their high global warming potentials. Figure 4-1 shows direct GHG emissions in this sector.

A preliminary analysis of the industrial sectors in Malta shows the relatively low presence of industrial production of significant GHG sources. Currently, greenhouse gases are mainly emitted from the use of products (especially F-gases, which are mainly used as refrigerants), rather than from production processes. In fact, a number of production sub-categories are considered to be not occurring.

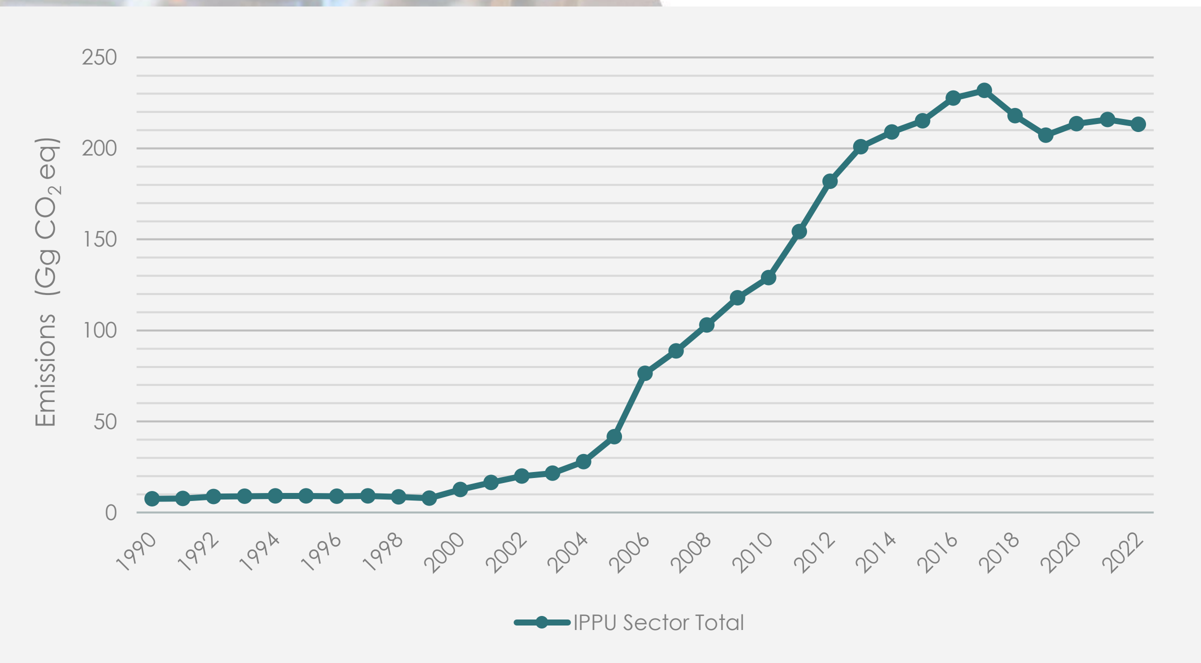


Figure 4-1 Direct GHG emissions for the Industrial Processes and Product Use (IPPU) sector

The direct greenhouses gases estimated for the *IPPU* sector, as presented in the inventory, are illustrated in Table 4-1 by emission sources category or sub-category, as applicable.

Table 4-1 The direct greenhouse gases estimated for the IPPU sector for the year 2022, as presented in the inventory, by emission source category or sub-category, as applicable

Direct greenhouse gas emissions: IPPU (2022)						
IPCC Category/Sub-category	CO_2	CH_4	N_2O	HFC	PFC	SF_6
	Gg CO_2 eq					
2A4b – Other Uses of Soda Ash	0.02					
2A4d - Other - Sodium Bicarbonate for Desulphurisdation	0.11					
2B11 - Other – Calcium Carbide Use	0.02					
2D1 - Lubricant Use	4.38					
2D2 - Paraffin Wax Use	0.27					
2D4 - Other - Road Paving with Asphalt	0.01					
2D4 - Other - Urea Use for Denoxification	0.86					
2F1 - Refrigeration and Air Conditioning				201.42	0.01	
2F2 - Foam Blowing				1.49		
2F3 - Fire Protection				1.52		
2F4 - Metered Dose Inhalers & Aerosols				0.54		
2G1 - Electrical Equipment						0.25
2G2d - SF_6 and PFCs from Other Product Uses – Other (Medical)					1.1E-06	2.9E-06
2G3a - N_2O from Product Uses – Medical Applications			1.88			
2G3b - N_2O from Product Uses - Propellant for pressure and aerosol products			0.34			

The data providers for the sector IPPU are primarily private sector industry enterprises, providing data related to their respective activities. Other data providers are the national statistics agency, the national greenhouse gases inventory compilers of the energy generation, transport and waste sectors and the Climate Change Unit within the Malta Resources Authority.

The internal transparency in the estimation of historical emissions from the IPPU sector has been enhanced. This is expected to improve the retention of knowledge at the Inventory Agency.

As recommended by the Expert Review Team in Finding ID# I.7 in FCCC/ARR/2022/MLT, the notation keys "IE" were explained in CRF table 9.

The use of R1234yf as a refrigerant in mobile air conditioning has been factored in the estimation of emissions from sub-category Mobile Air Conditioning (CRF 2.F.1.e).

Given the importance of category 2.F.1 Refrigeration and Air Conditioning (product uses as substitutes for ODS), the Inventory Agency is seeking to improve the activity data of the bulk imports of HFCs. With this aim, the Inventory Agency is trying to obtain more data on bulk imports of HFCs to get as complete a picture of the F-gases being consumed in Malta as possible. If more data is obtained, it could be used as activity data or for QA/QC. Furthermore, as more data for more years is collected, an analysis to determine more consistent data throughout the time series could be performed.

The 2019 Refinement to the 2006 IPCC Guidelines has been taken in consideration. However, given the methodologies being used or the national circumstances, so far, the 2019 IPCC Refinement could not be implemented in methodologies.

QA/QC procedures for the sub-categories under the IPPU sector have been implemented. A general comment in this regard for the sector IPPU applies. Data or information received from data providers is checked and compared to the trend of the specific activity data over the previous years. Substantial variations and outliers are brought to the attention of the data providers and discussed with the latter. In some cases, these discussions lead to revision of the data or information that would have been submitted. An exception to this is the case of data obtained from the national statistics agency. The data obtained from which would be of a provisional status. Discussions with this entity led to improved transfer of information between the latter and the Inventory Agency. Nonetheless, QA/QC procedures for the sub-categories under the IPPU sector should continue to be improved. Efforts are being made to try to identify alternative sources of data, where possible, to allow more robust QA/QC checks.

In general, prior to submission, it is made sure that all the cells in the CRF Reporter are adequately filled in with notation keys or data, as applicable. However, when tables are extracted following the submission of data in the CRF Reporter, it is observed that a number of cells in certain tables - namely Table 2(I)s1, Table 2(I)s2 and Table 2(II) - remain blank. This issue is being followed up on with the support of the CRF Reporter helpdesk. Other efforts such as the explanation of the use of notation keys in CRF table 9 are also being addressed.

Table 4-2, below, is intended to report on the status of implementation of recommendations and adjustments listed in the latest report on the individual review of the annual submission of Malta.

Table 4-2 Implementation of recommendations and adjustments listed in FCCC/ARR/2022/MLT, dated February 2023, being addressed

	Review recommendation	MS response / status of implementation	Chapter/section in the NIR
I.2	Investigate the extent of the use of carbonates in the production of ceramics (at least one company seems to produce ceramic products in Malta), calculate the emissions, if appropriate, and report on the results in the NIR.	Addressing. As referred to in section 4.2.4.2.6 of the NIR, the use of carbonates in the production of ceramics is being investigated further. It is the intention of the Inventory Agency to determine if the processes carried out in the local ceramics industry emit greenhouse gases or if the processes are simply working with imported products. It is the intention of the Inventory Agency to determine the CN code for clay. Subsequently, the related activity data will be requested and, following sub section "Ceramics" in chapter 2.5 "Other Process Uses of Carbonates" of the 2006 IPCC Guidelines, any emissions would be calculated.	4.2.4.3
I.3	Investigate the time series inconsistency of the estimates of CO2 emissions from road paving with asphalt, recalculate the emissions, if appropriate, and report on the findings in the NIR.	Addressing. As referred to in section 4.5.3.1.6 of the 2021 NIR, the time series consistency of the activity data is being analysed. The Inventory Agency has started a discussion on the matter with the data provider, which is the agency entrusted with the development, maintenance and upgrading of roads and other public infrastructure in the Maltese Islands. The aim is to determine a time series of actual data that is as consistent as possible and that dates back as far as possible. Based on such a time series, data could be back extrapolated to the year 1990. Moreover, it is planned to perform an analysis of the data that was reported in earlier GHG inventories, particularly for the years prior to 2004, to determine if this data needs to be revised.	4.5.3.1
I.6	Ensure consistency between the notation keys used to report AD for "Filled into new manufactured products" and for "Remaining in products and	Addressing.	4.7.1

	decommissioning" ("NE") and the associated emissions including explanations of its use in CRF table 9.		
I.7	Review the notation keys reported for disposal emissions in CRF table 2(II).B-H to ensure that the correct notation keys are used and explain notation keys "NE" and "IE" in CRF table 9.	Addressing.	4.7.1
I.9	Explain why the average charge factor for buses and coaches is higher than for mobile refrigeration vehicles.	Addressing. The Inventory Agency is considering the revision of some of the average charge factors such that, as much as possible, they are brought in line with the ranges defined in the 2019 Refinement to the 2006 IPCC Guidelines.	4.7.1.3 4.7.1.4
I.10	Ensure that there is a robust and consistent approach to collecting AD for this category in a way that eliminates any possibility of data gaps from some of the importers, and explain any significant inter-annual changes in emissions.	Addressed. According to information that has reached the Inventory Agency from the local market, importation of components for local blowing of closed cell foam has been interrupted in 2014 based on legal quotas. Moreover, according to information received from the local competent authority for the purposes of the F-gas Regulation, F-gases are not being imported for the blowing of foam, locally. An examination of the inter-annual variations observed by the Expert Review Team led to an analysis of the methodology used for this category. Errors in estimations were corrected and the notation keys being used were revised, accordingly.	4.7.2
I.11	Include a more detailed explanation of the model being used, describing the assumptions made and the experts judgements made.	Addressing. As referred to in section 4.7.1.6 of the NIR, it is the intention of the Inventory Agency to improve the transparency of this category by including a more detailed explanation of the model being used, describing the assumptions and the expert judgements made.	4.7

Table 4-3, below, illustrates the sector-specific improvement plan.

Table 4-3 Improvement plan for the IPPU sector

Action	IPCC Category / Sub-sector	Chapter / section in the NIR	Target date for implementation
The time series consistency of the activity data used for "Road Paving with Asphalt" is being analysed. (Finding ID# I.3 in FCCC/ARR/2022/MLT)	2D4 Other (Road paving with asphalt)	4.5.3.1	2024
The notation key "NE" reported for disposal emissions in CRF table 2(II).B-H will be explained in CRF table 9 as indicated in the recommendation. (Finding ID# I.7 in FCCC/ARR/2022/MLT)	2F1	4.7.1	2024
Consistency between the notation keys used to report AD for "Filled into new manufactured products" and for "Remaining in products and decommissioning" ("NE") and the associated emissions will be ensured, An explanation of the use of "NE" will be included in CRF table 9. (Finding ID# I.6 in FCCC/ARR/2022/MLT)	2F1	4.7.1	2024
The Inventory Agency is considering the revision of some of the average charge factors such that, as much as possible, they are brought in line with the ranges defined in the 2019 Refinement to the 2006 IPCC Guidelines. (Finding ID# I.9 in FCCC/ARR/2022/MLT)	2F1b	4.7.1	2024
The notation key "NE" for "2.G.2.e Other (Medical)" for SF_6 and C_3F_8 will be explained in CRF table 9.	2G2	4.8.2	2024
It is the intention of the Inventory Agency to determine if the processes carried out in the local ceramics industry emit greenhouse gases or if the processes are simply working with imported products. (Finding ID# I.2 in FCCC/ARR/2022/MLT)	2A4a	4.2.4.3	2024
The Inventory Agency is trying to obtain another set of data of the F-gases that are imported to and exported from Malta, from/to other countries, both within and outside the European Union. Thus, from this data, local consumption could be estimated. Moreover,	2F1	4.7.1	2024

this initiative should also help in identifying more importers of F-gases in Malta, from whom more data could be collected. If more data is obtained, it could be used as activity data or for QA/QC. Furthermore, as more data for more years is collected, an analysis to determine more consistent data throughout the time series could be performed. (Finding MT-2F1-2022-0004 in the 2022 ESD Review)			
The Inventory Agency is holding discussions with the national regulator on the environment to collect data related to the local collection of F-gases from equipment at end-of-life from permitted waste management installations so as to ensure an adequate coverage of the local market. (Finding MT-2F-2023-0001 in the 2023 ESR Review)	2F1	4.7.1	2024
Expert judgement on the share of R22 in the mass of refrigerants collected is being sought from the same source providing the mass of refrigerants collected from equipment at end-of-life.	2F1a	4.7.1	2024
The Inventory Agency is holding discussions with local market operators to verify the sources of data for the F-gases imported to Malta for local consumption so as to ensure an adequate coverage of the local market.	2F1	4.7.1	2025
The transparency of category 2.F.1 is being improved by including a more detailed explanation of the model being used, describing the assumptions and the expert judgements made. (Finding ID# I.11 in FCCC/ARR/2022/MLT)	2F1	4.7.1	2025
The Inventory Agency is holding discussions with local market operators to verify the sources of data for the substances imported to Malta for use in local fire protection applications to ensure an adequate coverage of the local market.	2F3	4.7.3	2025
The missing information on the import of F-gases in fire protection systems is being investigated.	2F3	4.7.3	2025
It is the intention of the Inventory Agency to improve the estimation of emissions from CRF 2.F.1.e Mobile Air Conditioning by including national data on the annual number of newly licensed cars and LGVs, on the split between new and second-hand newly licensed cars and	2F1b	4.7.1.4	2025

LGVs, as well as on the age of newly licensed second-hand cars and LGVs.			
The data on lubricant use in the national energy balance could serve as category-specific QA/QC and verification for the data on the lubricant use.	2D1	4.5.1	2026
Paraffin wax use is included in the national energy balance, however, no consumption of paraffin wax is reported. This matter should be looked into.	2D2	4.5.2	2026
It is the intention of the Inventory Agency to determine if the processes carried out in the local glass industry emit greenhouse gases.	2A3	4.2.3	2027
The Inventory Agency is holding discussions to determine a data collection process that ensures a better coverage of the applicable local market of metered dose inhalers.	2F4	4.7.4	2027
It is the intention of the Inventory Agency to continue with efforts to eliminate empty cells in CRF tables.	2	4	2028
It is the intention of the Inventory Agency to try and improve the method of distinction between the two-stroke engine oil that is intentionally co-combusted in engines (and therefore reported in the energy sector) and the remaining lubricants (reported in the IPPU sector).	2D1	4.5.1	2028
It is the intention of the Inventory Agency to determine if the activity data for the category "Other Product Manufacture and Use – SF_6 and PFC from Other Product Uses (Medical)" needs to be revised. (Finding MT-2G-2023-0002 in the 2023 ESR Review)	2G2	4.8.2	2028
It is the intention of the Inventory Agency to estimate and report in the CRF tables the amount of urea solution consumption for use in selective catalytic reduction in transport resulting from the COPERT model.	2D4 Other (Urea for denoxification)	4.5.3	2028

4.2 MINERAL PRODUCTS (CRF 2.A)

4.2.1 MINERAL PRODUCTS – CEMENT PRODUCTION (CRF 2.A.1)

4.2.1.1 Category Description

This category has not occurred in Malta throughout the whole time series.

4.2.1.2 Methodological Issues

This section is not applicable.

4.2.1.3 Uncertainties and time series consistency

This section is not applicable.

4.2.1.4 Category-specific QA/QC and verification

This section is not applicable.

4.2.1.5 Category-specific recalculations

This section is not applicable.

4.2.1.6 Category-specific planned improvements

This section is not applicable.

4.2.2 MINERAL PRODUCTS – LIME PRODUCTION (CRF 2.A.2)

4.2.2.1 Category Description

Lime production (Quick Lime) was commonplace in Malta in the past. The lime produced was of the high calcium type. Since 1999, lime production activities no longer take place and any lime used in Malta is imported. Thus, activity data and emissions are reported for the period 1990 to 1998.

For the period 1995 to 1998, activity data (quantity of lime produced) used for the estimation of emissions from this source category was compiled by Gauci (Gauci, 2000)[2] from data provided by the then National Office of Statistics (now the National Statistics Office). With regards to the period 1990 to 1994, it should be pointed that since, at the time, two lime production plants were operational, the quantities of lime produced could not be obtained from the operators due to confidentiality rules and perceived market sensitivity data. Hence, the activity data for each year of this period is the average activity data for the years 1995 to 1997. Consequently, CO_2 emissions from this activity are reported for the period 1990 to 1998.

4.2.2.2 Methodological Issues

The 2006 IPCC Guidelines provide two default emission factors. The lime produced in Malta can be classified as high calcium lime, thus an emission factor of 0.75tonnes CO_2 per tonne lime produced is used.

4.2.2.3 Uncertainty and time series consistency

The main issue with time series consistency in this sector has been described in section 4.2.2.1. Uncertainty is estimated at 8% for activity data and 2% for the emission factor.

[2] Gauci, V. (2000). National Greenhouse Gas Emissions Inventory for Malta 1990 to 2000. Malta: Environment protection Department.

4.2.2.4 Category-specific QA/QC and verification
This section is not applicable.

4.2.2.5 Source Specific Recalculations
No recalculations were required.

4.2.2.6 Category Specific planned improvements
No planned improvements in this specific category.

4.2.3 MINERAL PRODUCTS – GLASS PRODUCTION (CRF 2.A.3)

4.2.3.1 Category Description
This category has not occurred in Malta throughout the whole time series.

4.2.3.2 Methodological Issues
This section is not applicable.

4.2.3.3 Uncertainties and time series consistency
This section is not applicable.

4.2.3.4 Category-specific QA/QC and verification
This section is not applicable.

4.2.3.5 Category-specific recalculations
No recalculations were required.

4.2.3.6 Category-specific planned improvements
It is the understanding of the Inventory Agency that locally there are no GHG-emitting glass production processes, but only shaping and colouring of glass. However, as recommended during the capacity building visit organised by the *Effort Sharing Decision Review Team* in August 2018, this industry is being analysed further. It is the intention of the Inventory Agency to determine if the processes carried out in the local glass industry emit greenhouse gases.

4.2.4 MINERAL PRODUCTS – OTHER USES OF CARBONATES (CRF 2.A.4)

4.2.4.1 Other Uses of Soda Ash (CRF 2.A.4.b)
Emissions from all uses of soda ash (sodium carbonate, Na_2CO_3), other than emissions from the imports used in acid neutralisation (desulphurisation) used in energy generation and in waste incineration, are included under this heading.

4.2.4.1.1 Category Description

The use of soda ash (sodium carbonate) as a raw material was identified in a large number of industries; more commonly in soap and detergent manufacture and for water treatment. Soda ash is neither mined nor produced in Malta but imported. Part of the import is used in acid neutralisation (desulphurisation) in energy generation and in waste incineration. These emissions are reported under 2A4d. It is being assumed that emissive uses of carbonates other than soda ash are not occurring.

4.2.4.1.2 Methodological Issues

Data on mass of soda ash imports by year for the whole time series were obtained from the national statistics agency. On heating, Na_2CO_3 dissociates, releasing one mole of CO_2 per mole of Na_2CO_3 heated. Via a stoichiometric calculation, the emission factor is determined as 415kg CO_2 emitted per tonne Na_2CO_3 used.

4.2.4.1.3 Uncertainty and time series consistency

Activity data uncertainty is relatively low since the mass of imported carbonates is well-documented in trade statistics, thus an uncertainty of 2% is assumed. On the contrary, the emission factor has a relatively high uncertainty due to the fact that the fate of carbonates not destined to desulphurisation is unknown; thus, the assumption that all the carbonates imported are used in processes that release CO_2 may not be accurate. This is why a higher value of the emission factor uncertainty range (5%) is applied for this.

4.2.4.1.4 Category-specific QA/QC and verification

The activity data used in this category is trade imports from the national statistics agency. This data is analysed and compared to the trend in the respective market from the data received in previous years and any outlying data is verified with the data provider.

4.2.4.1.5 Source Specific Recalculations

No recalculations were required.

4.2.4.1.6 Category Specific planned improvements

No improvements are planned for this category.

4.2.4.2 Sodium Bicarbonate for Desulphurisation (CRF 2.A.4.d)

Emissions from the import of sodium bicarbonate ($NaHCO_3$) used in acid neutralisation (desulphurisation) in energy generation and in waste incineration are included under this heading.

Until the 2018 NIR, the emissions from imported sodium bicarbonate used in acid neutralisation (desulphurisation) in energy generation and in waste incineration were accounted for under the specific sectors. However, during a capacity building visit organised by the *Effort Sharing Decision Review Team* in August 2018, it was recommended to the Inventory Agency to include the said emissions under this category. As from the 2019 NIR, the said emissions are included under this category.

4.2.4.2.1 Category Description
Imported sodium bicarbonate is used in acid neutralisation (desulphurisation) in energy generation and waste incineration.

4.2.4.2.2 Methodological Issues
The data indicates that, locally, the desulphurisation process started in waste incineration in the year 2009, and, in energy generation, from 2012 onwards. Moreover, it should be pointed out that in 2017, an energy generation plant that does not make use of the technology utilising sodium bicarbonate, started operation.

The source of the data on the use of sodium bicarbonate at the energy generation plants and the respective emission factor of 0.525t CO_2/t $NaHCO_3$ is the Climate Change Unit at the MRA as the local administrator of the EU Emissions Trading System. This data is obtained through the energy generation sector inventory compiler.

The mass of sodium bicarbonate consumed annually in the desulphurisation process in waste incineration is obtained from the operator through the waste sector inventory compiler.

In both cases, the related emissions are obtained by multiplying the reported consumption of sodium bicarbonate by the said emission factor.

4.2.4.2.3 Uncertainty and time series consistency
The uncertainty of the activity data related to energy generation is low, given that the source of this data is the local administrator of the EU Emissions Trading System. Similarly, the uncertainty of activity data in waste incineration is also expected to be low, given the Integrated Pollution Prevention and Control (IPPC) permitting. The uncertainty of both sets of activity data was assumed to be equal to 5%. This value was also used as the uncertainty for the emission factor. Chapter 2.4 of Volume 2 of the 2006 IPCC Guidelines was used as guidelines.

4.2.4.2.4 Category-specific QA/QC and verification
Together with the respective inventory compilers – i.e. waste and energy generation, the data received is verified to be in line with the trends in the local sectors. Sodium bicarbonate was not used for desulphurisation in energy generation in 2019. Sodium bicarbonate and urea were originally used in energy generation when part of the power station used to be operated using heavy fuel oil and gasoil as the fuels for the generation of electricity. During 2017, the plant was converted to natural gas and gasoil. The use of sodium bicarbonate for desulphurisation was no longer needed and was, thus, ended during the course of 2017. The inter-annual variations in the mass of sodium bicarbonate used for desulphurisation in the waste sector were explained by the operator by variations in the number of days that the plant operates in one year and in the daily use of sodium bicarbonate.

4.2.4.2.5 Source Specific Recalculations
No recalculations were required.

4.2.4.2.6 Category Specific planned improvements
As recommended during the capacity building visit organised by the *Effort Sharing Decision Review Team* in August 2018 and in *Finding* ID# I.2 in FCCC/ARR/2022/MLT, the use of

carbonates in the production of ceramics is being investigated further. It is the intention of the Inventory Agency to determine if the processes carried out in the local ceramics industry emit greenhouse gases or if the processes are simply working with imported products. It is the intention of the Inventory Agency to determine the CN code for clay. Subsequently, the related activity data will be requested and, following sub-section “Ceramics” in chapter 2.5 “Other Process Uses of Carbonates” of the 2006 IPCC Guidelines, any emissions would be calculated.

4.3 CHEMICAL INDUSTRY (CRF 2.B)

4.3.1 CHEMICAL INDUSTRY – OTHER – CALCIUM CARBIDE USE (CRF 2.B.10)

Category 2B covers a wide variety of chemical production sub-categories for which, however, Malta does not have any activity. Nonetheless, Malta imports carbide for the production of acetylene.

4.3.1.1 Category Description

Malta imports carbide for the production of acetylene. Whereas the production process used emits no greenhouse gases, the use of acetylene in metal welding and cutting is a source of CO_2 emissions.

4.3.1.2 Methodological Issues

Imports of carbide of calcium used for acetylene production as previously reported falls under CN code 28491000. Calcium carbide imports can be assumed as being 100% directed towards acetylene production, thus imports under this CN code are included in the calculation.

The EF applied to this use is based on the stoichiometric calculation of the reactions involved in the use of acetylene based on the following assumptions:

- all the carbide imported is used in acetylene production;
- the process of acetylene production yield is 100%, thus all the carbide is transformed into acetylene;
- all the acetylene produced is combusted in the year of production;
- the acetylene oxidation factor is set to 1.0;
- acetylene use is not considered as an energy use, even though it is combusted in the process.

The chemical reactions involved are as follows:

$$2\ CaC_2 + 4\ H_2O \rightarrow 2\ C_2H_2 + 2\ Ca(OH)_2$$

$$2C_2H_2 + 3O_2 \rightarrow 4\ CO_2 + 2\ H_2O$$

This implies that 1 mole of CaC_2 would yield 2 moles of CO_2. Thus, considering the relative molecular mass of CaC_2 as being 64 and the relative molecular mass of CO_2 as being 44, the EF can be calculated as follows:

$$64t\ of\ CaC_2 \Rightarrow 88t\ of\ CO_2\ (2x\ 44)$$

Thus, 1t of CaC_2 would yield:

$$^{88}/_{64} = 1.375\ t\ CO_2/t\ CaC_2$$

4.3.1.3 Uncertainties and time series consistency

For activity data, noting that it is data reported to the national statistics agency in mass, an uncertainty of ±5% is used. The EF is based on a stoichiometric reaction, for which the uncertainty is very low. Nonetheless, the assumptions listed in the methodological description, invariably introduce higher uncertainty, which through expert judgment can be assumed to be as high as ±50%.

4.3.1.4 Category-specific QA/QC and verification

The activity data used in this category is trade imports from the national statistics agency. This data is analysed and compared to the trend in the respective market from the data received in previous years and any outlying data is verified with the data provider.

Since no data on the mass of calcium carbide imported in the year 2018 was reported, it was assumed that this value was equal to the data received for the year 2017. This matter is being investigated.

4.3.1.5 Category-specific recalculations

No recalculations were required.

4.3.1.6 Category-specific planned improvements

The mass of calcium carbide reported for the year 2018 is being investigated.

4.4 METAL INDUSTRY (CRF 2.C)

4.4.1 CATEGORY DESCRIPTION

The category 2C covers a wide variety of metal and alloy production activities, none of which, however, occur in Malta. This category is, thus, considered as not having occurred in Malta throughout the whole time series.

4.4.2 METHODOLOGICAL ISSUES

This section is not applicable.

4.4.3 UNCERTAINTIES AND TIME SERIES CONSISTENCY

This section is not applicable.

4.4.4 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

This section is not applicable.

4.4.5 CATEGORY-SPECIFIC RECALCULATIONS

This section is not applicable.

4.4.6 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS
This section is not applicable.

4.5 NON-ENERGY PRODUCTS FROM FUEL AND SOLVENT USE (CRF 2.D)

4.5.1 NON-ENERGY PRODUCTS FROM FUEL AND SOLVENT USE - LUBRICANT USE (CRF 2.D.1)

4.5.1.1 Category Description
The main function of lubricants is to minimise friction between moving surfaces; as lubricants are exposed to relatively high temperatures, oxidisation occurs which results in certain GHG emissions. This oxidisation is not considered as an energy use and, thus, the emissions from these lubricants are reported in this sector. However, emissions from lube oil used in two-stroke engines are included in the energy sector.

4.5.1.2 Methodological issues
Due to unavailability of segregated data on lubricant use, total importation data is used to calculate emissions from use. The assumption is that lubricants imported in one year are used throughout that same year and emissions are attributed in whole to that year.

The methodology for the estimation of emissions from this category was revised during step 1 of the 2018 annual *Effort Sharing Decision Review*.

Total lubricant consumption in Malta is provided by the national statistics agency. The gasoline consumption in motorcycles is obtained from CRF Table 1.A(a)s3 through the transport sector inventory compiler.

The share of lubricants used in two-stroke gasoline engines is estimated as follows:

- It is supposed that two-stroke gasoline engines are only found in road transport.
- In road transport, it is supposed that only motorcycles can have two-stroke gasoline engines.
- As a conservative estimate, it is supposed that all motorcycles are two-stroke gasoline engines.
- From 2006 IPCC Guidelines, Volume 2, Chapter 3, Box 3.2.4, the common mixture of lubricating oil and gasoline are 1:25, 1:33 and 1:50 depending on the engine type. The median value of 1:33 is chosen for this calculation.

Also, the following parameters are used:

- 0.03 t of lubricant / t of gasoline for the mixture lubricant/gasoline for two-stroke;
- 40.77TJ/kt for the NCV of gasoline (source: NIR 2018 page 55 and NSO News Release 106/2015 (value in t/toe)); and
- 40.20TJ/kt for the NCV of lubricants (source: Volume 2, Chapter 1, table 1.2).

Moreover, since no data is available for the years before 2004, a 5-year moving average is used to estimate data for the years 1990 to 2003.

2006 IPCC Guidelines, Volume 3, Chapter 5, equation 5.2 gives the Tier 1 calculation for estimating CO_2 emissions from non-energy use of lubricants. Using 20.0tC/TJ for the $CC_{Lubricant}$ (source: Volume 2, Chapter 1, table 1.3) and 0.2 as the $ODU_{Lubricant}$ (source: Volume 3, Chapter 5, table 5.2), the CO_2 emissions to be included under the IPPU sector are obtained.

4.5.1.3 Uncertainty and time series consistency

An uncertainty factor of 10% is used for the activity data in this sub-sector. The emission factor used is based on the Tier 1 approach specified in the 2006 IPCC Guidelines which also suggests that uncertainty could be as high as 50%. In view of this, the emission factor uncertainty is estimated at 50%.

4.5.1.4 Category-specific QA/QC and verification

The activity data used in this category is trade imports from the national statistics agency and gasoline consumption in motorcycles (1.A.3.b.iv) (source: CRF Table 1.A(a)s3) from the transport sector inventory compiler. This data is analysed and compared to the trend in the respective market from the data received in previous years and any outlying data is verified with the respective data provider.

4.5.1.5 Source Specific Recalculations

The activity data "Gasoline consumption in motorcycles 1.A.3.b.iv" was updated. This has, inevitably, led to the following recalculations.

Table 4-4 CRF 2.D.1 Lubricant Use - CO_2 - Emissions

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	3.01	3.01	not applicable
1991	3.01	3.01	0.000%
1992	3.01	3.01	0.000%
1993	3.01	3.01	0.000%
1994	3.00	3.00	0.000%
1995	3.00	3.00	0.000%
1996	3.01	3.01	0.000%
1997	3.01	3.01	0.000%
1998	3.02	3.02	0.000%
1999	2.98	2.98	0.000%
2000	2.97	2.97	0.000%
2001	3.07	3.07	0.000%
2002	3.03	3.03	0.000%
2003	3.06	3.06	0.000%
2004	2.76	2.76	0.000%
2005	2.94	2.94	0.000%
2006	3.54	3.54	0.000%
2007	2.83	2.83	0.000%
2008	3.21	3.21	0.000%
2009	3.37	3.37	0.000%
2010	3.00	3.00	0.000%
2011	3.33	3.33	0.000%

2012	2.83	2.83	0.000%
2013	2.89	2.89	0.000%
2014	2.83	2.83	0.000%
2015	3.14	3.14	0.000%
2016	3.77	3.77	0.000%
2017	3.44	3.44	0.000%
2018	3.93	3.93	-0.001%
2019	3.20	3.20	0.000%
2020	3.36	3.36	-0.002%
2021	3.68	3.68	-0.001%
2022	not applicable	4.38	not applicable

4.5.1.6 Category Specific planned improvements

The data on lubricant use in the national energy balance could serve as category-specific QA/QC and verification. Moreover, it is the intention of the Inventory Agency to try and improve the method of distinction between the two-stroke engine oil that is intentionally co-combusted in engines (and therefore reported in the energy sector) and the remaining lubricants (reported in the IPPU sector).

4.5.2 Non-energy Products from Fuel and Solvent Use - Paraffin Wax Use (CRF 2.D.2)

4.5.2.1 Category Description

Paraffin is a product of crude oil fractioning, and is commonly used in the production of candles, surfactants, paper coatings and polish. In Malta, since no petroleum refining occurs, all paraffin is imported, possibly transformed and largely used locally. The main source of emission from paraffin comes from its combustion in the form of candles, tapers etc. This is particularly relevant in the Maltese context due to the use of candles in religious and other popular practices. Most other uses do not emit GHGs.

4.5.2.2 Methodological issues

Activity data for this sector is obtained from importation data collected by the national statistics agency. Data for mass of imported material is reported under specific CN codes specific to the nature of the product being imported. For paraffin wax codes 3406 0000 and 2712 20(00-99) are included[3]. This data was readily available only from the year 2004 onwards, thus a gap-filling exercise was carried out to estimate activity in the sector prior to 2004. This was done through the back extrapolation of net emissions from the sector. Extrapolation of emissions was preferred to extrapolation of importation data. Since default emission factors are used in the present calculation, the back extrapolation of activity data was considered to be unnecessary.

The activity data referred to above is elaborated using the Tier 1 methodology and emission factors specified in the 2006 IPCC Guidelines. Default ODU and carbon content values are used to calculate emission factors for this sector. The net emission factor used is 14.6667tCO_2/TJ paraffin imported.

[3] IntraStat Combined Nomenclature 2013

4.5.2.3 Uncertainty and time series consistency

The consistency of the time series is ensured by the back-extrapolation exercise carried out, which on the basis of expert judgement provides a conservative estimate.

To date waxes and wanes are not reported in the national energy balance calculation, thus this introduces a further factor of uncertainty in the activity data used. An uncertainty factor of 10% is used for activity data in this sub-sector. The emission factor used is based on the Tier 1 approach specified in the 2006 IPCC Guidelines which also suggests that uncertainty could be as high as 50%. In view of this, the emission factor uncertainty is estimated at 50%.

4.5.2.4 Category-specific QA/QC and verification

The activity data used in this category is trade imports from the national statistics agency. This data is analysed and compared to the trend in the respective market from the data received in previous years and any outlying data is verified with the data provider.

4.5.2.5 Source Specific Recalculations

No recalculations were required.

4.5.2.6 Category Specific planned improvements

This category is included in the national energy balance, however, no consumption of paraffin wax is reported. This matter should be investigated.

4.5.3 NON-ENERGY PRODUCTS FROM FUEL AND SOLVENT USE - OTHER (CRF 2.D.3)

4.5.3.1 Road paving with asphalt (CRF 2.D.3. Other)

4.5.3.1.1 Category Description

Asphalt road surfacing is composed of compacted aggregate and an asphalt binder. CO_2 and NMVOC emissions from both the production phase and the application phase of asphalt to road surfaces are reported.

The quantity of asphalt used was obtained annually from the authority for transport in Malta. However, this responsibility has moved to the agency entrusted with the development, maintenance and upgrading of roads and other public infrastructure in the Maltese Islands. Since for the years prior to 2011, no consistent data source was identified, activity was back extrapolated from the available data.

4.5.3.1.2 Methodological Issues

Emissions of NMVOC for road surface (16g NMVOC per Mg asphalt produced and applied to the road surface) is used. The emission factor for both the production phase and the application phase of the asphalt to road surfaces are applied to the activity data. The emission factor was obtained from the *EMEP/EEA air pollutant emission inventory guidebook* (2013, 2019 and 2023 versions). Malta is additionally reporting an estimate of CO_2 emissions, using the methodology provided in the 2009 Portuguese GHG Inventory Report. The Portuguese asphalt methodology assumes that solvents in asphalt products are 100% composed of NMVOC. The emitted NMVOC from the asphalt processes have, on average, 85% carbon content, which is the normal carbon content for medium linear simple hydrocarbons. The resulting CO_2 emissions can, therefore, be estimated through multiplication:

Emissions (Gg CO_2) = Emissions (Gg NMVOC) * 0.85 * (44/12)

It is also essential to note that even though the 2006 IPCC Guidelines specify that significant emissions of CO can occur from this activity, no adequate emission factor was identified, thus no CO emissions are estimated for this activity.

4.5.3.1.3 Uncertainty and time series consistency

The data collected covers all public road works carried out in the geographical scope of the inventory, though private asphalt use is not included in the estimate. It is assumed that this use is limited and accounts for a marginal part of this sub-sector. Uncertainty of activity data is considered to be of 10%, in line with the 2006 IPCC Guidelines, whereas EF uncertainty is assumed at 100%. This high emission factor does not affect significantly the overall uncertainty of the inventory due to the small extent of the emissions in this sub-sector.

4.5.3.1.4 Category-specific QA/QC and verification

The activity data received is analysed and compared to the trend and, if necessary, it is verified with the data provider. The data for the year 2021 has not been received. This value was assumed to be equal to that of the year 2020. The data for the year 2022 has also not been received. This value was obtained by using a trend based on the previous five years.

4.5.3.1.5 Source Specific Recalculations

No recalculations were required.

4.5.3.1.6 Category Specific planned improvements

As recommended during the capacity building visit organised by the *Effort Sharing Decision Review Team* in August 2018 and in *Finding* ID# I.3 in FCCC/ARR/2022/MLT, the time series consistency of the activity data is being analysed. The Inventory Agency is discussing the matter with the data provider to determine a time series of actual data that is as consistent as possible and that dates back as far as possible. Efforts are being made to have a consistent set of data starting from the year 2004. Based on such a time series, data could be back extrapolated to the year 1990. Moreover, it is planned to perform an analysis of the data that was reported in earlier GHG inventories, particularly for the years prior to 2004, to determine if this data needs to be revised. Issues with consistent and timely receipt of data are also being discussed. Simultaneously, an alternative set of data is also being sought to be used as a sub-category-specific QA/QC.

4.5.3.2 Solvent use (CRF 2.D.3. Other)

4.5.3.2.1 Category Description

Estimated non-methane volatile organic compound emissions from the use of organic solvents and solvent-containing products are reported under this category. Solvents and related compounds include chemical cleaning substances used in dry cleaning, printing activities, metal degreasing and a variety of other industrial applications as well as household uses. All of these activities and applications make use of chemicals that contain a significant amount of NMVOCs. Emissions are produced through evaporation of the volatile chemicals when these products are exposed to air.

4.5.3.2.2 Methodological issues

The *EMEP/EEA air pollutant emission inventory guidebook* (2013, 2019 and 2023 versions) provides two methodologies that can be used to estimate NMVOC emissions:

- estimating the amount of (pure) solvents consumed; and
- estimating the amount of solvent containing products consumed (taking account of their solvent content).

The first method based on a mass balance per solvent is being used in this inventory process, where the sum of all solvent mass balances equals the NMVOC emission due to solvent use. The following equation was assumed for each inventory year in Malta:

Solvent Import Quantities = Solvent Consumption Quantities = NMVOC Emissions

The list of volatile chemical compounds has been used as a reference list for volatile chemicals that may be imported annually in Malta. This list of chemicals was then double-checked with the national statistics agency, which provides the yearly solvent import quantities.

In the methodology used, it is assumed that all the solvents imported are used locally, and, thus, no solvents are exported. It is also assumed that all the solvents imported are used in the year of importation.

4.5.3.2.3 Uncertainty and time series consistency

In terms of time series consistency, importation data provides time consistency but due to the variety of products falling under the different codes and the relatively different behaviour of each, the level of uncertainty is rather high.

4.5.3.2.4 Category-specific QA/QC and verification

The activity data used in this category is trade imports from the national statistics agency. This data is analysed and compared to the trend in the respective market from the data received in previous years and any outlying data is verified with the data provider.

4.5.3.2.5 Source Specific Recalculations

No recalculations were required.

4.5.3.2.6 Category Specific planned improvements

No planned improvements in this specific category.

4.5.3.3 Urea for Denoxification (CRF 2.D.3. Other)

4.5.3.3.1 Category Description

Imported urea is used in denoxification in energy generation, waste incineration and in selective catalytic reduction (SCR) in road transport.

Until the 2018 NIR, the emissions from the imported urea used in denoxification in energy generation and in waste incineration were accounted for under the specific sectors. However, during a capacity building visit organised by the *Effort Sharing Decision Review Team* in August 2018, it was recommended to the Inventory Agency to include the said emissions under this category. As from the 2019 NIR, the said emissions are included under this category.

Emissions from the use of urea in road transportation have been estimated and included in the national GHG inventory as from the 2020 NIR. The need for this inclusion was pointed out during the capacity building visit organised by the *Effort Sharing Decision Review Team* in August 2018 and in the capacity building webinars organised by the Effort Sharing Decision Review Team. Moreover, this inclusion was noted in *Finding* ID# I.4 in FCCC/ARR/2021/MLT. The methodology needed to estimate these emissions has been determined with the support provided by the *Effort Sharing Decision Review Team* in October 2019.

4.5.3.3.2 Methodological Issues

The denoxification process has been used in waste incineration in Malta since the year 2011, when the Marsa thermal treatment plant was upgraded with the installation of a deNOx facility which utilises urea in liquid form (AdBlue or ISO 22241 compliant fluid) to reduce NOx emissions. During this process of denoxification, CO_2 is released as a by-product. The volume of urea consumed annually in the denoxification process in waste incineration is obtained from the operator through the waste sector inventory compiler. The related emissions are calculated by multiplying the reported consumption of AdBlue (volume) by the density of AdBlue and the emission factor of 0.733t CO_2/t AdBlue.

The source of the data on the use of urea at the energy generation plants and the respective emission factor of 0.733t CO_2/t AdBlue is the Climate Change Unit at the MRA as the local administrator of the EU Emissions Trading System. This data is obtained through the energy generation sector inventory compiler. The related emissions are obtained by multiplying the reported consumption of AdBlue by the said emission factor.

The emissions from urea used in denoxification in selective catalytic reduction (SCR) in road transport have been estimated by means of the COPERT model, using the default values for the urea consumption, available therein, as a function of the fuel consumption. It should be pointed out that CO_2 is emitted from the use of urea in road transport only from vehicles equipped with SCR. Such technology is used only for diesel-engined vehicles. According to the default values in the COPERT model for the urea consumption in SCR in road transport, this technology is used as follows:

- in heavy duty vehicles, buses and coaches in Euro IV, V and VI standard (with a urea content of 6%, 6% and 3.5% of the fuel consumption, respectively according to the Euro standard);
- in light commercial vehicles in Euro 6 standard (with a urea content of 2% of the fuel consumption); and
- in passenger cars in Euro 6 standard (with a urea content of 2% of the fuel consumption).

4.5.3.3.3 Uncertainty and time series consistency

The uncertainty of the activity data related to energy generation is low, given that the source of this data is the local administrator of the EU Emissions Trading System. Similarly, the uncertainty of the activity data in waste incineration is also expected to be low, given the IPPC permitting. The uncertainty of both sets of activity data was assumed to be equal to 5%. This value was also used as the uncertainty for the emission factor. Chapter 3.2.2 of Volume 2 of the 2006 IPCC Guidelines was used as guidelines.

The uncertainty of the activity data related to selective catalytic reduction in transport is estimated automatically by the COPERT model based on the fuel consumption. Chapter 3.2.2 of Volume 2 of the 2006 IPCC Guidelines suggests that the uncertainty for the fuel consumption would typically be around 5%. Thus, the same uncertainty of 5% was assumed for the amount of urea solution consumption for use in selective catalytic reduction in transport. The uncertainty of the emission factor of urea solution consumption for use in selective catalytic reduction in transport was taken to be 1%. This was based on an expert judgement made during a capacity building activity under the Effort Sharing Decision review contract in October 2019.

However, since the urea used in energy generation, in waste incineration and in selective catalytic reduction in transport are reported in one table in the CRF, the same uncertainty for the emission factor was used for all the three uses. Thus, a conservative approach was followed and the uncertainty for the emission factor was assumed to be equal to 5%.

4.5.3.3.4 Category-specific QA/QC and verification

Together with the respective inventory compilers – i.e. energy generation and waste – the data received is verified to be in line with the trends in the local sectors. Similarly, with the road transport inventory compiler, for the emissions obtained from the use of urea in SCR in road transport.

Sodium bicarbonate and urea were originally used in energy generation when part of the power station used to be operated using heavy fuel oil and gasoil as the fuels for the generation of electricity. During 2017, the plant was converted to natural gas and gasoil. Due to the greater utilisation of natural gas, the mass of urea used for denoxification (of gasoil) had decreased. However, since the year 2019, an increase in the mass of urea used for denoxification in energy generation can be observed. During these years, the plant running on gasoil has increased generation, resulting in an increase in the consumption of urea for denoxification of the exhaust gases. In the year 2022, the consumption of urea in energy generation was very similar to that of the previous year, decreasing slightly.

The data for the year 2019 results in a sharp drop in the trend of the volume of urea used for denoxification in waste incineration. In fact, the year with the most similar use of urea ($2m^3$) to that reported (for the year 2019) was the year 2011, which was the first year when urea was used locally for this purpose in this sector. This decrease was explained by the operator by reporting that the urea injection system was not functioning for several months in 2019 due to a system breakdown and the subsequent upgrade. Moreover, the operator explained that later in the year, a major upgrade which required a lower volume of urea during operation was implemented. The further reduction of urea used in 2020 over 2019 ($4m^3$ vs $5m^3$, respectively), was attributed to two separate reasons by the operator, namely, improved nozzles within the new system which allow lower urea consumption and an increase in NH_3 levels in the incineration process, due to which urea injection could not be used. In the data for the year 2021, a further drop in the trend of the volume of urea used for denoxification in waste incineration ($1m^3$) has been observed. The operator has explained that urea solution is used to abate NO_X gases, but contributes to the formation of NH_3. It was also explained that in the years 2020 and 2021 there was an increase in the number of NH_3 exceedances when compared to those of NO_X. As a result of the fact that NH_3 levels were already higher than NO_X, the use of urea solution was limited during the years 2020 and 2021. Moreover, the operator has explained that the increase in NH_3 levels in the incineration process is due to the fact that the ratio of incineration between abattoir waste (wet) and clinical waste has shifted in favour of the former, thus more abattoir waste is being incinerated, resulting in a higher presence of NH_3 gases. In the data for the year 2022, a further drop in the volume of urea used for denoxification in waste incineration has been observed. In fact, in the year 2022, urea has not been used at all for denoxification in waste incineration. The operator has referred that this was due to the explanation given above. Moreover, it was also explained that since the combustion cycle of the incinerator was running with very limited oxygen, the formation of NO_X gases was restricted. In fact, the formation of NO_X gases was within the stipulated limits and, consequently, urea was not required.

Emissions from urea solution consumption for use in selective catalytic reduction in transport are calculated using the COPERT model. The amount of urea solution consumption for use in selective catalytic reduction in transport is estimated as percentages, as explained in section 4.5.3.3.2. The amount of urea solution per se has not been estimated and, thus, nor reported in the respective CRF table. On the other hand, both the amount of urea used for denoxification in energy generation and that used for denoxification in waste incineration have been reported in the same CRF table. This situation results in an unrealistically high implied emission factor. Nonetheless, it should be pointed out that the implied emission factor for urea used for denoxification in energy generation and in waste incineration is equal to 0.733 t/t.

4.5.3.3.5 Source Specific Recalculations

The activity data "Emissions of CO_2 from urea used in selective catalytic reduction in road transport" was updated. This has, inevitably, led to the following recalculations.

Table 4-5 CRF 2.D.3. Other Urea for Denoxification - CO_2 - Emissions

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	NO	NO	not applicable
2005	0.01	0.01	0.000%
2006	0.02	0.02	0.000%
2007	0.02	0.02	0.000%
2008	0.03	0.03	0.000%
2009	0.04	0.04	0.000%

2010	0.05	0.05	0.000%
2011	0.11	0.11	0.000%
2012	1.29	1.29	0.000%
2013	5.32	5.32	0.001%
2014	5.39	5.39	0.011%
2015	4.27	4.27	0.018%
2016	2.29	2.29	0.072%
2017	0.71	0.71	0.338%
2018	0.54	0.54	-0.293%
2019	0.58	0.58	-0.413%
2020	0.69	0.68	-0.293%
2021	0.74	0.74	-0.332%
2022	not applicable	0.86	not applicable

4.5.3.3.6 Category Specific planned improvements

It is the intention of the Inventory Agency to estimate and report in the CRF tables the amount of urea solution consumption for use in selective catalytic reduction in transport resulting from the COPERT model.

4.6 ELECTRONICS INDUSTRY (CRF 2.E)

4.6.1 Category Description

Advanced electronics production technologies use fluorinated compounds due to their chemical and physical characteristics. The industry makes use of both gaseous forms and liquid forms of fluorinated compounds.

The local electronics industry is relatively limited in scope, most of the processes that have been identified as emissive are not carried out locally. Local manufacturing of electronics, as defined in the 2006 IPCC Guidelines, generally does not occur in Malta. The semi-conductor manufacturing sub-sector present locally, performs only the final stages of semiconductor manufacture. Throughout the time series, the use of HFC-23 and SF_6 is reported. It has been reported that between 2018 and 2019, actions were put in place to align internal procedures with relevant European legislation. To this end, leak tests are being performed in the preventive maintenance schedule of the equipment. This is helping to reduce the consumption of F-gases.

4.6.2 Methodological Issues

Due to the very limited use of gases in this sector, activity data is directly obtained from the market from a GHG inventory compliant to ISO 14064. Due to the nature of the process, an EF of 1 is used, thus assuming that all fluid consumed is actually emitted.

Through the category-specific verification process, it transpired that a plasma etcher was used locally throughout the period 2006 to 2017 and eventually, during 2018, transferred to another site, abroad. Moreover, based on an expert judgement made by the data provider it was determined that this equipment consumed approximately 4kg of SF_6 each year throughout the period 2006 to 2017.

4.6.3 UNCERTAINTIES AND TIME SERIES CONSISTENCY

The availability of verified data in this sector, through ISO 14064 inventories, makes the uncertainty of activity data rather low and is assumed to be 2%. Since the data submitted is actual consumption data and considering the type of process, the emission factor uncertainty for HFC-23 is also low.

The uncertainty of the activity data for SF_6 is assumed to be higher, at 25%, due to the fact that the activity data was based on expert judgement. This was done since the relative process was identified as an activity that should be included in the annual GHG inventory when the process was no longer in operation. The uncertainty of the emission factor for SF_6 is assumed to be also higher, at 50%, due to lack of detailed information on the process. Chapters 6.2 and 6.3 of Volume 3 of the 2006 IPCC Guidelines were used as guidelines to identify the value for this uncertainty.

4.6.4 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

As stated earlier, verified data through ISO 14064 inventories is available for this sub-sector. Nonetheless, the information received from the data provider is analysed, the applicable data is extracted, compared to the trend over the previous years and verified with the data provider, if necessary.

During the year 2019, this process has determined that SF_6 cylinders intended to be used for the plasma etcher referred to in section 4.6.2, were removed from site and returned to the supplier during the year 2019, given that they were no longer required.

As a follow up to *Finding* ID# I.17 in the provisional main findings of the ERT Review of the 2019 annual submission of Malta, the whole time series for the consumption of HFC-23 was confirmed by the respective data provider and the necessary changes to the consumption and emissions were made.

4.6.5 CATEGORY-SPECIFIC RECALCULATIONS

No recalculations were required.

4.6.6 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

No planned improvements in this specific category.

4.7 PRODUCT USES AS SUBSTITUTES FOR OZONE DEPLETING SUBSTANCES (ODS) (CRF 2.F)

Current areas of application for the products in subject include refrigeration and air conditioning equipment, foam blowing applications, fire extinguishers and metered-dose inhalers. Figure 4-2 presents a pictorial overview of emissions of these gases from various applications over the whole time series covered by this report.

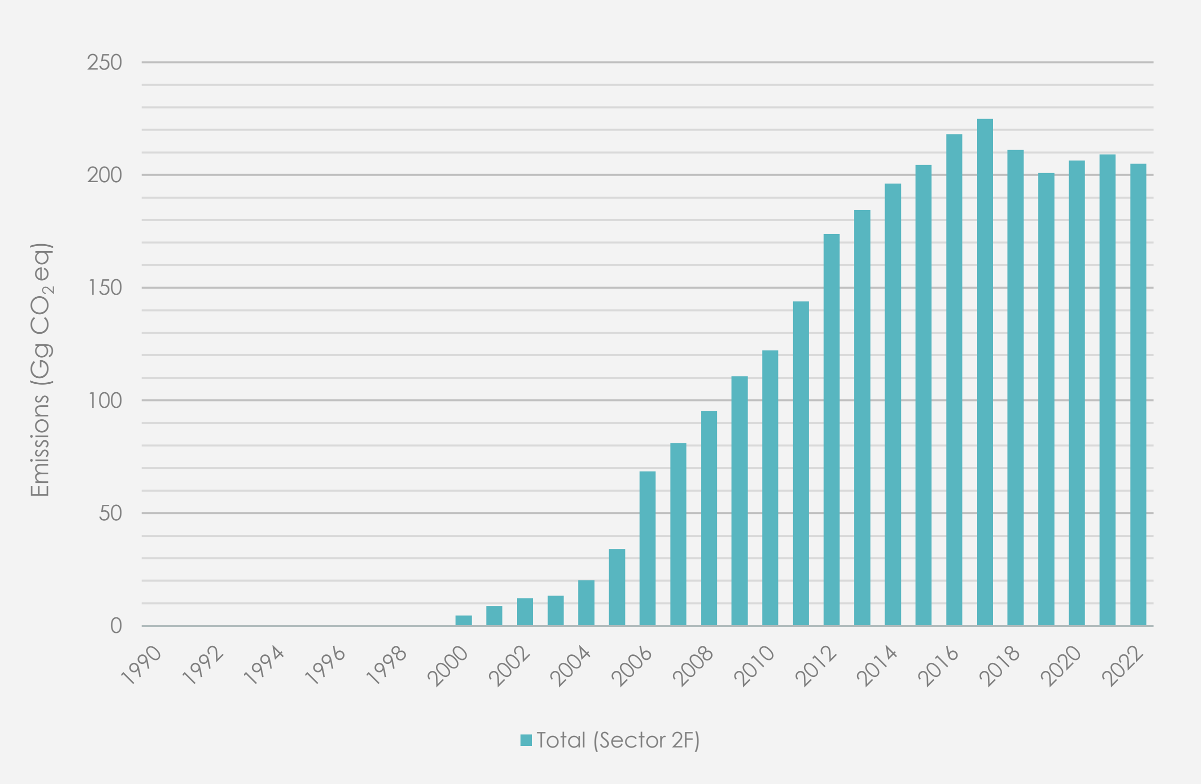


Figure 4-2 Actual emissions from sub-sector 2.F Product Uses as substitutes for ODS

4.7.1 Product Uses as Substitutes for ODS – Refrigeration and Air Conditioning (CRF 2.F.1)

A data gathering exercise was carried out in 2011/2012, in addition to another survey done in 2009, in which importation and consumption quantities of fluorinated gases, information on the processes taking place locally, as well as details on the gases being used were collected. The project for the improvement of the methodology of the national inventory report in the product uses as ozone depleting substances (ODS) substitutes sector conducted between 2012 and 2014 has been concluded and first used in the 2015 NIR. Other continuous improvements are being sustained. The current methodology is in line with the 2019 Refinement to the 2006 IPCC Guidelines. Figure 4-3 shows the emissions of these gases from the various sub-categories under category 2.F.1 over the whole time series covered by this report.

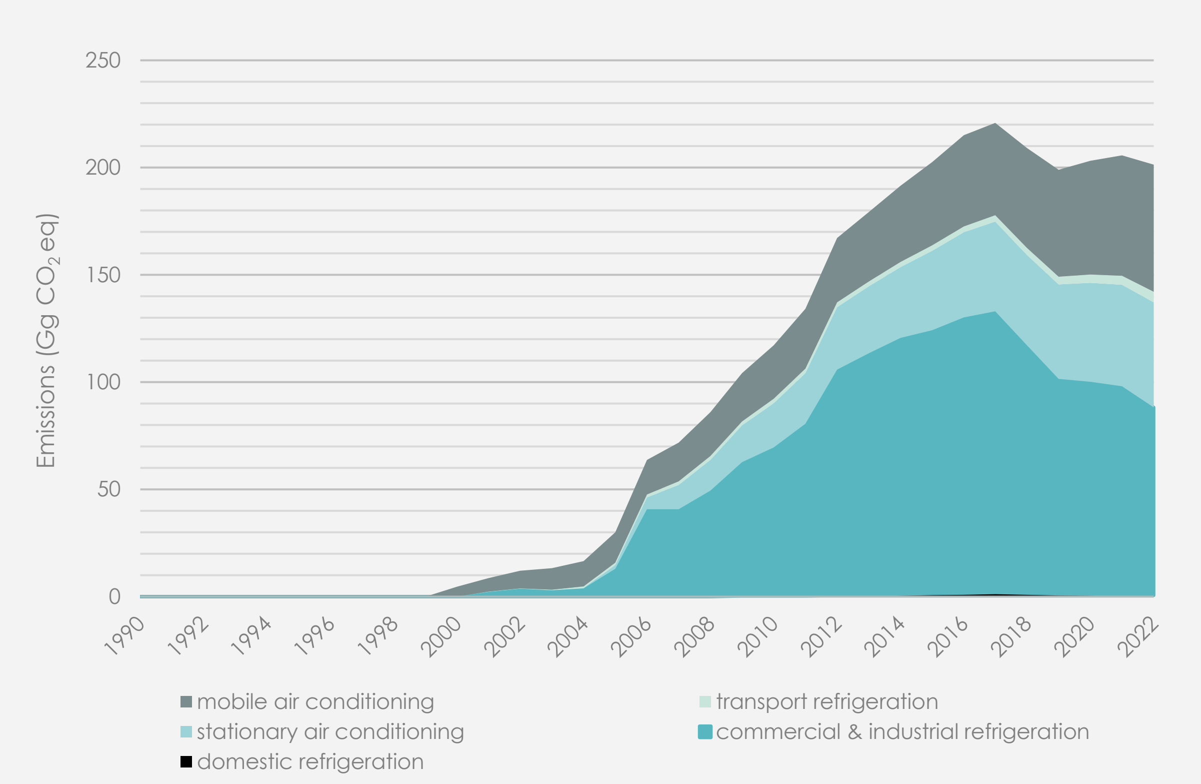


Figure 4-3 Actual emissions from category 2.F.1 Refrigeration and Air Conditioning

4.7.1.1 Stationary Refrigeration (CRF 2.F.1.a, 2.F.1.b & 2.F.1.c)

4.7.1.1.1 Category Description

As in most European countries, the local market for domestic refrigeration appliances has reached saturation since many years (Abela 2012). It is estimated that about 182,000 appliances exist in ca. 139,000 households in Malta. Based on a replacement rate of 6% of the existing stock, about 11,000 domestic refrigeration and freezing equipment units are imported annually.

Imports of appliances containing HFC-134a are estimated to have started in 1994 (as in most European countries) and increased gradually for some years. Previously, all units were running on R12 which is an ozone depleting substance and has been subject to substitution by HFC-134a. It is estimated that new units containing R12 were no longer imported from 2001 onwards.

Most central European manufacturers of domestic appliances had converted their production lines to hydrocarbons (R600a) by the late 1990s, and manufacturers in southern Europe have followed. Therefore, it is assumed that imports containing hydrocarbons as refrigerants started in 2000, at a low rate of 10%, and have increased from then onwards to a stable rate of 90% since 2008 and 100% since 2014.

Commercial refrigeration today accounts for large parts of the F-gas demand, with R404A being one of the main refrigerants imported to Malta. This refrigerant blend is mainly used in supermarket installations (centralised systems) but also other types of small commercial refrigeration equipment. Commercial refrigeration systems are very diverse as they are usually customised to meet specific requirements (e.g. concerning the temperature ranges for different products) and built on site. The same applies to industrial refrigeration equipment which includes a large range of equipment types to cater for the needs of various industries.

As no equipment register or statistical information on commercial and industrial refrigeration systems are available in Malta, the approach chosen for emission estimates relies on import data of HFC bulk substances which are partly used for first fill and refill of commercial and industrial refrigeration systems.

Import data received for the year 2017 included R407A and HFC-23. This was the first occurrence of these two gases, which according to the respective company importing them, are used in commercial refrigeration. Similarly, for the first time, the received import data for the year 2018 included R449A, which is also used in commercial refrigeration. R437A, which was first reported in the year 2020 is attributed to industrial refrigeration and, hence, to this sub-category. Similarly, R508B which was first reported in the year 2021.

4.7.1.1.2 Methodological Issues

An emission factor approach is used for emission estimates from the domestic refrigeration sub-category. The average charge size of 0.2 kg indicated by Abela (2012) is used, as well as an estimated average lifetime of 15 years (CasaInginiera, 2012). An operation emission rate of 0.3% is used since domestic refrigeration appliances are hermetically sealed which prevents emissions.

Emissions from disposal first occurred in 2009 (15 years after the first units containing HFCs were imported). However, detailed information on the disposal of domestic appliances is not available. CasaInginiera (2012) assumes that no recovery procedures are in place for scrapped equipment. The national authorities have confirmed that some form of recovery is taking place, but national data on this aspect is not readily available. Thus, a disposal emission rate of 100% is used.

For commercial refrigeration the method chosen is a top-down approach: imported quantities of different refrigerants, as reported by gas suppliers, are used as the starting point for estimates. The quantities of the refrigerants attributed to the commercial refrigeration sub-category imported annually are used both for first fill of new equipment and for refill of existing equipment. Refrigerants fully attributed to the commercial refrigeration subcategory (including industrial refrigeration) are R417A, R422D, R434A, R507A, R407F, R407A, HFC-23, R449A, R437A and R508B.

The situation is different for HFC-134a and R404A, which are mainly used in mobile air conditioning and transport refrigeration equipment, but also to some extent in stationary refrigeration applications. Thus, quantities used in the mobile air conditioning subcategory are calculated first (see relevant subcategory) and the remaining quantities are attributed to the commercial refrigeration subcategory.

The mass of refrigerants (mainly HFC-134a and some R404A) needed annually for servicing of mobile air conditioning and transport refrigeration are deducted from the total imports of HFC-134a and R404A that are attributed to the commercial refrigeration sub-category. It is assumed that due to the relatively high temperatures in Malta, mobile air conditioning and mobile refrigeration systems are being serviced regularly and that emitted refrigerants are refilled without major delay. Hence, the calculated emissions for mobile AC and mobile refrigeration equal the quantities refilled in the same year.

A sub-category specific emission factor of 20% from current year and banked gases is used. This emission factor includes both operation and disposal emissions in the sub-category, in view of the fact that disposal emissions for such larger systems are usually small due to recollection of gas. In the CRF tables, emissions from the industrial refrigeration sub-category (2.F.1.c) are reported under the commercial refrigeration sub-category (CRF 2.F.1.a).

The recovery reported for CRF sub-category 2.F.1.a (& 2.F.1.c) Commercial (& Industrial) refrigeration was obtained from the market. It should be specified that all the gases collected were exported; either for destruction by high temperature incineration or for recycling, when possible.

The data submitted consisted of the mass of gases collected, categorised by the year in which the gases collected were shipped. The data specified also the gases in each shipment and the equipment from which the gases were collected, as well as the next stage in the lifecycle of the gases following collection.

The total annual mass of ODS substitutes collected is estimated and reported in the CRF under "Recovery". As stated in the project for the improvement of the methodology of the national inventory report in the product uses as ozone depleting substances (ODS) substitutes sector conducted between 2012 and 2014, ODS substitutes entered the Maltese market only after the accession to the EU in 2005 as R22 was used previously. The average lifetime of the equipment is taken into consideration. R22 is considered to account for two-thirds of the mass collected during the years 2014 to 2020. The remaining mass is evenly distributed among the ODS substitutes. According to the equipment from which the gas was collected specified with the data submitted and the sector in which the gas is used, the mass of ODS substitutes collected is distributed between CRF sub-category 2.F.1.a (& 2.F.1.c) Commercial (& Industrial) Refrigeration and CRF sub-category 2.F.1.f Stationary Air Conditioning. This results in the total annual mass of ODS substitutes collected.

4.7.1.1.3 Source Specific Recalculations

Inconsistencies in the estimation of stock and emissions in sub-category CRF 2.F.1.b Domestic Refrigeration were corrected. This change has, inevitably, led to the following recalculations.

Table 4-6 CRF 2.F.1.b Domestic Refrigeration - HFC-134a - Stock

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	T	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	0.22	0.22	0.00%
1995	0.44	0.44	0.00%
1996	0.66	0.66	0.00%
1997	1.10	1.10	0.00%
1998	1.75	1.75	0.00%
1999	2.63	2.63	0.00%
2000	3.72	3.72	0.00%
2001	5.03	5.03	0.00%
2002	6.55	6.55	0.00%
2003	7.85	7.85	0.00%
2004	8.93	8.93	0.00%

2005	9.78	9.78	0.00%
2006	10.41	10.41	0.00%
2007	10.82	10.82	0.00%
2008	11.01	11.01	0.00%
2009	11.20	11.20	0.00%
2010	11.17	11.17	0.00%
2011	11.15	11.15	0.00%
2012	11.13	11.13	0.00%
2013	10.99	10.78	-1.91%
2014	10.54	10.12	-3.98%
2015	9.88	9.25	-6.36%
2016	9.01	8.17	-9.29%
2017	7.93	6.89	-13.17%
2018	6.65	5.39	-18.83%
2019	5.16	4.12	-20.12%
2020	3.88	3.06	-21.24%
2021	2.82	2.21	-21.71%
2022	not applicable	1.57	not applicable

Table 4-7 CRF 2.F.1.b Domestic Refrigeration - HFC-134a – Stock remaining in products at decommissioning

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	NO	NO	not applicable
2005	NO	NO	not applicable
2006	NO	NO	not applicable
2007	NO	NO	not applicable
2008	NO	NO	not applicable
2009	0.21	0.21	0.00%

2010	0.21	0.21	0.00%
2011	0.21	0.21	0.00%
2012	0.21	0.42	100.00%
2013	0.42	0.63	50.00%
2014	0.63	0.84	33.33%
2015	0.84	1.05	25.00%
2016	1.05	1.26	20.00%
2017	1.26	1.47	16.67%
2018	1.47	1.26	-14.29%
2019	1.26	1.05	-16.67%
2020	1.05	0.84	-20.00%
2021	0.84	0.63	-25.00%
2022	not applicable	0.42	not applicable

Table 4-8 CRF 2.F.1.b Domestic Refrigeration - HFC-134a – Emissions from stock

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	0.00	0.00	0.00%
1995	0.00	0.00	0.00%
1996	0.00	0.00	0.00%
1997	0.00	0.00	0.00%
1998	0.01	0.01	0.00%
1999	0.01	0.01	0.00%
2000	0.01	0.01	0.00%
2001	0.02	0.02	0.00%
2002	0.02	0.02	0.00%
2003	0.02	0.02	0.00%
2004	0.03	0.03	0.00%
2005	0.03	0.03	0.00%
2006	0.03	0.03	0.00%
2007	0.03	0.03	0.00%
2008	0.03	0.03	0.00%
2009	0.03	0.03	0.00%
2010	0.03	0.03	0.00%
2011	0.03	0.03	0.00%
2012	0.03	0.03	0.00%
2013	0.03	0.03	-1.91%
2014	0.03	0.03	-3.98%
2015	0.03	0.03	-6.36%

2016	0.03	0.02	-9.29%
2017	0.02	0.02	-13.17%
2018	0.02	0.02	-18.83%
2019	0.02	0.01	-20.12%
2020	0.01	0.01	-21.24%
2021	0.01	0.01	-21.71%
2022	not applicable	0.00	not applicable

Table 4-9 CRF 2.F.1.b Domestic Refrigeration - HFC-134a – Emissions from disposal

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	NO	NO	not applicable
2005	NO	NO	not applicable
2006	NO	NO	not applicable
2007	NO	NO	not applicable
2008	NO	NO	not applicable
2009	0.21	0.21	0.00%
2010	0.21	0.21	0.00%
2011	0.21	0.21	0.00%
2012	0.21	0.42	100.00%
2013	0.42	0.63	50.00%
2014	0.63	0.84	33.33%
2015	0.84	1.05	25.00%
2016	1.05	1.26	20.00%
2017	1.26	1.47	16.67%
2018	1.47	1.26	-14.29%
2019	1.26	1.05	-16.67%
2020	1.05	0.84	-20.00%
2021	0.84	0.63	-25.00%

2022	not applicable	0.42	not applicable

Inconsistencies in the estimation of stock and emissions in sub-category CRF 2.F.1.a(&c) Commercial (& Industrial) Refrigeration were corrected. The changes made in the estimation of stock and emissions in sub-category CRF 2.F.1.e Mobile Air Conditioning, have resulted in changes to the mass of imports of bulk HFC-134a to be attributed to the commercial refrigeration subcategory (activity data). These changes have, inevitably, resulted in the following recalculations.

Table 4-10 CRF 2.F.1.a(&c) Commercial (& Industrial) Refrigeration - HFC-134a - Stock

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	8.67	8.67	not applicable
2002	14.10	14.10	not applicable
2003	11.28	11.28	not applicable
2004	14.92	14.92	not applicable
2005	18.93	18.93	not applicable
2006	31.65	31.65	not applicable
2007	28.36	28.36	not applicable
2008	37.20	37.20	not applicable
2009	58.01	58.01	not applicable
2010	55.53	55.53	not applicable
2011	57.47	57.47	not applicable
2012	69.78	69.78	not applicable
2013	61.34	61.34	not applicable
2014	59.66	59.66	not applicable
2015	53.00	53.00	not applicable
2016	52.16	52.16	not applicable
2017	61.83	64.85	4.89%
2018	53.32	55.74	4.54%
2019	46.00	47.93	4.21%
2020	40.69	42.24	3.81%

2021	34.54	35.78	3.59%
2022	not applicable	32.19	not applicable

Table 4-11 CRF 2.F.1.a(&c) Commercial (& Industrial) Refrigeration - HFC-134a - Emissions

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	1.73	1.73	not applicable
2002	2.82	2.82	not applicable
2003	2.26	2.26	not applicable
2004	2.98	2.98	not applicable
2005	3.79	3.79	not applicable
2006	6.33	6.33	not applicable
2007	5.67	5.67	not applicable
2008	7.44	7.44	not applicable
2009	11.60	11.60	not applicable
2010	11.11	11.11	not applicable
2011	11.49	11.49	not applicable
2012	13.96	13.96	not applicable
2013	12.27	12.27	not applicable
2014	11.32	11.32	not applicable
2015	9.98	9.98	not applicable
2016	10.18	10.18	not applicable
2017	12.11	12.72	5.00%
2018	10.58	11.06	4.58%
2019	9.11	9.50	4.25%
2020	8.05	8.36	3.85%
2021	6.82	7.07	3.64%
2022	not applicable	6.35	not applicable

Table 4-12 CRF 2.F.1.a(&c) Commercial (& Industrial) Refrigeration - HFC-125 - Stock

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	NO	NO	not applicable
2005	4.71	4.71	not applicable
2006	18.75	18.75	not applicable
2007	19.37	19.37	not applicable
2008	25.18	25.18	not applicable
2009	31.57	31.57	not applicable
2010	38.74	38.74	not applicable
2011	47.32	47.32	not applicable
2012	61.94	61.94	not applicable
2013	70.80	70.80	not applicable
2014	79.90	79.90	not applicable
2015	83.50	83.50	not applicable
2016	87.89	87.89	not applicable
2017	89.29	89.29	not applicable
2018	79.06	79.06	not applicable
2019	70.74	70.74	not applicable
2020	66.64	66.64	not applicable
2021	63.93	63.93	0.01%
2022	not applicable	58.42	not applicable

Table 4-13 CRF 2.F.1.a(&c) Commercial (& Industrial) Refrigeration - HFC-125 - Emissions

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%

1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	NO	NO	not applicable
2005	0.94	0.94	not applicable
2006	3.75	3.75	not applicable
2007	3.87	3.87	not applicable
2008	5.04	5.04	not applicable
2009	6.31	6.31	not applicable
2010	7.75	7.75	not applicable
2011	9.46	9.46	not applicable
2012	12.39	12.39	not applicable
2013	14.16	14.16	not applicable
2014	15.62	15.62	not applicable
2015	16.34	16.34	not applicable
2016	17.43	17.43	not applicable
2017	17.71	17.71	not applicable
2018	15.81	15.81	not applicable
2019	14.15	14.15	not applicable
2020	13.33	13.33	not applicable
2021	12.79	12.79	0.01%
2022	not applicable	11.68	not applicable

Table 4-14 CRF 2.F.1.a(&c) Commercial (& Industrial) Refrigeration - HFC-143a - Stock

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable

1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	NO	NO	not applicable
2005	5.23	5.23	not applicable
2006	21.41	21.41	not applicable
2007	21.84	21.84	not applicable
2008	24.72	24.72	not applicable
2009	28.35	28.35	not applicable
2010	31.52	31.52	not applicable
2011	36.89	36.89	not applicable
2012	49.77	49.77	not applicable
2013	53.87	53.87	not applicable
2014	58.64	58.64	not applicable
2015	61.49	61.49	not applicable
2016	62.91	62.91	not applicable
2017	60.72	60.72	not applicable
2018	52.44	52.44	not applicable
2019	44.17	44.17	not applicable
2020	42.92	42.92	not applicable
2021	45.57	45.58	0.02%
2022	not applicable	38.18	not applicable

Table 4-15 CRF 2.F.1.a(&c) Commercial (& Industrial) Refrigeration - HFC-143a - Emissions

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable

2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	NO	NO	not applicable
2005	1.05	1.05	not applicable
2006	4.28	4.28	not applicable
2007	4.37	4.37	not applicable
2008	4.94	4.94	not applicable
2009	5.67	5.67	not applicable
2010	6.30	6.30	not applicable
2011	7.38	7.38	not applicable
2012	9.95	9.95	not applicable
2013	10.77	10.77	not applicable
2014	11.51	11.51	not applicable
2015	12.08	12.08	not applicable
2016	12.49	12.49	not applicable
2017	12.05	12.05	not applicable
2018	10.49	10.49	not applicable
2019	8.83	8.83	not applicable
2020	8.58	8.58	not applicable
2021	9.11	9.12	0.02%
2022	not applicable	7.64	not applicable

4.7.1.2 Stationary Air Conditioning (CRF 2.F.1.f)

1.1.1.1.1 Category Description

The Maltese stationary air conditioning market cannot yet be considered a mature market[4] but it is growing steadily.

The equipment types used include room air conditioners mainly imported from Asia, and chillers, mainly imported from Southern and Western Europe. Manufacturing emissions hardly occur but emissions during topping-up (mostly of pre-charged equipment) on installation do occur. These emissions are accounted for within lifetime emissions.

The refrigerants R407C, R410A, R427A, R428A and HFC-32 are the HFC refrigerants used in stationary air conditioning systems, apart from R22, in older systems. The latter however is an Ozone Depleting Substance (ODS) and, thus, not subject to reporting of GHG emissions. Hence, the quantities of these refrigerants imported for servicing are fully attributed to the stationary air conditioning category. These refrigerants entered the Maltese market only after its accession to the EU, in 2005, given that previously R22 was used. Thus, HFC emissions from this sub-category started occurring only from 2005 onwards.

1.1.1.1.2 Methodological issues

For stationary air conditioning systems, a tier 2 methodology has been preferred, mainly due to the general dissemination of equipment across all sectors including domestic and

[4] CasaInginiera. (2012). Analysis of the potential to decrease the proportion of HFC Emissions in the Refrigeration and Air Conditioning sector. Malta.

commercial, mainly composed of smaller equipment. The method chosen is a top-down approach.

Imported quantities of different refrigerants, as reported by gas suppliers, are used as the starting point for estimates. The refrigerants that are fully attributed to the stationary air conditioning subcategory are R407C and R410A (since 2005), R427A and R428A (intermittently from 2009) and HFC-32 (since 2016).

The quantities of the refrigerants attributed to the stationary air conditioning sub-category imported annually are used both for first fill of new equipment and for refill of existing equipment.

Just as for commercial refrigeration, a bank of gases is built up through yearly imports of gases assigned to this sub-category. An EF of 7% annual loss from the bank, has been assigned to this sub-category. This EF takes into account emissions from installation of VRF (variable refrigerant flow) systems, emissions from operation of both split units and VRF systems and emissions from disposal of both split units and VRF systems.

In earlier submissions of the annual national GHG inventory, it was stated that the methodology used at the time could have been improved by adequately addressing the emissions from imported pre-charged equipment. During the review of the 2019 annual submission, the *Expert Review Team* had identified a potential problem with this. As a response to this potential problem, the estimate of emissions from this sub-category was revised to include emissions from pre-charged equipment by using a country-specific method. The approach is primarily based on the *EWA Heat-Pumps Model*, which is a model developed by The Energy and Water Agency. Annex 3 A-3.3 is an extract from "*A Note on Data Collection and Methodology in the Development of the EWA Heat-Pumps Model - Split Units*" by the Energy and Water Agency, which describes the data collection process and the methodology of this model.

It was determined, during the 2019 review, that the pre-charged equipment imported into Malta; is used in stationary air conditioning in sub-category CRF 2.F.1.f, as well as in sub-category CRF 2.F.1.e Mobile Air Conditioning. Emissions from the latter sub-category were estimated in the 2019 submission and, also, in earlier submissions.

The *EWA Heat-Pumps Model*, lists two types of heat pumps being used in Malta, namely, VRF systems, which are not pre-charged, and split units, which are categorised into the "residential" and "non-residential" sectors. Split units from both "residential" and "non-residential" sectors are considered as pre-charged equipment in stationary air conditioning. The methodology to estimate the stock accumulated from the charge in pre-charged equipment, takes into account the stock remaining in pre-charged equipment imported in previous years. Thus, as from the 2021 GHG inventory, the annual imports of split units is used in the estimation of the stock accumulated from the charge in pre-charged equipment.

The distribution by refrigerant of the quantities from bulk imports attributed to stationary air conditioning is calculated. The mass of charge in pre-charged equipment is estimated by taking the estimated total stock of split units from the *EWA Heat-Pumps Model* rounded up to the nearest integer and multiplying this by the average fill. The distribution by refrigerant of the charge in pre-charged equipment is assumed to be equal to the distribution by refrigerant of the quantities of bulk imports attributed to stationary air conditioning. Similarly, the year of introduction of the refrigerant in the pre-charged equipment follows the same year of introduction of the respective refrigerant by bulk. The annual charge in pre-charged equipment constitutes the stock accumulated from the charge in pre-charged equipment, taking into account the average leak rate from pre-charged equipment. For reporting purposes, the stock accumulated from bulk and that accumulated from pre-charged equipment are then added together. Similarly, the emissions from each stock are added and reported together.

The *EWA Heat-Pumps Model* developed by The Energy and Water Agency estimates the mean lifetime for heat pumps to be equal to 16.8 years. Thus, this value is used as the average lifetime of pre-charged equipment. Similarly, as suggested in "Attachment A" of the "Potential Problems formulated in the course of the review of the 2019 annual submissions of Malta" and in the absence of country-specific data, the average fill of pre-charged equipment is 1kg of refrigerant.

As suggested in "Attachment A" of the "Potential Problems formulated in the course of the review of the 2019 annual submissions of Malta", in the absence of country-specific data, the average leak rate from pre-charged equipment is 1% per year.

For the estimates related to pre-charged equipment in sub-category 2.F.1.f, it is assumed that all the equipment imported pre-charged with F-gases is used locally, thus none of this equipment is exported and that all the equipment imported pre-charged with F-gases is sold in the year of importation.

The recovery reported for CRF sub-category 2.F.1.f stationary air conditioning was obtained from the market. It should be specified that all the gases collected were exported; either for destruction by high temperature incineration or for recycling, when possible.

The data submitted consisted of the mass of gases collected, categorised by the year in which the gases collected were shipped. The data specified also the gases in each shipment and the equipment from which the gases were collected, as well as the next stage in the lifecycle of the gases following collection.

The total annual mass of ODS substitutes collected is estimated and reported in the CRF under "Recovery". As stated in the project for the improvement of the methodology of the national inventory report in the product uses as ozone depleting substances (ODS) substitutes sector conducted between 2012 and 2014, ODS substitutes entered the Maltese market only after the accession to the EU in 2005 as R22 was used previously. The average lifetime of the equipment is taken into consideration. R22 is considered to account for two-thirds of the mass collected during the years 2014 to 2020. The remaining mass is evenly distributed among the ODS substitutes. According to the equipment from which the gas was collected specified with the data submitted and the sector in which the gas is used, the mass of ODS substitutes collected is distributed between CRF sub-category 2.F.1.a (& 2.F.1.c) Commercial (& Industrial) refrigeration and CRF sub-category 2.F.1.f Stationary Air Conditioning. This results in the total annual mass of ODS substitutes collected.

1.1.1.1.3 Source Specific Recalculations

Inconsistencies in the estimation of stock, emissions and recovery in sub-category CRF 2.F.1.f Stationary Air Conditioning were corrected. Also, the bulk imports of HFC-32 were updated (activity data). Similarly, the estimated annual imports of split units (activity data) was also updated for 2021. These changes have, inevitably, led to the following recalculations.

Table 4-16 CRF 2.F.1.f Stationary Air Conditioning - HFC-32 - Stock

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions

	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	NO	NO	not applicable
2005	4.03	8.52	111.38%
2006	5.94	20.03	236.94%
2007	9.58	40.74	325.46%
2008	19.59	56.57	188.86%
2009	23.88	65.03	172.33%
2010	30.94	75.27	143.25%
2011	38.32	86.25	125.07%
2012	51.98	106.59	105.04%
2013	64.34	118.99	84.96%
2014	76.23	132.00	73.17%
2015	97.65	154.53	58.25%
2016	114.41	175.62	53.49%
2017	142.09	203.52	43.24%
2018	165.32	232.65	40.72%
2019	209.73	280.42	33.70%
2020	298.01	367.46	23.31%
2021	341.71	402.91	17.91%
2022	not applicable	454.00	not applicable

Table 4-17 CRF 2.F.1.f Stationary Air Conditioning - HFC-32 - Emissions

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable

1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	NO	NO	not applicable
2005	0.15	0.31	111.38%
2006	0.24	0.89	266.92%
2007	0.40	1.79	348.84%
2008	0.80	2.39	200.59%
2009	1.04	2.86	175.88%
2010	1.44	3.44	138.43%
2011	1.80	3.96	119.61%
2012	2.52	5.02	98.90%
2013	3.08	5.54	79.83%
2014	3.55	6.01	69.30%
2015	4.54	7.02	54.55%
2016	5.08	7.66	50.90%
2017	6.06	8.59	41.81%
2018	6.39	8.95	40.06%
2019	7.39	9.98	34.96%
2020	10.36	12.83	23.89%
2021	11.14	13.41	20.41%
2022	not applicable	14.33	not applicable

Table 4-18 CRF 2.F.1.f Stationary Air Conditioning - HFC-32 - Recovery

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable

2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	NO	NO	not applicable
2005	NO	NO	not applicable
2006	NO	NO	not applicable
2007	NO	NO	not applicable
2008	NO	NO	not applicable
2009	NO	NO	not applicable
2010	NO	NO	not applicable
2011	NO	NO	not applicable
2012	NO	NO	not applicable
2013	NO	NO	not applicable
2014	NO	NO	not applicable
2015	NO	NO	not applicable
2016	NO	NO	not applicable
2017	NO	NO	not applicable
2018	NO	0.02	not applicable
2019	NO	0.02	not applicable
2020	NO	0.02	not applicable
2021	NO	0.02	not applicable
2022	not applicable	0.02	not applicable

Table 4-19 CRF 2.F.1.f Stationary Air Conditioning - HFC-134a - Stock

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	NO	NO	not applicable
2005	7.80	10.14	30.00%
2006	24.49	31.84	30.00%

2007	54.20	70.46	30.00%
2008	64.33	83.63	30.00%
2009	71.57	93.04	30.00%
2010	81.25	104.38	28.47%
2011	89.87	114.88	27.82%
2012	101.12	129.61	28.17%
2013	101.58	130.10	28.07%
2014	103.18	132.28	28.20%
2015	105.46	135.14	28.14%
2016	112.64	144.57	28.35%
2017	112.73	144.78	28.43%
2018	122.67	157.80	28.63%
2019	125.17	160.94	28.57%
2020	122.90	158.06	28.61%
2021	119.20	153.22	28.53%
2022	not applicable	150.69	not applicable

Table 4-20 CRF 2.F.1.f Stationary Air Conditioning - HFC-134a - Emissions

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	NO	NO	not applicable
2005	0.28	0.37	30.00%
2006	1.12	1.46	30.00%
2007	2.42	3.15	30.00%
2008	2.77	3.61	30.00%
2009	3.17	4.12	30.00%
2010	3.72	4.76	28.04%
2011	4.11	5.24	27.37%
2012	4.68	5.98	27.85%

2013	4.62	5.91	27.75%
2014	4.60	5.89	27.89%
2015	4.64	5.94	27.83%
2016	4.81	6.16	28.04%
2017	4.70	6.02	28.13%
2018	4.72	6.06	28.26%
2019	4.63	5.94	28.30%
2020	4.43	5.68	28.34%
2021	4.18	5.36	28.33%
2022	not applicable	5.11	not applicable

Table 4-21 CRF 2.F.1.f Stationary Air Conditioning - HFC-134a - Recovery

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	NO	NO	not applicable
2005	NO	NO	not applicable
2006	NO	NO	not applicable
2007	NO	NO	not applicable
2008	NO	NO	not applicable
2009	NO	NO	not applicable
2010	NO	NO	not applicable
2011	NO	NO	not applicable
2012	NO	NO	not applicable
2013	NO	NO	not applicable
2014	NO	NO	not applicable
2015	NO	NO	not applicable
2016	NO	NO	not applicable
2017	NO	NO	not applicable
2018	0.03	0.04	30.00%

2019	0.03	0.04	30.00%
2020	0.03	0.04	30.00%
2021	0.03	0.04	30.00%
2022	not applicable	0.04	not applicable

Table 4-22 CRF 2.F.1.f Stationary Air Conditioning - HFC-143a - Stock

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	0	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	NO	NO	not applicable
2005	7.80	NO	not applicable
2006	24.49	NO	not applicable
2007	54.20	NO	not applicable
2008	64.33	NO	not applicable
2009	71.87	0.31	-99.58%
2010	78.21	1.12	-98.57%
2011	84.93	1.58	-98.15%
2012	97.10	2.14	-97.80%
2013	97.47	2.41	-97.52%
2014	99.29	2.28	-97.70%
2015	101.48	2.55	-97.49%
2016	109.20	2.76	-97.48%
2017	109.47	2.62	-97.60%
2018	119.58	2.50	-97.91%
2019	122.24	2.38	-98.05%
2020	120.11	2.27	-98.11%
2021	116.55	2.17	-98.14%
2022	not applicable	2.07	not applicable

Table 4-23 CRF 2.F.1.f Stationary Air Conditioning - HFC-143a - Emissions

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	NO	NO	not applicable
2005	0.28	NO	not applicable
2006	1.12	NO	not applicable
2007	2.42	NO	not applicable
2008	2.77	NO	not applicable
2009	3.19	0.02	-99.45%
2010	3.54	0.06	-98.17%
2011	3.84	0.09	-97.73%
2012	4.46	0.12	-97.38%
2013	4.40	0.13	-97.10%
2014	4.40	0.12	-97.29%
2015	4.44	0.13	-97.07%
2016	4.63	0.13	-97.09%
2017	4.53	0.13	-97.22%
2018	4.57	0.12	-97.43%
2019	4.48	0.11	-97.55%
2020	4.29	0.10	-97.61%
2021	4.05	0.10	-97.63%
2022	not applicable	0.09	not applicable

Table 4-24 CRF 2.F.1.f Stationary Air Conditioning - HFC-143a - Recovery

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%

1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	NO	NO	not applicable
2005	NO	NO	not applicable
2006	NO	NO	not applicable
2007	NO	NO	not applicable
2008	NO	NO	not applicable
2009	NO	NO	not applicable
2010	NO	NO	not applicable
2011	NO	NO	not applicable
2012	NO	NO	not applicable
2013	NO	NO	not applicable
2014	NO	NO	not applicable
2015	NO	NO	not applicable
2016	NO	NO	not applicable
2017	NO	NO	not applicable
2018	0.03	NO	not applicable
2019	0.03	NO	not applicable
2020	0.03	NO	not applicable
2021	0.03	NO	not applicable
2022	not applicable	NO	not applicable

Table 4-25 CRF 2.F.1.f Stationary Air Conditioning - HFC-125 - Stock

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable

1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	NO	NO	not applicable
2005	7.93	8.91	12.30%
2006	18.19	21.25	16.83%
2007	36.68	43.45	18.47%
2008	51.75	59.79	15.54%
2009	60.85	69.79	14.69%
2010	71.45	81.08	13.48%
2011	82.36	92.77	12.64%
2012	104.24	116.08	11.37%
2013	117.49	129.34	10.09%
2014	130.06	142.15	9.30%
2015	153.27	165.61	8.05%
2016	173.07	186.34	7.67%
2017	192.16	205.48	6.93%
2018	206.09	220.69	7.08%
2019	231.95	246.18	6.14%
2020	243.44	257.43	5.75%
2021	273.07	282.25	3.36%
2022	not applicable	305.50	not applicable

Table 4-26 CRF 2.F.1.f Stationary Air Conditioning - HFC-125 - Emissions

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable

2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	NO	NO	not applicable
2005	0.29	0.33	12.30%
2006	0.80	0.95	17.47%
2007	1.61	1.91	18.80%
2008	2.18	2.53	15.89%
2009	2.69	3.08	14.72%
2010	3.29	3.73	13.18%
2011	3.81	4.28	12.30%
2012	4.96	5.50	10.93%
2013	5.51	6.05	9.67%
2014	5.97	6.50	8.94%
2015	7.01	7.55	7.66%
2016	7.60	8.16	7.37%
2017	8.18	8.73	6.71%
2018	8.18	8.74	6.78%
2019	8.61	9.15	6.25%
2020	8.80	9.31	5.86%
2021	9.26	9.70	4.78%
2022	not applicable	10.00	not applicable

Table 4-27 CRF 2.F.1.f Stationary Air Conditioning - HFC-125 - Recovery

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	NO	NO	not applicable
2005	NO	NO	not applicable
2006	NO	NO	not applicable
2007	NO	NO	not applicable

2008	NO	NO	not applicable
2009	NO	NO	not applicable
2010	NO	NO	not applicable
2011	NO	NO	not applicable
2012	NO	NO	not applicable
2013	NO	NO	not applicable
2014	NO	NO	not applicable
2015	NO	NO	not applicable
2016	NO	NO	not applicable
2017	NO	NO	not applicable
2018	0.02	0.02	25.00%
2019	0.02	0.02	25.00%
2020	0.02	0.02	25.00%
2021	0.02	0.02	25.00%
2022	not applicable	0.02	not applicable

4.7.1.3 Transport Refrigeration (CRF 2.F.1.d)

4.7.1.3.1 Category Description

Transport refrigeration comprises vehicle and self-powered refrigeration units used in commercial vehicles. The biggest source within transport refrigeration is the local movement of perishable (frozen or refrigerated) goods in Malta. This includes transport from port or producer to distributor and from distributor to commercial premises. The sector also includes emissions from the use of refrigerated trailers. Contrary to air conditioning systems, it is estimated that the dominant refrigerant used in the transport refrigeration sector is R404A and not HFC-134a. In Malta, HFCs started to be used in transport refrigeration in the year 2001.

4.7.1.3.2 Methodological issues

The emissions from sub-categories 2.F.1.d Transport Refrigeration and 2.F.1.e Mobile Air Conditioning are reported separately as from the 2022 GHG inventory. Emission estimates for transport refrigeration are based on an emission factor approach. Since most vehicles are imported from the UK, the same average charge of 3.9kg for mobile refrigeration is used as reported in the UK NIR (2013).

Data on the total number of refrigerated vans, trucks and trailers (arctic heavy goods vehicles, HGVs) from the VERA system was available from the year 2000 to the year 2012. (The VERA system is managed by the authority for transport in Malta and the national statistics agency.) The total number of HGVs and LGVs since the year 2013 are obtained from the Eurostat database, as explained in section 4.7.1.4.2.1. The share of arctic HGVs as a percentage of the total number of HGVs and light goods vehicles (LGVs) was determined for the period 2000 to 2012 and extrapolated for each year since 2013. This respective annual value is subsequently multiplied by the total number of HGVs and LGVs for each year since 2013 and rounded up to the nearest integer to obtain the total number of arctic HGVs for each year.

Both R404A and R134a are used in transport refrigeration today and the split of the two refrigerants can be assumed to be 90% of R404A and 10% of R134a (expert estimate[5]). However, it is also assumed that R134a was the only refrigerant used in transport refrigeration

[5] Stakeholder consultation: Sébastien Lemoine, company "Carrier", 5 November 2013.

in the period 2000-2004. R404A units were introduced in 2004 and emissions in that year only arose from the newly imported units. Refill of these units is assumed to have taken place in 2005 when imports of bulk quantities of R404A were first reported. The ratios of the different gases used in transport refrigeration reflect the introduction of the gases, as was recommended in the project for the improvement of the methodology of the national inventory report in the product uses as ozone depleting substances (ODS) substitutes sector conducted between 2012 and 2014. The following ratios of HFC134a:HFC-404A are used:

- pre-2001: 0:0;
- 2001-2003: 100:0;
- 2004: 50:50;
- 2005: 30:70; and
- 2006 to date: 10:90.

Manufacturing emissions do not occur in Malta since no vehicle production takes place. The current number of refrigerated vans, trucks and trailers is not available from vehicle registration data or model reported.

A rate of 15% for operation emissions is used, based on the fact that mainly short-distance transportation is carried out, and on the assumption that servicing and repair take place regularly. However, a European study (Schwarz et al. 2011)[6] suggests higher emission rates of up to 25%.

A "charge at disposal" of 85%, as recommended in the project for the improvement of the methodology of the national inventory report in the product uses as ozone depleting substances (ODS) substitutes sector conducted between 2012 and 2014, is used for transport refrigeration.

The mass of gas remaining in products at decommissioning and the emissions from disposal reflect the ratios of the different gases used in transport refrigeration in the year the vehicles were introduced.

In the absence of national data or of data from the local market on the share of refrigerant recovered from vehicles that reach their end-of-life, the recovery rate is taken to be zero.

Disposal emissions from this sub-category first feature in the year 2017 due to the introduction of HFC refrigerants in transport refrigeration in 2001 and the estimated lifetime of vehicles of 16 years.

4.7.1.3.3 Source Specific Recalculations

The number of vehicles (activity data) for 2021 was updated. This change has, inevitably, led to the following recalculations.

Table 4-28 CRF 2.F.1.d Transport Refrigeration - HFC-125 - Stock

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	T	%

[6] Schwarz, W., Gschrey, B., Leisewitz, A., Herold, A., Gores, S., Papst, I., . . . Lindborg, A. (2011). Pedersen, P.H.; Colbourne, D.; Kauffeld, M.; Kaar, K.; Lindborg, A.: Preparatory study for a review of Regulation (EC) No. 842/2006 on certain fluorinated greenhouse gases. Brussels: European Commission.

1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	0.44	0.44	0.00%
2005	0.77	0.77	0.00%
2006	1.04	1.04	0.00%
2007	1.16	1.16	0.00%
2008	1.32	1.32	0.00%
2009	1.37	1.37	0.00%
2010	1.46	1.46	0.00%
2011	1.56	1.56	0.00%
2012	1.58	1.58	0.00%
2013	1.65	1.65	0.00%
2014	1.75	1.75	0.00%
2015	1.83	1.83	0.00%
2016	1.95	1.95	0.00%
2017	2.10	2.10	0.00%
2018	2.26	2.26	0.00%
2019	2.43	2.43	0.00%
2020	2.58	2.58	0.00%
2021	2.76	2.71	-2.01%
2022	not applicable	2.83	not applicable

Table 4-29 CRF 2.F.1.d Transport Refrigeration - HFC-125 - Emissions from stock

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	T	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable

1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	0.07	0.066	0.00%
2005	0.12	0.12	0.00%
2006	0.16	0.16	0.00%
2007	0.17	0.17	0.00%
2008	0.20	0.20	0.00%
2009	0.20	0.20	0.00%
2010	0.22	0.22	0.00%
2011	0.23	0.23	0.00%
2012	0.24	0.24	0.00%
2013	0.25	0.25	0.00%
2014	0.26	0.26	0.00%
2015	0.27	0.27	0.00%
2016	0.29	0.29	0.00%
2017	0.31	0.31	0.00%
2018	0.34	0.34	0.00%
2019	0.36	0.36	0.00%
2020	0.39	0.39	0.00%
2021	0.41	0.41	-2.01%
2022	not applicable	0.42	not applicable

Table 4-30 CRF 2.F.1.d Transport Refrigeration - HFC-143a - Stock

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	T	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable

2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	0.52	0.52	0.00%
2005	0.91	0.91	0.00%
2006	1.23	1.23	0.00%
2007	1.38	1.38	0.00%
2008	1.56	1.56	0.00%
2009	1.61	1.61	0.00%
2010	1.72	1.72	0.00%
2011	1.84	1.84	0.00%
2012	1.86	1.86	0.00%
2013	1.95	1.95	0.00%
2014	2.07	2.07	0.00%
2015	2.16	2.16	0.00%
2016	2.30	2.30	0.00%
2017	2.48	2.48	0.00%
2018	2.67	2.67	0.00%
2019	2.87	2.87	0.00%
2020	3.05	3.05	0.00%
2021	3.26	3.20	-2.01%
2022	not applicable	3.35	not applicable

Table 4-31 CRF 2.F.1.d Transport Refrigeration - HFC-143a - Emissions from stock

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	T	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	0.08	0.08	0.00%
2005	0.14	0.14	0.00%
2006	0.18	0.18	0.00%
2007	0.21	0.21	0.00%

2008	0.23	0.23	0.00%
2009	0.24	0.24	0.00%
2010	0.26	0.26	0.00%
2011	0.28	0.28	0.00%
2012	0.28	0.28	0.00%
2013	0.29	0.29	0.00%
2014	0.31	0.31	0.00%
2015	0.32	0.32	0.00%
2016	0.35	0.35	0.00%
2017	0.37	0.37	0.00%
2018	0.40	0.40	0.00%
2019	0.43	0.43	0.00%
2020	0.46	0.46	0.00%
2021	0.49	0.48	-2.01%
2022	not applicable	0.50	not applicable

Table 4-32 CRF 2.F.1.d Transport Refrigeration - HFC-134a - Stock

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	T	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	0.50	0.50	0.00%
2002	1.00	1.00	0.00%
2003	1.50	1.50	0.00%
2004	1.04	1.04	0.00%
2005	0.82	0.82	0.00%
2006	0.36	0.36	0.00%
2007	0.40	0.40	0.00%
2008	0.45	0.45	0.00%
2009	0.47	0.47	0.00%
2010	0.50	0.50	0.00%
2011	0.53	0.53	0.00%
2012	0.54	0.54	0.00%
2013	0.57	0.57	0.00%

2014	0.60	0.60	0.00%
2015	0.63	0.63	0.00%
2016	0.67	0.67	0.00%
2017	0.72	0.72	0.00%
2018	0.78	0.78	0.00%
2019	0.83	0.83	0.00%
2020	0.89	0.89	0.00%
2021	0.95	0.93	-2.01%
2022	not applicable	0.97	not applicable

Table 4-33 CRF 2.F.1.d Transport Refrigeration - HFC-134a - Emissions from stock

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	T	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	0.08	0.08	0.00%
2002	0.15	0.15	0.00%
2003	0.23	0.23	0.00%
2004	0.16	0.16	0.00%
2005	0.12	0.12	0.00%
2006	0.05	0.05	0.00%
2007	0.06	0.06	0.00%
2008	0.07	0.07	0.00%
2009	0.07	0.07	0.00%
2010	0.08	0.08	0.00%
2011	0.08	0.08	0.00%
2012	0.08	0.08	0.00%
2013	0.09	0.09	0.00%
2014	0.09	0.09	0.00%
2015	0.09	0.09	0.00%
2016	0.10	0.10	0.00%
2017	0.11	0.11	0.00%
2018	0.12	0.12	0.00%
2019	0.13	0.13	0.00%

2020	0.13	0.13	0.00%
2021	0.14	0.14	-2.01%
2022	not applicable	0.15	not applicable

4.7.1.4 Mobile Air Conditioning (CRF 2.F.1.e)

4.7.1.4.1 Category Description

Emissions from mobile air conditioning today account for large shares of F-gas emissions in all European countries. Most vehicles imported in recent years are equipped with air conditioning. In view of the local weather patterns, it is also expected that air conditioning in vehicles is regularly maintained in running order.

To reduce emissions of F-gases from mobile air-conditioning systems, Directive 2006/40/EC of the European Parliament and of the Council of 17 May 2006 relating to emissions from air conditioning systems in motor vehicles introduces a gradual ban on these gases in passenger cars. The said Directive covers mobile air-conditioning systems fitted to passenger cars (vehicles of category M1) and light commercial vehicles (category N1, class 1). In line with the third phase (of three) of this Directive, from 1 January 2017, the use of F-gases with a GWP higher than 150 in all new vehicles put on the EU market are totally banned. Thus, new vehicles with mobile air-conditioning systems using these gases are not registered, sold, or able to enter into service in the EU.

4.7.1.4.2 Methodological Issues

The emissions from sub-categories 2.F.1.d Transport Refrigeration and 2.F.1.e Mobile Air Conditioning are reported separately as from the 2022 GHG inventory. As the refrigerant HFC-134a is the main refrigerant used in mobile air conditioning of road vehicles and the number of passenger cars, minibuses, buses and trucks could be determined, emission estimates follow an emission-factor approach. For emission estimates from mobile air conditioning in ships, on the other hand, the approach chosen relies on data of bulk imports.

4.7.1.4.3 Road vehicles

Vehicle registration data for passenger cars, minibuses, buses and trucks was available from the year 2000, when HFCs started to be used in mobile air conditioning, to the year 2012. The number of passenger cars for the years 2003 and 2004, the number of minbuses for the year 2004 and the total number of LGVs and HGVs for the year 2005 were considered to be outliers. These values were obtained by using the linear interpolation formula.

The values for the years since 2013 are obtained from the Eurostat database, as follows:

- number of passenger cars, by age: https://ec.europa.eu/eurostat/databrowser/view/ROAD_EQS_CARAGE__custom_9902441/default/table?lang=en last updated on 13th February 2024;
- number of mini buses and mini coaches: https://ec.europa.eu/eurostat/databrowser/view/ROAD_EQS_BUSVEH__custom_9902453/default/table?lang=en last updated on 13th February 2024;
- number of buses: https://ec.europa.eu/eurostat/databrowser/view/ROAD_EQS_BUSVEH__custom_9902462/default/table?lang=en last updated on 13th February 2024;
- number of motor coaches:

https://ec.europa.eu/eurostat/databrowser/view/ROAD_EQS_BUSVEH__custom_9902476/default/table?lang=en last updated on 13th February 2024;

- number of LGVs (<= 3.5 tonnes): https://ec.europa.eu/eurostat/databrowser/view/ROAD_EQS_LORROA__custom_9902499/default/table?lang=en last updated on 13th February 2024; and
- number of HGVs (> 3.5 tonnes): https://ec.europa.eu/eurostat/databrowser/view/ROAD_EQS_LORROA__custom_9902521/default/table?lang=en last updated on 13th February 2024.

All the above-mentioned sets of data were retrieved on 16th February 2024.

Relative to the size of the country, the size of the car fleet of Malta is significant and higher than the EU average. However, it is assumed that a proportion of these cars are not used on a daily basis. Both new and second-hand vehicles are being imported, mainly from the UK and Japan (due to the common left-hand driving system). Export of end-of-life vehicles or second-hand cars is negligible.

A lifetime of 16 years for all types of road vehicles (cars, trucks and buses) is used. This value ranges at the upper end of the span of 9 to 16 years provided in the 2006 IPCC Guidelines (table 7.9, p. 7.52). Moreover, this value for the lifetime of vehicles in Malta is comparably high since it is a country heavily dependent on imports.

Local experts in the business of mobile AC servicing[7] estimated that the refrigerant R134a, introduced in new cars in 2000[8], has been the only refrigerant for car air conditioning since 2005 both in new and in second-hand cars. Due to the phase-out of the ozone depleting refrigerant R12 and the accession of Malta to the EU in 2004, R12 was no longer available from then onwards.

R1234yf has been introduced in new car models from 2017 onwards. Directive 2006/40/EC covers mobile air conditioners fitted to passenger cars (vehicles of category M1) and light commercial vehicles (category N1, class 1). Also, the aim of the Directive 2006/40/EC is to enforce the use of gases with GWP lower than 150. Since, a quantitative analysis on the use of R1234yf in the local mobile air conditioning market is not readily available, this development needed to be factored in the estimation of emissions from sub-category Mobile Air Conditioning (CRF 2.F.1.e) using the data shared by the *Effort Sharing Regulation Review Team* (in Finding MT-2F1-2023-0001 in the 2023 ESR Review). Thus, it was assumed that all new cars and light goods vehicles (LGVs) from 2017 onwards use R1234yf as a refrigerant. R1234yf is an HFO which is not subject to reporting. Therefore, the estimated mass of R1234yf was removed from the estimation.

A time series of the vehicle fleet in Malta (passenger cars, vans, trucks, buses) and an estimated number of air-conditioned vehicles has been used for emission estimates. In the absence of readily available data on the number of new cars, this data set was obtained by calculating the stock divided by the average lifetime plus the increase in stock compared to the year before.

For passenger cars, the average charge is estimated to be 0.8 kg, which is also the default value given in the IPCC Good Practice Guidelines and well within the range of 0.5 to 1.5 kg provided by the 2006 IPCC Guidelines. The value is somewhat higher than in other European countries but takes into account the relatively long average lifetime of vehicles in Malta. For

[7] References: Companies “V.Spiteri”, “Tecnoplus”.

[8] This finding is somewhat contradictory to the situation in most other European countries as the European carmakers were not producing cars with air conditioning systems containing R12 from 1995 onwards. However, second-hand cars running on R12 might have been imported well beyond 2000.

buses and coaches, the average charge is 12 kg and for mobile air conditioning in trucks, a charge of 0.9 kg is assumed.

The following "charge at disposal", as recommended in the project for the improvement of the methodology of the national inventory report in the product uses as ozone depleting substances (ODS) substitutes sector conducted between 2012 and 2014, is used:

- cars and minibuses: 50%;
- buses: 50%; and
- vans and trucks: 50%.

The mass of gas remaining in products at decommissioning and the emissions from disposal reflect the ratios of the different gases used in transport refrigeration in the year the vehicles were introduced. In the absence of national data or of data from the local market on the share of refrigerant recovered from vehicles that reach their end-of-life, the recovery rate is taken to be zero.

Disposal emissions of HFC-134a from this sub-category first feature in the year 2016 due to the introduction of HFC refrigerants in mobile air conditioning in the year 2000 and the estimated lifetime of all types of road vehicles of 16 years.

4.7.1.4.4 Ships

During the stakeholder consultation, it was determined that two ship repair facilities and a major local provider of general servicing and refitting services for yachts are located in Malta. Until the year 2010, one of the ship repair facilities used to be the state-owned Malta Shipyards/Drydocks.

Additional quantities of refrigerants had been imported by one of the ship repair companies and used for the refill of refrigeration and air conditioning systems of yachts and small Maltese ships and not sold on the Maltese market. The other ship repair company was custom to sub-contract repair work of air conditioning and refrigeration systems of ships to Maltese service companies. Refrigerant quantities used are hence accounted for within the commercial refrigeration or stationary air conditioning sub-category and cannot be separated.

Large sea-going ships that are registered under Malta's flag, but are operated by foreign owners, and coming to Maltese ports, usually bring along their own refrigerant supplies which is mostly not purchased in Malta due to comparably high prices. Thus, the refrigerant supply of the ship itself is used for servicing and repair needs. Emissions from ships which occur in areas beyond national jurisdiction are not accounted for in the national inventory.

Imports of bulk HFC quantities by one ship repair company amount to 120 kg of R410A (50% HFC-32; 50% HFC-125) and 80 kg of HFC-134a annually since 2010. These quantities account for emissions from certain air conditioning systems on small national ships operating in Maltese waters and are, thus, equal to the operation emissions from these ships in the respective year.

Before 2010, the ship repair facility which used to be the state-owned Malta Shipyards/Drydocks was substantially larger. No information on the historic time series before 2010 is available. However, based on the information for bulk imports reported by companies and expert input, it is estimated that the same level of F-gas emissions occurred since 2005 (first year of import of R410A). Prior to 2005, only R22 was used in refrigeration and air conditioning systems on ships.

1.1.1.1.4 Source Specific Recalculations

The number of vehicles (activity data) for 2021 was updated. Inconsistencies in the estimation of disposal emissions were corrected. Following the observation made by the *Effort Sharing*

Regulation Review Team (Finding MT-2F1-2023-0001 in the 2023 ESR Review), the use of R1234yf as a refrigerant in the local mobile air conditioning market was factored in the estimation of emissions. These changes have, inevitably, led to the following recalculations.

Table 4-34 CRF 2.F.1.e Mobile Air Conditioning - HFC-134a - Stock

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	17.59	17.59	not applicable
2001	24.42	24.42	not applicable
2002	31.56	31.56	not applicable
2003	38.59	38.59	not applicable
2004	45.74	45.74	not applicable
2005	53.55	53.55	not applicable
2006	60.77	60.77	not applicable
2007	69.12	69.12	not applicable
2008	77.61	77.61	not applicable
2009	85.70	85.70	not applicable
2010	94.93	94.93	not applicable
2011	107.06	107.06	not applicable
2012	115.54	115.54	not applicable
2013	124.36	124.36	not applicable
2014	136.43	136.43	not applicable
2015	148.98	148.98	not applicable
2016	161.20	161.20	not applicable
2017	174.82	159.69	-8.65%
2018	187.27	171.31	-8.52%
2019	199.30	183.18	-8.09%
2020	207.29	193.80	-6.51%
2021	222.31	202.09	-9.10%
2022	not applicable	212.34	not applicable

Table 4-35 CRF 2.F.1.e Mobile Air Conditioning - HFC-134a - Stock remaining in products at decommissioning

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	NO	NO	not applicable
2005	NO	NO	not applicable
2006	NO	NO	not applicable
2007	NO	NO	not applicable
2008	NO	NO	not applicable
2009	NO	NO	not applicable
2010	NO	NO	not applicable
2011	NO	NO	not applicable
2012	NO	NO	not applicable
2013	NO	NO	not applicable
2014	NO	NO	not applicable
2015	NO	NO	not applicable
2016	0.47	0.47	0.00%
2017	1.13	1.14	1.27%
2018	1.55	1.54	-0.85%
2019	1.66	1.70	2.06%
2020	2.02	1.97	-2.68%
2021	2.72	2.71	-0.03%
2022	not applicable	3.17	not applicable

Table 4-36 CRF 2.F.1.e Mobile Air Conditioning - HFC-134a - Emissions from stock

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions

	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable
1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	3.52	3.52	not applicable
2001	4.87	4.87	not applicable
2002	6.29	6.29	not applicable
2003	7.69	7.69	not applicable
2004	9.12	9.12	not applicable
2005	10.71	10.71	not applicable
2006	12.16	12.16	not applicable
2007	13.82	13.82	not applicable
2008	15.52	15.52	not applicable
2009	17.14	17.14	not applicable
2010	18.97	18.97	not applicable
2011	21.26	21.26	not applicable
2012	22.95	22.95	not applicable
2013	24.74	24.74	not applicable
2014	27.15	27.15	not applicable
2015	29.66	29.66	not applicable
2016	32.10	32.10	not applicable
2017	34.82	31.80	-8.69%
2018	37.30	34.11	-8.56%
2019	39.70	36.48	-8.12%
2020	41.34	38.64	-6.53%
2021	44.29	40.29	-9.03%
2022	not applicable	42.33	not applicable

Table 4-37 CRF 2.F.1.e Mobile Air Conditioning - HFC-134a - Emissions from disposal

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	NO	NO	not applicable
1991	NO	NO	not applicable
1992	NO	NO	not applicable
1993	NO	NO	not applicable
1994	NO	NO	not applicable

1995	NO	NO	not applicable
1996	NO	NO	not applicable
1997	NO	NO	not applicable
1998	NO	NO	not applicable
1999	NO	NO	not applicable
2000	NO	NO	not applicable
2001	NO	NO	not applicable
2002	NO	NO	not applicable
2003	NO	NO	not applicable
2004	NO	NO	not applicable
2005	NO	NO	not applicable
2006	NO	NO	not applicable
2007	NO	NO	not applicable
2008	NO	NO	not applicable
2009	NO	NO	not applicable
2010	NO	NO	not applicable
2011	NO	NO	not applicable
2012	NO	NO	not applicable
2013	NO	NO	not applicable
2014	NO	NO	not applicable
2015	NO	NO	not applicable
2016	0.47	0.47	0.00%
2017	1.13	1.14	1.27%
2018	1.55	1.54	-0.85%
2019	1.66	1.70	2.06%
2020	2.02	1.97	-2.68%
2021	2.72	2.71	-0.03%
2022	not applicable	3.17	not applicable

4.7.1.5 Uncertainty and time series consistency

AD uncertainty is mainly due to the lack of availability of actual data on the size of the Maltese market of refrigerants (mainly F-gases) – i.e. the amount of each type of refrigerant (mainly F-gas) being consumed in Malta.

Activity data for bulk imports of HFCs for the period up to the year 2019 was obtained directly from the importers.

The source of the same activity data for the year 2020 was the annual statistical data on imported shipments from third countries (outside the European Union) compiled and shared, for the first time, by the local competent authority for the purposes of Regulation (EU) No. 517/2014. This data was higher than that obtained directly from the importers.

Data on bulk imports of HFCs for the years 2021 and 2022 was compiled from both sets of data described above; the annual statistical data on imported shipments from third countries (outside the European Union) compiled by the local competent authority for the purposes of Regulation (EU) No. 517/2014 and the data obtained directly from the importers, which includes imports from both EU and non-EU countries. Each data set was sorted by type of F-gas imported and the higher value for each F-gas was chosen. The annual statistical data on imported shipments from third countries for the year 2022 shows a sharp drop in the total mass of gas imported (kg) when compared to the same value for the year 2021.

Historically, an "activity uncertainty" of 10.0% was given to category 2.F.1. Given the situation described with regards to the data on bulk imports of HFCs, this "activity uncertainty" was revised upwards. The values for the year 2020 (the first year for which the annual statistical data from the local competent authority for the purposes of Regulation (EU) No. 517/2014 was available) were obtained by using the extrapolation formula using the data for the years 1990 to 2017. Finally, based on the percentage difference between the data for the year 2020 and the projected value for the same year, the activity uncertainty for category 2.F.1 was changed to 50.0% for the year 2020 and has been maintained ever since.

EF uncertainty originates mainly from the use of emission factors that are either default emission factors or based on general Europe-wide data, which may not completely represent the Maltese situation. However, it is still considered as good practice to use such emission factors in the absence of country-specific emission factors.

4.7.1.6 Category-specific QA/QC and verification

The data and information received from importers of F-gas is analysed and compared to the trend of the specific activity data over the previous years. Any variations and outliers are brought to the attention of the data providers and discussed with the latter. Similarly, for the annual statistical data on imported shipments from third countries (outside the European Union) compiled by the local competent authority for the purposes of Regulation (EU) No. 517/2014. Moreover, it should be pointed out that not all the information requested on the bulk HFC import has been received for 2022. In those cases in which an importer did not submit data, it was assumed that the gases imported in the year 2022 were the same gases reported by the same supplier in the last year for which data was reported, where this was available.

Data on bulk imports of HFCs for the year 2022 was compiled from two sets of data; the annual statistical data on imported shipments from third countries (outside the European Union) compiled by the local competent authority for the purposes of Regulation (EU) No. 517/2014 and the data obtained directly from the importers, which includes imports from both EU and non-EU countries. Each data set was sorted by type of F-gas imported and the higher value for each F-gas was chosen. The annual statistical data on imported shipments from third countries for the year 2022 shows a sharp drop in the total mass of gas imported (kg) when compared to the same value for the year 2021.

The annual statistical data from the local competent authority for the purposes of Regulation (EU) No. 517/2014 shows imported shipments from third countries. It does not show local consumption – i.e. exported quantities are not excluded from imported quantities. So, this data could result in over-reporting from this point of view. Furthermore, this data does not include imports from EU countries. So, there is the risk of under-reporting from this aspect. On the other hand, the data from importers includes imports from both EU and non-EU countries, for local consumption.

The annual statistical data from the local competent authority for the purposes of Regulation (EU) No. 517/2014 is available to the Inventory Agency only in an anonymised format, so, this set of data cannot be mapped with the data from importers.

The local competent authority for the purposes of Regulation (EU) No. 517/2014 has compiled and shared, annual statistical data on the imports of pre-charged equipment from third countries (outside the European Union) for the period 2020 onwards. As explained for the data on bulk imports of HFCs, this data shows imported shipments from third countries. Hence, it does not include imports from EU countries and it does not exclude exports to other countries. This said annual statistical data was compared to the estimated annual imports of split units used in the annual national GHG inventory. The latter values were higher than the annual statistical data for the years 2020 and 2021. However, after cleaning the annual statistical data for 2022, based on the information available, this was higher than the estimated annual imports of split units used in the annual national GHG inventory by 2.70%.

Data on the F-gases collected has not been received for 2021 and 2022. This was assumed to be equal to that for the year 2020.

4.7.1.7 Category Specific planned improvements

As recommended during the capacity building visit organised by the *Effort Sharing Decision Review Team* in August 2018, the transparency of this category is being improved by including a more detailed explanation of the model being used, describing the assumptions and the expert judgements made. This should address *Finding* ID# I.11 in FCCC/ARR/2022/MLT.

The Inventory Agency is determining the applicable CN (Combined Nomenclature) codes for F-gases. This could provide another set of data of the F-gases that are imported to and exported from Malta, from/to other countries, both within and outside the European Union. Thus, from this data, local consumption could be estimated. Moreover, this initiative should also help in identifying more importers of F-gases in Malta, from whom more data could be collected. It should be pointed out that the nomenclature is updated yearly. In this regard, Malta is benefitting from capacity-building in effort sharing sectors for European Member States which is being facilitated by Umweltbundesamt (UBA). Thus, the Inventory Agency is trying to obtain more data on bulk imports and exports of HFCs to get as complete a picture of the F-gases consumed in Malta as possible. If more data is obtained, it could be used as activity data or for QA/QC. Furthermore, as more data for more years is collected, an analysis to determine more consistent data throughout the time series could be performed. (Finding MT-2F1-2022-0004 in the 2022 ESD Review)

The Inventory Agency is holding discussions with the national regulator on the environment to collect data related to the local collection of F-gases from equipment at end-of-life from permitted waste management installations so as to ensure an adequate coverage of the local market. (Finding MT-2F-2023-0001 in the 2023 ESR Review)

It is the intention of the Inventory Agency to improve the estimation of emissions from CRF 2.F.1.e Mobile Air Conditioning by including national data on the annual number of newly licensed cars and LGVs, on the split between new and second-hand newly licensed cars and LGVs, as well as on the age of newly licensed second-hand cars and LGVs.

The intention to revise the number of vehicles for the whole time series with data obtained directly from the local authority for transport is no longer considered to be a priority. This is because the quality of the data obtained from the Eurostat database is satisfactory to enable the annual national GHG inventory to be prepared in accordance with the TACCC (transparency, accuracy, completeness, comparability, consistency) principles.

4.7.2 Product Uses as Substitutes for ODS – Foam Blowing Agents (CRF 2.F.2)

4.7.2.1 Category Description

HFCs are commonly used in the foam blowing industry, mainly as replacements for CFCs and HCFCs.

The distinction in types of foam between open-cell and closed-cell relates to the way in which the blowing agent is lost from the product. For open-cell foam, emissions of fluorinated gases used as blowing agents are likely to occur during the manufacturing process and shortly thereafter. Open-cell foams are used for applications such as household furniture cushioning, mattresses and moulded products.

In closed-cell foam, only minimum emissions occur during the manufacturing phase. Emissions, therefore, extend into the in-use phase and, often, the majority of emissions do not occur until end-of-life. Closed-cell foams are primarily used for insulating applications where the gaseous thermal conductivity of the chosen blowing agent is used to contribute to the insulating performance of the product throughout its lifetime.

The earliest import of HFCs in Malta dates back to 2000. Thus, in the period 1990-1999 HFC emissions from this category did not occur in Malta.

According to information that has reached the Inventory Agency from the local market, importation of F-gases for local blowing of closed cell foam has been interrupted based on legal quotas. The situation in this regard is being monitored by the local competent authority for the purposes of Regulation (EU) No 517/2014 (implemented locally by "Subsidiary Legislation 427.94, Fluorinated Greenhouse Gases (Implementing) Regulations"). According to information dated July 2023 received from the local competent authority for the purposes of Regulation (EU) No 517/2014, F-gases are not being imported for the blowing of foam, locally.

Emissions of the following gases are reported from this category, HFC-134a, HFC-365mfc, HFC-245fa and HFC-227ea. HFC-134a is emitted from imported closed-cell foam panels under both CN code 39211100 and CN code and 39211310. HFC-365mfc was emitted from locally manufactured open-cell foam and is also emitted from imported closed-cell foam panels under CN code 39211310. HFC-245fa is emitted from imported closed-cell foam panels under CN code 39211310. HFC-227ea was emitted from locally manufactured open-cell foam and is also emitted from imported closed-cell spray-on foams.

Table 4-38, below, is intended to summarise the gases that are emitted from the different activities under this sub-category.

Table 4-38 A summary of the gases that are emitted from the different activities under sub-category CRF 2.F.2

	from locally manufactured open-cell foam	from imported closed-cell spray-on foams	imported closed-cell foam panels	
			under CN code 39211100	under CN code 39211310
HFC-134a	/	/	HFC-134a	HFC-134a
HFC-245fa	/	/	/	HFC-245fa
HFC-227ea	HFC-227ea	HFC-227ea	/	/
HFC-365mfc	HFC-365mfc	/	/	HFC-365mfc

Table 4-39, below, is intended to summarise the years in which the different activities under this sub-category took place.

Table 4-39 A summary of the years in which the different activities under sub-category CRF 2.F.2 took place

from locally manufactured open-cell foam	from imported closed-cell spray-on foams	imported closed-cell foam panels	
		under CN code 39211100	under CN code 39211310
2006 – 2009 2011	2008 – 2012	2000 – latest inventory year	2000 – latest inventory year

4.7.2.2 Methodological issues

Estimating emissions for the different types of foam requires different methodological approaches.

In the estimation of emissions from locally-manufactured open-cell foams, an emission factor of 100% is used. The activity data for this category was collected by contacting all foam sector businesses registered with the Regulator for Energy and Water Services, a list of which is available at http://www.rews.org.mt, as part of a government-run rebate scheme for the promotion of insulation in households. The rate of response was rather limited; however, it is assumed that the vast majority of the local foam blowing market is covered by the data actually gathered.

Closed-cell foams, due to their characteristics, cannot be accounted for using a simple methodology similar to the one used for open-cell foams. Thus, a different model is used for estimating emissions from both spray-on foams and foam panels.

The method used to estimate emissions from imported closed-cell spray-on foams is based on the mass of foam blown in a year. It is assumed that the blowing agent accounts for 1% of the mass of the foam and that the lifetime of the product is 15 years. Moreover, it is assumed that a constant 4.5% of blowing agent is emitted annually during the lifetime of the product and the remaining 32.5% of blowing agent is emitted in the year of destruction.

The method used to estimate emissions from imported closed-cell foam panels is similar to the one used for imported closed-cell spray-on foams, however, the emissions occurring in the first year are omitted as it is assumed that this emission will mainly take place at the point of production or during transit, in either case, before entering the geographical scope of this inventory. Imported closed-cell foams under CN codes 39211100 and 39211310 are accounted for. In the case of imported closed-cell foams under CN code 39211100, it is taken that the percentage containing HFC-134a is 20% and that the content of HFC-134a by mass is equal to 6%. Moreover, the first-year loss is taken to be 40% and the annual year loss, 3%. The lifetime of the product is 20 years and all the HFC-134a in the product is emitted during the lifetime of the product. In the case of imported closed-cell foams under CN code 39211310, the percentage containing HFCs varies throughout the time series, as follows: 1990 – 1999: 20%; 2000 – 2002: 18%, 2003 & 2004: 16%, 2005: 14%, 2006: 12% and 2007 - to-date: 10%. This is distributed among HFC-365mfc:HFC-245fa:HFC 134a, as follows, 50:40:10. The content of HFC by mass is equal to 6%. Moreover, the first-year loss is taken to be 10% and the annual year loss, 5%. The lifetime of the product is 18 years and all the HFC in the product is emitted during the lifetime of the product.

The parameters used in the estimation of emissions from CN code 39211100 are the following:

- 100% of the mass imported relates to XPS foams.
- The share of products blown with HFC-134a is 20% throughout the whole time series.
- The quantity of HFC blowing agents contained in the quantity of foam products is 6%.

- First year loss: 40%
- Subsequent year loss: 3%
- Product lifetime: 50 years
- Maximum Potential End-of-Life Loss: 0

The parameters used in the estimation of emissions from CN code 39211310 are the following:

- 100% of the mass imported relates to PU foams.
- The share of HFC blowing agents in PU foams is as follows: 20% until 1999, decreasing gradually to 10% in 2007.
- The quantity of HFC blowing agents contained in the quantity of foam products is 8%.
- The HFC blowing agents are distributed as follows: 50% of HFC-365mfc, 40% of HFC-245fa and 10% of HFC-134a.
- First year loss: 10%
- Subsequent year loss: 5%
- Product lifetime: 20 years
- Maximum Potential End-of-Life Loss: 0

4.7.2.3 Uncertainty and time series consistency

As specified in the 2006 IPCC Guidelines, there is significant uncertainty in the estimations of activity and emissions in this sector. This is especially relevant to such source categories in countries where consumption is very limited.

Inter-annual variations can be observed. There are limited inter-annual variations in the emissions of HFC-245fa. Only HFC-365mfc & HFC-227ea have been used in locally manufactured open-cell foam. The inter-annual variations in the emissions of these two gases are primarily due to the inter-annual variations in the activity data available from this market sector. Only HFC-134a is emitted from imported closed-cell foam panels under CN code 39211100. The inter-annual variations in the emissions of HFC-134a is primarily due to the inter-annual variations in the activity data available from this market sector. It should be pointed out that this data is obtained from the national statistics agency.

4.7.2.4 Category-specific QA/QC and verification

The activity data used in this category is trade imports from the national statistics agency. This data is analysed and compared to the trend in the respective market from the data received in previous years and any outlying data is verified with the data provider.

4.7.2.5 Source Specific Recalculations

No recalculations were required.

4.7.2.6 Category Specific planned improvements

No planned improvements in this specific category.

4.7.3 *PRODUCT USES AS SUBSTITUTES FOR ODS – FIRE PROTECTION (CRF 2.F.3)*

4.7.3.1 Category Description

Nowadays fire protection (fire suppression) equipment using HFCs and/or PFCs is being used as partial replacement for halons. However, prior to the year 2004, non-HFC halons were used in Malta. While actual emissions from the fire protection sub-sector are expected to be quite small, the use of such gases is growing, resulting in an accumulating bank of future potential emissions.

4.7.3.2 Methodological issues

The use of HFC-227ea has been identified in such applications. The use of HFC-227ea in fire protection systems is provided by local enterprises providing fire protection services. It is assumed that the reported mass of HFC-227ea imported during a particular year is consumed within the same year.

It has been difficult to identify all the establishments that have fire protection systems containing HFC-227ea installed on their premises. In the past, where this was possible, the annual releases of HFC-227ea during fire incidents or accidental leakages were reported by the establishments, with annual activity data since the year 2004 being provided.

4.7.3.3 Uncertainty and time series consistency

Activity data uncertainty in this sector has been assumed as 50% since the coverage of this sector could be improved.

4.7.3.4 Category-specific QA/QC and verification

The data and information received is compared to the trend of the specific activity data over the previous years. Any outliers are brought to the attention of the data provider and discussed with the latter. Moreover, it should be pointed out that the information requested on the import of F-gas in fire protection systems has not been received. Thus, the data for the year 2022 was obtained by using a trend based on the previous two years.

4.7.3.5 Source Specific Recalculations

No recalculations were required.

4.7.3.6 Category Specific planned improvements

The Inventory Agency is holding discussions with local market operators to verify the sources of data for the substances imported to Malta for use in local fire protection applications to ensure an adequate coverage of the local market. Moreover, the missing information on the import of F-gas in fire protection systems is being investigated.

4.7.4 Product Uses as Substitutes for ODS – Aerosols and Metered Dose Inhalers (CRF 2.F.4)

4.7.4.1 Category Description

Most aerosol packages contain hydrocarbons as propellants albeit in a small fraction of the total content. HFCs and PFCs may be used as propellants or solvents. Through the use of aerosol products, 100% of the propellant or solvent chemicals in such products are emitted.

Local potential importers were identified through communication with the Medicines Authority. It was established that Metered-Dose Inhalers (MDIs) containing the medical fluorinated propellant Norfluorane (HFC-134a) have been imported since the year 2004. In general, today only a few technical aerosol products contain HFCs and relate mainly to technical sprays used for the manufacture and/ or the repair of electrical and electronic equipment where only non-flammable substances (such as HFCs) may be used. No other uses of aerosols have been identified.

4.7.4.2 Methodological issues

The local importers have provided activity data on the annual quantities of imported inhalers containing Norfluorane. The charge of propellant per inhaler type was also provided. In some instances, where the actual charge of propellant was not identified, the default value of 10g Norfluorane per inhaler was applied. Emissions from the use of MDIs were assumed to take place during the actual importation year. The emissions of HFCs from use are proportional to the number of imported MDIs containing HFC and their relative charge. It is also noted that the average charge per unit imported increased from 10.8g/unit to 12.4g/unit between 2009 and 2011.

The development of an alternative approach, which could be based on the prevalence of asthma amongst the Maltese population and the methods of treatment (i.e. type of inhalation therapy)[9] is being considered. This methodology could serve as a quality assurance mechanism. Only two types of HFCs are used in MDIs: HFC-134a and HFC-227ea (only one manufacturer worldwide). The typical charge contained in each product (10 ml) ranges at 12 grams of HFC-134a and at 14 grams of HFC-227ea (reference for example: 2012 NIR Germany, p. 351: "0.15 g per 10 ml inhaler").

4.7.4.3 Uncertainty and time series consistency

Production and imports of medicinal products is controlled through the Medicines Authority, though data on propellants used may not be always readily available. The main uncertainty in this field is the uncertainty with respect to propellant charge per unit and the fate of residual charge after use of the product or its expiry.

4.7.4.4 Category-specific QA/QC and verification

The data and information received is compared to the trend of the specific activity data over the previous years and any outliers are brought to the attention of the data providers and discussed with the latter.

4.7.4.5 Source Specific Recalculations

No recalculations were required.

4.7.4.6 Category Specific planned improvements

The Inventory Agency is holding discussions to determine a data collection process that ensures a better coverage of the applicable local market of metered dose inhalers.

[9] Schwarz, W., Gschrey, B., Leisewitz, A., Herold, A., Gores, S., Papst, I., . . . Lindborg, A. (2011). Pedersen, P.H.; Colbourne, D.; Kauffeld, M.; Kaar, K.; Lindborg, A.: Preparatory study for a review of Regulation (EC) No. 842/2006 on certain fluorinated greenhouse gases. Brussels: European Commission.

4.8 OTHER PRODUCT MANUFACTURE AND USE (CRF 2.G)

4.8.1 OTHER PRODUCT MANUFACTURE AND USE – ELECTRICAL EQUIPMENT (CRF 2.G.1)

4.8.1.1 Category Description

SF_6 has unique properties that allow the optimised operation of electrical switchgear and electricity networks. Electrical equipment based on SF_6 technology is used in the generation, transmission and distribution of electricity. SF_6 is also used in medical radiotherapy linear accelerators. While SF_6 possesses a unique combination of properties ideal for its uses, it has a potent greenhouse effect and despite great research efforts, to date no equivalent alternative gas has been identified.

Locally, the main use of SF_6 is in switchgear used in electricity generation plants and in the electricity distribution network (substations and distribution centres). This sector is identified as being also the main contributor to local emissions of SF_6. During the year 2017, two additional plants started generating electricity in Malta. Other users of equipment containing SF_6 include two hospitals as well as a number of private establishments.

One of the local plants that started generating electricity in the year 2017 used equipment containing SF_6 which was previously used at another local electricity generation plant. However, during the year 2016, equipment which was not used locally before, containing SF_6, was installed at the other local plant that started generating electricity in the year 2017.

4.8.1.2 Methodological issues

In the year 2008, as part of this inventory process, industrial establishments and institutions that are in possession of operational equipment containing SF_6 were identified. Through contacts with these organisations, data on the quantities of SF_6 gas contained in equipment by type (closed or sealed switchgear, linear accelerator), as well as information on installation dates, maintenance procedures and leakage rates per equipment type, were made available. The leakage rates as provided by the manufacturers of the respective equipment have been used to estimate emissions. It has been noted that during maintenance work, contaminated SF_6 is evacuated, collected in cylinders and shipped abroad for purification.

Where entities operating equipment containing SF_6 have not reported changes to equipment, that equipment is considered as still being in operation under constant operating conditions, with the level of emissions being assumed to be at a constant rate. In the case of any equipment that has been identified as being in operation but for which the respective operator has not provided estimates of emissions, IPCC 2006 Guidelines default emission factors have been used.

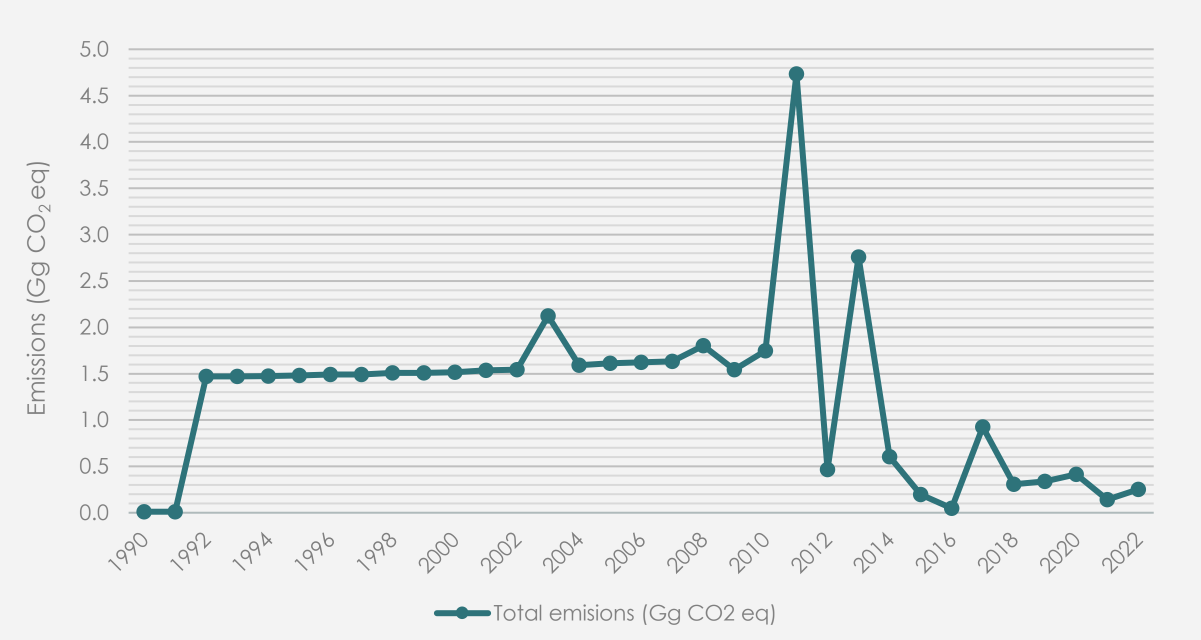


Figure 4-4 Emissions from sub-category 2.G.1 Electrical Equipment

Figure 4-4 presents the sulphur hexafluoride emissions in carbon dioxide equivalents over the inventory time series. The emissions in the years 1990 and 1991 were minimal due to the very limited extent to which equipment containing SF_6 was used at the time. This was mainly in the electricity distribution network. The subsequent significant increase was due to the commissioning of new equipment, by operators who had already been active and by new ones, including private industry as from around the year 2000. The increase following the years 1990 and 1991, was also due to extensions to existing systems.

The spike in emissions reported for the year 2003 resulted from an incident at one of the establishments operating such equipment during which SF_6 was released from switchgear equipment in a substation badly damaged by a storm. The much more significant spike in emissions reported for 2011 is the consequence of a leak detected in a local power plant which could not be immediately repaired, with the operator having to continuously maintain the charging of gas into the leaking system until the leak was eventually fixed.

In the year 2013, the 20-year maintenance of specific switchgear at both the generation and the distribution side was due. Moreover, the maintenance needed was held concurrently and the equipment in question had to be kept in operation, even until the required parts were available, and the service engineer could travel to Malta to carry out the necessary repairs. Thus, until this plan could be fulfilled, the switchgear had to be repeatedly topped up with SF_6, resulting in increased emissions of SF_6 during the year 2013. However, during this maintenance, an unspecified amount of SF_6 in use was adequately extracted, handled and replaced with new SF_6 gas and thus, not emitted. Moreover, it was confirmed by the data provider that given the large volumes of compartments of the equipment on which the maintenance was performed, the use of such quantities of gas is to be expected.

The low emissions for the year 2016 reflect the activity data received. This situation was confirmed by the data provider.

The data available indicates that, during the year 2017, leaks of SF_6 during operation occurred primarily in the electricity distribution network. The major contributor to the increased emissions was a switchgear in a distribution centre. This equipment needed to be repaired, however, it had to be kept in operation, even until the service engineer was available to travel to Malta to carry out the necessary repairs. This combination of events has resulted in increased emissions of SF_6. Nonetheless, the emissions of SF_6 for the year 2017 are below the mean and the median of the annual emissions of SF_6 over the whole time series.

During the years 2018 to 2021, the SF_6 consumed under this category has been used for topping up to maintain the correct operational pressures in equipment used in generation and distribution (both substations and distribution centres) of electricity. The losses of SF_6 are attributed to very slight leakages which develop in time mainly at the rubber seals in the equipment. The operator of the equipment has stated that the maintenance schedule, including the general maintenance program during which all the seals are replaced, is followed, as recommended by the manufacturer. In the year 2018, SF_6 was also used to replace the amount of gas lost from a switchgear which was dismantled from one site and transferred and installed again at another electricity generation plant.

4.8.1.3 Uncertainty and time series consistency

The data for the major contributor to emissions under this category - i.e. electricity generation and distribution - is obtained from the distribution system operator in Malta and from the operators of the local electricity generation plants. Due to this, the data has very low uncertainty. It is assumed that 5% activity data uncertainty and 2% emission factor uncertainty is sufficient.

4.8.1.4 Category-specific QA/QC and verification

The information received from data providers is analysed and the applicable data is extracted and verified with the respective data provider, if necessary. Not all the data requested for the year 2022 has been received. Thus, this value was obtained by using a trend based on the previous four years.

4.8.1.5 Source Specific Recalculations

The data for the year 2021 had not been received in time for the 2023 submission. However, this data was eventually received. The inclusion of the data for the year 2021 has, inevitably, led to the following recalculations.

Table 4-40 CRF 2.G.1 Electrical Equipment - SF_6 - Emissions

Year	Emissions as reported in the 2023 inventory report	Emissions as reported in the 2024 inventory report	Percentage change in reported emissions
	t	t	%
1990	0.00	0.00	not applicable
1991	0.00	0.00	0.00%
1992	0.06	0.06	0.00%
1993	0.06	0.06	0.00%
1994	0.06	0.06	0.00%
1995	0.06	0.06	0.00%
1996	0.06	0.06	0.00%
1997	0.06	0.06	0.00%

1998	0.06	0.06	0.00%
1999	0.06	0.06	0.00%
2000	0.06	0.06	0.00%
2001	0.07	0.07	0.00%
2002	0.07	0.07	0.00%
2003	0.09	0.09	0.00%
2004	0.07	0.07	0.00%
2005	0.07	0.07	0.00%
2006	0.07	0.07	0.00%
2007	0.07	0.07	0.00%
2008	0.08	0.08	0.00%
2009	0.07	0.07	0.00%
2010	0.07	0.07	0.00%
2011	0.20	0.20	0.00%
2012	0.02	0.02	0.00%
2013	0.12	0.12	0.00%
2014	0.03	0.03	0.00%
2015	0.01	0.01	0.00%
2016	0.00	0.00	0.00%
2017	0.04	0.04	0.00%
2018	0.01	0.01	0.00%
2019	0.01	0.01	0.00%
2020	0.02	0.02	0.00%
2021	0.02	0.01	-66.07%
2022	not applicable	0.01	not applicable

4.8.1.6 Category Specific planned improvements

There are no planned improvements for this specific category.

4.8.2 OTHER PRODUCT MANUFACTURE AND USE – SF_6 AND PFC FROM OTHER PRODUCT USES (MEDICAL) (CRF 2.G.2)

4.8.2.1 Category Description

HFCs, PFCs and SF_6 represent a large choice of gases the properties of which make them attractive for a variety of niche applications which are aggregated for the purpose of the inventory. As part of a data gathering exercise on the use of fluorinated gases in Malta, it was determined that very small quantities of SF_6 and PFC-218 (perfluoropropane, C_3F_8) were used during hospital operations.

4.8.2.2 Methodological Issues

The activity data for this sector was collected through communication with the known local users of these gases, dated 2009. All the users reported the use of small amounts in the medical sector. The amount of gases for this category is assumed to remain constant. This assumption is based on the fact that the amount of gases emitted from this category are estimated to range between 0.0000037% (in 2007) and 0.0000015% (in 2019) of the total emissions from the IPPU sector.

4.8.2.3 Uncertainty and time series consistency

Uncertainty in this sector is mainly attributable to the small quantities and very specific applications in which such fluids are used. The possibility of incomplete coverage is present, though the scale of this incompleteness is presumably small enough not to affect significantly the end result. Activity data uncertainty is assumed at 100%, whereas emission factor uncertainty is assumed at 5%.

4.8.2.4 Category-specific QA/QC and verification

This section is not applicable.

4.8.2.5 Source Specific Recalculations

No recalculations were required.

4.8.2.6 Category Specific planned improvements

Following the observation made by the *Effort Sharing Regulation Review Team* (Finding MT-2G-2023-0002 in the 2023 ESR Review), it is the intention of the Inventory Agency to determine if the activity data for the category "Other Product Manufacture and Use – SF_6 and PFC from Other Product Uses (Medical)" needs to be revised.

4.8.3 Other Product Manufacture and Use – N_2O from Product Use (CRF 2.G.3)

4.8.3.1 Category Description

In Malta, medical grade nitrous oxide is used for anaesthetic, analgesic use and veterinary use. Other uses of N_2O is as propellant in whipped cream preparations (in aerosol cans).

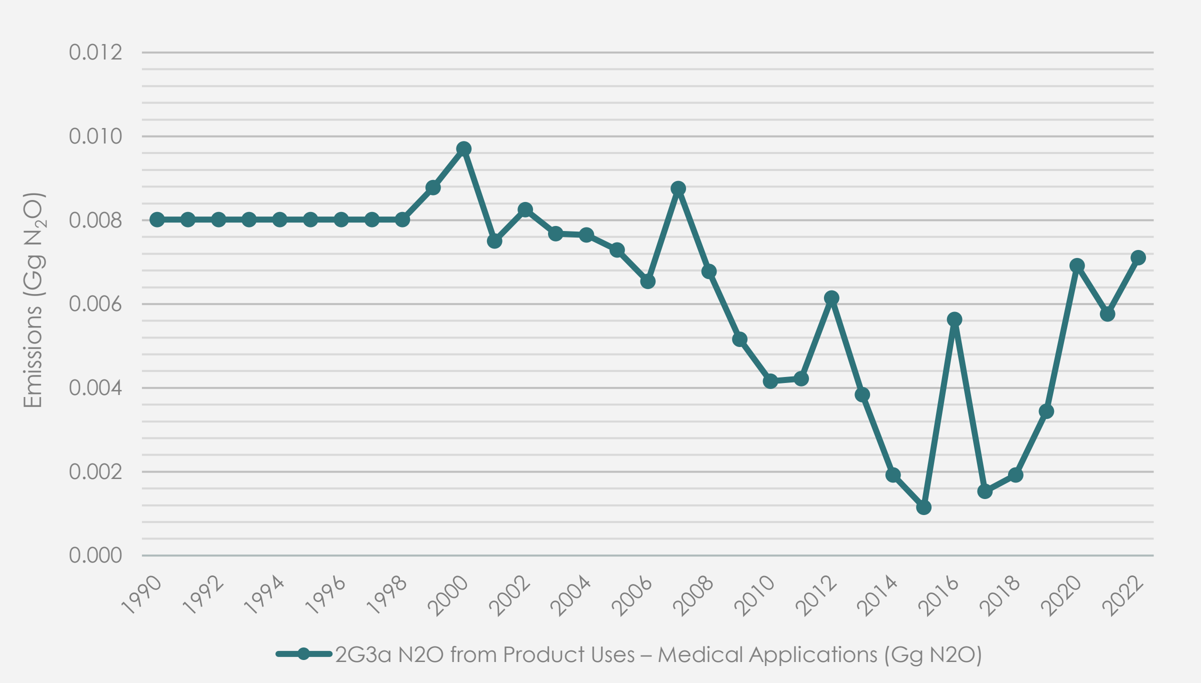


Figure 4-5 Nitrous Oxide emissions from anaesthetic use

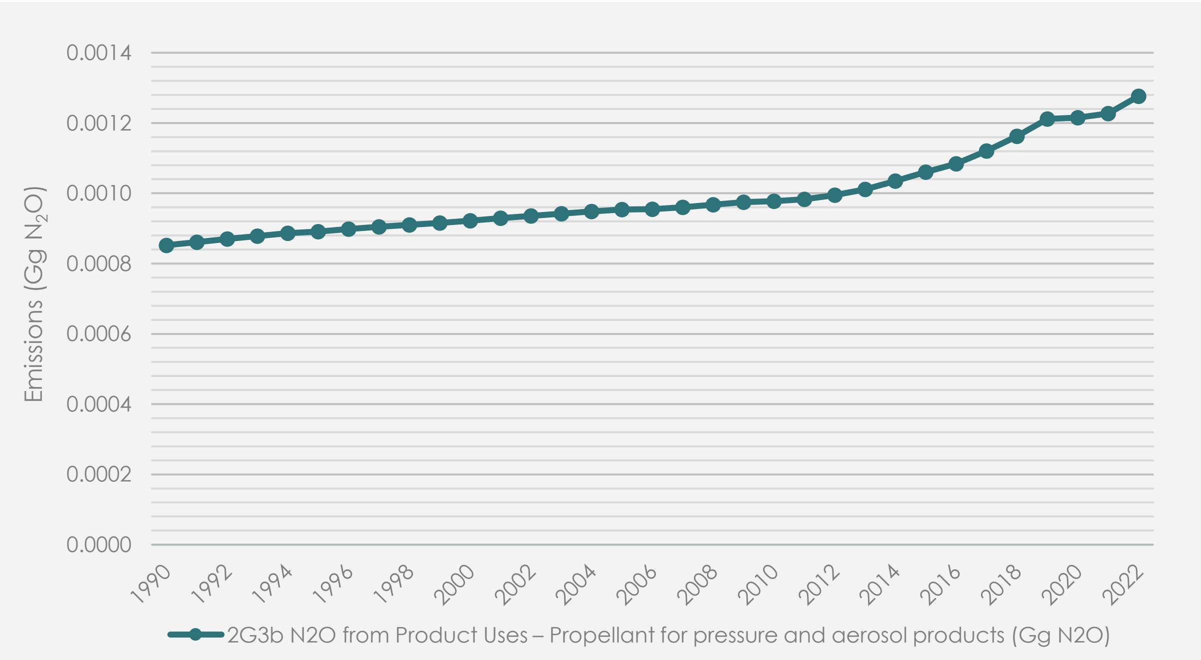


Figure 4-6 Nitrous Oxide emissions from aerosol cans

Figure 4-5 and Figure 4-6 show the variations in N_2O emissions that result from the consumption of medical grade N_2O during medical applications and the emissions of N_2O from aerosol cans, respectively. The emissions figure for medical grade N_2O being reported for the years 1990 to 1998 (0.008 Gg N_2O per year) is the calculated average of the actual consumption of N_2O during the years 1999 till 2007.

4.8.3.2 Methodological Issues

4.8.3.2.1 Medical use of N_2O

The use of medical grade nitrous oxide in public and private hospitals and other small clinics operating in Malta has been investigated through communication with these institutions in 2008. A comparative analysis of the information provided by these institutions and the available imports data of medical grade nitrous oxide in Malta shows that the institutions were only able to provide reliable and complete information for the most recent years, whereas the complete imports statistics are available as from 1999 onwards. This inventory process therefore uses the imports data of medical grade nitrous oxide rather than relying solely on the information provided by the institutions.

The methodology as available in the IPCC 2006 Guidelines has been followed, with an emission factor of 1.0 made applicable to the activity data, since it can be assumed that all of the administered nitrous oxide is returned to the atmosphere. It is also assumed that the quantity of medical grade nitrous oxide imported is all consumed during the same importation year. Since actual imports data for the years 1990 to 1998 are unavailable, the average import figure for the years 1999 to 2007 has been applied to the years 1990 till 1998.

4.8.3.2.2 Aerosol cans

Data on local use of cans of edible products in which N_2O is used as a propellant is very limited and thus a proxy needed to be developed. Influence of British cuisine on Maltese cuisine and the fact that the UK inventory has a well-developed methodology to estimate emissions from this sector, triggered the decision to use the UK data as a proxy for Malta's activity. The per capita emission factor based on the 2016 submission of the UK under the convention, which amounts to 2.3548×10^{-9} GgN_2O/capita was multiplied by the Maltese population over the time series. The standard population data used by the Inventory Agency for the year 2018 is the end-of-year figure issued by the national statistics agency.

4.8.3.3 Uncertainty and time series consistency

Data collection coverage of medical grade nitrous oxide is complete, since only one manufacturer of medical grade N_2O exists in Malta. Thus, it is assumed that activity data uncertainty in this sub-sector only pertains to the instrumental uncertainty of the bottling plant, which is assumed at 3%. On the other hand, the data on N_2O from aerosol cans was obtained by using a proxy to determine the local use of whipped cream preparation, as the main type of aerosol can in which N_2O is used as a propellant. Thus, in the absence of actual data, the activity data uncertainty in this sector is assumed to be high, at 50%.

The emission factor uncertainty is presumably very low. As described in the IPCC 2006 Guidelines, it can be assumed that all gas inhaled is eventually exhaled. Similarly, in the case of use as a propellant in aerosol products, N_2O is not likely to react. Thus, an arbitrary 1% EF uncertainty is used.

4.8.3.4 Category-specific QA/QC and verification

The data on the mass of N_2O for medical use imported annually for medical use that is received is compared to the trend of the specific activity data over the previous years. Any outliers are brought to the attention of the data provider and discussed with the latter. In general, inter-annual variations in the imported mass of medical N_2O reflect changes in demand from hospitals.

4.8.3.5 Source Specific Recalculations
No recalculations were required.

4.8.3.6 Category Specific planned improvements
No planned improvements in this specific category.

4.8.4 OTHER PRODUCT MANUFACTURE AND USE – OTHER (CRF 2.G.4)
This section is not applicable.

4.8.4.1 Category Description
This section is not applicable.

4.8.4.2 Methodological Issues
This section is not applicable.

4.8.4.3 Uncertainty and time series consistency
This section is not applicable.

4.8.4.4 Category-specific QA/QC and verification
This section is not applicable.

4.8.4.5 Source Specific Recalculations
This section is not applicable.

4.8.4.6 Category Specific planned improvements
This section is not applicable.

4.9 OTHER (CRF 2.H)

This section is not applicable.

4.9.1 CATEGORY DESCRIPTION
This section is not applicable.

4.9.2 METHODOLOGICAL ISSUES
This section is not applicable.

4.9.3 UNCERTAINTIES AND TIME SERIES CONSISTENCY
This section is not applicable.

4.9.4 Category-specific QA/QC and verification

This section is not applicable.

4.9.5 Category-specific recalculations

This section is not applicable.

4.9.6 Category-specific planned improvements

This section is not applicable.

CHAPTER 5 AGRICULTURE

ENTERIC FERMENTATION, MANURE MANAGEMENT & SOILS

5.1 OVERVIEW OF SECTOR

The agriculture sector has contributed around 4% of Malta's total greenhouse gas (GHG) emissions annually since 1990, and emissions within the sector decreased by 32% between 1990 and 2022 (Figure 5-1). Emission sources from the agriculture sector include the Enteric Fermentation (methane [CH4]) and Manure Management (nitrous oxide [N2O] and [CH4]) categories for emissions associated with livestock production and the Agricultural Soils (N2O) categories.

*N.B. All emissions given in Chapter 5 are calculated using AR5 GWPs.

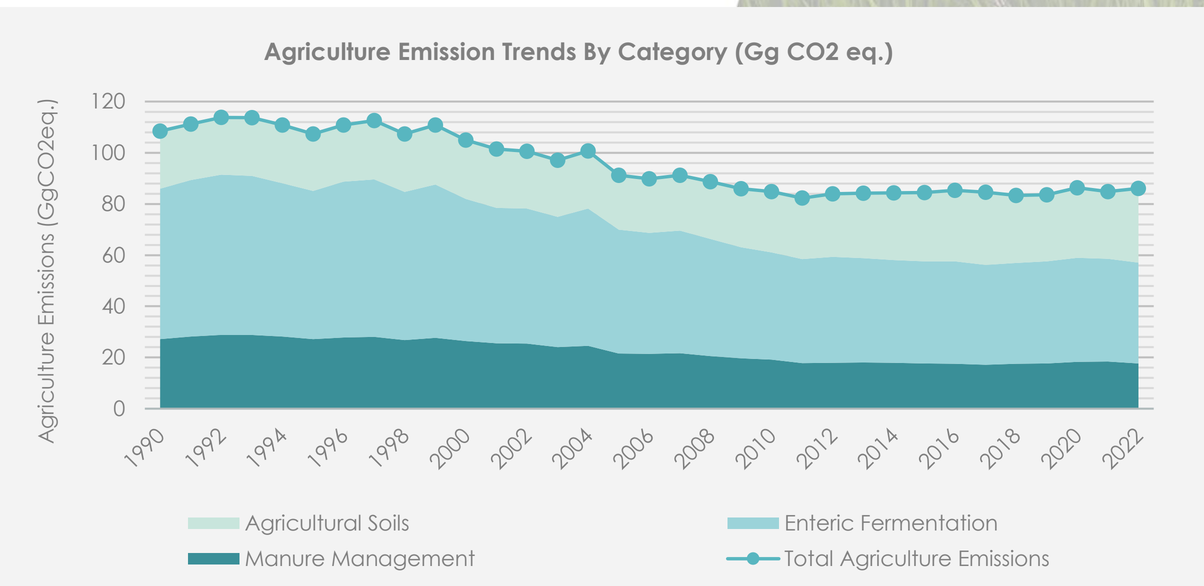


Figure 5-1 Agriculture shares of emissions by subsector, in GgCO2eq (AR5).

In the last agriculture census conducted by the National Statistics Office, it was found that during 2020, the total number of agricultural holdings in Malta amounted to 10,449. Most of the agricultural holdings (98.7 %) were found to be run by sole holders. Holdings that were found to be managed by groups, partnerships and companies accounted for 1.3%. Farmers who were both the farm manager and the sole holder of the activity accounted for 93.8 % of all the sole-holder agricultural holdings. Agricultural managers were mostly male, with 11.1 % being female. Moreover, managers aged 44 years and younger amounted to 17.6 % of the total, compared to 16.8 % in 2010. Managers aged 65 years and over accounted for 35.9 % of the total. The Census revealed that most of the holdings in MALTA were relatively small, with 7,280 holdings (69.7 %) managed a Utilised Agricultural Area (UAA) of less than one hectare. Medium-sized agricultural holdings that managed between one to five hectares of land amounted to 2,904 (27.8 %), while 265 holdings (2.5 %) were considered large, managing over five hectares of UAA. Moreover, it resulted that a total of 4,327 agricultural holdings, accounting for 41.4 % of all holdings, produced products for their own consumption while the remaining 6,122 holdings, or 58.6 %, sold all or a share of their produce through the various available market niches.

In 2020, the total UAA in Malta amounted to 10,730 hectares. A total of 3,252 hectares or 30.3 % of the entire UAA, were found to be situated in the Western, followed by the Northern and Gozo and Comino districts with 2,541 (23.7 %) and 2,449 hectares (22.8 %) respectively. Arable land accounted for 72.5 % of the total UAA, while permanent crops and kitchen gardens made up the remaining 8.9 and 18.6 % of the UAA respectively. Over the last 10 years, there has been a downward trend in arable land and permanent crops cultivation areas, while the area used for kitchen gardens has increased. The cultivation of forage crops (67.5 %) was predominant in the use of arable land. The total area designated for permanent crops in 2020 amounted to 953 hectares, of which 456 hectares were dedicated to vineyards and whose cultivation declined by 158 hectares when compared to 2010. Similarly, areas of fruit and berry plantations decreased by an area of 143 hectares over the 10-year span. On the contrary, areas of olive plantations increased by 14 hectares.

In 2020, Malta had a total of 241 cattle farms with a cattle population of 14,447 heads of which, 5,996 were dairy cows. This figure represents a decline of 7.9 % in the cattle population from 15,688 heads in 2010. A decrease of 17.2 % was also recorded over the 10-year period in the number of cattle farms, from 291 farms in 2010 to 241 in 2020. Moreover, during 2020, the number of reared sheep stood at 16,177 heads. Although there was a decline of 11.8 % in the holdings engaged in this activity from 1,081 holdings in 2010 to 953 holdings in 2020, the sheep population increased by 36.3 % over this 10-year span. During 2022 farmers have had to cull many of their sheep due to a rise in forage prices following the Russia's invasion of Ukraine. The number of reared goats increased by 31.5 %, from 4,384 heads in 2010 to 5,764 in 2020, whereas the number of holdings in this activity declined by 15.5 %, from 595 holdings in 2010 to 503 in 2020. On a similar trend, the pig population stood at 40,090 in 2020, marking a decline of 43.2 % over 2010. Also, the number of pig farms in Malta declined by 29.5 % over the same 10-year period, from 132 farms in 2010 to 93 farms in 2020. Sheep and goats are raised however their production is very small compared to other livestock categories, and their milk is used for traditional products, such as the production of Cheeselets (ġbejniet).

A total of one million poultry heads was recorded in 2020; of which, 696,010 (67.3 %) were broilers. This figure decreased by 17.7 % over that of 2010 when 846,143 heads were recorded. A similar decline of 27.9 % was also registered in the number of holdings in this agricultural activity, from 154 in 2010 to 111 in 2020. On the contrary, however, the number of laying hens increased by 12.6 % in the 10-year period under review, from 300,667 in 2010 to 338,516 in 2020. Notwithstanding this, the number of holdings engaged in the latter agricultural activity dropped by 27.1 %, from 652 in 2010 to 475 in 2020. A total of 7,326 breeding female rabbits were recorded as being reared in 2020.

As a result of the combined changes in livestock and agricultural land, as well as improvements in animal feeds and manure management systems, Malta's total GHG emissions from the agriculture sector have dropped from 108.51 ktCO2eq. in 1990 to 86.09 ktCO2eq. in 2022 (Table 5-1).

This Chapter describes the estimation methods, equations, activity data, emission factors, parameters and assumptions used to estimate the greenhouse gas emissions in the agriculture sector, namely:

- Methane emissions from Enteric Fermentation (3A);

- Methane and Nitrous Oxide emissions from Manure Management (3B);
- Direct and indirect Nitrous Oxide emissions from Managed Agricultural Soils (3D);

Indirect emissions of Nox, Sox, CO and MVOC from agriculture sector are given in Chapter 9.

Table 5-1 Agriculture emissions by Subsector and by Gas (AR5).

	Enteric Fermentation	Manure Management	Manure Management	Manure Management	Agricultural Soils	**Total**
	CH4	CH4	N2O	Total	N2O	
1990	58.80	10.13	17.07	27.19	22.52	108.51
1991	61.23	10.45	17.70	28.15	21.86	111.24
1992	62.57	10.72	18.14	28.86	22.35	113.79
1993	62.10	10.72	18.11	28.82	22.77	113.69
1994	59.92	10.52	17.64	28.16	22.80	110.88
1995	57.79	10.22	17.02	27.24	22.36	107.38
1996	60.97	10.37	17.38	27.75	22.09	110.81
1997	61.56	10.48	17.55	28.03	23.04	112.63
1998	57.88	10.09	16.69	26.78	22.72	107.38
1999	59.90	10.39	17.23	27.62	23.29	110.81
2000	55.60	9.77	16.60	26.37	23.03	105.01
2001	52.95	9.45	16.07	25.52	23.00	101.47
2002	52.74	9.36	16.10	25.45	22.40	100.60
2003	50.92	8.79	15.22	24.01	22.18	97.12
2004	53.58	8.89	15.70	24.60	22.55	100.73
2005	48.44	7.30	14.21	21.51	21.22	91.17
2006	47.36	7.30	14.08	21.38	21.06	89.80
2007	47.86	7.41	14.30	21.71	21.67	91.24
2008	45.73	7.06	13.47	20.53	22.42	88.68
2009	43.39	6.80	12.88	19.68	22.86	85.93
2010	41.85	6.68	12.51	19.19	23.73	84.77
2011	40.63	6.13	11.68	17.81	23.83	82.27
2012	41.41	6.15	11.77	17.93	24.63	83.97
2013	40.80	6.22	11.80	18.02	25.41	84.24
2014	40.20	6.19	11.69	17.88	26.19	84.27
2015	39.98	6.01	11.61	17.62	26.83	84.43
2016	40.10	6.09	11.42	17.52	27.73	85.34
2017	39.03	5.99	11.14	17.13	28.40	84.56
2018	39.43	6.17	11.36	17.53	26.35	83.31
2019	39.83	6.27	11.45	17.72	25.99	83.54
2020	40.60	6.54	11.78	18.32	27.38	86.30
2021	40.05	6.64	11.82	18.47	26.30	84.82
2022	39.32	6.32	11.40	17.72	29.05	86.09

In Malta, there is no rice cultivation nor Savannas and hence source categories *Rice cultivation* (3C) and *Burning of Savannas* (3E), are not included in the report as they do not occur (NO).

Field burning of agricultural residues (3F) and *Liming* (3G) are not included in this report, given that such practices do not occur in Malta as described under the relevant sections of this NIR. No emissions have been included under source categories *other carbon-containing fertilizers* (3I) and *Other* (3J). The *application of Urea* (3H) has not been estimated due to insufficient data, as described under section 5.9 of the NIR.

5.1.1 Methodological Overview

In Malta, the Characterisation of Livestock and Agricultural soils are significantly grounded on Expert Judgment attributed to the limitation of the data available. Subsequently, some of the information provided might not be substantiated by published data and official documents. The experts consulted are experienced professors, veterinarians and experts in the field ensuring the expert judgement is sound. The National Statistics Office (NSO), FAOSTAT, Malta Dairy Products (MDP), Koperattiva Produtturi tal-Halib (KPH), and numerous publications are utilised to obtain the activity date and country-specific parameters required for the compilation of the Maltese National GHG Inventory. Experts in the field are consulted where no consolidated data or statistics are in existence or readily available.

The National Statistics Office (NSO), FAOSTAT, Malta Dairy Products (MDP), Koperattiva Produtturi tal-Halib (KPH), Eurostat and numerous publications are utilised to obtain the activity date and country-specific parameters required for the compilation of the Maltese National GHG Inventory. Experts in the field are consulted where no consolidated data or statistics are in existence or readily available.

Most annual livestock population data is obtained from the National Statistics Office (NSO), who collect livestock statistics through the following six censuses/surveys:

- Census of Agriculture (published every decade);
- Cattle census (published annually);
- Sheep and goats census (published annually);
- Pig census (published annually);
- Farm Structure survey (published every 2 years); and
- Agriculture and Fisheries Census (published annually),

However, some livestock categories are based on data from other sources. Please refer to Annex 3-4 (Chapter 17) for a livestock population analysis report conducted in 2022.

Other activity data used in the estimation of emissions from livestock and agricultural soils are reported in Table 5-2.

Table 5-2 Sources for the activity data used in the agriculture sector

PARAMETER	SOURCE
Livestock Population (number of heads)	NSO; FAOSTAT; AHWD; EUROSTAT
Females in gestation (%)	KPH
Weight (kg) **(Cattle, sheep, swine, horses & goats)**	KPH; VPRD
Total cow milk (T)	NSO; MDP
Total sheep milk (T)	NSO; MDP

Cow milk fat content (%)	MDP
Feed statistics: **Protein in feed (%)** **Feed, of which forage & of which concentrate (kg/day);** **Energy content of feed (MJ/day)**	KPH
Nitrogen Fertilizer: Rate of N application (Kg N/ha)	NSO, Tapas Action, 2007 Agriculture Department, 2022
Total Agricultural Land, **Utilized Agricultural Land,** **Land Area (under fodder, wheat, barley, bean, other fodder, potato, carrot, clover & vetch) (ha)**	NSO & FAOSTAT
N mineralised	LULUCF Sector Compiler MRA
Manure Management Systems	Agriculture Department; KIM; KPH
Swine Characterisation	KIM; Andrew's Feeds
Rabbit characterisation	Ghaqda produtturi tal-fniek

The complete timeseries of livestock population can be found in Annex 3-4 (Chapter 17). With regards to the classification of livestock within each category, the same classification used by the NSO and cooperatives relevant to the livestock category is used (i.e. NSO for poultry, KIM for Swine, KPH for cattle, goats and sheep and Ghaqda produtturi tal-fniek for rabbits).

The calculation of GHG emissions from agriculture is based on the methodologies and emission factors provided in the IPCC 2006 Guidelines and 2019 IPCC Refinements, with some country specific emission factors. Table 5-3 gives the methods and tiers applied for every livestock category.

Table 5-3 A summary of tier methodologies and emission factors used for Agriculture.

	Tier Level (Method & Emission Factor)							
	Cattle	Sheep	Swine	Poultry	Goats	Rabbits	Horses	Hinnies, asses & mules
3A. Enteric Fermentation CH_4	T2/CS	T2/CS	T1/D	NA	T1/D	T1/CS	T1/D	T1/D
3B1. Manure Man. CH_4	T2/CS	T1/D	T2/CS	T2/CS	T1/D	T2/CS	T1/D	T1/D
3B2. Manure Man. N_2O	T2/CS	T2/CS	T1/D	T1/CS	T1/D	T1/D	T1/D	T1/D
3C. Rice Cultivation	NO							
3D. Agricultural Soils N_2O	T1/D							
3E. Burning of Savannas	NO							

3F. Field Burning of agricultural residues	NO
3G. Liming	NO
3I. Other carbon-containing fertilizers (3I)	NO
3J. Application of Urea	NE

5.1.2 Sector specific QA/QC & Verification

QA/QC checks are performed on a yearly basis by the agriculture expert. Moreover, an additional QA/QC exercise is performed by an external consultant (Aether) to identify any errors, gaps in the reporting leading to transparency, consistency or comparability issues, and areas for improvement. UNFCCC and ESD Review findings are recorded centrally in a Corrective Preventive Action.

Table 5-4 QA/QC Checks performed for the Agriculture Sector

Item		**Check**
EMISSION DATA QUALITY CHECKS		
1	Are emission comparisons for historical data source performed	Yes
2	Are emission comparisons for significant sub-source categories performed	Yes
3	If applicable, are checks against independent estimates or estimates based on alternative methods performed	Yes
4	Are reference calculations performed	N.A.
5	Is completeness check performed	Yes
6	Other (detailed checks)	Yes
EMISSION FACTOR QUALITY CHECKS		
IPCC default emission factors		
7	Are the national conditions comparable to the context of the IPCC default emission factors study	No
8	Are default IPCC factors compared with country-specific emissions factors	Yes
Country-specific emission factors		
Comparisons		
19	Are country-specific factors compared with IPCC default factors	Yes

20	Is comparison between countries, including historical trends, min and max value, base and most recent year value, IEF performed	Yes
21	If applicable, is comparison to plant-level emission factors performed	N.A.
22	Other (detailed checks)	
ACTIVITY DATA QUALITY CHECKS		
National level activity data		
23	Are alternative activity data sets based on independent data available	No
24	Were comparisons with independently compiled data sets performed	Independently compiled data is difficult to find
25	Were the national data compared with extrapolated samples or partial data at sub-national level	Yes
26	Was a historical trend check performed	Yes
27	Are any sharp increases/decreases detected and checked for calculation errors	Yes
28	Are any sharp increases/decreases explained and documented	Yes
CALCULATION RELATED QUALITY CHECKS		
36	Are checks of the calculation algorithm (duplications, unit conversion, calculation errors) performed	Yes
37	Are the calculations reproducible	Yes
38	Are all calculation procedures recorded	Yes
39	Other (please specify)	Cross check of calculations using different units (example Kt and GgCO2 eq. are performed to verify calculation is performed correctly. 4-eyes check performed by someone other than the agriculture sector compiler.

5.1.3 SECTOR-SPECIFIC RECALCULATIONS & PLANNED IMPROVEMENTS

With regards to the implementation of the 2019 Refinements one should note that, not all the 2019 IPCC Refinements have been implemented yet. This is because not all the data necessary to implement changes is available yet. Moreover, implementation of the new guidelines takes time, given that the agriculture sector expert needs to go through all the revisions and assess their impact on the emissions, as well as their applicability to the country, especially in the case of changes to emission factors. In most cases, where the 2019 Refinements were implemented, emissions increased slightly; this was not deemed to be an issue for Malta, given that the refinements present a much more detailed methodology, and one which we are assured to be applicable for and representative of our country, given its size and environmental conditions. Moreover, revisions presented in the 2019 IPCC Refinements are based upon the latest research, which when compared to the 2006 IPCC Guidelines, which use dated research, are favoured. There are no planned improvements relating to the 2019 Refinements for the 2023 submission, as priority will be given to the planned improvements listed in Table 5-5.

Table 5-5 Improvement plan for the agriculture sector

Correction or Improvement	Recalculation Category	Years Affected	Planned revision
• **Include indirect emissions from IAR**	3A., 3B., 3D.	1990 - 2022	Implemented in this Report
• **Swine N emissions using T2 (dependant upon corrigendum)**	3B., 3D.	1990 - 2022	Depending on publishing of corrigendum

Table 5-6 Below gives the status of implementation of issues raised in the findings of the ESD 2020 Review and UNFCCC 2021 Review.

Table 5-6 Status of implementation of issues and/or problems raised in the provisional main findings review reports of Malta *(ESD 2020 Review & FCCC/ARR/2018/MLT)*.

ID	Recommendation for issue identified	Report Name	Status	NIR chapter/ CRF category
A.1	Use complete livestock population data substantiated by published data and official documents or provide a detailed review of the population data for all livestock categories, ensure time-series consistency and report on any recalculations.	FCCC/ARR/2022/MLT	Resolved. An analysis of the livestock populations was carried out during 2022, where 4 sources of information were consulted. In tandem with the NSO and the AHWD. For each livestock category, data was agreed upon for the purposes of the inventory.	Annex 3-4 (Chapter 17, p.506)
A.2	Use appropriate techniques as detailed in the 2006 IPCC Guidelines for the development of a consistent time series of AD (animal populations).	FCCC/ARR/2022/MLT	Resolved. An analysis of the livestock populations was carried out during 2022, where 4 sources of information were consulted. In tandem with the NSO and the AHWD. For each livestock category, data was agreed upon for the purposes of the inventory.	Annex 3-4(Chapter 17, p.506)
A.3	Include in the NIR a description of the national characterisation and classification of the six swine categories presented in CRF table 3.A.	FCCC/ARR/2022/MLT	Resolved. The Party reported in its NIR (section 5.2.2.4, page 206) the description of the six swine categories and its characterisation.	section 5.2.2.4

A.4	Document the methodologies and assumptions taken from the 2019 Refinement to estimate CH4 emissions from enteric fermentation for cattle, demonstrate that they better represent the national circumstances and justify their use in the NIR.	FCCC/ARR/2022/MLT	Resolved. The Party reported in its NIR (section 5.1.3, page 188) the methodologies and assumptions taken from the 2019 Refinement to estimate CH4 emissions from enteric fermentation for cattle. Due to 2019 Refinement implementation, emissions from Agricultural categories increased slightly (a comparison between IPCC 2006 and 2019 is included in Table 5.5 for all categories of Agriculture). The Party also demonstrated that the more detailed methodology provided in the 2019 Refinement is more representative of Malta circumstances, given its size and environmental conditions.	section 5.1.3
A.5	Include a description of gap-filling methods used for milk production data across the time series in the NIR.	FCCC/ARR/2022/MLT	Resolved. The Party included in its NIR (chapter 17 – Annexes, page 443) a “Note on Gap Filling in Milk Production” explaining that an interpolation between two existing points was performed (activity data on milk production available for 1990 and 1995) and validated using surrogate data.	chapter 17 – Annex 3-4, page 443
A.6	Describe the data compilation, analysis and validation processes carried out on cattle feed data and other characterizing data, provide details on the sample size, and justify that the values used are representative of the country.	FCCC/ARR/2022/MLT	Resolved. The Party reported in its NIR (section 5.2.4 Category Specific QA/QC Verification, page 210) an explanation on the feed and other characterizing data. The Party clarified that as part of internal data QA/QC, data which does not change annually is revisited with the data provider every 5 years, to verify any possible changes. As a result, the feed intake by non-lactating cows has been revised down to 15kg/day from 24kg/day following consultations with the local experts at KPH, the data provider. This decision was taken after it was found that a feed intake of 15kg/day to non-lactating cows is more efficient in terms of yield returns per unit feed given (in terms of milk production, beef, etc.). Further, the Party indicated that additional checks are made by the inventory team to the extent possible, including data comparisons with other data sources, such as FAOSTAT.	

A.7	Review the EFs reported by the small number of Parties that report CH4 emissions from enteric fermentation for poultry, choose an EF that best represents poultry production practices in Malta, revise the estimates, if appropriate, and provide an appropriate rationale and reference for the choice of EF in the NIR.	FCCC/ARR/2022/MLT	Previous reviews had suggested that since no methodology and Emission factor exists in the 2006 IPCC guidelines (as specifically indicated in Table 10.10 of the guidelines) methane emissions for poultry enteric fermentation should be omitted if no country specific emission factor is available. Moreover, Malta has reviewed the EFs reported by other countries, and has observed that most countries who used to estimate CH4 emissions from enteric Fermentation of poultry have now stopped doing so, as per the reviewer's recommendations. Those who have not stopped doing so, have their own country specific emission factor which cannot be used by Malta given that the rearing practices and environmental conditions are not the same as those of Malta. Therefore, Malta, stopped reporting emissions of CH4 from poultry enteric fermentation from March 2022, upon much consideration of the reviewers' recommendations. Moreover, Table 3.A.s1 does not include any emissions for poultry.	section 5.2.2.5
A.8	Explain in the NIR how N2O emissions from manure management for dairy cattle, including the Nex used, and N2O emissions from animal manure applied to soils are estimated, and how these estimates are consistent with the tier 2 approach used to estimate CH4 emissions from enteric fermentation for dairy cattle.	FCCC/ARR/2022/MLT	Resolved. The Party reported in its NIR (section 5.3.2.2 – Nitrous Oxide Emissions, pp. 221 - 225) the complete list of equations, assumptions and values from the 2019 Refinement. Further, the full list of EFs and relevant data (including the N retention) is presented in the NIR (Annex 3-4, Chapter 17, Table 17.21). The NIR explains that the N intake of cattle and sheep is estimated using equation 10.32 of the 2019 Refinement. The N retention rate of cattle is estimated by equation 10.33. The milk fat content is provided annually by the Malta Dairy Products; this value varies annually, as does the milk production rate, based upon the diet fed to dairy cattle. The gross energy intake is used for determining the nitrogen excretion rate and the methane emissions from manure and enteric fermentation.	section 5.3.2.2 (resolved)
A.9	Correct the IEF values for cattle reported in the NIR to ensure consistency between the NIR and CRF table 3.B(a).	FCCC/ARR/2022/MLT	Resolved. The correct value is presented in the CRF tables and no longer in the NIR.	CRF (resolved)
A.10	Explain how the two values for the fraction applied to soils (0.10 and 0.05) in 2021 NIR equation 5.2 are obtained and what they represent and explain and justify the values for the amount of slurry applied to soils across the time series.	FCCC/ARR/2022/MLT	Addressing. The Party reported in its NIR (section 5.3.2.1.2, pp. 216 and 217) that the 2 factors used for fraction of slurry applied to soils (up to 2012, 0.1 and after 2012, 0.05) were based on expert judgment and on the document "Nitrates action plan".	section 5.3.2.1.2 (resolved)

A.11	Include background information on how the Nex values from poultry were obtained and justify and document the use of these country-specific values in the NIR.	FCCC/ARR/2022/MLT	Addressing. The Party reported in its NIR (section 5.3.2.2, p.223) that the country-specific nitrogen excretion rates used for poultry are 0.82 kg/place (for broilers and other poultry) and 0.87 kg/place (for layers), which were taken from the 'Agricultural Waste Management Plan for the Maltese Islands' (Sustech, 2008, Table 4 page 63 accessed at Agricultural Waste Management Plan for the Maltese Islands - Gov.mt (yumpu.com)). The Sustech report mentioned in the NIR provides the values and refers to a previous study that analysed the quantity and the composition of the manure without any further information on the specific study generating that data.	section 5.3.2.2 (resolved)
A.12	Obtain data on consumption and application of inorganic N fertilizer and provide the estimates for application rates of inorganic N fertilizer.	FCCC/ARR/2022/MLT	Addressing. Data on the application of N has been received from a survey conducted by the Agriculture Department, and recalculations based upon the new data have been presented in this submission. New estimations and explanations are now available in Chapter 5.3.3.	section 5.3.3 (resolved)
A.13	Undertake a representative survey of AWMS for all livestock species as part of future improvements to the inventory and include in the NIR information on the AWMS used in the country.	FCCC/ARR/2022/MLT	Resolved. The Party reported in its NIR (Chapter 5.3.2, Table 5.13, page 214) that manure management system information has been provided by the Agriculture Department and supported by farm visits. During the review, the Party clarified that they have performed a data gathering exercise with multiple cooperatives and data sources, and provided a description of AWMS in the NIR.	Chapter 5.3.2 (resolved)
A.14	Include in the NIR details of the values used for N loss due to volatilization of NH3+NOX fraction of total N excreted values for sheep, goats, horses and rabbits, including their sources and any assumption used.	FCCC/ARR/2022/MLT	Resolved. The Party reported in its NIR (chapter 17, table 17.21, pp. 221-225) that the Malta's 'Nitrates Action Plan and Code of Good Agricultural Practice', relative to the requirements laid down by Directive 91/676/EEC, requires that all agricultural holdings store their manure in enclosed, leak-proof spaces. In this regard, emissions from range, pasture and paddock are not estimated, given that no manure is left to lie as deposited and unmanaged.	chapter 17, table 17.21 (resolved)

MT-3B-2021-0006	The TERT recommends that Malta (1) include in the next submission of the NIR the information provided during the ESD Review to justify why the 2019 IPCC Refinement methodology better reflects the national circumstances than the 2006 IPCC methodology; (2) develop a Tier 2 methodology to derive Nex rates for Swine.	340201/ 2020/838280/SER/CLIMA.C	The Party reported in its NIR (chapter 17, table 17.21, pp. 221-225) that the Malta's 'Nitrates Action Plan and Code of Good Agricultural Practice', relative to the requirements laid down by Directive 91/676/EEC, requires that all agricultural holdings store their manure in enclosed, leak-proof spaces. In this regard, emissions from range, pasture and paddock are not estimated, given that no manure is left to lie as deposited and unmanaged. During the review, the Party clarified that they have used the 2019 Refinement (equation 10.26, using default values in Table 10.22) including for the calculations of Nex since they are more specific and detailed and revised the calculation of N loss due to volatilisation from manure management. Further, the NIR mentions that the Tier 1 annual nitrogen excretion rates of swine, poultry, goats, horses, and rabbits are estimated by equation 10.30, while default Nrate are taken from Table 10.19 of the 2019 Refinement, with the exception of poultry, where Nex rates are taken from a 2008 Sustech Report. For sheep, Equation 10.31 is used to calculate the Tier 2 annual nitrogen excretion rates (cattle and sheep).	Chapter 5

Table 5-7 gives a summary of the revisions in methodologies, corrections and improvements carried out for the 2023 submission, while Table 5-8 gives a summary of recalculations, with a comparison between the 2021 and 2022 submissions, for every sector. For the list of revisions in emissions factors following the adoption of the 2019 Refinements, kindly refer to Annex A-3.4.

Table 5-7 Summary of revisions in methodology resulting in recalculations.

Correction or Improvement	Recalculation Category	Years Affected
No methodological revisions were made in this submission, Recalculations were due to a technical error in the worksheets.	EF/MM/AS	1990-onwards

Table 5-8 A summary of recalculations in the agriculture sector (AR5)

Summary of Recalculations								
		1990	1995	2000	2005	2010	2015	2020
Current Submission	Gg CO2 eq.	108.51	107.38	105.01	91.17	84.77	84.43	86.3
Previous Submission	Gg CO2 eq.	108.77	107.67	105.23	91.46	85.05	88.35	89.27
Percentage Change	%	-0.24%	-0.27%	-0.21%	-0.32%	-0.33%	-4.44%	-3.33%
Enteric Fermentation	Gg CO2 eq.	58.8	57.79	55.6	48.44	41.85	39.98	40.6
Previous Submission		58.8	57.79	55.6	48.44	41.85	39.98	40.6
	%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Manure Management	Gg CO2 eq.	27.19	27.24	26.37	21.51	19.19	17.62	18.32
Previous Submission		27.32	27.36	26.46	21.62	19.27	17.69	18.41
	%	-0.48%	-0.44%	-0.34%	-0.51%	-0.42%	-0.40%	-0.49%

Agricultural Soils	Gg CO2 eq.	22.52	22.36	23.03	21.22	23.73	26.83	27.38
Previous Submission		22.66	22.52	23.16	21.4	23.93	26.99	30.27
	%	-0.62%	-0.71%	-0.56%	-0.84%	-0.84%	-0.59%	-9.55%

In 2019, the Ministry for the Environment, Energy and Regeneration of the Grand Harbour (MEER) had commissioned a study entitled "*Technical support on the Emission Framework for the Agricultural Sector in Malta*", under the European Commission's SRSS Programme, to elaborate methodologies for the collection of data of parameters that are currently excluded from the data collection processes. Principally, the aim is to achieve a level of transparency, accuracy, completeness, and consistency appropriate to the size of the sector. Furthermore, reducing the uncertainty in emission estimates, and lessen reliance on default values, expert judgements, and proxy values from other countries for key categories and non-key categories alike, concurrently addressing the issues and recommendations identified by the Expert Review Teams of United Nations Framework Convention on Climate Change (UNFCCC). This project was concluded and a methodology for the collection of required data had been prepared. Nonetheless, at present no data has been collected yet, and therefore, unfortunately, the collection of the required data for the inventory is still limited to the methods listed in this report. This is linked to the lack of both financial and human resources in various government and private departments. Thus, there is no timeline of implementation of this improvement given that it is dependent upon availability of resources.

Another improvement planned is the revision of method for N2O emissions from manure management. The IPCC 2019 Refinements give equations of N retention rates for different categories of swine (Eqn. 10.33 A - 10.33 C), and default values in Table 10.20 B. The issue lies mainly with the Sow N retention equation (Eqn. 10.33 A), which does not take into consideration the piglet N retention (and thus is leading to an overestimation). This issue in fact has been discussed by European agriculture experts, co-ordinated by the EU, and the IPCC have been contacted already over this matter, who in turn noted the following: " The factor "Skg" in the nitrogen excretion balance that is used to calculate the nitrogen retention that results from pregnancy of Sows is intended to be a country-specific factor that is specific to the production system of each individual country that is using the Tier 2 method. In the text of the Refinement, the details of how this value is to be derived was not clear and there was confusion as to the treatment of weight gain resulting from the growth of young gilts in the breeding herd. Further, the values that were provided in Table 10.20B were calculated incorrectly, as they did not include the N retention in the piglets prior to parturition, but only the weight gain for young gilts that have not yet achieved mature weight. A corrigendum proposed by authors will be subject to the IPCC Error Protocol, and its publication as a corrigendum to the 2019 Refinement is subject to the final approval." Malta will revise their estimations to T2 as soon as the corrigendum has been published.

5.2 ENTERIC FERMENTATION (CRF 3A)

5.2.1 CATEGORY DESCRIPTION

Enteric fermentation is the process by which carbohydrates are broken down by microorganisms in the rumen of animals. While ruminant animals (cattle, goats and sheep) are the largest contributors of Methane (CH4) emissions from enteric fermentation, pseudo-ruminant and monogastric animals are also included in the emission calculations. The quantity of CH4 produced and excreted by a single animal is dependent on several factors, mainly; the species, age, weight of the animal, characteristics of the digestive system, and the type and quantity of the feed consumed. Emissions from wild animals and pets do not fall within the scope of the national GHG inventories and thus are omitted from this report. Emissions from Enteric Fermentation have decreased from 1990 onwards; this change is mainly attributed to changes in livestock (Figure 5-2). In 2022, enteric fermentation was responsible for 46% of total agriculture emissions.

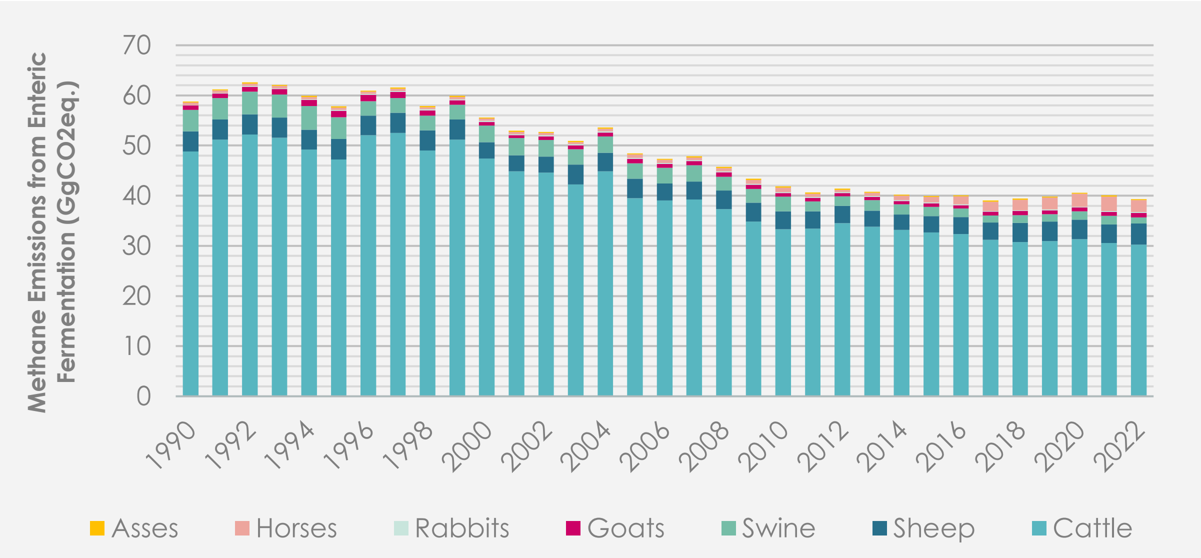


Figure 5-2 A graphical representation of methane emissions from enteric fermentation by livestock category (AR5)

5.2.2 *METHODOLOGICAL ISSUES*

Parameters, emission factors, equations and resultant values used in the calculation of emissions from enteric fermentation, for the livestock categories cattle, sheep and other livestock are provided below and in Annex 3-4 (Chapter 17). Activity data is provided in Chapter 17 Annex 3.4.

5.2.2.1 Cattle

The cattle population is split into growing cattle (calves <1 year and cattle 1 – 2 years of age), dairy cows and mature cattle (bulls and non-lactating cows). The parameters used in the estimation of emissions from cattle enteric fermentation are tabulated in Table 5-9 . Cattle are characterised using the values given in Annex 3-4.

The same method is applied for sheep milk yield, where the sum of ewes and ewe lambs is used. The milk production yield and fat content for the whole timeseries are provided in Annex 3-4. Subsequently, the milk yield will vary on a yearly basis depending on the population of dairy cows and the total milk produced.

Two feed digestibility values are being utilised for low quality forage (FD%LQF). The Feed digestibility of low-quality forage (FD%LQF) for the period 1990-2004 is being taken as 45% (S. Sammut, 2015; 2019 IPCC Refinements Table 10.1), whilst 50% is being used for 2005 onwards (IPCC guidelines table 10.2). On the other hand, the Feed digestibility >85% concentrate (FD%85) is being taken as a constant 78.5% throughout the entire time series (2019 IPCC Refinement).

The calculation of DE% was developed by the agriculture compiler, given that no formula is given in the IPCC guidelines, and has been revised following 2020 ESD Reviews. Since the equation for DE% also incorporates the Feed (F)(kg/day), the result is dependent on and fluctuates with changes in the feed. The feed, as well as the portions of which are forage and concentrate have not been constant throughout the whole time series, since improvements are made from time to time in the feed given to the livestock; this is based on information provided by experts (veterinarians) who work in the field. The feed as well as the portions change as a result of what the experts and producers believe will yield them the highest milk production.

Equations used in the calculation of enteric fermentation methane [CH4] emissions from cattle are given below (Equation number refers to equation reference in 2019 IPCC refinements).

Equation 10.3 Net energy for maintenance

NE_m=Cfi*$W^{0.75}$

Equation 10.4 Net energy for activity

NE_a = NE_m * Ca

Equation 10.6 Net energy for growth

NE_g = 22.02 ((W/C/W)$^{0.75}$*WG$^{1.097}$

The weight gain (WG) for mature cattle is assumed to be 0.

Equation 10.8 Net energy for lactation

NE_l = MY * (1.47+0.4*MF)

Equation 10.13 Net energy for pregnancy

NE_p = C_{preg}*NE_m*Portion Pregnant

Digestible Energy

DE% = ((Fowf/F)*(FD%LQF))+((Fowc/F)*(FD%>85))

Fowf: Feed of which is forage

Fowc: Feed of which is concentrate

FD%>85%: Feed Digestibility of feedlot animals fed with >85% concentrate or high-grain diet

FD%LQF: Feed digestibility low quality forage

Equation 10.14 Ratio of net energy available in diet for maintenance to digestible energy consumed (REM)

REM=(1.123-(4.092*10^{-3})*DE%)+(1.126*10^{-5}*DE%^{2}))-(25.4/DE%))

Equation 10.15 Ratio of net energy available for growth in diet to digestible energy consumed (REG)

$REG=(1.164-(5.16*10^{-3})*DE\%)+(1.308*10^{-5}*DE\%^{2}))-(37.4/DE\%))$

Equation 10.16 Gross Energy (Dairy cattle)

GE= $[((NE_m+NE_a+Ne_l+Ne_p$~~$+NE_{work}$~~$)/REM)+((NE_g$~~$+NE_{wool}$~~$)/REG)]/DE\%$

Equation 10.16 Gross Energy (Non-lactating cattle & bulls)

$GE= ((NE_m+NE_a)/REM)/DE\%$

Equation 10.16 Gross Energy (Calves & Growing Cattle)

$GE= [((NE_m+NE_a)/REM)+((NE_g /REG)]/DE\%$

Equation 10.21 Methane emission factors for enteric fermentation from cattle

$EFCH_4 = (GE*YM/100)*365)/55.65$

Equation 10.19 Enteric Fermentation emissions from cattle

Emissions $CH_4 = ((EF*N)/10^6)*GWP$

Table 5-9 Parameters used in the estimation of enteric CH4 emissions in cattle.

PARAMETERS		Source	Dairy Cattle	Non-Lactating Cattle	Bulls	Calves	Growing Cattle
Cfi	Coefficient for calculating NEm	Table 10.4 (IPCC 2019 Refinements)	0.386	0.322	0.37	0.322	0.322
Ca	Coefficient corresponding to animal feeding situation	(IPCC 2019 Refinements) MJ/day/Kg (goats only)	0	0	0	0	0
C	Coefficient	Table 10.4	0.8	0.8	1.2	1	1
Cpreg	Coefficient for pregnancy	Table 10.7	0.1	n.a.	n.a.	n.a.	n.a.
PG	Portion of females gestating	KPH	0.7	n.a.	n.a.	n.a.	n.a.
FD%LQF *	Feed Digestibility Low Quality Forage	Table 10.1 S. Sammut, 2015 p.6	45, 50	45, 50	45, 50	n.a.	n.a.
FD%>85	Feed Digestibility of feedlot animals fed with >85%	Table 10.2 (2019 Refinements)	78.5	78.5	78.5	78.5	78.5

	concentrate or high-grain diet						
YM	Methane Conversion Factor	Table 10.12 (IPCC 2006)	6.5	6.5	6.5	6.5	6.5

**FD%LQF 45 (1990-2004), 50 (2005 onwards); the values taken from S. Sammut 2015 agree with IPCC 2019 Refinement Table 10.2. Feed proportions change along the years due to changes in the feeding system, as explained in the text. Feed proportions are given in Annex 3.4.*

5.2.2.2 Sheep

Sheep and goats are mainly reared to produce the traditional Maltese Cheeselets, largely marketed by the producers themselves. Only a minimal number of sheep and goats are slaughtered at the civil abattoir. In the past, sheep rearing was also important for wool production as this was in great demand due to the thriving artisanal craft of wool weaving. At present, however, the number of local weavers has drastically diminished resulting in a drastic decline in the demand and utilisation of wool. In fact, it is common practice for farmers to discard the wool.

Methane emissions from sheep enteric fermentation are calculated using Tier 2 methodologies as per the 2019 IPCC Refinements. The sheep population is split into lambs, ewes (ewes and ewe lambs) and male sheep. Sheep are characterised using the values in Table 5-10 and default values taken from the 2019 IPCC Refinements.

The coefficient for pregnancy was provided by an external consultant using country specific values derived from a study by Valletta P.P., (2011). The values in the study were averaged for single and twin pregnancies, obtaining values of 0.1873 and 0.7853 respectively. These were then multiplied by the respective $C_{pregnancy}$ values provided in the guidelines (0.077 and 0.126).

For the livestock category sheep, default methane conversion factors from Table 10.13 of the 2019 IPCC Refinements are applied to Gross Energy values determined as described above using Equation 10.21 of the 2019 IPCC Refinements to develop a methane emission factor for each animal category as shown in Table 5-10.

The Net Energy associated with wool production is estimated by equation 10.12 of the 2019 IPCC Refinements, given below. Since the sheep are kept in stables and not left to roam in pastures, the Net Energy for Work (NE_{work}) is excluded from the GE calculation.

Equations used in the calculation of enteric fermentation methane [CH4] emissions from sheep are given below (Equation number refers to equation reference in 2019 IPCC refinements).

<u>Equation 10.3 Net energy for mainenance</u>

$NE_m = Cfi * W^{0.75}$

<u>Equation 10.5 Net energy for activity</u>

$NE_a = W * Ca$

<u>Equation 10.7 Net energy for growth</u>

$NE_g = WG((a+0.5b(BW_i+BW_f)/365)$

The weight gain (WG) for mature sheep is assumed to be 0.

Equation 10.9 Net energy for lactation

$NE_l = MY * EV_{milk}$

The milk yield is taken from milk production provided by NSO on a yearly basis, while the EVmilk, which is the Net energy required to produce 1kg of milk, is taken from p 10.26 of the 2019 IPCC Refinements.

Equation 10.12 Net Energy for wool

$NE_{wool} = (EV_{wool}*PR_{wool})/365$

The EV_{wool}, which is the energy value of each kg of wool produced (weighed after drying but before scouring), is given as 24MJ/kg by the 2019 IPCC Refinements (p 10.27). The annual wool production per sheep (PR_{wool}) is taken from Bigi, D & Zanon, A. (2020). PR_{wool} value for ME sits at 1.3, while that for OMS sits at 2.5 kg/yr.

Equation Coefficient for pregnancy (p.10.28 2019 IPCC refinements)

$C_{preg} = (0.126*0.785) + (0.77*0187)$

Equation 10.13 Net energy for pregnancy

$NE_p = C_{preg}*NE_m*\text{Portion Pregnant}$

Digestible Energy

DE% = ((Fowf/F)*(FD%LQF))+((Fowc/F)*(FD%>85))

Where Fowf is the feed of which is forage, Fowc is the feed of which is concentrate, FD%LQF, is the Feed digestibility Low quality forage and FD%>85 is the Feed digestibility of feedlot animals fed with >85% concentrate or high-grain diet.

Equation 10.14 Ratio of net energy available in diet for maintenance to digestible energy consumed (REM)

$REM=(1.123-(4.092*10^{-3})*DE\%)+(1.126*10^{-5}*DE\%^{2}))-(25.4/DE\%))$

Equation 10.15 Ratio of net energy available for growth in diet to digestible energy consumed (REG)

$REG=(1.164-(5.16*10^{-3})*DE\%)+(1.308*10^{-5}*DE\%^{2}))-(37.4/DE\%))$

Equation 10.16 Gross Energy (Mature Ewes)

$GE= [((NE_m+NE_a+Ne_l+Ne_p)/REM)+((NE_g+NE_{wool})/REG)]/DE\%$

Equation 10.16 Gross Energy (other mature sheep & growing lambs)

$GE= [((NE_m+NE_a)/REM)+((Neg+NEwool)/REG)]/DE\%$

<u>Equation 10.21 Methane emission factors for enteric fermentation from sheep</u>

$EFCH_4$ = (GE*YM/100)*365)/55.65

<u>Equation 10.19 Enteric Fermentation emissions from sheep</u>

Emissions CH_4 = ((EF*N)/10^6)*GWP

Table 5-10 Parameters used in the estimation of enteric CH4 emissions in sheep.

PARAMETERS		Source	Mature Ewes	Other Mature Sheep	Growing Lambs
EvMilk	Net Energy required to produce 1Kg of Milk	p.10.26 IPCC 2019 Ref	4.6	n.a.	n.a.
PrWool	Annual wool production	Bigi, D & Zanon, A. (2020) Atlante delle razze autoctone	1.3	2.5	n.a.
EvWool	Net Energy required to produce 1Kg of wool	IPCC, 2019 Refinements p. 10.27	24	24	24
Cfi	Coefficient for calculating NEm	Table 10.4 (IPCC 2019 Refinements)	0.217	0.217	0.236
Ca	Coefficient corresponding to animal feeding situation	(IPCC 2019 Refinements) MJ/day/Kg	0.0096	0.0096	0.0067
a	Constant for use in calculating NEg	Table 10.6 IPCC 2006	2.1	2.1	2.3
b	Constant for use in calculating NEg	Table 10.6 IPCC 2006	0.45	0.45	0.4
Bwi	Body wight at weaning	KPH	11	11	3
BWf	Body weight at 1 yr. old or at slaughter	KPH	18	18	30
W	Weight	KPH	50	60	20
Cpreg	Coefficient for pregnancy	Table 10.7	0.113	n.a.	n.a.
PG	Portion Gestating	KPH	0.65		
MY	Milk Yield	NSO/MDP			
FOWF	Feed of which Forage	KPH	2.75	1	0.8
FOWC	Feed of which Concentrate	KPH	1.05	1.5	0.7
FD%LQF	Feed Digestibility Low Quality Forage	KPH	50	50	50
FD%>85	Feed Digestibility of feedlot animals fed with	Table 10.2 (cattle and other ruminants) – 2019 Refinements	78.5%	78.5%	78.5%

	>85% concentrate or high-grain diet				
YM	Methane Conversion Factor	Table 10.13 (IPCC 2019 Refinements (sheep),	6.7%	6.7%	6.7%

Parameters do not change along the timeseries for sheep.

5.2.2.3 Goats

Emissions from enteric fermentation in goats were estimated using equation 10.19 of the 2019 IPCC Refinements. The EF is taken from table 10.10 of the IPCC Refinements **(5 kgCH4/head/yr low productivity systems).** This EF was used since the productivity system of Goats in Malta is very low, since goats are not bred specifically for economic purposes.

Equation 10.19 Enteric Fermentation emissions from goats

Emissions $CH_4 = ((EF*N)/10^6)*GWP$

5.2.2.4 Swine

Malta's inventory categorises swine in 6 different classes:

Fatteners:

- Piglets: 1kg-20kg (live weight of a piglet at birth is 0.8-1.2 kg; and average of 1kg.
- Young pigs (20-50kg)
- Fattening Pigs: 50kg - 115kg (we aim for a slaughter weight of approx 85 kg which relates to a live weight of approx 115kg).

Breeders:

- Breeding females - sows: 180 - 250 kg (based on slaughter weights in 2021 to date)
- Breeding females - gilts: 120 - 150kg
- Breeding boars: 190 - 275kg (based on slaughter weights in 2021 to date)

In the pig industry, the term 'producer' refers to breeders who breed boars and gilts and who sell their grown pigs to a market weight. The term fattener refers to farms that purchase pigs and fatten them to a market weight.

The life cycle of a pig in the typical rearing conditions in Malta is as follows: Piglets weaned at 4 weeks or 30 days generally weigh about 9 - 10 kg. It will take them almost another month to reach 20kg. They can eat by themselves before 4 weeks if they are offered "creep" feeds from 7 - 10 days of age. Weaning at 21 days is quite normal in intensive production systems around the world but it is not used in Malta except in emergency situations where the sow is sick or otherwise unable to care for the piglets safely. A sow will have on average 2 parturitions per year in Malta, but it is technically possible to get up to 2.4 parturitions per year if there are no failed pregnancies (returns to heat / abortions etc) and few open days (the time between weaning and getting pregnant again). The global benchmark (aim) is about 2.3 but it is not easy to achieve.

Generally, an ideal reproductive cycle with 30-day weaning would be:

- Mating to Farrowing (pregnancy): 116 days
- Farrowing to Weaning (lactation): 30 days
- Weaning to mating (open days): 4 days

This would give a 150-day cycle, which equates to about 2.4 reproductive cycles (365/150=2.43).

With regards to the weight disparities in gilts and sows, once a female pig is old enough to be selected for breeding it is identified and tagged as a gilt. However, this does not mean that it is mated immediately. Though classified as a gilt at 6 months of age or 120 kg, it may not be mated until 2 months later in which time it continues to gain weight. If mated at 8 months of age, gilts may weigh more than 150kg by the time of mating.

Pigs at this age (i.e. 8 months) are not as efficient at converting food as younger pigs; they may need to eat >4kg to grow 1 kg, but they are capable of eating more than that per day, so they can grow up to 1kg per day if fed sufficiently. A gilt will continue to gain weight during pregnancy; partly due to development of the litter (14 piglets x 1 kg each = 14kg by farrowing), but mostly because at 150kg gilts are far from fully grown and are fed to continue developing.

Once a gilt farrows, it becomes classified as a sow; generally, by the time this happens, they weigh about 180kg, but a 1st parity sow is still far from her maximum size and weight. The growth continues over subsequent parities causing the difference in weight between 1st parity sows at about 1 year of age (e.g 180kg) up to 5th parity sows at 3 - 4 years of age (e.g 250kg). This growth is not linear. Sows which have large litters tend to lose weight during each lactation, since they use more energy to produce milk than they can consume in feed for a few weeks. A sow may lose more than 15% of her body weight during each lactation and must be fed sufficiently to be putting weight back on by the time they are mated again, to ensure fertility. However, while not linear the weight gain is generally consistent and higher parity sows tend to be heavier if they are healthy and properly fed.

There are many studies and ongoing debate about whether it is viable to keep sows longer, since they get bigger and metabolic energy requirements for sustenance increase with body weight (larger animals need to eat more per day to stay alive). There is also debate about whether we should select for larger sows, for the same reason.

The Manure Management system of swine is pit storage below animal confinement for most pigs & pig farms in Malta. In terms of productivity, pigs are farmed in a manner that would be described as intensive, but our productivity is not as high as in northern or central European countries, due to our climate and the fact that our farms and farming systems are more traditional. Nonetheless, for the sake of the inventory, we take a conservative approach and assume high productivity systems (KIM, 2021).

Emissions from enteric fermentation in swine were estimated using equation 10.19 of the 2019 IPCC Refinements. The EF is taken from table 10.10 of the IPCC Refinements **(1.5 kgCH4/head/yr high productivity systems).**

<u>Equation 10.19 Enteric Fermentation emissions from swine</u>

Emissions $CH_4 = ((EF*N)/10^6)*GWP$

5.2.2.5 Poultry

Methane emissions from Enteric fermentation of poultry have been omitted from Malta's national GHG inventory, following UNFCCC Review finding below (Provisional main findings 2021) and an ESD Step 1 Review (2022) recommendation. Previous reviews had suggested that since no methodology and Emission factor exists in the 2006 IPCC guidelines (as specifically indicated in Table 10.10 of the guidelines) methane emissions for poultry enteric fermentation should be omitted if no country specific emission factor is available. Moreover, Malta has reviewed the EFs reported by other countries, and has observed that most countries who used to estimate CH4 emissions from enteric Fermentation of poultry have now stopped doing so, as per the reviewer's recommendations. Those who have not stopped doing so, have their own country specific emission factor which cannot be used by Malta given that the rearing practices and environmental conditions are not the same as those of Malta. Therefore, Malta, stopped reporting emissions of CH4 from poultry enteric fermentation from March 2022, upon much consideration of the reviewers' recommendations. Moreover, Table 3.A.s1 does not include any emissions for poultry.

ID#: *A.1;* A.7 (UNFCCC/ARR/2022/MLT

Issue/ problem classification: 3.A.4 Other livestock – CH4 (A.20, 2019) Accuracy

Recommendation made in previous review report: "Review the EFs reported by the small number of Parties that report CH4 emissions from enteric fermentation for poultry, choose an EF that best represents poultry production practices in Malta, revise its estimates, if appropriate, and provide an appropriate rationale and reference for the choice of EF in the NIR".

ERT assessment and rationale:

"Not resolved. The Party reported tier1 methodology for estimating enteric CH4 emissions from poultry and in the CRF Table 3A.s1 the emissions from this category. During the review, the Party clarified that in Italy's 2021 NIR submission the below is being stated on page 199: "Methane emissions from poultry and fur animals are not applicable." This excludes rabbits since they further state "Emissions from rabbits, mules and asses, goats, buffalo and horses are estimated and included in "Other livestock" as shown in the CRF tables." Nonetheless, for poultry Italy does not seem to be including any estimations of CH4 emissions from Enteric Fermentation and thus we do not have an Italian EF to follow. The ERT agrees that no enteric CH4 emissions should occur for poultry as the 2006 IPCC guidelines do not recommend EFs associated with this category (Tables10.9, 10.10). The ERT considers that the recommendation has not yet been addressed because the Party has not yet reviewed the application of an EF for enteric CH4 emissions from poultry."

5.2.2.6 Rabbits

In Malta, there are around five major commercial farms that breed rabbits, however most of the rabbit breeding takes place as a backyard industry. The Maltese rabbit breeding stock is comprised mainly of the New Zealand Whites and the Californian breed. The New Zealand Whites are a medium sized breed, with adults weighing between 5 kg to 5.5 kg. It satisfies the characteristics of a meat producing rabbit since it has well-developed and robust body, as well as a good reproductive rate, and the ability to produce large litters consistently. The California breed originated from a mix between the Himalayan and the Chinchilla varieties. The offspring were then bred with the New Zealand whites. The Californian breed is slightly smaller than the New Zealand White and the adult can reach an average weight of 5kg. The ratio of meat to bone is much better and they are used to create hybrids with the New Zealand Whites to produce stronger and healthier offspring. A semi-intensive husbandry method is preferred on Maltese farms given that it gives enough time to the doe to rest in between birth and impregnation. The doe is mated fourteen days after giving birth and the young are weaned for 4 to 5 weeks after birth. The doe is limited to six to seven litters per year and is used for breeding for up to two and a half years. A raised caging system is used in Malta, where the does are separated from each other and allows easy cleaning and handling of the rabbit while keeping the animal in a clean and safe place reducing risk of injuries and disease. In Malta, rabbit production losses occur mainly due to high temperatures or rapid changes in the temperature. The heat stress results in mortality, reduction in growth, poor weight gain, impaired appetite and feed conversion, reduction in reproductive efficiency, impaired milk production, increased disease incidence and decreased fertility (smaller litters). In December 2014 and January 2015, sudden cold temperatures resulted in higher rates of mortality in both juveniles and does; however, this cannot be seen in population trend given that unfortunately the data for rabbit heads is very limited and numbers for the years 2011 - 2015 are approximate.

It is vital to note that backyard breeders who do not breed or own rabbits for commercial purposes, and are thus not on the farm register, may not have been captured during the census. Statistics on rabbit numbers are collected for breeding females on agricultural holdings having at least 50 does. Thus, implying that any other holding with less than 50 does are not statistically captured as part of the rabbit population. Preliminary estimates based on rabbit feed sold indicate that the statistical numbers are not representative of the total population and are in fact only a small proportion. Subsequently, the rabbit population data utilised is extrapolated, based upon the historical population of rabbits (that is when the entire rabbit population was being reported (1990 – 2001)) and upon rabbit breeding characteristics (such as fertility rate, number of kits etc).

The 2006 IPCC Guidelines does not provide a default Emission Factor Value for Enteric Fermentation for rabbits. Subsequently, it was decided, following consultation with local experts in the Rabbit Husbandry, that the emission factor shall be taken from a report drawn up by the Italian Agency for the Protection of the Environment and for technical Services. It is assumed that Italy, as a neighbouring country has a similar scenario on rabbits and the Italian CH4 Emission factor should be applied to the local scenario as the neighbouring country. Hence, the Emission Factor Values quoted by the Italian Agency are the closest to reflect the local Maltese Scenario, and thus their usage.

It was suggested in the 2021 UN reviews that Malta stops estimating CH4 emissions from rabbit enteric Fermentation, given that there is no clear method and EF in the IPCC guidelines. While it is a reasonable suggestion, Malta notes that the rabbit rearing sector in Malta is quite large due to rabbit meat being one of the traditional foods in Malta. Hence, emissions from rabbits are included in this NIR submission, given that if we exclude rabbit emissions, it might result in a significant underestimation of methane emissions.

Emissions from enteric fermentation in rabbits were estimated using equation 10.19 of the 2019 IPCC Refinements. The EF is taken as **0.08 kgCH4/head/yr** from APAT (2005, p 16).

Equation 10.19 Enteric Fermentation emissions from rabbits

Emissions $CH_4 = ((EF*N)/10^6)*GWP$

5.2.2.7 Horses

The equine population is very small and includes foal, mare, stallion, and donkeys.

Emissions from enteric fermentation in horses were estimated using equation 10.19 of the 2019 IPCC Refinements. The EF is taken from table 10.10 of the IPCC Refinements **(18 kgCH4/head/yr).**

Equation 10.19 Enteric Fermentation emissions from goats

Emissions $CH_4 = ((EF*N)/10^6)*GWP$

5.2.2.8 Asses, mules and hinnies

The population of assess, mules and hinnies is unavailable from the National Statistics Office. Hence, data is taken from the FAOSTAT, whose data is estimated.

Emissions from enteric fermentation in asses, hinnies and mules were estimated using equation 10.19 of the 2019 IPCC Refinements. The EF is taken from table 10.10 of the IPCC Refinements **(10 kgCH4/head/yr).**

Equation 10.19 Enteric Fermentation emissions from goats

Emissions $CH_4 = ((EF*N)/10^6)*GWP$

5.2.3 *UNCERTAINTIES AND TIME-SERIES CONSISTENCY*

Time-series consistency has been improved by using consistent sources for animal populations, as specified in the Livestock Analysis (Annex 3-4). Any remaining gaps in cattle, swine, goats, sheep and poultry data, prior to 2000, have been interpolated or extrapolated using methods given in the 2006 IPCC guidelines Volume 1.

Milk production data for cattle and sheep is only available as far back as 1995. The preceding five years are gap-filled using a 5-year average. Changes in feed conditions for cattle have been taken into consideration as far as possible, based on expert judgement.

Emission Factors and activity data uncertainties were taken as listed in the IPCC guidelines (2006 and 2019 Refinements where available), or as provided by the data providers. In the case where no uncertainty value was available for the activity data, an uncertainty value was given based on expert judgement. In the case of uncertainty values for activity data, population data was given an uncertainty of 20% as suggested in the IPCC guidelines. Whereas all other activity data is given an uncertainty value based on discussions carried out with the data providers and local expertise during informal meetings.

For uncertainties, please refer to Annex 2.

5.2.4 *CATEGORY-SPECIFIC QA/QC AND VERIFICATION*

Since Enteric Fermentation is a Key Category, it has undergone QA/QC checks as outlined in Chapter 6 of volume 1 of the IPCC Guidelines (2006). The activity data, methods and changes are documented within the agriculture worksheets, in electronic form.

Wherever possible, data is verified with other sources, such as National statistics office data with FAOSTAT data. Data on animal numbers and milk production is obtained annually from NSO. Data on cattle milk fat content is collected annually from Malta Dairy Products, who also provide cattle milk production, with which the data from NSO is validated against.

All data collected is stored and logged. In cases where a break in trend is observed, for example in milk productivity, the correctness of the data is checked. It must be noted that with the small animal populations, annual variations in the livestock numbers can cause significant changes in the time series.

Data that is received from data providers is logged into an activity data log sheet to allow traceability and transparency of data sources, QA/QC etc. Data received from data providers such as the National Statistics Office (NSO) are readily subjected to quality assurance/quality control checks by the data providers themselves. Additional checks are made by the inventory team to the extent possible, including data comparisons with other data sources, such as FAOSTAT. Emission factors developed using Tier 2 methods are cross-checked against IPCC defaults. Generally, the emission factors are comparable with the default values. Yet, there were instances where numerous parameters were fed into the construction of the emission factor that are based on expert judgment and thus reflect the present local scenario.

As part of internal data QA/QC, it was decided that any data which does not change annually, is revisited with the data provider every 5 years, to verify any possible changes. As a result, the feed intake by non-lactating cows has been revised down to 15kg/day from 24kg/day following consultations with the local experts at KPH, the data provider. This decision was taken after it was found that a feed intake of 15kg/day to non-lactating cows is more efficient in terms of yield returns per unit feed given (in terms of milk production, beef, etc.).

5.2.5 CATEGORY-SPECIFIC RECALCULATIONS

Recalculations in this category were due to revisions in livestock population, that were made to improve timeseries consistency and address 2 findings of the 2021 UNFCCC Review (A1. And A2. Of FCCC/PMF/2021/MLT), and due to the addition of Mules, hinnies and asses as a new livestock category.

Table 5-11 A table of recalculations for the Enteric Fermentation category.

Year	Enteric Fermentation 2022 NIR	Enteric Fermentation 2023 NIR	Percentage change in reported emissions	Change
	Gg CO2 eq.	Gg CO2 eq.	%	Gg CO2 eq.
1990	58.80	58.80	0%	0.00
1991	61.23	61.23	0%	0.00
1992	62.57	62.57	0%	0.00
1993	62.10	62.10	0%	0.00
1994	59.92	59.92	0%	0.00
1995	57.79	57.79	0%	0.00
1996	60.97	60.97	0%	0.00
1997	61.56	61.56	0%	0.00
1998	57.88	57.88	0%	0.00
1999	59.90	59.90	0%	0.00
2000	55.60	55.60	0%	0.00
2001	52.95	52.95	0%	0.00
2002	52.74	52.74	0%	0.00
2003	50.92	50.92	0%	0.00
2004	53.58	53.58	0%	0.00

2005	48.44	48.44	0%	0.00
2006	47.36	47.36	0%	0.00
2007	47.86	47.86	0%	0.00
2008	45.73	45.73	0%	0.00
2009	43.39	43.39	0%	0.00
2010	41.85	41.85	0%	0.00
2011	40.63	40.63	0%	0.00
2012	41.41	41.41	0%	0.00
2013	40.80	40.80	0%	0.00
2014	40.20	40.20	0%	0.00
2015	39.98	39.98	0%	0.00
2016	40.10	40.10	0%	0.00
2017	39.03	39.03	0%	0.00
2018	39.43	39.43	0%	0.00
2019	39.83	39.83	0%	0.00
2020	40.60	40.60	0%	0.00
2021	40.05	40.05	0%	0.00

5.2.6 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

Planned improvements in the Enteric Fermentation include addressing the issues and recommendations identified by the Expert Review Teams of United Nations Framework Convention on Climate Change (UNFCCC) and the European Commission.

The aim remains to achieve a level of transparency, accuracy, completeness, and consistency appropriate to the size of the sector. Furthermore, reducing the uncertainty in emission estimates, and lessen reliance on default values, expert judgements, and proxy values from other countries for key categories and non-key categories alike.

5.3 MANURE MANAGEMENT (CRF 3B)

5.3.1 CATEGORY DESCRIPTION

This category reports emissions of methane [CH_4] and nitrous oxide [N_2O] from animal manure, including its storage. The management of domestic livestock manure leads to the emission of CH_4 and N_2O. The decomposition of manure by methanogenic bacteria, under anaerobic conditions releases CH_4, while the nitrification and denitrification of manure nitrogen, produces N_2O. CH4 emissions are highly dependent upon the manure management system used (whether it is open or closed, wet or dry, etc) and the food intake of the animal (Gross Energy etc). N_2O emissions from manure management vary significantly between the types of manure management systems used (e.g. solid or liquid). When manure is stored or treated as liquid in a pond or tank it tends to decompose anaerobically and produce a significant quantity of methane. When manure is handled as a solid or when it is deposited on pastures, it tends to decompose aerobically and little or no methane is produced. Hence, the system of manure management used affects emission rates.

In Malta, the animal waste management systems (AWMS) used in animal production includes solid storage, deep bedding, poultry with litter and pit storage. It should be noted that since livestock in Malta are not left out to roam on pasture, and are always enclosed, no manure is deposited on land, unless it is to be used as fertilizer. Nonetheless, indirect emissions from manure deposited on soils, i.e. through volatilisation and run-off are accounted for under 3B.2. (Chapter 5.3.3.). Both methane and nitrous oxide emissions from manure management have decreased from 1990 onwards; this change is mainly attributed to changes in livestock population, but also changes in the manure management systems (Figure 5-3 and Figure 5-4).

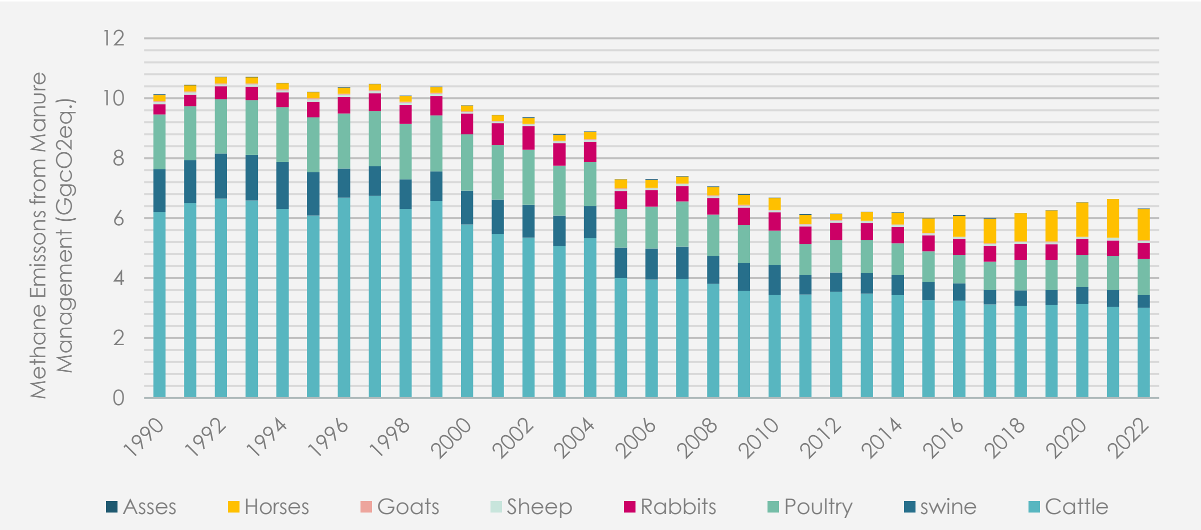


Figure 5-3 A graphical representation of CH4 emissions from manure management by livestock category (AR5)

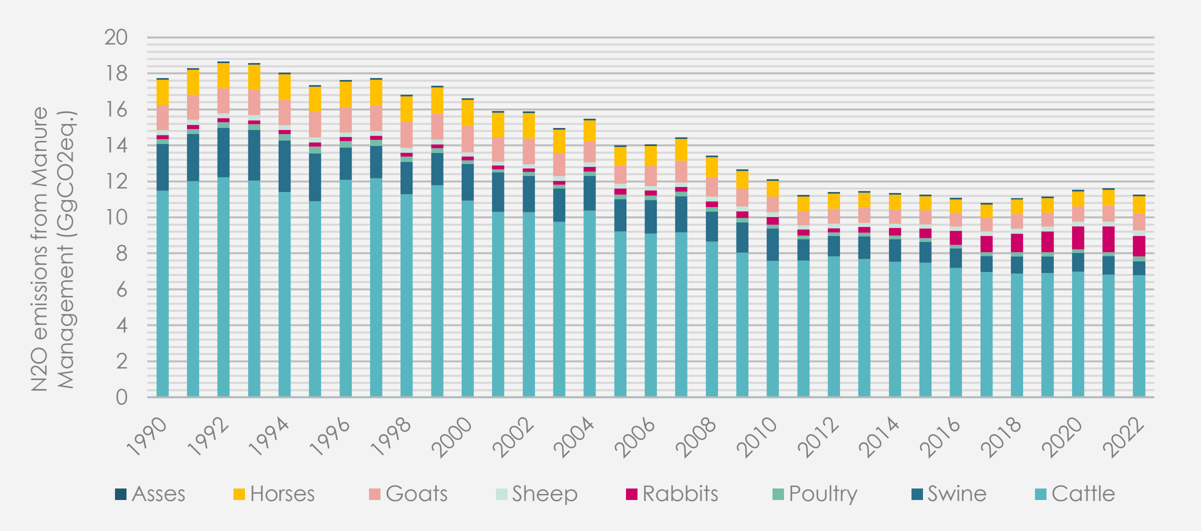


Figure 5-4 A graphical representation of N2O emissions from manure management by livestock category (AR5)

In 2022, emissions from manure management account for 21% of the total agriculture emissions. CH4 emissions from Manure management accounted for 36% of total CH4 emissions, while N2O emissions from MM accounted for 64% of total N2O emissions.

5.3.2 *Methodological Issues*

5.3.2.1 Methane Emissions

Methane emissions from cattle, swine, poultry, and rabbits have been estimated using Tier 2 methodology with country specific parameters. A Tier 1 methodology and default emission factors for other livestock are applied.

Manure management systems for all livestock categories in Malta are tabulated below (Table 5-12); manure management system information has been provided by the Agriculture Department and supported by farm visits.

Table 5-12 A description of manure management systems and productivity levels in Malta for every livestock category

Livestock Category	Manure Management System & productivity levels Description
Cattle	Solid Storage Cattle are kept in partly enclosed systems, where manure falls in the slats beneath them, which is collected and stored, while the urine is diluted with water which is flows directly into the sewerage system. High productivity, intensive
Sheep	Cattle & swine deep bedding Sheep are kept in fully enclosed spaces. The floor is solid stone, which allows no runoff or leaching of liquids from the system and is covered in deep bedding which collects manure and urine, and which is replaced on a regular basis by the farmer.

	Low productivity/ non-intensive.
Goats	Cattle & swine deep bedding Goats are kept in fully enclosed spaces. The floor is solid stone, which allows no runoff or leaching of liquids from the system and is covered in deep bedding which collects manure and urine, and which is replaced on a regular basis by the farmer. Low productivity/ non-intensive.
Pigs	Pit storage without cover Pigs are kept in fully enclosed spaces. The floor is slats, which allows liquid manure to fall under the animal (without cover). The liquid manure is then collected and passed to the sewerage system. Only a tiny fraction is applied to soils given that swine slurry application to soils in Malta is illegal. High productivity, intensive.
Horses Hinnies, asses & mules	Solid Storage Horses are kept in stables; their manure is piled and then collected for application to soils or to go to waste stream. Low productivity, non-intensive.
Poultry	Poultry manure with litter Poultry are kept in cages; their manure is left to fall into the litter trays beneath them, which are cleaned regularly to avoid any diseases. High productivity, intensive
Rabbits	Poultry manure with litter Like Poultry, rabbits are kept in cages; their manure is left to fall into the litter trays beneath them, which are cleaned regularly to avoid any diseases. High productivity, intensive

5.3.2.1.1 Cattle

The Estimation of methane emissions from Cattle are based on the livestock characterisation developed for enteric fermentation. Gross Energy and Digestible Energy are used as inputs to derive a methane emission factor. VS, MCF and Bo values for solid storage in temperate regions (19°C) and Western Europe (given the climatic conditions of the Maltese islands) (Table 5-13) were selected, given Malta's climate and geographical location. Equation 10.23 of the 2019 IPCC Refinement is applied to develop a methane emission factor.

Table 5-13 Parameters used in the estimation of CH4 emissions from manure management of cattle.

PARAMETERS		Source	Dairy cattle	Bulls	Non-lactating cows	Calves	Growing cattle
DE%	Digestible Energy		Taken from Enteric Fermentation				

GE	Gross Energy	Eqn. 10.16		
MCF	Methane Conversion Factor	Table 10A-4/10A-5	4%	
VS	Volatile Solid	Eqn. 10.24		
UE	Urinary Energy	p.10.42, IPCC 2006	0.04	
ASH	Ash content of manure	P.10.43, IPCC 2006	0.08	
Bo	Methane Potential	Table 10.16, IPCC 2019	0.24	0.18

Equations used in the calculation of CH4 emissions from the manure management of cattle are provided below.

Equation 10.24 Volatile solid excretion rates

VS = (GE(1-DE%/100)+(UE*GE))*((1-ASH)/18.45)

Equation 10.23 CH_4 emission factor from manure management

$MMCH_4EF = (VS*365)*(B_o*0.67*(MCF/100))$

Equation 10.22 Methane Emissions from Cattle manure management (part of equation 10.22)

Emissions $CH_4 = ((EF*N/10^6))*GWP$

5.3.2.1.2 *Swine*

Despite the limited characterisation of the swine livestock due to the fragmented information available, an acceptable amount of information is available to enable a Tier 2 estimation of methane emissions from manure management. Some values are presented in draft and final reports drawn up to inform the Agricultural Waste Management Plan.

To estimate the amount of dry matter excreted, the average excretion of wet slurry (16.05 kg animal^{-1} day^{-1}, Sustech, 2008, p.64 Agricultural Waste Management Plan for the Maltese Islands - Gov.mt (yumpu.com)) is multiplied by the dry solid content, which results in a value of 0.25 kg dry matter animal^{-1} day^{-1}. Multiplying this value by the percentage content of volatile solids results in 0.15 kg VSday^{-1}.

There is no solid waste generated on pig farms. Faeces and urine from the pigs, and unconsumed water from drinking nipples, fall through the slats in the pen floor and is flushed with additional washing water to cesspits. In general, the liquid slurry is transported to a sewage manhole by means of a bowser. The cesspit capacity must be sufficient to collect all urine and washing for at least 15 days. Cesspits in pig production should be emptied every week but extra space for at least another week should be available. It is prohibited to direct pig slurry to the sewer system; however, the practice remains. It is also not allowed to apply pig slurry to soils but based on expert judgement (Prof. George Attard, 2019) about 10% of slurry is applied to soils. This is revised downwards to 5% after the adoption of the "Nitrates Action Plan" 2013 (UNFCCC/ARR/2022/MLT A.10).

To reflect this manure management system, two default methane conversion factors are applied from Table 10.17 of the 2006 IPCC Guidelines, taking into consideration the fraction of slurry that is applied to soils (0.1 (1990-2012) and 0.05 (2012 onwards)) and the fraction that is directed to the sewer system (0.9 (1990-2012) and 0.95 (2012 onwards)).

Equations used in the calculation of CH4 emissions from the manure management of swine are provided below; parameters are given in Table 5-14.

Equation Manure Dry Matter

MDM = ML*(DS%/100)

Equation Volatile Solids

VS = VS%*(MDM/100)

Equation MCF at 19 degrees Celsius

= MCF*1-SATS

Where 1990 – 2012 = (3(1-0.1))

2013 onwards = (3(1-0.05))

Equation 10.23 CH4 Emission factor from manure management

EFsewer = (VS*365)*(Bo*0.67)*(MCF/100)*(1-SATS)

EFsoils = (VS*365)*(Bo*0.67)*(MCF/100)*(SATS)

EFTotal = EFsewer + EFsoils

Equation 10.22 CH4 Emissions from manure management

Emissions CH_4 = ((EFTotal*N/10^6))*GWP

Table 5-14 Parameters used in the estimation of CH4 emissions from manure management of swine.

PARAMETERS		Source	Swine
ML	Manure Solids + Liquids	Sustech 2008 Table 4	16.05 kg/animal/day
DS%	Dry Solid %	Sustech 2008 Table 4	1.55%
MDM	Manure Dry Matter	ML*(DS%/100)	
VS%	Volatile Solid %	Sustech 2005 Table 7	61.1%
SATS	Slurry applied to soils (NAP)	NAP	0.10 & 0.05 (2013 onwards)
MCF	Methane Conversion Factor	Table 10.17	3
MCF 19degC	Methane Conversion Factor	MCF*(1-SATS)	
Bo	Methane Potential	Table 10.16	0.45$m^3 CH_4$/Kg VS

5.3.2.1.3 Poultry

The poultry figures include “Broilers”, “Laying hens”, and “Other poultry”, which is mainly comprised of the turkey population. As previously mentioned, livestock data is gathered through agricultural censuses carried out by the National Statistics Office. Presently, the data provided by NSO mainly reports the population statistics for the categories “Layers”, and “Broilers”. The contribution of broilers to the poultry industry in Malta is around 58%, whereas laying hens contribute around 41%, and other poultry contribute for less than 1%. Every three years the number of turkeys is reported under the category "other poultry" as such data is collected during the "Farm Structure Survey " Census, starting from the year 2010. Thus, data for "other poultry" is available for the years 2010, 2013, and 2016. For the interim years Malta does not have any data on the category. As a result, the population data used is extrapolated based upon the historic populations of turkey.

The methane emissions from enteric fermentation for poultry are estimated using a Tier 2 approach corresponding to 2006 IPCC guidelines. In order to estimate the amount of dry matter excreted, the average excretion of wet slurry (0.149 kg animal^{-1} day^{-1} for broilers and other poultry and 0.167 kg animal^{-1} day^{-1} for layers) is multiplied by the dry solid content, which results in a value of 0.05 kg dry matter animal^{-1} day^{-1} in the case of layers and 0.03 kg dry matter animal^{-1} day^{-1} in the case of broilers and other poultry. Multiplying this value by the percentage content of volatile solids, results in 0.034 kg VSday^{-1} for layers and 0.030 kg VSday^{-1} for broilers. A default methane conversion factor is applied for poultry representing solid storage in temperate regions, resulting in separate emission factors for each category using Equation 10.23 of the 2019 IPCC Refinements.

Equations used in the calculation of CH4 emissions from the manure management of poultry and rabbits are provided below. Parameters used in the estimation of emissions from poultry are given in Table 5-15.

<u>Equation Conversion to kilograms of manure</u>

Mkg = (ML*density)/1000

<u>Equation Manure Dry Matter</u>

MDM = DS%*Mkg/100

<u>Equation Volatile Solids Excreted</u>

VS = VS%*MDM/100

<u>Equation 10.23 CH4 emissions factor</u>

EF = (VS*365)*(Bo*0.67)*(MCF/100)

<u>Equation 10.22 CH4 Emissions from manure management</u>

Emissions $CH_4 = ((EF_{Total}*N/10^6))*GWP$

Table 5-15 Parameters used in the estimation of CH4 emissions from manure management of poultry.

PARAMETERS		Source	Layers	Broilers + OP
ML	Manure Solids + Liquids	Sustech 2008 Table 4	0.167 L/animal/day	0.149 L/animal/day
Density		Sustech 2008 Table 4	944 kgm^{-3}	503 kgm^{-3}
Mkg	Manure/animal/day	(ML*density)/1000	0.16	0.07
DS%	Dry Solid %	Sustech 2008 Table 4	29.44%	46.15%
MDM	Manure Dry Matter	DS%*Mkg/100	0.05	0.03
VS%	Volatile Solid %	Sustech 2005 Table 7	74.06%	85.97%
VS	Volatile Solid	VS%*MDM/100	0.03	0.03
MCF	Methane Conversion Factor	Table 10A-9	1.5	1.5
Bo	Methane Potential	Table 10A-4	0.39	0.36

5.3.2.1.4 Rabbits

A default methane conversion factor is applied for poultry and rabbits from Table 10A-9 of the 2006 IPCC guidelines (rabbits) representing solid storage in temperate regions, resulting in separate emission factors for each category using Equation 10.23 of the 2019 IPCC Refinements.

Equations used in the calculation of CH4 emissions from the manure management of rabbits are provided below.

<u>Equation Conversion to kilograms of manure</u>

Mkg = (ML*density)/1000

<u>Equation Manure Dry Matter</u>

MDM = DS%*Mkg/100

<u>Equation Volatile Solids Excreted</u>

VS = VS%*MDM/100

<u>Equation 10.23 CH4 emissions factor</u>

EF = (VS*365)*(Bo*0.67)*(MCF/100)

<u>Equation 10.22 CH4 Emissions from manure management</u>

Emissions CH_4 = $((EF_{Total}*N/10^6))*GWP$

Methane emissions from rabbits are estimated using Tier 2 methodology, with some country specific emission factors. Parameters used in the estimation are tabulated in Table 5-16.

Table 5-16 Parameters used in the estimation of CH4 emissions from manure management of rabbits

PARAMETERS		Source	Rabbits
ML	Manure Solids + Liquids	Sustech 2008, Table 4	1.97
Density		Sustech 2008, Table 4	717 kgm^{-3}
Mkg		ML*Density/1000	1.41kg/animal/day
DS%	Dry Solid %	Sustech 2008, Table 4	26.28%
MDM	Manure Dry Matter	Mkg*DS%/100	0.37
VS%	Volatile Solid %	Sustech 2005 p. 59	84.4%
VS	Volatile Solid	VS%*MDM/100	0.31
MCF	Methane Conversion Factor	Table 10A-9 (2006)	1
Bo	Methane Potential	Table 10A-9 (Temperate/ solid storage)	0.32

5.3.2.1.5 Other Livestock

Methane emissions from sheep, goats. Asses, hinnies and mules, and horses are estimated using Tier 1 methodology. Emission factors used are tabulated in Table 5-17.

Table 5-17 Parameters used in the estimation of CH4 emissions from manure management of other livestock

PARAMETERS	Unit	Source	Sheep	Horses	Asses, hinnies & mules	Goats
EF	g CH4 kg VS-1	Table 10.14 (2019), Table 10.15 (2006)	1.3	7	1.1	1.3

Equation CH4 Emissions from manure management of sheep, goats, and horses.

Emission CH4 = $((EF*N/10^6))*GWP$

5.3.2.2 Nitrous oxide emissions

Malta follows the method given in the 2019 IPCC Refinements to calculate direct and indirect N_2O emissions from manure management.

Parameters, activity data and emission factors used in the estimation of N2O emissions from manure management can be found in Chapter 17 Annex 3.4.

<u>Equation 10.25 – Direct N_2O emissions from manure management</u>

N_2O_{DMM} = $S(N_T*Nex_T)*AWMS)+N_{cdgs})*EF_3)*44/28$

EF_3, which is the emission factor for direct N_2O emissions from manure management, is taken from table 10.21 of the 2019 IPCC Refinements. The N_{cdgs} is assumed to be 0.

Equation 10.26 – N losses due to volatilisation from manure management systems

$N_{Volatilisation-MMS} = S(N_T*Nex_T)*AWMS)+N_{cdgs})*Frac_{GasMS}$

Default values for nitrogen loss fractions due to volatilisation of NH_3 and NO_x and leaching of nitrogen from manure management are taken from Table 10.22 of the 2019 IPCC Refinements.

Equation 10.27 – N losses due to leaching from manure management systems

$N_2O_{Leaching-MMS} = S(N_T*Nex_T)*AWMS)+N_{cdgs})*Frac_{Leach}$

The AWMS is 1 for every livestock category, since all livestock in Malta is kept in enclosures all day long, within the same manure management system. The N_{cdgs} is 0 since no nitrogen from co-digestates is added to biogas plants in Malta.

Equation 10.28 – Indirect N_2O emissions due to volatilisation of N from MMS

$N_2O_{G(MM)} = (N_{volatilisation-MMS}*EF_4)*44/28$

EF_4, which is the emission factor for N_2O emissions from atmospheric deposition of nitrogen on soils and water surfaces, is taken from table 11.3 of the 2019 IPCC Refinements.

Equation 10.29 – Indirect N_2O emissions due to leaching and run-off of N from MMS

$N_2O_{L(MM)} = (N_{leaching-MMS}*EF_5)*44/28$

EF_5, which is the emission factor for N2O emissions from nitrogen leaching and run-off, is taken from table 11.3 of the 2019 IPCC Refinements.

The Tier 1 annual nitrogen excretion rates of swine, poultry, goats, horses, and rabbits are estimated by equation 10.30, while default N_{rate} are taken from Table 10.19 of the 2019 IPCC Refinements, with the exception of poultry, where Nex rates are taken from a 2008 Sustech Report (Table 4, p. 63).

*Note on use of T1 method for swine: The party has attempted to calculate N2O direct emissions from swine using a T2 method, nonetheless an error was flagged, whereby the N retention for piglets was higher than the N intake. This was due to an error in the equation provided in the 2019 IPCC Refinements. It was thus decided by the party to retain the use of a Tier 1 method until a corrigendum is issued by the IPCC.

Equation 10.30 – Annual N excretion rates (T1)

$N_{ex} = N_{rate}*(TAM/1000)*365$

Default values for Nrate can be found in the annex. In past editions of the NIR the mid-range value was taken as the country specific excretion rate. Following the outcomes of recent ESD and UNFCCC Reviews, in conjunction with our efforts towards attaining continuous improvements of the NIR, it was decided that a more conservative approach should be opted for. Subsequently, since the default value given in the 2019 IPCC Guidelines is quoted at 1.14kgN/1000kg/day, which is beyond the higher end of the range quoted above, it was decided that the highest value of the range, i.e. 0.82kgN/place shall be utilised for both broiler and other poultry.

Equation 10.31 is used to calculate the Tier 2 annual nitrogen excretion rates of cattle and sheep.

Equation 10.31 – Annual N excretion rates (T2) (cattle, sheep)

$N_{ex} = N_{intake}*(1-N_{retention\ fraction}) *365$

The N intake of cattle and sheep is estimated using equation 10.32. The N retention rate of cattle is estimated by equation 10.33 of the 2019 IPCC Refinements. The milk fat content is provided annually by the Malta Dairy Products; this value varies annually as does the milk production rate, based upon the diet fed to dairy cattle.

The nitrogen excretion depends on the N intake and N retention. The N intake is dependent on the Gross Energy, which is quite constant throughout the timeseries leading to a fairly constant N intake. On the other hand, the N retention is dependent upon the milk yield, which increases throughout the timeseries. Since the equation of Nex multiplies the N intake by 1 minus the N retention, a "mathematical reversal" in values occurs. This means that when more N is retained in the animal, less N is excreted by the animal (as it is being used to yield more milk).

Equation 10.32 – N intake rate for cattle & sheep

$N_{intake} = GE/18.45*[(CP\%/100)/6.25]$

Equation 10.33 – N retention rate for cattle

$N_{retention} = [milk*(milk\ PR\%/100)/6.35] + [WG*((268-((7.03*NE_g)/WG))/1000)/6.25]$

The NE_g and GE of cattle is equal to the previously calculated NE_g and GE values in the Enteric Fermentation category.

Equation 10.34 of the 2019 IPCC Refinements is used for the estimation of managed manure N available for application to managed soils, while equation 10.34A of the 2019 IPCC guidelines is used to estimate the fraction of managed manure N lost prior to application to managed soils ($FRAC_{LOSS}$) and equation 10.34B is used to estimate the $FRAC_{N2}$. Nbedding was not taken into account in these equations.

Equation 10.34

$N_{MMSAVB} = S([(N_T*Nex*AWMS+N_{cdgs})*(1-Frac_{Loss})]+[N*AWMS*N_{bedding}])$

Equation 10.34A

$FRAC_{LOSS} = FRAC_{GAS} + FRAC_{LEACH} + FRAC_{N2} + EF_3$

Equation 10.34B

$FRAC_{N2} = R_{N2(N20)} + EF_3$

The molecular nitrogen (N2) loss from manure management (R_{N2_N20}) is taken as the default value 3 kgN_2-N(kgN_20-N)$^{-1}$ given in table 10.23 of the 2019 IPCC Guidelines.

The fraction of nitrogen thus volatilised is multiplied with the default emission factor to estimate indirect N2O-N emissions from manure management (0.01 kg N2O-N kg N-1), as presented in Table 11.3 of the 2019 IPCC Refinements.

Where the 2019 Refinements to the IPCC guidelines provide more specific and in-depth estimations of Nitrogen intake, losses, excretion and emissions, the refinements were favoured, to achieve more accurate estimations, also given the fact that these refinements were drawn up based upon new peer-reviewed research.

5.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The characterisation of the animal waste management systems and the treatment of manure is not sufficiently documented due to fragmented information. Assessment of animal waste management systems are based on discussions with experts. Changes to these management systems throughout the time series can therefore not be accurately accounted for.

5.3.4 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

The same QA/QC procedure recommended in Chapter 6 of Volume 1 of the IPCC guidelines was followed for Manure Management.

5.3.5 CATEGORY-SPECIFIC RECALCULATIONS

Recalculations in this category resulted from recommendations of the ERT during the 2022 ESD Reviews (Table 5-18) and from revisions to the livestock populations. Moreover, the method of calculating the N available to soils from poultry is now being done individually for broilers, layers and other poultry.

Table 5-18 A table of recalculations for the Manure Management sector.

Year	Manure Management 2022 NIR	Manure Management 2023 NIR	Percentage change in reported emissions	Change
	Gg CO2 eq.	Gg CO2 eq.	%	Gg CO2 eq.
1990	27.32	27.19	0.00	-0.12
1991	28.28	28.15	0.00	-0.12
1992	28.98	28.86	0.00	-0.12
1993	28.95	28.82	0.00	-0.12
1994	28.28	28.16	0.00	-0.12

1995	27.36	27.24	0.00	-0.12
1996	27.88	27.75	0.00	-0.13
1997	28.15	28.03	0.00	-0.12
1998	26.90	26.78	0.00	-0.12
1999	27.75	27.62	0.00	-0.12
2000	26.46	26.37	0.00	-0.09
2001	25.61	25.52	0.00	-0.09
2002	25.55	25.45	0.00	-0.09
2003	24.12	24.01	0.00	-0.11
2004	24.70	24.60	0.00	-0.11
2005	21.62	21.51	-0.01	-0.11
2006	21.47	21.38	0.00	-0.09
2007	21.79	21.71	0.00	-0.08
2008	20.62	20.53	0.00	-0.09
2009	19.77	19.68	0.00	-0.09
2010	19.27	19.19	0.00	-0.08
2011	17.89	17.81	0.00	-0.08
2012	18.01	17.93	0.00	-0.08
2013	18.09	18.02	0.00	-0.07
2014	17.95	17.88	0.00	-0.07
2015	17.69	17.62	0.00	-0.07
2016	17.59	17.52	0.00	-0.08
2017	17.21	17.13	0.00	-0.08
2018	17.62	17.53	0.00	-0.09
2019	17.81	17.72	0.00	-0.09
2020	18.41	18.32	0.00	-0.09
2021	18.55	18.47	0.00	-0.08

5.3.6 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

Improvements planned in this subsector include the implementation of T2 for N2O manure management swine, provided a corrigendum is issued by the IPCC to correct the errors in the calculations provided in the 2019 IPCC Refinements for Piglets and Breeding sows. Moreover, the investigation/inclusion of turkeys as a separate category is also expected to take place for the next submission.

5.4 RICE CULTIVATION (CRF 3C)

5.4.1 *Category Description*

This category does not occur.

5.4.2 *Methodological Issues*

Not applicable.

5.4.3 *Uncertainties and Time-Series Consistency*

Not applicable.

5.4.4 *Category-specific QA/QC and verification*

Not applicable.

5.4.5 *Category-specific Recalculations*

Not applicable.

5.4.6 *Category-specific planned Improvements*

Not applicable.

5.5 AGRICULTURAL SOILS (CRF 3D)

5.5.1 *Category description*

Nitrous oxide is produced as an intermediate in the denitrification reaction and as a by-product of nitrification. The availability of inorganic nitrogen in the soil is a controlling factor in the process and therefore, N_2O emissions are estimated through human-induced N additions into the soil or N mineralisation. Emissions of N_2O occur through direct and indirect pathways. Direct emissions result from the addition or release of N directly from the soil, while indirect emissions occur through volatilisation of NH_3 and NO_x from managed soils, or after leaching and runoff of N mainly as NO_3^-. In 2022, nitrous oxide emissions from agricultural soils accounted for 34% of the total agricultural emissions (figure below).

Nitrogen inputs that are considered for direct and indirect nitrous oxide emissions from soils are:

- Application of synthetic nitrogen fertilisers (F_{SN});
- Application of organic nitrogen as fertiliser (animal manure) (F_{ON});
- Nitrogen input from crop residues (F_{CR});
- Nitrogen mineralisation associated with loss of soil organic carbon (F_{SOM}).

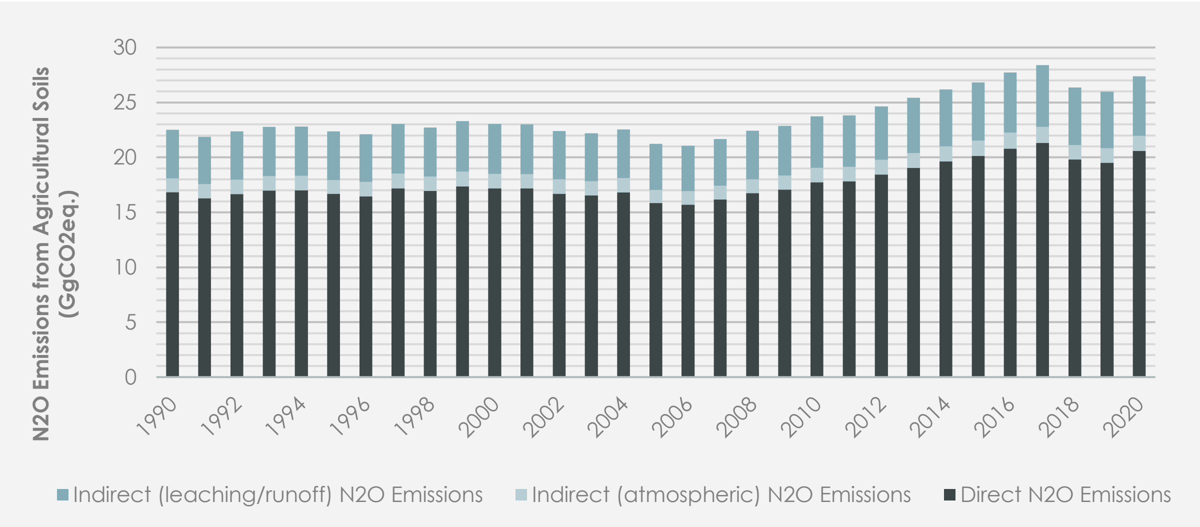


Figure 5-5 A representation of the direct and indirect N2O emissions from Agricultural Soils.

Organic soils and grazing do not occur in Malta, and therefore there is no contribution of nitrogen inputs to be considered.

5.5.2 *Methodological Issues*

Tier 1 methodologies were applied for the calculation of both direct and indirect soil emissions.

5.5.2.1 Activity Data

5.5.2.1.1 Synthetic Fertilizer Nitrogen Applied to Soils

**** Addressing UNFCCC/ARR/2022/MLT A.12**

The Ministry for Agriculture, Fisheries and Animal Rights commissioned a study to quantify the importation, purchase, distribution and sales of inorganic fertilisers, with the objective of obtaining better knowledge of what fertilisers are being imported, purchased throughout the value chain, distributed and sold to farmers, giving categorisation to their NPK ratios concentration. An analysis of organic fertiliser was also included.

Information on imports obtained from the National Statistics Office (NSO) covered the period 2017-2021. Inorganic fertilisers were seen to fluctuate in weight imported, albeit increases in value over the 5-year period. On the other hand, both purchase and cost of organic fertilisers experienced a decline. Results showed that during the 5-year period under study, out of 49 forms of inorganic fertilisers classified by the HS code system (HS code 310), only 9 types are being imported in Malta.

The table below gives the list of fertilizers imported in Malta. Code 31010000 relates to organic fertilisers (grey). All other categories within HS code 310 relate to inorganic fertilisers (blue).

Table 5-19 Fertilizers imported by HS code and description.

HS code	Description
31010000	Animal or vegetable fertilisers, whether or not mixed together or chemically treated; fertilisers produced by the mixing or chemical treatment of animal or vegetable products (excl. those in tablets or similar forms, or in packages with a gross weight of <= 10 kg)
31021010	Urea, whether in aqueous solution or not, containing > 45% nitrogen in relation to the weight of the dry product (excl. that in tablets or similar forms, or in packages with a gross weight of <= 10 kg)
31022100	Ammonium sulphate (excl. that in tablets or similar forms, or in packages with a gross weight of <= 10 kg)
31022900	Double salts and mixtures of ammonium sulphate and ammonium nitrate (excl. goods of this chapter in tablets or similar forms or in packages of a gross weight of <= 10 kg)
31023010	Ammonium nitrate in aqueous solution (excl. that in packages with a gross weight of <= 10 kg)
31023090	Ammonium nitrate (excl. that in aqueous solution, in tablets or similar forms, or in packages with a gross weight of <= 10 kg)
31024090	Mixtures of ammonium nitrate with calcium carbonate or other inorganic non-fertilising substances, for use as fertilisers, containing > 28% nitrogen by weight (excl. those in tablets or similar forms, or in packages with a gross weight of <= 10 kg)
31029000	Mineral or chemical nitrogen fertilisers (excl. urea; ammonium sulphate; ammonium nitrate; sodium nitrate; double salts and mixtures of ammonium nitrate with ammonium sulphate or calcium; mixtures of urea and ammonium nitrate in aqueous or ammoniacal solution; mixtures of ammonium nitrate and calcium carbonate or other non-fertilising inorganic elements; in tablets or similar in packages <= 10 kg)
31039000	Mineral or chemical phosphatic fertilisers (excl. superphosphates, those in tablets or similar forms, or in packages with a gross weight of <= 10 kg)
31042010	Potassium chloride containing <= 40% potassium monoxide in relation to the weight of the dry product (excl. that in pellet or similar forms, or in packages with a gross weight of <= 10 kg)
31042090	Potassium chloride containing > 62% potassium monoxide in relation to the weight of the dry product (excl. that in pellet or similar forms, or in packages with a gross weight of <= 10 kg)
31049000	Carnallite, sylvite and other crude natural potassium salts, potassium magnesium sulphate and mixtures of potassic fertilisers, e.g. mixtures of potassium chloride and potassium sulphate (excl. those in pellet or similar forms, or in packages with a gross weight of <= 10 kg)

31051000	Mineral or chemical fertilisers of animal or vegetable origin, in pellet or similar forms, or in packages with a gross weight of <= 10 kg
31052010	Mineral or chemical fertilisers containing phosphorus and potassium, with a nitrogen content > 10 % by weight on the dry anhydrous product (excl. those in tablets or similar forms, or in packages with a gross weight of <= 10 kg)
31052090	Mineral or chemical fertilisers containing nitrogen, phosphorus and potassium, with a nitrogen content <= 10 % by weight on the dry anhydrous product (excl. those in tablets or similar forms, or in packages with a gross weight of <= 10 kg)
31055900	Mineral or chemical fertilisers containing the two fertilising elements nitrogen (excl. nitrate) and phosphorus but not nitrates (excl. ammonium dihydrogen orthophosphate "monoammonium phosphate", diammonium hydrogen orthophosphate "diammonium phosphate" in pellet or similar forms, or in packages with a gross weight of <= 10 kg)
31056000	Mineral or chemical fertilisers containing the two fertilising elements phosphorus and potassium (excl. those in tablets or similar forms, or in packages with a gross weight of <= 10 kg)
31059020	Mineral or chemical fertilisers containing the two fertilising elements nitrogen and potassium, or one principal fertilising substance only, incl. mixtures of animal or vegetable fertilisers with chemical or mineral fertilisers, containing > 10% nitrogen
31059080	Mineral or chemical fertilisers containing the two fertilising elements nitrogen and potassium, or one main fertilising element, incl. mixtures of animal or vegetable fertilisers with chemical or mineral fertilisers, not containing nitrogen or with a nitrogen content by weight, of <= 10% (excl. in tablets or similar forms or in packages of a gross weight of <= 10 kg)

Table 5-20 Fertilizer imports and cost, by HS code, by year

	2017		2018		2019		2020		2021	
HS Code	Sum of Kg	Sum of €	Sum of Kg	Sum of €	Sum of Kg	Sum of €	Sum of Kg	Sum of €	Sum of Kg	Sum of €
31010000	925703	297739	557444	197132	711282	182479	495341	159456	396035	153080
31021010	1071706	295600	521148	173631	377624	153062	765710	256416	1043037	378421
31022100	198802	43844	267171	49944	271364	55986	408263	47722	135326	50498
31022900	51237	48831	138600	39222	63110	26264	102700	33760	22200	6771
31023010	650	1995	50	50	0	0	21000	7014	150	468
31023090	197735	103449	133022	72564	186319	89349	142600	69080	102626	58946
31024090	0	0	0	0	0	0	200	120	0	0
31029000	20050	24994	47271	21603	23150	10514	10400	5303	8505	12430
31039000	200	621	0	0	0	0	0	0	17	176
31042010	0	0	0	0	1015	1625	1104	3066	0	0
31042090	1000	1510	250	370	1000	1349	4	45	14	214
31049000	24201	7951	0	0	0	0	0	0	0	0
31051000	5994	28859	12137	49900	55545	82168	49385	90301	75755	54698
31052010	254738	205892	638747	282909	664916	385693	506249	353932	474691	360145
31052090	87367	61184	148971	101515	43719	64116	84142	102997	137353	120416
31055900	660	2739	6950	14773	340	2539	5228	5137	2668	4170
31056000	3653	5504	3625	4586	16646	20476	2400	3590	2450	3769
31059020	436	710	100	160	60	332	2338	41939	0	0
31059080	74845	79872	77543	74599	20157	66148	88655	108510	49656	69526
Total incl. organic	*2918977*	*1211294*	*2553029*	*1082958*	*2436247*	*1142100*	*2685719*	*1288388*	*2450483*	*1273728*
Total excl. organic	*1993274*	*913555*	*1995585*	*885826*	*1724965*	*959621*	*2190378*	*1128932*	*2054448*	*1120648*

Table 5-21 New synthetic fertiliser application data and emissions

	UAA	Average N rate	FSN consumption	2022 FSN Emissions	2023 FSN Emissions	Recalculations March 2022 – March 2023
	ha	*kg N/yr.*	*Kg N/yr.*	*ktCO2eq.*	*ktCO2eq.*	*ktCO2eq.*
1990	9780	60.30	589714	1.94	2.46	27%
1991	9768	60.30	589039	1.92	2.45	28%
1992	9757	60.30	588363	2.14	2.45	14%
1993	9746	60.30	587688	2.05	2.45	19%
1994	9735	60.30	587013	2.05	2.44	19%
1995	9724	60.30	586338	3.66	2.44	-33%
1996	9712	60.30	585663	2.44	2.44	0%
1997	9701	60.30	584988	2.47	2.44	-1%
1998	9690	60.30	584312	3.82	2.43	-36%
1999	9679	60.30	583637	2.35	2.43	3%
2000	9668	60.30	582962	3.14	2.43	-23%
2001	9657	60.30	582287	2.6	2.42	-7%
2002	10223	60.30	616462	2.75	2.57	-7%
2003	10790	60.30	650637	2.23	2.71	21%
2004	10520	60.30	634356	2.19	2.64	21%
2005	10250	60.30	618075	2.46	2.57	5%
2006	10290	60.30	620487	2.84	2.58	-9%
2007	10330	60.30	622899	2.46	2.59	5%
2008	10703	71.00	759937	1.7	3.16	86%
2009	11077	80.98	896974	1.83	3.74	104%
2010	11450	90.31	1034012	2.3	4.31	87%
2011	11260	104.00	1171049	1.96	4.88	149%
2012	11070	118.16	1308087	2.28	5.45	139%
2013	10880	132.82	1445124	2.38	6.02	153%
2014	10980	144.09	1582162	2.48	6.59	166%
2015	11080	155.16	1719199	2.57	7.16	179%
2016	11180	166.03	1856237	2.37	7.73	226%
2017	11929	167.09	1993274	2.44	8.30	240%
2018	11530	173.08	1995585	2.44	8.31	241%
2019	11130	154.98	1724965	2.44	7.18	194%
2020	10731	204.12	2190378	2.44	9.12	274%
Source	NSO, FAOSTAT, Eurostat	NSO (2007), EMCS (2022)	NSO (2007), EMCS (2022)			

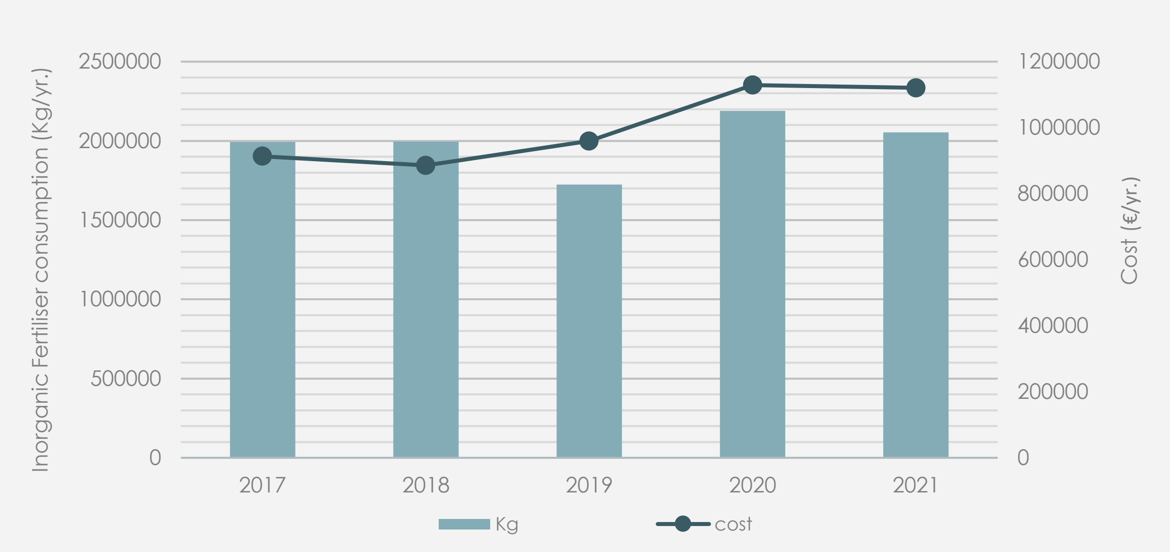


Figure 5-6 Inorganic fertiliser consumption and cost for the years 2017 – 2021.

Apart from import data obtained from NSO, the contracted entity also carried out a survey with a total of 259 businesses to obtain a list of all inorganic fertiliser consumed.

Table 5-22 List of inorganic fertilisers imported and sold in Malta

NPK: 12-12-7	NPK: 20-20-20	NPK: 15-30-15	NPK: 15-5-30	NPK: 10-53-10	NPK: 15-15-1
NPK: 30-10-10	NPK: 7-3-5	NPK: 18-5-5	NPK: 3-5-7	NPK: 10-5-15	NPK: 13-13-13
NPK: 21-7-7	NPK: 1-3-6	NPK: 16-5-3-	NPK: 0-0-51	NPK: 7-5-5	NPK: 12-40-6
NPK: 18-18-18	NPK: 12-61-0	NPK: 15-9-15	NPK: 24-10-10	NPK: 6-3-8	NPK: 12-5-5
NPK: 16-8-32	NPK: 4-3-3	NPK: 13-4-13	NPK: 20-10-20	NPK: 4-7-14	NPK: 10-10-22
NPK: 13-40-13	NPK: 46-0-0	NPK: 12-6-5	NPK: 18-46-0	NPK: 3-3-2	NPK: 7-7-9
NPK: 7-7-7	NPK: 34-0-0	NPK: 11-0-40	NPK: 16-10-24	NPK: 24-8-17	NPK: 7-4-6
NPK: 30-10-5	NPK: 26-0-0	NPK: 10-5-40	NPK: 15-15-30	NPK: 20-8-10	NPK: 6-3-6
NPK: 12-5-15	NPK: 24-12-12	NPK: 7-5-12	NPK: 13-14-13	NPK: 18-44-0	NPK: 4-4-4
NPK: 3-0-1	NPK: 21-0-0	NPK: 6.5-4-6	NPK: 13-0-46	NPK: 16-8-24	NPK: 2-6-5
NPK: 18-9-27	NPK: 19-19-19	NPK: 5-5-8	NPK: 12-5-40		

Greenview	Canna PK 13/14	Piscopo Gardens Green Plants: NPK 10-5-5
Biorax	Stender C900: NPK 14-10-18	Piscopo Gardens Citrus Plant Food: NPK 6-7-9
Growth Boost and Flowering	Plagron Growmix: NPK 12-14-24	Terra Bloom: NPK 2-2-4
Phosphagen	Plagron Royalmix: NPK 5.5-11-5.5	Cocos A: NPK 4-0-1
Advance	Plagron Lightmix: NPK 12-14-24	Cocos B: NPK 1-4-2
Greenhouse	Plagron Seeding & Cutting: NPK 12-14-24	Alga Grow: NPK 4-2-4
Baby Bio	Plagron Bat Guano: NPK 3-15-4	Alga Bloom: NPK 3-2-5
Phostrogen	Plagron Batmix: NPK 5.5-11-5.5	PH Plus: NPK 0-0-25
Pro-Verde	Plagron Growmix: NPK12-14-24	Power Roots: NPK 0-0-2
Terra Aquatica Grow	Piscopo Gardens Food for flowering plant: NPK 8-7-12	Sugar Royal: NPK 9-0-0
Supermix Additive: NPK 1-2-0	Fish Force: NPK 3-5-2	Seed Booster: NPK 5-4-7

This new data has allowed the revision of synthetic fertilizer application to soils. Given that data is only available for the years 2017 to 2021, an interpolation was done to obtain historic data.

The interpolation took into consideration available data for this 5-year period, and surrogate data (the average nitrogen rate available for 2007 published in an NSO study on the gross nitrogen balance for Malta published in 2008[10] and the change in UAA).

A revision in the UAA was also carried out based upon available/published historic data.

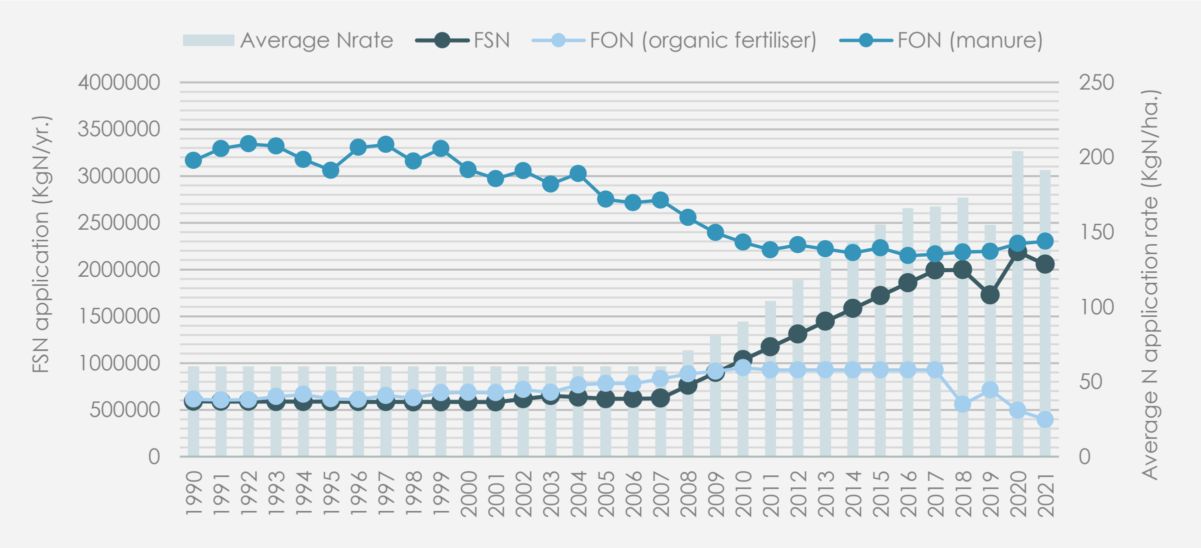


Figure 5-7 Nitrogen consumption and average nitrogen application rate; 1990 – 2021.

Data currently available through NSO and FAOSTAT covers parameters such as UAA, TAL and Fodder crop land, land area under potato and total land area for vegetables. However, such data is solely available since 2001 and only at 2- or 3-year intervals, through the "*Farm Structure Survey*" undertaken by NSO. The data available through FAOSTAT and Eurostat is used for filling of gaps in the 1991 - 2000 period. Additionally, for those years for which data is not available, the quantification of land area categories is estimated through interpolation, making use of the quantified data for those years for which NSO/FAOSTAT/Eurostat data is available.

Equation Synthetic Nitrogen Application (Kg N/yr.)

FSN = Average N rate * UAA

5.5.2.1.2 Organic Nitrogen Applied to Soils

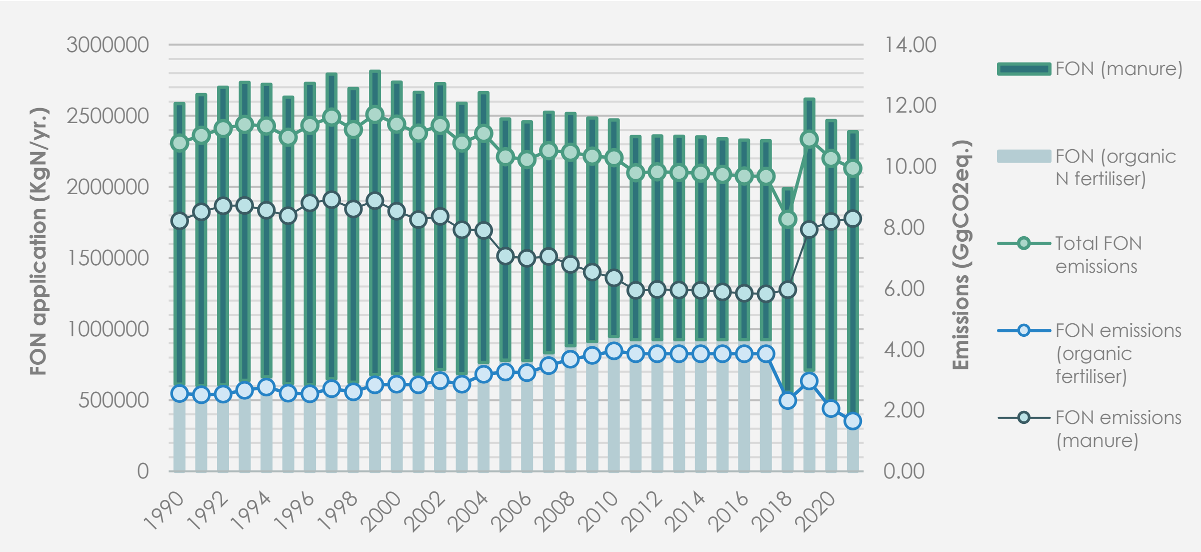


Figure 5-8 Organic N fertiliser application and related emissions.

The study carried out by the Ministry for Agriculture, Fisheries and Animal Rights also collected data on organic fertiliser imports Figure 5-9.

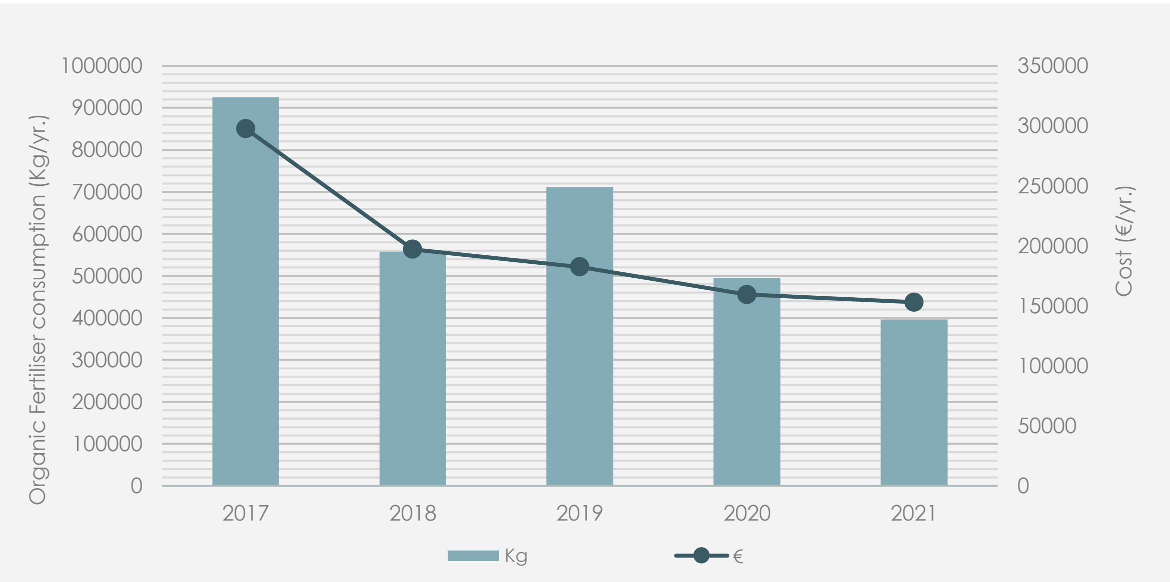


Figure 5-9 Organic fertiliser consumption and cost for the years 2017 - 2021

Since this data is available only for 2017 – 2021, data was extrapolated using the surrogate method, based upon animal manure nitrogen available for application to soils.

The amount of nitrogen remaining in manure after direct and indirect emissions accounted for within section 3.B., is the amount of nitrogen used for estimation of emission from agricultural soils. There is no other use of manure since manure is neither burnt nor used for construction. As explained in Chapter 5.3, the method used is taken from the 2019 IPCC Refinements, equations 10.34, 10.34A and 10.34B.

Equation 10.34 of the 2019 IPCC Refinements is used for the estimation of managed manure N available for application to managed soils, while equation 10.34A of the 2019 IPCC guidelines is used to estimate the fraction of managed manure N lost prior to application to managed soils ($FRAC_{LOSS}$) and equation 10.34B is used to estimate the $FRAC_{N2}$.

Equation 10.34 Managed manure N available for application to managed soils (kgN/yr)

$N_{MMSAVB} = S([(N_T*Nex*AWMS+N_{cdgs})*(1-Frac_{Loss})]+[N*AWMS*N_{bedding}])$

As previously explained, the equation given by the IPCC guidelines assumes that 100% of the swine slurry is applied to soils. This is not the case in Malta, given that up to 2010, only 1% of slurry was allowed to be applied to soils, whereas only 0.05% of slurry was allowed to be applied to soils since 2011, as required by the Nitrates Directive. This would lead to an overestimation in the $Frac_{Loss}$ and therefore in the amount of N available for application to soils. For this matter, for swine, only the actual fraction of slurry applied to soils is transferred to 3D. The rest of the slurry is accounted for under the Waste Sector, as it is taken to Sant' Antnin Treatment plant where it is treated.

Equation 10.34A Fraction of managed manure N lost prior to application to managed soils

$FRAC_{LOSS} = FRAC_{GAS} + FRAC_{LEACH} + FRAC_{N2} + EF_3$

Equation 10.34B Estimation of $FRAC_{N2MS}$

$FRAC_{N2} = R_{N2(N20)} + EF_3$

The molecular nitrogen (N2) loss from manure management (R_{N2_N20}) is taken as the default value 3 kgN_2-N($kgN_2$0-N)$^{-1}$ given in table 10.23 of the 2019 IPCC Guidelines.

Note: Malta's Nitrates Action Plan, relative to the requirements laid down by *Directive 91/676/EEC*, prohibits the application of untreated sewage sludge to the fields. In this regard, sewage sludge applied to soils is reported as "*Not Occurring*". It is not the common practice in Malta to apply organic N fertilizers other than animal manure. Sewage sludge from wastewater treatment is disposed in landfills. Any untreated wastewaters are also disposed of at sea. Anaerobic digestions have replaced mass composting, other than any small-scale composting that may take place in households for own use). Additionally, rendering of animal waste is not practiced in Malta but rather such waste is incinerated. Therefore, any other types of wastes are not known to occur in Malta and are thus being reported as "*Not Occurring*".

*Note on Anaerobic digestion: The Malta Mechanical Biological Treatment Plant (MBT) is the anaerobic digestor in Malta. It has started its operation in 2016 by treating municipal solid waste (MSW) and animal manure. The MBT addresses waste management through three different sections: the Mechanical Treatment Plant (MTP) where MSW is segregated into five fractions (organic waste, ferrous and non-ferrous metals, refuse derived fuel (RDF) and rejects); the Materials Recovery Facility (MRF) where the recyclable items from bring-in-sites and recycling bags are separated to be sold abroad for recycling; and Anaerobic Digestion Plant (AD Plant)/Biogas Plant in which the organic waste (from MTP) undergoes a fermentation process in closed vessels, and gas is produced.

5.5.2.1.3 Nitrogen in Crop Residues Returned to Soils

Calculations of the amount of nitrogen available from crop residues were based on the information in Table 11.2 of the 2019 IPCC refinements for the main crops under the categories listed: 1. *non-N fixing grain crops*, 2. *N-fixing grains and pulses*, 3. *Root and tuber crops*, 4. *N-fixing forage crops* and 5. *Other forages / perennial grasses*. In practice this includes wheat, barley, beans, chickpeas, sulla, peas, potato, carrots, any other vetch.

The approximate yield (in terms of weight of dry matter per hectare) for each of the main crops considered was obtained from different sources, using national data wherever possible. Country-specific data on crop yields was in fact obtained for wheat, barley and sulla [Vella, S., 1997] and for potato [Vella, S., 2003]. Parameters and equations used in the crop residue estimations are given in Table 5-23 and Table 5-24.

Table 5-23 Parameters used in crop residue estimations (IPCC 2006)

Crop Type	Slope	Intercept	CropT	NAG	NBG
Wheat	1.51	0.52	4534.6	0.006	0.009
Barley	0.98	0.59	5446.8	0.007	0.014
Sulla	0.29	0	3973.8	0.02	0.019
Potato	0.1	1.06	5060	0.019	0.014
Carrot	1.07	1.54	4800	0.016	0.014
Bean	1.13	0.85	4500	0.008	0.008
Other fodder	1.13	0.85	455	0.008	0.008

The estimation of nitrogen in crop residues follows the Tier 1 methodology given in the IPCC guidelines, as indicated below.

Equation Crop yield wheat, barley and sulla

$Crop_T = (DMY*1000)/100$

Equation 11.7 Crop yield potato and carrot

$Crop_T = Yield * DMC$

Equation 11.2 Above Ground Dry Matter

$AGDM = Crop_T*slope+intercept$

Equation Ratio of above ground dry matter

$RAGT = AGDM*1000$

Equation Ratio of below ground dry matter

$RBGT = (AGDM*1000+Crop_T)/Crop_T$

Equation Above Ground Dry Matter

AGDM = $(RAG_T+Crop_T)/Crop_T$

Equation Annual amount of N in crop residues

FCR = CropT*CropArea*((RAG*NAG)+(RBG*NBG)

Table 5-24 Parameters and equations used in emissions from crop residues.

Parameter	Source
Areas	NSO/FAOSTAT Time series data (1990-X-2)
Average N rate	Worked out based on application and consumption data and calculated on change in UAA Time series data (1990-X-2)
Average FSN	
CropT (wheat, barley, sulla)	DMY (Vella, 1997)
CropT (potato)	Yield (Vella, 2001), DMC (IPCC 2006)
CropT (carrot)	Yied (manuale di concimazione in NS0 2017), DMC (IPCC 2006)
CropT (bean)	DMC (IPCC) Assumed in accordance to low yield levels reported from other countries; no data for MT
AGDM	Table 11.2
RAG(T)	Ratio of above ground residue dry matter to harvested yield for crop T (Table11.1A, IPCC 2006)
RBG(T)	Ratio of below ground residue dry matter to harvested yield for crop T (Table11.1A, IPCC 2006)
NAG	N content of above ground residue (Table11.1A, IPCC 2006)
NBG	N content of below ground residue (Table11.1A, IPCC 2006)
FCR (Annual amount of N in crop residues)	$FCR/10^6$

5.5.2.1.4 *Amount of Nitrogen mineralisation associated with loss of soil organic matter*

The amount of nitrogen mineralised due to changes in land-use areas are accounted for within the Cropland category of the LULUCF sector (chapter 6). Nonetheless N_2O losses associated with loss of soil organic carbon are considered for their contribution in direct emissions from managed soils. Refer to Section 6.5.2.1 for method description.

5.5.2.2 Nitrous Oxide Emissions

Default emission factors are used for the estimation of direct and indirect nitrous oxide emissions, applying Equations 11.1, 11.9 and 11.10 of the 2019 IPCC Refinements.

Equation 11.1 Direct N2O emissions from managed soils

$N2O_{Direct-N}$ = $N2O-N_{Ninputs}$

Where:

$N2O-N_{Ninputs} = [[(F_{SN}+F_{ON}+F_{CR}+F_{SOM})*EF_1]$

Only part of equation 11.1 is used since Malta does not have any F_{PRP}, F_R and F_{OS}.

The individual N addition emissions are estimated as follows:

Synthetic Fertiliser = $((F_{SN}*EF_1)*44/28)/10^6$

Animal Manure = $((F_{ON}*EF_1)*44/28)/10^6$

Crop Residue = $((F_{CR}*EF_1)*44/28)/10^6$

Mineralised N = $((F_{SOM}*EF_1)*44/28)/10^6$

For the estimation of direct emissions, the total nitrogen applied to soils is multiplied by the respective emission factor (EF_1) (table 11.1). In the case of the annual amount of N in crop residue retuned to soil, equation 11.1 of the 2019 IPCC refinements was used.

Indirect emissions due to volatilisation are estimated by first determining the amount of nitrogen that is volatilised from synthetic fertilisers and animal manure ($Frac_{GASF}$ and $Frac_{GASM}$ respectively). The resulting nitrogen amount is then multiplied by the relevant emission factor (EF_4).

Equation 11.9 N2O from Atmospheric deposition of N volatilised from managed soils

$N2O_{(ATD)}-N = [(F_{SN}*Frac_{GASF})+((F_{ON}*Frac_{GASM})]*EF_4$

Equation 11.10 N2O from N leaching/runoff from managed soils in regions where leaching/runoff occurs.

$N2O_{(L)-N} = (F_{SN}+F_{ON}+F_{CR}+F_{SOM})*FRAC_{Leach-(H)}*EF_5$

Leaching and run-off accounts for another source of indirect nitrous oxide emissions. Emissions are estimated by multiplying the total amount of N applied/returned to soils by $Frac_{Leach}$ and the relevant emission factor (EF_5). Table 5-25 gives the emission factors used in the estimation of N2O emissions from agricultural soils.

Table 5-25 Emission factors used in the estimation of N2O emissions from agricultural soils.

Parameter		Source	Value
EF4	Default EF for indirect N2O emissions from volatilisation	2019 IPCC Refinements Table 11.3	0.005
EF5	Default EF for indirect N2O emissions from leaching		0.011
FracGasF	Default EF for nitrogen loss due to volatilisation - fertiliser (kg NH3-N + Nox-N)		0.11
FracGasM	Fraction of livestock N excretion that volatilises as NH3 and Nox		0.21
FracLeach	Default EF for Nitrogen loss due to leaching		0.24

* *Emission factors have been updated to IPCC 2019 Refinements for the March 2023 Submission, to better reflect the circumstance of the agriculture sector and environmental conditions of the Maltese Islands.*

5.5.3 Uncertainties and time-series consistency

The uncertainty in this sector lies mainly with the application of nitrogen fertilizer to soils. At present, farmers are not obliged to report the Nitrogen applied to soils. Nonetheless, the Department of Agriculture within the Ministry for Agriculture, Fisheries and Aquaculture will be conducting a survey to find out the nitrogen that is applied to agricultural soils based upon the Fertilizer Plan. This exercise was planned to take place in 2021, and although no exact completion date can be provided at this point, it was assumed that it would be completed by end of 2021. Nonetheless, to this day, no results have yet been made available. Up to this point, for the purposes of the national greenhouse gas inventory, the uncertainty revolving around the use of fertilisers and the input from inorganic nitrogen to soils has been partially addressed through the re-estimation of nitrogen applied through the newly calculated utilised agricultural area and rate of application. Moreover, there were plans within the Agriculture Department, to conduct a study on the cattle and swine manure that is applied to soils. This will be invaluable in the validation of our calculations on the portion of animal manure that is applied to agricultural soils.

In relation to emissions from leaching, efforts have been made to determine the significance of the emissions risen from this leaching. It was found that precipitation is lower than evapotranspiration throughout most of the year and leaching is therefore unlikely to occur. However, the information available is inconclusive and thus, a conservative approach is taken, and emissions from leaching are estimated.

5.5.4 Category-specific QA/QC and verification

Wherever possible, data was verified with other sources, such as National statistics office data with FAOSTAT data. The inconsistencies in *Utilisable Agricultural Land Area* (UAA), *Fodder Crop Land* (FCL) and *Total Agricultural Land* (TAL), which were identified through a comparison of available data from NSO and FAOSTAT, have been addressed through changes in the methodology and revisions in the data. UAA values were taken from 2 data sources (NSO and FAOSTAT), while FCL and TAL were computed using Arable Land data, as well as UAA as surrogate data. In addition, some gaps in crop area data were filled using available FAOSTAT data.

5.5.5 CATEGORY-SPECIFIC RECALCULATIONS

Recalculations in this category were due to changes in the emission factors (EF4, EF5, FracLeach, FracGasMS and FracGasF – now being taken from 2019 Refinements), the subtraction of animal faeces, urine and manure collected separately and treated off-site from manure N available to soils (being accounted for already in the waste sector) due to the treatment of some manure in the Mechanical biological treatment plant, the revision in artificial fertilizer rates (resulting from availability of new data) and the addition of other organic Nitrogen to FON (i.e. organic fertilizer bought not including animal manure generated on local farms).

Table 5-26 A table of recalculations for the Agricultural Soils sector.

Year	Agricultural Soils 2023 NIR	Agricultural Soils 2022 NIR	Percentage change in reported emissions	Change
	Gg CO_2 eq.	Gg CO_2 eq.	%	Gg CO_2 eq.
1990	22.66	22.52	-0.01	-0.14
1991	22.00	21.86	-0.01	-0.14
1992	22.50	22.35	-0.01	-0.15
1993	22.93	22.77	-0.01	-0.15
1994	22.96	22.80	-0.01	-0.16
1995	22.52	22.36	-0.01	-0.16
1996	22.26	22.09	-0.01	-0.17
1997	23.22	23.04	-0.01	-0.17
1998	22.90	22.72	-0.01	-0.18
1999	23.47	23.29	-0.01	-0.18
2000	23.16	23.03	-0.01	-0.13
2001	23.14	23.00	-0.01	-0.14
2002	22.54	22.40	-0.01	-0.14
2003	22.36	22.18	-0.01	-0.17
2004	22.72	22.55	-0.01	-0.17
2005	21.40	21.22	-0.01	-0.19
2006	21.22	21.06	-0.01	-0.16
2007	21.84	21.67	-0.01	-0.16
2008	22.60	22.42	-0.01	-0.18
2009	23.05	22.86	-0.01	-0.19
2010	23.93	23.73	-0.01	-0.20
2011	24.02	23.83	-0.01	-0.19
2012	24.81	24.63	-0.01	-0.18
2013	25.58	25.41	-0.01	-0.16

2014	26.35	26.19	-0.01	-0.16
2015	26.99	26.83	-0.01	-0.16
2016	27.89	27.73	-0.01	-0.16
2017	28.56	28.40	-0.01	-0.16
2018	26.52	26.35	-0.01	-0.17
2019	28.77	25.99	-0.10	-2.78
2020	30.27	27.38	-0.10	-2.88
2021	29.11	26.30	-0.10	-2.81

5.5.6 *Category-specific planned improvements*

No further improvements are planned for this category, apart from any that may arise during the ESD or UNFCCC Reviews.

5.6 PRESCRIBED BURNING OF SAVANNAS (CRF 3E)

5.6.1 *Category Description*

This category does not occur.

5.6.2 *Methodological Issues*

Not applicable.

5.6.3 *Uncertainties and Time-Series Consistency*

Not applicable.

5.6.4 *Category-specific QA/QC and verification*

Not applicable.

5.6.5 *Category-specific Recalculations*

Not applicable.

5.6.6 *Category-specific planned Improvements*

Not applicable.

5.7 FIELD BURNING OF AGRICULTURAL RESIDUES (CRF 3F)

5.7.1 *CATEGORY DESCRIPTION*

In accordance with Standard B2 of the first set of national Good Agricultural and Environmental Conditions (GAEC) adopted for Malta (Rural Development Programme for Malta 2007 – 2013, Rural Development Department Ministry for Sustainable Development, the Environment and Climate Change, April 2013), stubble and vegetable residue should not be burnt in the field, except by order of the local Plant Health authorities in case of the presence of harmful pests and diseases. In view of this condition, there is no need to consider emissions arising from the burning of crop residues on the fields (Sammut & associates, 2015).

5.7.2 *METHODOLOGICAL ISSUES*

Not applicable.

5.7.3 *UNCERTAINTIES AND TIME-SERIES CONSISTENCY*

Not applicable.

5.7.4 *CATEGORY-SPECIFIC QA/QC AND VERIFICATION*

Not applicable.

5.7.5 *CATEGORY-SPECIFIC RECALCULATIONS*

Not applicable.

5.7.6 *CATEGORY-SPECIFIC PLANNED IMPROVEMENTS*

Not applicable.

5.8 LIMING (CRF 3G)

5.8.1 *CATEGORY DESCRIPTION*

The Maltese Islands are characterised by three main types of soils, all of which are largely alkaline in nature similar to the parent rock, the sedimentary rock (limestone). The Maltese Soil Information system (MALSIS) has identified calcisols as the dominant soil group in Malta. This soil group is characterised by the presence of secondary $CaCO_3$ concentrations as coating on soil structure faces. These lime-rich soils occupy 27% of the Maltese agricultural land areas, together with other lime-rich soil types [MALSIS, 2004 in SOER, 2005]. Moreover, Maltese Islands are composed entirely of Oligo-Miocene sedimentary rocks which are largely of marine biogenic origin. These are highly calcareous thus giving rise to alkaline soils with a pH generally ranging from 7.0 to about 8.5. (Lanfranco, n.d. [Vegetation of the Maltese Islands (maltawildplants.com)]). More information regarding the soil types of Malta can be found at Soil types (gov.mt).

Subsequently, due to the alkaline nature of the Maltese soils lime application is not required. Therefore, this category is reported as not occurring.

5.8.2 Methodological Issues

Not applicable.

5.8.3 Uncertainties and Time-Series Consistency

Not applicable.

5.8.4 Category-specific QA/QC and verification

Not applicable.

5.8.5 Category-specific Recalculations

Not applicable.

5.8.6 Category-specific planned Improvements

Not applicable.

5.9 UREA APPLICATION (CRF 3H)

5.9.1 Category Description

Data on urea imports through customs is not disaggregated by end use. Unfortunately, there is no record being kept in Malta of how much of the imported Urea is purchased for agricultural use due to confidentiality/data protection reasons.

It is known that most likely the bulk of urea imports goes towards utilisation by the IPPU generation sector, which we have confirmed with the IPPU. Previous investigations on the urea data from FAOSTAT and EUROSTAT found that the data did not indicate which part of the imports were for agricultural use and which were for IPPU/Energy Use.

Existing data reported by FAOSTAT for urea imports quantity and agricultural use, and urea and ammonium nitrate solutions import quantities and agricultural use can be observed in Table 5-27. The data clearly shows that the import quantity of both Urea and UAN is being allocated to agriculture. However, this is not the case, since it is known that urea is used in the road transport. Thus, using these values to calculate emissions from urea in agriculture would result in double counting, since they are already being reported under IPPU Sector. The emissions from urea consumption in Road is reported under IPPU, however the values are calculated by the COPERT model using vehicle stock used in Energy.

The issue of data unavailability was discussed with the National Statistics Office (on 04/02/2020) who will be including a question in their census to investigate the amount of urea applied to soils. The next census, however, will be carried out in 2026. From a survey carried out in 2014 it results that urea utilised for agricultural purposes amounted to 60kg in 2010, 360kg in 2011, and 750kg in 2012. Resulting emissions are therefore 0.044t CO_2 in 2010, 0.264t in 2011, and 0.55t in 2012. These estimates represent a minute share of national totals. The survey has not been repeated after 2014, and there are no plans for another survey to be carried out. Therefore, reporting these 3 years would create an issue with the values for other years where no data is available.

Considering all the above, this category is reported as not estimated.

However, we will keep investigating those sources for a possible indication.

Table 5-27. Urea and UAN import quantities and Agricultural use (tonnes) reported by FAOSTAT.

Year	Urea		Urea and ammonium nitrate solutions (UAN)	
	Import Quantity	Agricultural Use	Import Quantity	Agricultural Use
1990-2001	N.D.	N.D.	N.D.	N.D.
2002	N.D.	N.D.	2.14	2
2003	3.18	3	N.D.	N.D.
2004	0	N.D.	N.D.	N.D.
2005	0	N.D.	N.D.	N.D.
2007	19.39	19.39	N.D.	N.D.
2008	14.67	14.67	N.D.	N.D.
2009	10.77	11	N.D.	N.D.
2010	37.95	37.95	5	5
2011	312.52	312.52	N.D.	N.D.
2012	3431.83	N.D.	N.D.	N.D.
2013	6398.5	N.D.	0.05	N.D.
2014	7698.85	N.D.	N.D.	N.D.
2015	8046.67	N.D.	0.05	N.D.
2016	4027.12	N.D.	N.D.	N.D.
2017	809.51	N.D.	3.23	N.D.
2018	972.63	N.D.	2.41	N.D.
2019	1209.92	N.D.	1.82	N.D.

2020	1693.31	N.D.	0.62	N.D.

*N.D. No Data

5.9.2 METHODOLOGICAL ISSUES

Not applicable.

5.9.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Not applicable.

5.9.4 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

Not applicable.

5.9.5 CATEGORY-SPECIFIC RECALCULATIONS

Not applicable.

5.9.6 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

Not applicable.

5.10 OTHER CARBON-CONTAINING FERTILIZERS (CRF 3I)

5.10.1 CATEGORY DESCRIPTION

This category does not occur.

5.10.2 METHODOLOGICAL ISSUES

Not applicable.

5.10.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Not applicable.

5.10.4 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

Not applicable.

5.10.5 Category-specific recalculations

Not applicable.

5.10.6 Category-specific planned improvements

Not applicable.

5.11 OTHER (CRF 3J)

5.11.1 Category Description

This category does not occur.

5.11.2 Methodological Issues

Not applicable.

5.11.3 Uncertainties and time-series consistency

Not applicable.

5.11.4 Category-specific QA/QC and verification

Not applicable.

5.11.5 Category-specific recalculations

Not applicable.

5.11.6 Category-specific planned improvements

Not applicable.

CHAPTER 6 LULUCF

LAND USE, LAND USE CHANGE & FORESTRY

6.1 OVERVIEW OF SECTOR

In this chapter emissions and removals of greenhouse gases from the Land Use, Land-Use Change and Forestry (LULUCF) sector, and methodologies used to estimate emissions/removals by each source/sink category are presented. The calculations for this sector were formulated using the '2006 IPCC Guidelines for National Greenhouse Gas Inventories', the '2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories' following 'Volume 4: Agriculture, Forestry and Other Land Use', and '2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands' applied for the relevant categories of this sector. Expert judgment, in accordance with the 'Elicitation Protocol' as described in Chapter 2 Approaches to Data Collection of the 2006 IPCC Guidelines, was also considered, in view of the assistance provided from LULUCF expert reviewers and consultants in the contribution of the compilation of methodologies and estimations in the LULUCF sector. The categories described in the IPCC Guidelines for estimating and reporting emissions and removals of greenhouse gases are based on the six top-level land-use categories: (1) Forest Land, (2) Cropland, (3) Grassland (4) Wetlands (5) Settlements and (6) Other Land.

The Malta national LULUCF sector has undergone various updates throughout the past years. In 2014-2015, the Malta Resources Authority sub-contracted the Institute for Climate Change and Sustainable Development of the University of Malta a project to produce a detailed map of Malta's land use for the purposes of maintaining the GHG Emission Inventory and reporting obligations to the UNFCCC. The Institute produced a national scale land use map for the Maltese Islands, which allowed the production of specific, more accurate and reliable data about land use change at national level. The Institute proposed the establishment of a National Land Use Map through a pilot project which identified the national classification system, cartographic parameters, and nomenclatures for the LULUCF map and the development of the first land use map and respective methodology.

In order to achieve the objective to develop the National Land Cover Map for the Maltese Islands, the Institute implemented the CORINE Land Cover methodology performed by the European Environment Agency. However, some key aspects were modified to adapt the process to the Maltese geography and land use singularity. The key aspects of the project included:

- Sources of the data – aerial images, satellite images, topographic maps, thematic maps, inventories, statistical information of land cover, digital elevation model, etc.
- Cartography parameters – mapping scale, minimum mapping unit, spatial reference, image file format.
- National Land Use Nomenclatures – levels, categories and definitions for the national classification.

Research into these key aspects have assisted in defining the classification (land use categories used for the map), the National Land Use Nomenclatures and the subsequent methodology for the LULUCF national system. The fact that the CORINE project scale was 1:100.000 and the minimum mapping unit is 25ha makes the spatial resolutions of these satellite images good enough for the European CORINE project. However, for a Maltese map with a larger scale (around 1:10.000) and smaller minimum mapping unit (around 0.5ha.), a more detailed spatial resolution was required. Thus, to perform a very detailed photointerpretation, the spatial resolution of the image had to be as detailed as possible. The ortho-aerial image of Malta produced by Terra Image under the European Regional Development Fund for Malta 2007-2013 was used for this task. The images were acquired in 2012 and have a spatial resolution of 15cm. (0.15m). Each pixel in the image represents a surface of 15 square centimetres.

The land use data was mainly extracted and calculated through visual photo interpretation. A well-trained image interpreter identified objects and judges their uses according to basic principles: location, size, shape, shadow, tone/colour, texture, pattern, height/depth and site /situation/association. In terms of methodology, interpretation combined fieldwork and computer work. Field interpretation involved either complete or selective examination of the area, and determination of the necessary information by direct study of the objects to be interpreted. Once the land use classification was defined, the image interpreter identified and assigned a class attribute to a certain area delimited by a polygon according to elements within the area. The Institute made use of satellite images from the following satellites for the purposes of this project – GeoEYE, Quickbird and RapidEye. Each one represented different resolutions and images which have been taken at different times. By means of the basic colours red, green and blue (RGB) it was possible to construct several band combinations in which the colours identified the parts of the spectrum that are represented by the three RGB colours. This further enhanced the data capture for the LULUCF Map. Further detailed information about this project can be found in the final report entitled 'Assess land use change through the use of map layering from the CORINE Land Cover data for the years 1996, 2000 and 2006' (Sanz & Attard, 2015), published by the same Institute.

Further updates to the LULUCF sector followed as a result of the UNFCCC in-country review which was conducted in October 2016, as well as the latest in-country capacity building support offered by the contractors (also referred as project experts) in co-ordination with the European Commission (EC) and Joint research Centre (JRC), under the project Technical Support for capacity building in Member States to implement Forest Reference Levels and improvements of greenhouse gas inventories conducted throughout 2018 and 2019.

The purpose of this project was to provide technical support to Malta in the preparation of the National Forestry Accounting Plan (NFAP) & Forest Reference Level (FRL) for 2021-2025 (Task 1) pursuant to Article 8(3) of Regulation (EU) 2018/841, and of GHG inventories of emissions and removals needed for accounting under the same Regulation (Task 2). The support under both tasks were hold in 2018 and 2019. The review and the capacity-building support in-country visit tasks have led for the planning for a more accurate representation of the Maltese LULUCF sector. The information pertaining to the updates recommended and formulated during the Task visits were based on the assistance and recommendations provided by the contractors, Commission and JRC. More details and further discussion of the status and the planning of these updates are mentioned in this NIR, based on the analysis and conclusions from the Capacity Building Plan report developed by the project experts.

The in-country visits served to assist significantly and provide recommendations to improve the LULUCF sector of Malta, whereby, to streamline the work involved with the stakeholders and entities which are relevant to gather data collection, and to coordinate the data and information which is currently present, as well as gathering other relevant data from international institutes, which is necessary to be utilised to compile the LULUCF chapter in this report. The Task 1 visit on the capacity building support with regards to the establishment of the NFAP and the FRL for Malta served to be an effective streamlining exercise to the GHG Inventory LULUCF sector, more specifically on the Forest Land category. The Expert Team from the 'International Institute for Applied Systems Analysis' (IIASA) and from the Commission assisted the LULUCF sector team of Malta to analyse the Forest Land category better through implementation of new national data and incorporate it with the methodology and modelling necessary to develop the NFAP and establish the FRL, and as a result integrating directly the data to the Forest Land category.

Moreover, Task 2 saw a similar approach to the project exercise, whereby information and data from the relevant stakeholders and entities, as well as data from other sources can be streamlined to accurately and transparently improve the LULUCF reporting of the GHG Inventory. The visit was supported by the contractors, also referred to project experts, in co-ordination with the European Commission and the JRC under the above-mentioned project. The visit served to assist Malta to prioritise and identify the main issues required to be improved in the LULUCF sector reporting. Four main issues were identified and evaluated by the project experts through discussions with the Maltese inventory compilers, which as a result recognised as highest priority to be assessed and addressed:

- Issue 1: Improve the spatially-explicit land use representation and the consistency across the land use categories.
- Issue 2: Improve the reconstruction of the historical land use matrix.
- Issue 3: Improve the representation of land use sub-categories, management practices and emission factors in Cropland and Grassland.
- Issue 4: Improve the representation of Forest Land based on new data sources.

In summary, the key outcomes of the capacity building support visit and recommendations provided by the project experts were the following:

a. There is an opportunity to combine existing datasets from different national sources, as well as European sources, for creating a complete spatial explicit representation of land use and tracking changes over time in Malta.

b. A historical reconstruction of the land use matrix can be obtained by considering different spatial datasets; verification of their accuracy is essential before combining them and consistently integrating the historical information on a national grid hosting the current, past and future land uses.

c. Use of spatial information from the Land Parcel Identification System (LPIS)/integrated administration and control system (IACS), Nitrate Directive Registry, data from other national entities and European datasets can improve the representation of Cropland and Grassland, the application of IPCC methodologies and the selection of more accurate parameters in the calculation of GHG emission.

d. Malta can improve the representation of Forest Land for reaching consistency between the GHG Inventory and the submitted FRL; this can be achieved by means of the spatial explicit mapping of land uses converted to forest land.

During 2021 a collaboration project was started together with the Malta College of Arts, Science & Technology (MCAST), to address the issue of achieving a complete spatial explicit representation of land use and tracking changes over time in Malta. This includes data related to land and land use imagery and land statistics for the determination of the areas for each category as activity data, including among others, imagery of the Maltese Islands, Copernicus datasets and national statistics. The project in question is in the generation of the Land-use and Land coverage (LULC) mapping of the Maltese Islands.

A number of requirements were identified including revisions of previous LULC dating back to 1990. For this reason, a multi-phase approach was recommended by MCAST. The first phase addresses the generation of the LULC 2020. MCAST proposed the use of remote sensing to address this need, specifically the Sentinel-2 satellite from the European Space Agency (ESA) Copernicus Programme, to gather the necessary products in 2-day intervals so to average the LULC properly. The success of the first phase serves as a pre-cursor for the subsequent phases which address past LULC year coverages as well as future reporting. The multi-phase proposal being presented is indicated in Table 6-1.

Table 6-1 Project phases

Phase	Scope	Period	Description
01	2020	June 2021 – December 2021	LULC 2020 generation
02	2022	January 2022 – December 2022	LULC 2022 with ground truthing and corrections to Sentinel-2 based LULC creation
03	2016+	January 2023 – December 2023	Automation of Sentinel-2 based LULC creation
+	1990-2016	TBA	Research in creation of past LULC with different satellites available for study period

Prior to the formulation of this proposal, a proof-of-concept has been created for some areas for one specific day in 2020. This has validated the use of the proposed technology, showcasing the possible extension to the current-state-of-the-art (CSOTA) as well as having presented a number of issues which would need to be addressed during regular meetings amongst the team.

The survival of satellites ranged from 5-7 years and therefore different satellites need to be used when addressing past years, which obviously have varying technology specifications offering different accuracy levels. A second important point to be noted is the importance of ground truthing, meaning the gathering of in-situ evidence to validate remote sensing data. This can be undertaken in future phases for future reporting such as LULC 2022 reporting. More detailed information can be found in the project report (Scerri, Inguanez & Bonello, 2021).

During the previous submission, the LULUCF sector has undergone updates with regards to the land use matrix. The LUM was developed further to better represent the land use representation, in view of the implementation of the new updates, based on the 2018 and 2020 land use imagery developed during the project in collaboration with MCAST. The LUM updates were performed with the assistance of consulting experts from Aether Limited. As a result, noting the revision in the land use matrix to better represent the different land use categories of Malta and the conversion within the years, the estimations for the LULUCF time-series were recalculated. The relevant revisions in the LULUCF sector are indicated in more detail in their respective sections. For this year's submission the reporting areas were further updated, based on the implementation of the imagery and statistical areas from the relevant national authorities. In view of this, the estimations for the total timeseries were revised. As a result, the changes in the total trends for the timeseries are not substantial, in which it follows a similar trend to the previous year.

The compilation of this chapter followed specific quality assurance and quality control procedures, following the established Quality Management System of the National GHG Inventory of Malta. Moreover, uncertainties were estimated pertaining to the information provided to calculate emission and removals in this sector. As for every submission performed, for this year's submission the emissions and removals were calculated utilising spreadsheets specifically made to manually insert the values for the time series from 1990 to 2022.

6.1.1 EMISSION AND REMOVAL TRENDS

Starting from the 2023 submission of the National GHG Inventory Report and subsequent inventory submissions, the Governance Regulation shall apply. Member States have to report to the Commission using the Global Warming Potentials (GWP) adopted from the IPCC Fifth Assessment Report (AR5). In view of this, the reporting of estimations have shifted from the Fourth Assessment Report (AR4) GWPs to AR5 GWPs. Table 6-2 represents the GWP values as adopted in the AR4 and AR5 for the reported gases.

Table 6-2 Global warming potential (GWP) values

Gas	GWP values for 100-year time horizon	
	IPCC Fourth Assessment Report (AR4)	IPCC Fifth Assessment Report (AR5)
Carbon dioxide (CO2)	1	1
Methane (CH4)	25	28
Nitrous oxide (N2O)	298	265

The Land Use, Land-Use Change and Forestry (LULUCF) sector can contribute to both emissions (from sources) and removals (through sinks) of kt CO_2 equivalent. Using the AR5 GWPs, the sector accounted for 0.77 kt of CO_2 equivalent emissions in 2022.

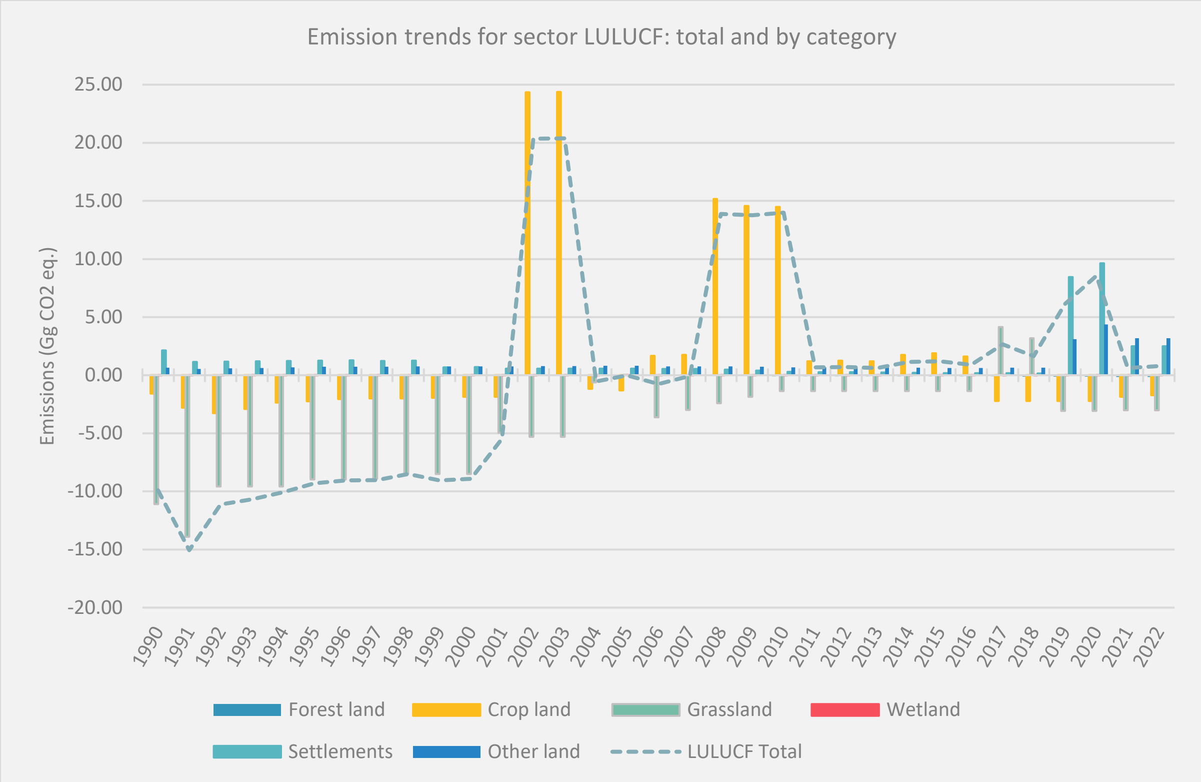


Figure 6-1 Total emissions/removals trends for the LULUCF sector (kt CO_2 eq. – AR5 GWPs)

CO_2 is the main greenhouse gas emission source and sink from the various categories. Non-CO_2 emissions also occur in the sector including N_2O and CH_4. From the figure one can notice the trend for some categories varying throughout the years. This is mainly due to some large area conversions occurring in the categories, which lead to high emissions in certain years.

Further description of trends corresponding to the LULUCF sector emissions/removals are explained in Chapter 2 section 2.3.5.

More detailed information on the estimations of each category is presented in subsequent sections. The estimations in each category are presented in **AR5 GWPs** in the respective category chapters.

Table 6-3 includes the total GHG emission/removal estimates for each category for the LULUCF sector for the period 1990-2022 in AR5 GWP.

Table 6-3 GHG emissions/removals by category in the LULUCF sector for 1990-2022 using AR5 GWP (kt CO_2 eq.)

	A. Forest Land	B. Cropland	C. Grassland	D. Wetlands	E. Settlements	F. Other Land	G. HWPs	Total LULUCF
1990	-0.013	-1.583	-11.082	-0.015	2.131	0.656	NO	-9.906
1991	-0.013	-2.805	-13.906	-0.015	1.147	0.535	NO	-15.058
1992	-0.012	-3.264	-9.586	-0.015	1.173	0.582	NO	-11.123
1993	-0.012	-2.900	-9.586	-0.015	1.199	0.628	NO	-10.686

1994	-0.011	-2.368	-9.586	-0.015	1.225	0.675	NO	-10.080
1995	-0.011	-2.258	-8.979	-0.015	1.251	0.717	NO	-9.295
1996	-0.010	-2.042	-8.979	-0.015	1.275	0.717	NO	-9.055
1997	-0.010	-2.011	-8.928	-0.015	1.228	0.722	NO	-9.015
1998	-0.009	-1.989	-8.503	-0.015	1.254	0.769	NO	-8.494
1999	-0.009	-1.956	-8.503	-0.015	0.672	0.769	NO	-9.042
2000	-0.008	-1.849	-8.503	-0.015	0.699	0.770	NO	-8.907
2001	-0.008	-1.849	-4.947	-0.015	0.558	0.770	NO	-5.484
2002	-0.008	24.357	-5.296	-0.015	0.558	0.771	NO	20.354
2003	-0.008	24.373	-5.296	-0.015	0.558	0.782	NO	20.381
2004	-0.081	-1.184	-0.605	-0.015	0.558	0.808	NO	-0.532
2005	-0.082	-1.309	0.015	-0.015	0.558	0.819	NO	-0.028
2006	-0.082	1.660	-3.610	-0.015	0.533	0.765	NO	-0.762
2007	-0.083	1.739	-2.978	-0.015	0.530	0.762	NO	-0.058
2008	-0.083	15.162	-2.407	-0.015	0.469	0.750	NO	13.862
2009	-0.084	14.558	-1.837	-0.015	0.408	0.737	NO	13.754
2010	-0.084	14.482	-1.354	-0.014	0.292	0.679	NO	13.989
2011	-0.085	1.199	-1.354	-0.014	0.271	0.668	NO	0.672
2012	-0.085	1.254	-1.354	-0.014	0.250	0.657	NO	0.695
2013	-0.086	1.201	-1.354	-0.014	0.228	0.645	NO	0.608
2014	-0.086	1.759	-1.354	-0.014	0.207	0.634	NO	1.133
2015	-0.108	1.875	-1.354	-0.014	0.186	0.622	NO	1.195
2016	-0.109	1.622	-1.354	-0.014	0.165	0.611	NO	0.908
2017	-0.109	-2.226	4.170	-0.014	0.183	0.655	NO	2.646
2018	-0.112	-2.226	3.186	-0.014	0.162	0.645	NO	1.628
2019	-0.116	-2.226	-3.061	-0.014	8.454	3.096	NO	6.120
2020	-0.135	-2.226	-3.061	-0.014	9.620	4.372	NO	8.543
2021	-0.142	-1.867	-3.008	-0.014	2.480	3.176	NO	0.625
2022	-0.149	-1.735	-3.008	-0.014	2.482	3.195	NO	0.772

Table 6-4 shows the total GHG emission/removal estimates share by gas in AR5 GWP.

Table 6-4 GHG emissions/removals by gas in the LULUCF sector for 1990-2022 using AR5 GWP (kt CO_2 eq.)

	CO_2	N_2O	CH_4
1990	-10.255	0.321	0.027
1991	-15.411	0.326	0.027
1992	-11.428	0.278	0.027
1993	-10.994	0.281	0.027
1994	-10.390	0.283	0.027
1995	-9.601	0.279	0.027
1996	-9.359	0.277	0.027
1997	-9.313	0.271	0.027
1998	-8.793	0.272	0.027

1999	-9.300	0.230	0.027
2000	-9.166	0.232	0.027
2001	-5.697	0.186	0.027
2002	20.130	0.197	0.027
2003	20.145	0.208	0.027
2004	-0.769	0.210	0.027
2005	-0.264	0.208	0.027
2006	-0.986	0.196	0.027
2007	-0.271	0.186	0.027
2008	13.663	0.172	0.027
2009	13.569	0.157	0.027
2010	13.855	0.134	-
2011	0.540	0.132	-
2012	0.565	0.130	-
2013	0.480	0.128	-
2014	1.005	0.128	-
2015	1.067	0.128	-
2016	0.781	0.127	-
2017	2.510	0.136	-
2018	1.477	0.151	-
2019	5.751	0.369	-
2020	7.955	0.588	-
2021	0.036	0.590	-
2022	0.193	0.579	-

6.1.2 METHODOLOGY

The estimations of GHG emissions and removals from the LULUCF sector are based on the methodologies and assumptions as suggested by Volume 4 of the '2006 IPCC Guidelines for National GHG Inventories', Volume 4 of the '2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories', and 'Wetlands 2013 Supplement to the 2006 IPCC Guidelines for National GHG Inventories'. Moreover, specific assistance was also derived from the JRC, and from Technical Expert Reviewers and consultants such as Aether Limited.

The data and information utilised to compile the LULUCF sector was derived from National Statistics Office (NSO) of Malta, Corine Land Cover (CLC) land use maps, as well as local and national reports, both acquired from national entities and from online sources, as well as data sheets. Moreover, activity data on areas were acquired from MCAST through the development of the land use maps of Malta. Table 6-5 below presents the data providers list for the data necessary to compile the LULUCF chapter.

Table 6-5 Data providers list

Description	Provider	Source
Forest Land areas	Accessed online	Buskett SAC map, Ballut SAC map, North West Local Plan, PA geoserver website
	Environment Resource Authority	Datasheets & expert judgement
	Ambjent Malta	Datasheets
	BirdLife	Foresta 2000 Datasheets
	Accessed online	News articles
	Malta College of Arts, Science & Technology & European Space Agency (ESA) Copernicus Programme	Land use cover and changes maps
Annual and Perennial Cropland areas	National Statistics Office (Malta)	Agriculture Census 2001, Agriculture Statistics 2000-2014, NSO statistics
	Malta College of Arts, Science & Technology & European Space Agency (ESA) Copernicus Programme	Land use cover and changes maps
Maquis and Other Grassland areas	Planning Authority	Corine Land Cover maps
	Malta College of Arts, Science & Technology & European Space Agency (ESA) Copernicus Programme	Land use cover and changes maps
Wetland areas	Accessed online	PA geoserver website, Ramsar information sheets
	Malta College of Arts, Science & Technology & European Space Agency (ESA) Copernicus Programme	Land use cover and changes maps
Settlement areas	Planning Authority	Corine Land Cover maps
	Malta College of Arts, Science & Technology & European Space Agency (ESA) Copernicus Programme	Land use cover and changes maps
Other Land areas	Planning Authority	Corine Land Cover maps
	Malta College of Arts, Science & Technology & European Space Agency (ESA) Copernicus Programme	Land use cover and changes maps

Since national information on emissions factors is not available, default information from the IPCC Guidelines were utilised, as well as data related to Mediterranean Emission Factors from Mediterranean countries sourced from the LIFE Project MediNet (Canaveira, et al., 2018), which have closer land conditions to the Maltese conditions. For this year's submission the land use representation was updated to reflect new updates in the land categories. Further detail and information are presented in the upcoming sections of this chapter.

6.1.2.1 Key Categories

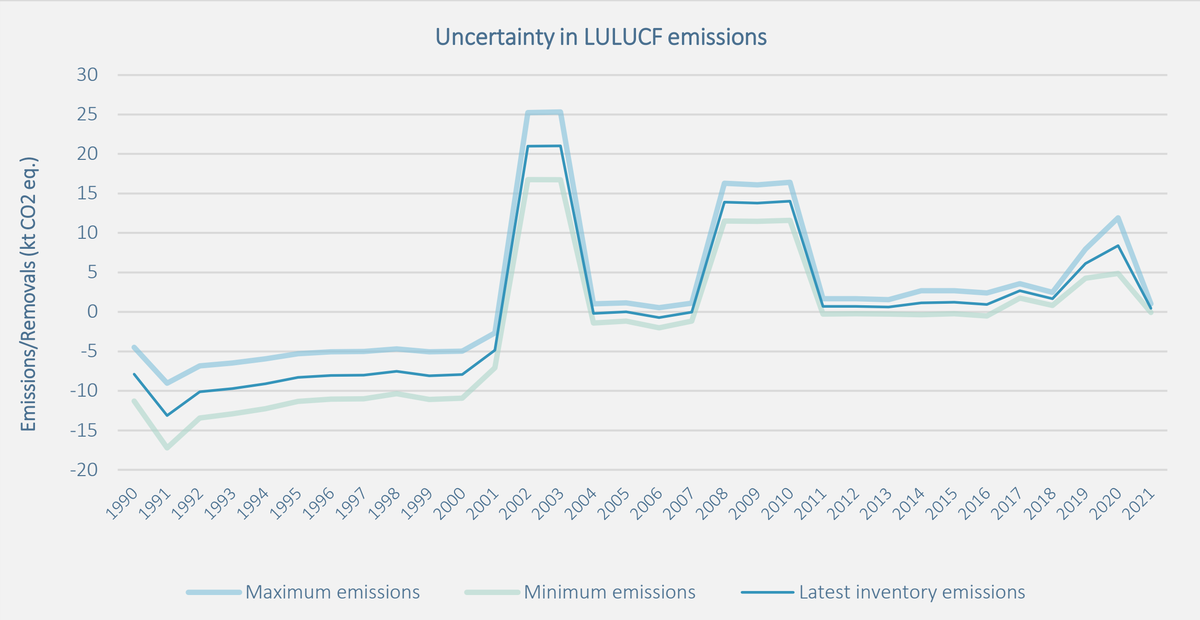
A key source/sink category is defined in the IPCC Guidelines as 'one that is prioritised within the national inventory system because its estimate has a significant influence on a county's total inventory of greenhouse gases in terms of absolute level, the trend, or the uncertainty in emissions and removals.' There are no Level Assessment key categories within the LULUCF sector. Category Grassland is key in the Trend Assessment Approach 2 in year 2022. The decrease in trend in category Grassland arises due to the decreasing 20-year cumulative area, in which this conversion amounts to a considerate rate of biomass C stock in category Grassland, thus decreasing the trend in biomass stock in that conversion. Noting that the emissions/removals from the LULUCF sector are significantly small, further prioritisation of resources will not be given due attention at the moment.

6.1.2.2 Uncertainty

The uncertainty analysis was developed based on estimations from previous submissions and compared to the present one. Uncertainty was also analysed on the emission factors utilised for the calculations as well as the activity data used.

The uncertainty analysis was analysed by comparing the trends from past inventories to the latest inventory. The trends from the period of 1990 to the latest submission period of 2022 were selected, starting from the inventory submission from the past 5 years i.e., 2020 to the current inventory submission of 2024. The uncertainty was calculated by applying a maximum and a minimum value of trend time-series. The time-series trend averages, standard deviation and count were computed, to then calculate the uncertainty levels. The uncertainty in the trends were calculated by dividing the sum of the standard deviation by the square root of the count, and the percentage in the uncertainty was calculated by dividing the result of the uncertainty by the average. The maximum level of uncertainty was then calculated by adding up the uncertainty level to the actual emission of the specified year, whereas the minimum level of uncertainty was calculated by subtracting the actual emissions to the result of the uncertainty. The results of the uncertainty analysis for the LULUCF sector is presented in Figure 6-2.

Figure 6-2 Uncertainty graph for the emissions in the LULUCF sector



The uncertainty analysis was also examined for the activity data used in the LULUCF sector. The primary activity data in this sector is the land area, which was derived from national statistics provided by the National Statistics Office, the Corine Land Cover (CLC), reports, and areas acquired from the development of the land use maps of Malta.

Based on expert judgement, it is assumed that NSO data on land areas might present a 15% source of uncertainty due to some inaccuracies in human error. The CLC contains a range of approximately 15% uncertainty as well, which is referenced from the CLC website and quoted as "Two European validation studies have shown that the achieved thematic accuracy is above the specified minimum (85 %)" (Source: http://land.copernicus.eu/pan-european/corine-land-cover/clc-2012). No national data on uncertainty is available currently on the CLC.

With reference to the Maltese land use maps, the overall classification by the Artificial Intelligence (AI) algorithm has an accuracy of 99.69%, a precision of 99.06%, and therefore an error rate of 0.31%. There is a confidence level/probability of 95% that the classification is correct within a range of 0.00245 to 0.0038. It must be noted that, following the AI classification, manual corrections were made to cater for the class definitions such as turning all grassland over the airport territory to built-up.

After satellite product acquisition, the team created several annotations for each class. These were used to train/teach an AI algorithm to recognize/classify the terrain in the various classes. When an AI algorithm is trained the data covered by the annotations and satellite products provided is split into training and testing. The training is used for the algorithm to learn, whilst the testing is used for evaluation purposes, from which the results are cited. Even though there are six classes, these are evaluated individually such that when evaluating a class, this is considered as the target class (positive) and all other classes are considered the other class (negative). After training, the AI algorithm is given the testing data where the evaluation asks the algorithm whether the subject area is the target class or not, thus comparing the response with the known value. The following terminology is used, for which the respective definitions are provided:

- **True Positive (TP)**: Study area is correctly recognized as being the target class.
- **True Negative (TN)**: Study area is correctly recognized as not being the target class.
- **False Positive (FP)**: Study area is incorrectly recognized as being the target class.
- **False Negative (FN)**: Study area is incorrectly recognized as not being the target class.

Using this terminology, a confusion matrix is created for each class from which metrices are generated.

Table 6-6 Confusion Matrix definition

Target Class			
		Predicted	
		Positive	Negative
Actual	Positive	True Positive	False Negative
	Negative	False Positive	True Negative

Table 6-7 Sample Confusion Matrix for Built-up class

Built-up			
		Predicted	
		Built-up	Non-Built-up
Actual	Built-up	826 (TP)	7 (FN)
	Non-Built-up	22 (FP)	3517 (TN)

The following metrices are generated from the results, which are shown in Table 6-8.

- **Accuracy** = (TP + TN) / (P + N)
- **Precision** = TP / (TP + FP)
- **Error Rate** = 1 – Accuracy

Table 6-8 Classification results

Class	TP	FP	TN	FN	Accuracy	Precision	Error Rate
Built-up	826	22	3517	7	99.34%	97.41%	0.66%
Cropland	830	4	3535	3	99.84%	99.52%	0.16%
Forest	619	4	3747	2	99.86%	99.36%	0.14%
Grassland	832	6	3533	1	99.84%	99.28%	0.16%
Other	821	5	3534	12	99.61%	99.39%	0.39%
Wetland	403	0	3953	16	99.63%	100.00%	0.37%
Overall	4331	41	21819	41	99.69%	99.06%	0.31%

To determine the confidence interval/range, Table 6-9 is used to obtain the confidence constant for a confidence probability/level of 95%. From which the confidence interval/range of 0.0024 and 0.0038 is obtained.

Table 6-9 Confidence level constant

Level	Constant
90%	1.64
95%	1.96
98%	2.33
99%	2.58

The information pertaining to the uncertainty analysis of the emission factors used is examined in the following sections of the specific LULUCF categories and sub-categories.

6.1.3 COMPLETENESS

Table 6-10 below indicates the completeness of the LULUCF sector by Method and Emission Factor per category for each gas (referred also in the CRF tables).

Table 6-10 Summary of methodologies used in the LULUCF GHGI, by land use category and gas

IPCC category	CO_2		N_2O		CH_4	
	Method	EF	Method	EF	Method	EF
A. Forest Land						
1. FL remaining FL	T1	D, OTH	NA	NA	NA	NA
2. Land converted to FL	T1	D, OTH	NA	NA	NA	NA
B. Cropland						
1. CL remaining CL	T1	D, OTH	NA	NA	NA	NA
2. Land converted to CL	T1	D, OTH	T1	D	NA	NA
C. Grassland						
1. GL remaining GL	T1	D, OTH	NA	NA	NA	NA
2. Land converted to GL	T1	D, OTH	NA	NA	NA	NA
D. Wetlands						
1. WL remaining WL	T1	D, OTH	NA	NA	NA	NA
2. Land converted to WL	T1	D, OTH	T1	D	T1	D
E. Settlements						
1. SL remaining SL	NA	NA	NA	NA	NA	NA
2. Land converted to SL	T1	D, OTH	T1	D	NA	NA
F. Other Land						
1. OL remaining OL	NA	NA	NA	NA	NA	NA
2. Land converted to OL	T1	D, OTH	T1	D	NA	NA
G. Harvested wood products	NA	NA	NA	NA	NA	NA

T1: IPCC Tier 1
D: IPCC Default
OTH: Other
NA: Not Applicable

6.1.4 CATEGORY SPECIFIC QA/QC PROCEDURES

The relevant quality checks for the LULUCF sector are carried out based on the principles of inventory Quality Assurance and Quality control plan. The procedures that are followed to undertake the QA/QC checks in this sector are the following:

- A comparison check between the information on emission factors from other countries having similar land conditions to Malta, as well as the IPCC default emission factors.
- Cross checking the information on the land areas that are provided by the CLC, Malta National Statistics Office, data provided in reports and online sources, as well as the areas provided from the development of the land use maps.
- Cross checking the estimations and calculations to assure maximum accuracy of the results obtained, more importantly between the NIR and CRF values.
- Ensure that the QA/QC checks are done vis-à-vis and following the established Quality Management System of the GHG Inventory process.

Table 6-11 QA/QC Checks performed for the LULUCF Sector

Item		Check
EMISSION DATA QUALITY CHECKS		
1	Are emission comparisons for historical data source performed	Yes – emissions checked for the whole time-series
2	Are emission comparisons for significant sub-source categories performed	Yes - emissions checked for the whole time-series
3	If applicable, are checks against independent estimates or estimates based on alternative methods performed	N. A
4	Are reference calculations performed	N. A
5	Is completeness check performed	Yes – categories are checked for reporting completeness as per section 'Completeness'
6	Other (detailed checks)	Yes – checks are performed to ensure the correct values are reported in NIR and CRF
EMISSION FACTOR QUALITY CHECKS		
IPCC default emission factors		
7	Are the national conditions comparable to the context of the IPCC default emission factors study	Where relevant, yes – In relation to the national definitions of each category and the land use description of the categories
8	Are default IPCC factors compared with country-specific emission factors	At times Yes, for other EFs – comparison checks for the Mediterranean EFs
Country-specific emission factors Comparisons		
9	Are country-specific factors compared with IPCC default factors	Where relevant for other EFs yes – comparison checks for the Mediterranean EFs
10	Is comparison between countries, including historical trends, min and max value, base and most recent year value, IEF performed	Yes
ACTIVITY DATA QUALITY CHECKS		
National level activity data		

11	Are alternative activity data sets based on independent data available	No
12	Were comparisons with independently compiled data sets performed	Independently compiled data is difficult to find
13	Were the national data compared with extrapolated samples or partial data at sub-national level	Yes, where activity data was not available, data was extrapolated/interpolated and checked for consistency throughout the whole time-series
14	Was a historical trend check performed	Yes
15	Are any sharp increases/decreases detected and checked for calculation errors	Yes
16	Are any sharp increases/decreases explained and documented	Yes
CALCULATION RELATED QUALITY CHECKS		
17	Are checks of the calculation algorithm (duplications, unit conversion, calculation errors) performed	Yes
18	Are the calculations reproducible	Yes
19	Are all calculation procedures recorded	Yes

6.1.5 RECALCULATIONS AND IMPROVEMENTS

The following updates below indicate the improvements made throughout the years in the LULUCF chapter submission:

- *Accuracy*: Better reconstruction of the land use areas and land use changes/conversions as per the 2006 IPCC Guidelines Approach 2 on representing land-use areas to acquire a more accurate representation of the land use matrix for the years starting 1970 to the present year minus 2.
- *Accuracy*: Update in the Forest Land category, following the provision of new information and data related to Malta's woodland reserves, as well as update in Wetlands category, thus allowing for the addition of estimations in these categories.
- *Consistency*: application of the correct Notation Keys in the CRF tables.
- *Accuracy*: Improved estimations in the categories and sub-categories of the LULUCF sector, through the use of Mediterranean emission factors from other countries having similar land conditions to Malta, with the assistance of the external experts and reviewers.
- *Completeness*: Reporting uncertainty and performing the relevant QA/QC checks.
- *Transparency*: Presenting adequate and detailed information on the reporting of estimates, and information on the national land use categories to improve the NIR.

The numerous reviews of the national GHG inventory of Malta undergone over the past few years, including the in-country review and the centralised review from the UNFCCC, as well as the capacity building support in-country visits on the NFAP and the GHG Inventory, as well as external reviews from expert consultants, served to address issues that required significant action in the LULUCF sector which include:

- Acquiring a national land use map of Malta and the annual changes in land for the relevant years through the development of spatial maps

- Revision of the Land Use Matrix to reflect accurate reporting of historic and present land use conditions of Malta, and thus try to eliminate the need for assumptions, as well as limiting the extrapolations within the time-series.

A number of issues and recommendations identified in the LULUCF and KP-LULUCF sectors were resolved throughout the past inventories, as part of the improvement plan in the sector. Issues and recommendations were issued following past UNFCCC reviews, based on the Expert Review Team's views on the issues raised during the reviews. The recommendations and status of the issues can be referred to in the last review reports of the UNFCCC centralized review of the 2021 annual submission of Malta 'FCCC/PMF/2021/MLT' and report on the individual review submission of Malta of 2022 'FCCC/ARR/2022/MLT'.

6.2 LAND-USE DEFINITIONS AND THE CLASSIFICATION SYSTEMS USED AND THEIR CORRESPONDENCE TO THE LAND USE, LAND-USE CHANGE AND FORESTRY CATEGORIES

The definitions established and used for this reporting are thus:

- **Forest Land** is defined as an area with minimum area of land of 1 hectare, tree crown-cover of more than 30% and tree minimum height of more than 5 meters.

- **Cropland** includes arable and tillage land, and agro-forestry systems. Cropland includes all annual and perennial crops as well as temporary fallow land (i.e., land set at rest for one or several years before being cultivated again). Annual crops may include cereals, vegetables, root crops and forages. Perennial crops can include herbaceous crops (e.g. agroforestry) or vineyards.

- **Grassland** is defined as a system of vegetational assemblages which can be generally categorised as falling into one of three types, often with an overlap between them:

  - Vegetation which forms part of a community pertaining to the natural successional series, i.e. maquis, garigue and steppe
  - vegetation communities of specialised habitats:
    - rupestral areas
    - coastal communities, e.g. sand dunes, rocky shores, saline marshlands and transitional coastal wetland
    - valleys
  - vegetation communities of disturbed ground

- **Wetlands** include any land that is covered or saturated by water for all or part of the year, and that does not fall into the Forest Land, Cropland, or Grassland categories. Wetlands in Malta are defined the same as for the RAMSAR Convention. L-Għadira and is-Simar are considered to be two of the few main wetlands in the Maltese Islands, being designated as Ramsar Sites.

- **Settlements** includes all developed land, including transportation, infrastructure, human settlements of any size, soils, herbaceous perennial vegetation such as turf grass and garden plants, trees in rural settlements and urban areas, unless they are already included under other categories.

- **Other Land** includes bare soil, rock, quarries, landfills, and all unmanaged land areas that do not fall into any of the other five categories.

Detailed information on the land type and use of each category is presented in the sections pertaining to the categories.

6.3 INFORMATION ON APPROACHES USED FOR REPRESENTING LAND AREAS AND ON LAND-USE DATABASES USED FOR THE INVENTORY PREPARATION

For the identification of the land use areas, Approach 2 as described in 'Volume 4 Agriculture, Forestry, and Other Land Use (Part 1)' of the 2006 IPCC Guidelines was utilised, providing an assessment of the total areas of specific land-use categories including also the changes between categories, i.e. the conversions between the land use categories occurring within the time series. Data for the elaboration of land-use transition matrices was obtained from national reports/plans, datasheets, Corine Land Cover (1990, 2000, 2006 and 2012), data from the National Statistics Office such as the Agriculture statistics and the Planning Authority's public map Geoserver, maps developed by the Malta College of Arts, Science & Technology (MCAST) which were accessed from the European Space Agency (ESA) Copernicus Programme, as well as data which was accessed online as indicated in Table 6-5.

Table 6-12 demonstrates a comparison exercise for the categorisation of the different land use categories involved in the LULUCF sectors, as per the IPCC Guidelines, in relation to the sources of data used for the Activity Data. It is to note that for the classification of the land use maps produced by MCAST, the same classifications were used to classify the categories as per the LULUCF IPCC categories reporting.

Table 6-12 Land use categories used for reporting vs land use categories in the IPCC Guidelines.

IPCC Guidelines Land-Use Categories	Source of Data	Reporting categories
Forest Land	Management plans & Datasheets	Coniferous species
		Broad-leaved species
Annual Cropland	NSO statistics	Potatoes
		Forage
		Annuals
		Market gardening
		Fallow land
		Kitchen gardens
		Other areas grow in open
Perennial Cropland	NSO statistics	Vineyards
		Permanent crops
		Fruits
Maquis Grassland	Corine Land Cover	Sclerophyllous vegetation
Other Grassland	Corine Land Cover	Sparsely vegetated areas

Wetland	Ramsar information & Map Server	Ramsar wetlands
Settlements	Corine Land Cover	Airports
		Continuous urban fabric
		Discontinuous urban fabric
		Sport and leisure facilities
		Green urban areas
		Industrial or commercial units
		Port Areas
Other Land	Corine Land Cover	Mineral extraction sites
		Dump sites
		Extraction sites

6.3.1 THE LAND USE TRANSITION MATRIX

The land use matrix (LUM) was created to represent, in a consistent quantified manner, land-use and land-use conversions, which allow for the determination of areas under land-use transition for different initial and final land use combinations. Annual values for areas in transition from one type of land use to another have been derived by a hierarchy of basic assumptions together with national statistics and sources of land-use changes in Malta. Land-use change matrices for each year of the period 1970-2022 have been drawn up, based on national land use statistics for categories Forest land, Cropland (divided into sub-categories Annual Cropland, and Perennial Cropland), Grassland (divided into sub-categories Maquis Grassland, and Other Grassland), Wetlands, Settlements and Other Land.

The following is an explanation of the methodology and assumptions taken for the development of the land-use representation. Areas of land use and land-use change are compiled from a number of sources. Areas of Forest Land are derived from national management plans and datasheets to determine the areas of the woodlands considered under Forest Land. The Map Server was also referred in instances to confirm the areas. Areas of Annual and Perennial Cropland are derived from agriculture statistics and census from the Nationals Statistics Office. Areas for Cropland were not available for all the years in the whole time series, thus the missing years had to be interpolated or extrapolated to complete the series. Areas for Grassland, Settlement and Other Land are derived from the CLC 1990, 2000, 2006 and 2012, where areas were only available for the corresponding years, thus the remaining years had to be gap-filled through the assumption hierarchy exercise. Areas for Wetland were derived from the Ramsar information sheets, and furthermore, the Map server was referred for area confirmations.

The values for the land use transition matrix were firstly developed by the LULUCF Expert Review Team during a past in-country review of the GHG Inventory to create a more robust time series of area data for each of the land use change category reported, as well as addressing the issues pertaining to inconsistencies in areas. Moreover, this was done to reflect the reliability and accuracy of the matrix, as well as changes in the cumulated 20-year areas.

The land area representation, and eventually the land use matrix, were updated during 2021 with the assistance of Aether Limited, to reflect the additions of areas in Forest Land and

Wetland, and as a result updating the whole land areas and land use matrix for the other categories.

The land-use matrix was constructed by firstly arranging the areas which are available from the above-mentioned sources of data, for which years data is readily available. The areas were utilised to construct a 2-phase calculation for the annual areas remaining in the same category, and for the annual conversions, whilst developing proxies for the assumptions and a hierarchy. This was done to finally verify that the conversions and the total area remain consistent throughout the whole period. Where historic data was not available, a gap filling exercise using interpolation and extrapolation was carried out, as above-mentioned, to be consistent with the trendline of the whole time-series. The proxies for the rules to construct the land use change consider the following:

- There must be an overall annual gain in area for that Land Use (LU)
- There must be an overall annual loss in area for the LU being converted
- The absolute annual change in the land being converted must be less than or equal to the gain in annual area for that LU
- Any LU conversion must account for any annual gain in that area from LUs higher in the hierarchy

The hierarchy for the assumptions taken to construct the land use conversions are shown below. The first hierarchy (Previous hierarchy) was the one as presented in the previous submissions which was initially developed by a LULUCF expert from the Expert Review Team, whilst the second hierarchy (New adapted hierarchy) and the hierarchy presented in Table 6-13 are the new one adapted by the expert consultants from Aether Limited following this years' update of the land use representation:

Abbreviations:

L: Land
FL: Forest Land
CLa: Annual Cropland
CLp: Perennial Cropland
GLm: Maquis Grassland
GLo: Other Grassland
WL: Wetlands
SL: Settlements
OL: Other Land

Previous hierarchy:

L - CLa
I) GLo losses --> CLa
II) CLp losses --> CLa
III) GLm losses --> CLa
L - CLp
I) CLa losses --> CLp
II) GLo losses --> CLp
III) GLm losses --> CLp
L - SL
I) CLa losses --> SL
II) CLp losses --> SL
III) GLo losses --> SL
IV) GLm losses --> SL
L - OL

I) GLo losses --> OL
II) GLm losses --> OL
III) SL losses --> OL
L - GLm
I) GLo losses --> GLm
II) CLp losses --> GLm
III) SL losses --> GLm

New adapted hierarchy:

L - FL
I) GLo --> FL (total gain) up to 2004; CLa --> FL (total gain) from 2005
L - WL
I) OL --> WL (total gain) from 1981
L - CLa
I) GLo losses --> CLa
II) CLp losses --> CLa
III) GLm losses --> CLa
L - CLp
I) CLa losses --> CLp
II) GLo losses --> CLp
III) GLm losses --> CLp
L - SL
I) CLa losses --> SL
II) CLp losses --> SL
III) GLo losses --> SL
IV) GLm losses --> SL
L - OL
I) GLo losses --> OL
II) GLm losses --> OL
III) SL losses --> OL
L - GLm
I) GLo losses --> GLm
II) CLp losses --> GLm
III) SL losses --> GLm
L – Glo

Table 6-13 Hierarchy for assumptions for Land conversions

Final Land Use									
		FL	CLa	CLp	GLm	GLo	WL	SL	OL
Original Land Use	FL								
	CLa	1 (>=2005)		1		1		1	
	CLp		2		2			4	
	GLm		3	3		2		3	2
	GLo	1 (<2005)	1	2	1			2	1
	WL								
	SL				3				3
	OL						1 (>=1981)		

The land area representation was further updated by expert consultants from Aether Limited, noting the updates required in areas, and eventually areas being updated in each category and the land matrices. Moreover, areas were also updated in the land use matrix following the development of the land use area maps by MCAST. The details of the project, and methodology used to develop the land use and land use change maps, are explained in Section 6.1. Following the latest developments with the land use maps the areas were updated based on the maps. Some important notes considered when implementing the new updates based on the LUC maps:

- The areas for 2018 – 2020 were considered to be the best estimates and thus recalculated the timeseries backwards using the annual changes, so that a jump in areas between 2017 and 2018 will be avoided.
- The total area changed very slightly based on the 2018 – 2020 data, which has been applied to the whole time series using the method described above.
- The LU changes for 2018 – 2020 were integrated directly to the approach, so as to not confuse the methodology for implementing the hierarchy for the older years, in which the hierarchy remains unchanged.

The land-use matrix of the annual matrices from 1990-2022, and the 20-year land use change matrices from 1971-2022, are presented in Table 6-and Table 6-14 below. The annual land-use change matrices areas were utilised to fill CRF Table 4.1, whereas the 20-year land use changes were utilised in CRF 4.A to 4.E.

[N.B It is to note that between the land areas and the areas presented in the Common Reporting Format Software (CRF), there may arise very minor (almost insignificant) discrepancies in the areas reported in CRF table 4.1 due to the decimal places rounding between the CRF and the sector excel worksheets

Table 6-14 Annual land-use change matrices for the years 1990-2021 (areas in kilo hectares)

20 Years Matrix 1971-1990		1990						Total 1971
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1971	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**8.452**	4.312	-	0.223	0.036	13.022
	Grassland	-	2.158	**7.291**	-	0.354	0.019	9.822
	Wetland	-	-	-	**0.002**	-	-	0.002
	Settlement	-	0.218	0.314	-	**6.382**	0.056	6.970
	Other Land	-	-	-	0.005	-	**0.293**	0.298
Total 1990		1.434	10.828	11.917	0.007	6.958	0.404	**31.548**
Land converted to:		**0.000**	**2.376**	**4.626**	**0.005**	**0.576**	**0.111**	

20 Years Matrix 1972-1991		1991						Total 1972
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1972	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**8.440**	4.312	-	0.234	0.036	13.022
	Grassland	-	2.158	**7.289**	-	0.361	0.023	9.832
	Wetland	-	-	-	**0.002**	-	-	0.002
	Settlement	-	0.218	0.303	-	**6.382**	0.053	6.955
	Other Land	-	-	-	0.005	-	**0.299**	0.304
Total 1991		1.434	10.817	11.904	0.007	6.977	0.410	**31.548**
Land converted to:		**0.000**	**2.376**	**4.615**	**0.005**	**0.595**	**0.111**	

20 Years Matrix 1973-1992		1992						Total 1973
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1973	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**8.429**	3.156	-	0.245	0.036	11.866
	Grassland	-	2.158	**8.580**	-	0.369	0.028	11.135
	Wetland	-	-	-	**0.002**	-	-	0.002
	Settlement	-	0.218	0.156	-	**6.382**	0.047	6.803
	Other Land	-	-	-	0.005	-	**0.304**	0.309
Total 1992		1.434	10.805	11.891	0.007	6.996	0.415	**31.548**
Land converted to:		**0.000**	**2.376**	**3.311**	**0.005**	**0.614**	**0.111**	

20 Years Matrix 1974-1993		1993						Total 1974
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1974	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**8.709**	3.156	-	0.256	0.036	12.157
	Grassland	-	1.919	**8.567**	-	0.377	0.033	10.897
	Wetland	-	-	-	**0.002**	-	-	0.002
	Settlement	-	0.166	0.156	-	**6.382**	0.042	6.745
	Other Land	-	-	-	0.005	-	**0.309**	0.314
Total 1993		1.434	10.794	11.878	0.007	7.015	0.420	**31.548**
Land converted to:		**0.000**	**2.085**	**3.311**	**0.005**	**0.633**	**0.111**	

Table 6-15 20-year land-use change matrices for the years 1990-2021 (areas in kilo hectares)

Annual Matrix 1989-1990		1990						Total 1989
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1989	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**10.828**	0.187	-	0.067	0.010	11.092
	Grassland	-	-	**11.731**	-	-	-	11.731
	Wetland	-	-	-	**0.002**	-	-	0.002
	Settlement	-	-	-	-	**6.891**	-	6.891
	Other Land	-	-	-	0.005	-	**0.394**	0.399
Total 1990		1.434	10.828	11.917	0.007	6.958	0.404	**31.548**
Land converted to		**-**	**-**	**0.187**	**0.005**	**0.067**	**0.010**	

Annual Matrix 1990-1991		1991						Total 1990
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1990	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**10.817**	-	-	0.011	-	10.828
	Grassland	-	-	**11.904**	-	0.008	0.005	11.917
	Wetland	-	-	-	**0.007**	-	-	0.007
	Settlement	-	-	-	-	**6.958**	-	6.958
	Other Land	-	-	-	-	-	**0.404**	0.404
Total 1991		1.434	10.817	11.904	0.007	6.977	0.410	**31.548**
Land converted to		**-**	**-**	**-**	**-**	**0.019**	**0.005**	

Annual Matrix 1991-1992		1992						Total 1991
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1991	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**10.805**	-	-	0.011	-	10.817
	Grassland	-	-	**11.891**	-	0.008	0.005	11.904
	Wetland	-	-	-	**0.007**	-	-	0.007
	Settlement	-	-	-	-	**6.977**	-	6.977
	Other Land	-	-	-	-	-	**0.410**	0.410
Total 1992		1.434	10.805	11.891	0.007	6.996	0.415	**31.548**
Land converted to		**-**	**-**	**-**	**-**	**0.019**	**0.005**	

Annual Matrix 1992-1993		1993						Total 1992
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1992	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**10.794**	-	-	0.011	-	10.805
	Grassland	-	-	**11.878**	-	0.008	0.005	11.891
	Wetland	-	-	-	**0.007**	-	-	0.007
	Settlement	-	-	-	-	**6.996**	-	6.996
	Other Land	-	-	-	-	-	**0.415**	0.415
Total 1993		1.434	10.794	11.878	0.007	7.015	0.420	**31.548**
Land converted to		**-**	**-**	**-**	**-**	**0.019**	**0.005**	

20 Years Matrix 1975-1994		1994						Total 1975
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1975	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**9.455**	3.156	-	0.268	0.036	12.914
	Grassland	-	1.226	**8.554**	-	0.385	0.038	10.203
	Wetland	-	-	-	**0.002**	-	-	0.002
	Settlement	-	0.102	0.156	-	**6.382**	0.037	6.676
	Other Land	-	-	-	0.005	-	**0.315**	0.320
Total 1994		1.434	10.783	11.865	0.007	7.034	0.426	**31.548**
Land converted to:		0.000	1.328	3.311	0.005	0.652	0.111	

Annual Matrix 1993-1994		1994						Total 1993
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1993	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**10.783**	-	-	0.011	-	10.794
	Grassland	-	-	**11.865**	-	0.008	0.005	11.878
	Wetland	-	-	-	**0.007**	-	-	0.007
	Settlement	-	-	-	-	**7.015**	-	7.015
	Other Land	-	-	-	-	-	**0.420**	0.420
Total 1994		1.434	10.783	11.865	0.007	7.034	0.426	**31.548**
Land converted to		-	-	-	-	0.019	0.005	

20 Years Matrix 1976-1995		1995						Total 1976
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1976	Forest Land	**1.434**	**-**	**-**	**-**	**-**	**-**	1.434
	Cropland	**-**	**9.444**	**2.914**	**-**	**0.279**	**0.035**	12.673
	Grassland	**-**	**1.226**	**8.782**	**-**	**0.392**	**0.044**	10.444
	Wetland	**-**	**-**	**-**	**0.002**	**-**	**-**	0.002
	Settlement	**-**	**0.102**	**0.156**	**-**	**6.382**	**0.032**	6.672
	Other Land	**-**	**-**	**-**	**0.005**	**-**	**0.320**	0.325
Total 1995		1.434	10.772	11.852	0.007	7.053	0.431	**31.548**
Land converted to:		0.000	1.328	3.070	0.005	0.671	0.111	

Annual Matrix 1994-1995		1995						Total 1994
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1994	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**10.772**	-	-	0.011	-	10.783
	Grassland	-	-	**11.852**	-	0.008	0.005	11.865
	Wetland	-	-	-	**0.007**	-	-	0.007
	Settlement	-	-	-	-	**7.034**	-	7.034
	Other Land	-	-	-	-	-	**0.426**	0.426
Total 1995		1.434	10.772	11.852	0.007	7.053	0.431	**31.548**
Land converted to		-	-	-	-	0.019	0.005	

20 Years Matrix 1977-1996		1996						Total 1977
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1977	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**9.818**	2.914	-	0.290	0.035	13.058
	Grassland	-	0.840	**8.769**	-	0.399	0.044	10.052
	Wetland	-	-	-	**0.002**	-	-	0.002
	Settlement	-	0.102	0.156	-	**6.383**	0.032	6.673
	Other Land	-	-	-	0.005	-	**0.325**	0.330
Total 1996		1.434	10.760	11.839	0.007	7.072	0.436	**31.548**
Land converted to:		0.000	0.942	3.070	0.005	0.689	0.111	

Annual Matrix 1995-1996		1996						Total 1995
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1995	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**10.760**	-	-	0.011	-	10.772
	Grassland	-	-	**11.839**	-	0.008	0.005	11.852
	Wetland	-	-	-	**0.007**	-	-	0.007
	Settlement	-	-	-	-	**7.053**	-	7.053
	Other Land	-	-	-	-	-	**0.431**	0.431
Total 1996		1.434	10.760	11.839	0.007	7.072	0.436	**31.548**
Land converted to		-	-	-	-	0.019	0.005	

20 Years Matrix 1978-1997		1997						Total 1978
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1978	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**9.807**	2.900	-	0.261	0.031	12.999
	Grassland	-	0.840	**8.771**	-	0.406	0.048	10.064
	Wetland	-	-	-	**0.002**	-	-	0.002
	Settlement	-	0.102	0.156	-	**6.424**	0.032	6.714
	Other Land	-	-	-	0.005	-	**0.330**	0.335
Total 1997		1.434	10.749	11.826	0.007	7.091	0.441	**31.548**
Land converted to:		0.000	0.942	3.056	0.005	0.667	0.111	

Annual Matrix 1996-1997		1997						Total 1996
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1996	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**10.749**	-	-	0.011	-	10.760
	Grassland	-	-	**11.826**	-	0.008	0.005	11.839
	Wetland	-	-	-	**0.007**	-	-	0.007
	Settlement	-	-	-	-	**7.072**	-	7.072
	Other Land	-	-	-	-	-	**0.436**	0.436
Total 1997		1.434	10.749	11.826	0.007	7.091	0.441	**31.548**
Land converted to		-	-	-	-	0.019	0.005	

	1998	Total 1979

	1998	Total 1997

20 Years Matrix 1979-1998		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1979	Forest Land	**1.434**	-	-	-	-	-	*1.434*
	Cropland	-	**9.796**	2.752	-	0.272	0.031	*12.851*
	Grassland	-	0.840	**8.910**	-	0.414	0.053	*10.217*
	Wetland	-	-	-	**0.002**	-	-	*0.002*
	Settlement	-	0.102	0.152	-	**6.424**	0.027	*6.704*
	Other Land	-	-	-	0.005	-	**0.336**	*0.341*
Total 1998		*1.434*	*10.738*	*11.813*	*0.007*	*7.110*	*0.447*	**31.548**
Land converted to:		**0.000**	**0.942**	**2.904**	**0.005**	**0.686**	**0.111**	

Annual Matrix 1997-1998		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1997	Forest Land	**1.434**	-	-	-	-	-	*1.434*
	Cropland	-	**10.738**	-	-	0.011	-	*10.749*
	Grassland	-	-	**11.813**	-	0.008	0.005	*11.826*
	Wetland	-	-	-	**0.007**	-	-	*0.007*
	Settlement	-	-	-	-	**7.091**	-	*7.091*
	Other Land	-	-	-	-	-	**0.441**	*0.441*
Total 1998		1.434	10.738	11.813	0.007	7.110	0.447	**31.548**
Land converted to		**-**	**-**	**-**	**-**	**0.019**	**0.005**	

20 Years Matrix 1980-1999		1999						Total 1980
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1980	Forest Land	**1.434**	-	-	-	-	-	*1.434*
	Cropland	-	**9.784**	2.752	-	0.265	0.031	*12.833*
	Grassland	-	0.840	**8.897**	-	0.069	0.053	*9.859*
	Wetland	-	-	-	**0.002**	-	-	*0.002*
	Settlement	-	0.102	0.152	-	**6.794**	0.027	*7.075*
	Other Land	-	-	-	0.005	-	**0.341**	0.346
Total 1999		*1.434*	*10.726*	*11.800*	*0.007*	*7.129*	*0.452*	**31.548**
Land converted to:		**0.000**	**0.942**	**2.904**	**0.005**	**0.335**	**0.111**	

Annual Matrix 1998-1999		1999						Total 1998
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1998	Forest Land	**1.434**	-	-	-	-	-	*1.434*
	Cropland	-	**10.726**	-	-	0.011	-	*10.738*
	Grassland	-	-	**11.800**	-	0.008	0.005	*11.813*
	Wetland	-	-	-	**0.007**	-	-	*0.007*
	Settlement	-	-	-	-	**7.110**	-	*7.110*
	Other Land	-	-	-	-	-	**0.447**	*0.447*
Total 1999		1.434	10.726	11.800	0.007	7.129	0.452	**31.548**
Land converted to		**-**	**-**	**-**	**-**	**0.019**	**0.005**	

20 Years Matrix 1981-2000		2000						Total 1981
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1981	Forest Land	**1.434**	-	-	-	-	-	*1.434*
	Cropland	-	**9.853**	2.752	-	0.277	0.031	*12.913*
	Grassland	-	0.760	**8.884**	-	0.077	0.053	*9.774*
	Wetland	-	-	-	**0.002**	-	-	*0.002*
	Settlement	-	0.102	0.152	-	**6.794**	0.027	*7.075*
	Other Land	-	-	-	0.005	-	**0.346**	0.351
Total 2000		*1.434*	*10.715*	*11.787*	*0.007*	*7.148*	*0.457*	**31.548**
Land converted to:		**0.000**	**0.862**	**2.904**	**0.005**	**0.354**	**0.111**	

Annual Matrix 1999-2000		2000						Total 1999
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1999	Forest Land	**1.434**	-	-	-	-	-	*1.434*
	Cropland	-	**10.715**	-	-	0.011	-	*10.726*
	Grassland	-	-	**11.787**	-	0.008	0.005	*11.800*
	Wetland	-	-	-	**0.007**	-	-	*0.007*
	Settlement	-	-	-	-	**7.129**	-	*7.129*
	Other Land	-	-	-	-	-	**0.452**	*0.452*
Total 2000		1.434	10.715	11.787	0.007	7.148	0.457	**31.548**
Land converted to		**-**	**-**	**-**	**-**	**0.019**	**0.005**	

20 Years Matrix 1982-2001		2001						Total 1982
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1982	Forest Land	**1.434**	-	-	-	-	-	*1.434*
	Cropland	-	**9.842**	1.662	-	0.277	0.031	*11.812*
	Grassland	-	0.760	**10.036**	-	0.077	0.054	*10.927*
	Wetland	-	-	-	**0.002**	-	-	*0.002*
	Settlement	-	0.102	0.099	-	**6.794**	0.021	*7.017*
	Other Land	-	-	-	0.005	-	**0.352**	*0.357*
Total 2001		*1.434*	*10.704*	*11.797*	*0.007*	*7.148*	*0.458*	**31.548**
Land converted to:		**0.000**	**0.862**	**1.762**	**0.005**	**0.354**	**0.107**	

Annual Matrix 2000-2001		2001						Total 2000
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2000	Forest Land	**1.434**	-	-	-	-	-	*1.434*
	Cropland	-	**10.704**	0.011	-	-	-	*10.715*
	Grassland	-	-	**11.786**	-	-	0.001	*11.787*
	Wetland	-	-	-	**0.007**	-	-	*0.007*
	Settlement	-	-	-	-	**7.148**	-	*7.148*
	Other Land	-	-	-	-	-	**0.457**	*0.457*
Total 2001		1.434	10.704	11.797	0.007	7.148	0.458	**31.548**
Land converted to		**-**	**-**	**0.011**	**-**	**-**	**0.001**	

	2002	Total 1983

	2002	Total 2001

20 Years Matrix 1983-2002		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1983	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**10.308**	1.662	-	0.277	0.031	12.278
	Grassland	-	0.914	**9.466**	-	0.077	0.055	10.512
	Wetland	-	-	-	**0.002**	-	-	0.002
	Settlement	-	0.051	0.099	-	**6.794**	0.016	6.960
	Other Land	-	-	-	0.005	-	**0.357**	0.362
Total 2002		1.434	11.273	11.228	0.007	7.148	0.460	**31.548**
Land converted to:		0.000	0.965	1.762	0.005	0.354	0.103	

Annual Matrix 2001-2002		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2001	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**10.704**	-	-	-	-	10.704
	Grassland	-	0.569	**11.228**	-	-	0.001	11.797
	Wetland	-	-	-	**0.007**	-	-	0.007
	Settlement	-	-	-	-	**7.148**	-	7.148
	Other Land	-	-	-	-	-	**0.458**	0.458
Total 2002		1.434	11.273	11.228	0.007	7.148	0.460	**31.548**
Land converted to		-	0.569	-	-	-	0.001	

20 Years Matrix 1984-2003		2003						Total 1984
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1984	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**10.704**	1.662	-	0.277	0.031	12.674
	Grassland	-	1.137	**8.896**	-	0.077	0.056	10.167
	Wetland	-	-	-	**0.002**	-	-	0.002
	Settlement	-	-	0.099	-	**6.794**	0.011	6.904
	Other Land	-	-	-	0.005	-	**0.362**	0.367
Total 2003		1.434	11.841	10.658	0.007	7.148	0.461	**31.548**
Land converted to:		0.000	1.137	1.762	0.005	0.354	0.099	

Annual Matrix 2002-2003		2003						Total 2002
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2002	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**11.273**	-	-	-	-	11.273
	Grassland	-	0.569	**10.658**	-	-	0.001	11.228
	Wetland	-	-	-	**0.007**	-	-	0.007
	Settlement	-	-	-	-	**7.148**	-	7.148
	Other Land	-	-	-	-	-	**0.460**	0.460
Total 2003		1.434	11.841	10.658	0.007	7.148	0.461	**31.548**
Land converted to		-	0.569	-	-	-	0.001	

20 Years Matrix 1985-2004		2004						Total 1985
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1985	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**10.434**	1.667	-	0.277	0.033	12.411
	Grassland	0.014	1.137	**9.196**	-	0.077	0.056	10.481
	Wetland	-	-	-	**0.002**	-	-	0.002
	Settlement	-	-	0.049	-	**6.794**	0.005	6.849
	Other Land	-	-	-	0.005	-	**0.368**	0.373
Total 2004		1.448	11.572	10.912	0.007	7.148	0.462	**31.548**
Land converted to:		0.014	1.137	1.716	0.005	0.354	0.094	

Annual Matrix 2003-2004		2004						Total 2003
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2003	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**11.572**	0.268	-	-	0.001	11.841
	Grassland	0.014	-	**10.644**	-	-	-	10.658
	Wetland	-	-	-	**0.007**	-	-	0.007
	Settlement	-	-	-	-	**7.148**	-	7.148
	Other Land	-	-	-	-	-	**0.461**	0.461
Total 1990		1.448	11.572	10.912	0.007	7.148	0.462	**31.548**
Land converted to		0.014	-	0.268	-	-	0.001	

20 Years Matrix 1986-2005		2005						Total 1986
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1986	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	-	**10.165**	1.672	-	0.277	0.034	12.147
	Grassland	0.014	1.137	**9.509**	-	0.077	0.056	10.794
	Wetland	-	-	-	**0.002**	-	-	0.002
	Settlement	-	-	-	-	**6.794**	-	6.794
	Other Land	-	-	-	0.005	-	**0.373**	0.378
Total 2005		1.448	11.302	11.180	0.007	7.148	0.463	**31.548**
Land converted to:		0.014	1.137	1.672	0.005	0.354	0.090	

Annual Matrix 2004-2005		2005						Total 2004
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2004	Forest Land	**1.448**	-	-	-	-	-	1.448
	Cropland	-	**11.302**	0.268	-	-	0.001	11.572
	Grassland	-	-	**10.912**	-	-	-	10.912
	Wetland	-	-	-	**0.007**	-	-	0.007
	Settlement	-	-	-	-	**7.148**	-	7.148
	Other Land	-	-	-	-	-	**0.462**	0.462
Total 2005		1.448	11.302	11.180	0.007	7.148	0.463	**31.548**
Land converted to		-	-	0.268	-	-	0.001	

20 Years Matrix 1987-2006	2006						Total 1987
	Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	

Annual Matrix 2005-2006	2006						Total 2005
	Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	

1987	Forest Land	1.434	-	-	-	-	-	1.434
	Cropland	-	10.165	1.427	-	0.263	0.029	11.883
	Grassland	0.014	1.172	9.718	-	0.077	0.058	11.039
	Wetland	-	-	-	0.002	-	-	0.002
	Settlement	-	-	-	-	6.808	-	6.808
	Other Land	-	-	-	0.005	-	0.378	0.383
Total 2006		1.448	11.337	11.144	0.007	7.148	0.464	31.548
Land converted to:		0.014	1.172	1.427	0.005	0.340	0.086	

20 Years Matrix 1988-2007		2007						Total 1988
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1988	Forest Land	1.434	-	-	-	-	-	1.434
	Cropland	-	10.165	1.178	-	0.253	0.023	11.619
	Grassland	0.014	1.207	9.924	-	0.080	0.062	11.287
	Wetland	-	-	-	0.002	-	-	0.002
	Settlement	-	-	-	-	6.818	-	6.818
	Other Land	-	-	-	0.005	-	0.383	0.388
Total 2007		1.448	11.372	11.103	0.007	7.151	0.468	31.548
Land converted to:		0.014	1.207	1.178	0.005	0.333	0.085	

20 Years Matrix 1989-2008		2008						Total 1989
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1989	Forest Land	1.434	-	-	-	-	-	1.434
	Cropland	-	10.165	0.956	-	0.216	0.018	11.356
	Grassland	0.014	1.583	9.763	-	0.083	0.066	11.509
	Wetland	-	-	-	0.002	-	-	0.002
	Settlement	-	-	-	-	6.854	-	6.854
	Other Land	-	-	-	0.005	-	0.389	0.394
Total 2008		1.448	11.748	10.719	0.007	7.154	0.472	31.548
Land converted to:		0.014	1.583	0.956	0.005	0.299	0.084	

20 Years Matrix 1990-2009		2009						Total 1990
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1990	Forest Land	1.434	-	-	-	-	-	1.434
	Cropland	-	10.165	0.735	-	0.180	0.013	11.092
	Grassland	0.014	1.960	9.602	-	0.086	0.070	11.731
	Wetland	-	-	-	0.002	-	-	0.002
	Settlement	-	-	-	-	6.891	-	6.891
	Other Land	-	-	-	0.005	-	0.394	0.399
Total 2009		1.448	12.125	10.336	0.007	7.157	0.476	31.548
Land converted to:		0.014	1.960	0.735	0.005	0.265	0.082	

20 Years Matrix 1991-2010		2010						Total 1991
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1991	Forest Land	1.434	-	-	-	-	-	1.434

2005	Forest Land	1.448	-	-	-	-	-	1.448
	Cropland	-	11.302	-	-	-	-	11.302
	Grassland	-	0.035	11.144	-	-	0.001	11.180
	Wetland	-	-	-	0.007	-	-	0.007
	Settlement	-	-	-	-	7.148	-	7.148
	Other Land	-	-	-	-	-	0.463	0.463
Total 2006		1.448	11.337	11.144	0.007	7.148	0.464	31.548
Land converted to		-	0.035	-	-	-	0.001	

Annual Matrix 2006-2007		2007						Total 2006
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2006	Forest Land	1.448	-	-	-	-	-	1.448
	Cropland	-	11.337	-	-	-	-	11.337
	Grassland	-	0.035	11.103	-	0.003	0.004	11.144
	Wetland	-	-	-	0.007	-	-	0.007
	Settlement	-	-	-	-	7.148	-	7.148
	Other Land	-	-	-	-	-	0.464	0.464
Total 2007		1.448	11.372	11.103	0.007	7.151	0.468	31.548
Land converted to		-	0.035	-	-	0.003	0.004	

Annual Matrix 2007-2008		2008						Total 2007
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2007	Forest Land	1.448	-	-	-	-	-	1.448
	Cropland	-	11.372	-	-	-	-	11.372
	Grassland	-	0.376	10.719	-	0.003	0.004	11.103
	Wetland	-	-	-	0.007	-	-	0.007
	Settlement	-	-	-	-	7.151	-	7.151
	Other Land	-	-	-	-	-	0.468	0.468
Total 2008		1.448	11.748	10.719	0.007	7.154	0.472	31.548
Land converted to		-	0.376	-	-	0.003	0.004	

Annual Matrix 2008-2009		2009						Total 2008
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2008	Forest Land	1.448	-	-	-	-	-	1.448
	Cropland	-	11.748	-	-	-	-	11.748
	Grassland	-	0.376	10.336	-	0.003	0.004	10.719
	Wetland	-	-	-	0.007	-	-	0.007
	Settlement	-	-	-	-	7.154	-	7.154
	Other Land	-	-	-	-	-	0.472	0.472
Total 2009		1.448	12.125	10.336	0.007	7.157	0.476	31.548
Land converted to		-	0.376	-	-	0.003	0.004	

Annual Matrix 2009-2010		2010						Total 2009
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2009	Forest Land	1.448	-	-	-	-	-	1.448

	Cropland	-	10.165	0.548	-	0.113	0.002	10.828
	Grassland	0.014	2.336	9.405	-	0.089	0.074	11.917
	Wetland	-	-	-	0.007	-	-	0.007
	Settlement	-	-	-	-	6.958	-	6.958
	Other Land	-	-	-	-	-	0.404	0.404
Total 2010		1.448	12.501	9.953	0.007	7.159	0.480	31.548
Land converted to:		0.014	2.336	0.548	0.000	0.201	0.076	

20 Years Matrix 1992-2011		2011						Total 1992
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1992	Forest Land	1.434	-	-	-	-	-	1.434
	Cropland	-	10.165	0.548	-	0.102	0.002	10.817
	Grassland	0.014	2.415	9.319	-	0.084	0.072	11.904
	Wetland	-	-	-	0.007	-	-	0.007
	Settlement	-	-	-	-	6.977	-	6.977
	Other Land	-	-	-	-	-	0.410	0.410
Total 2011		1.448	12.580	9.867	0.007	7.162	0.484	31.548
Land converted to:		0.014	2.415	0.548	0.000	0.185	0.075	

20 Years Matrix 1993-2012		2012						Total 1993
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1993	Forest Land	1.434	-	-	-	-	-	1.434
	Cropland	-	10.165	0.548	-	0.090	0.002	10.805
	Grassland	0.014	2.494	9.233	-	0.079	0.071	11.891
	Wetland	-	-	-	0.007	-	-	0.007
	Settlement	-	-	-	-	6.996	-	6.996
	Other Land	-	-	-	-	-	0.415	0.415
Total 2012		1.448	12.659	9.781	0.007	7.165	0.488	31.548
Land converted to:		0.014	2.494	0.548	0.000	0.169	0.073	

20 Years Matrix 1994-2013		2013						Total 1994
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1994	Forest Land	1.434	-	-	-	-	-	1.434
	Cropland	-	10.165	0.548	-	0.079	0.002	10.794
	Grassland	0.014	2.573	9.147	-	0.074	0.070	11.878
	Wetland	-	-	-	0.007	-	-	0.007
	Settlement	-	-	-	-	7.015	-	7.015
	Other Land	-	-	-	-	-	0.420	0.420
Total 2013		1.448	12.738	9.695	0.007	7.168	0.492	31.548
Land converted to:		0.014	2.573	0.548	0.000	0.153	0.072	

20 Years Matrix 1995-2014		2014						Total 1995
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1995	Forest Land	1.434	-	-	-	-	-	1.434
	Cropland	-	10.165	0.548	-	0.068	0.002	10.783

	Cropland	-	12.125	-	-	-	-	12.125
	Grassland	-	0.376	9.953	-	0.003	0.004	10.336
	Wetland	-	-	-	0.007	-	-	0.007
	Settlement	-	-	-	-	7.157	-	7.157
	Other Land	-	-	-	-	-	0.476	0.476
Total 2010		1.448	12.501	9.953	0.007	7.159	0.480	31.548
Land converted to		-	0.376	-	-	0.003	0.004	

Annual Matrix 2010-2011		2011						Total 2010
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2010	Forest Land	1.448	-	-	-	-	-	1.448
	Cropland	-	12.501	-	-	-	-	12.501
	Grassland	-	0.079	9.867	-	0.003	0.004	9.953
	Wetland	-	-	-	0.007	-	-	0.007
	Settlement	-	-	-	-	7.159	-	7.159
	Other Land	-	-	-	-	-	0.480	0.480
Total 2011		1.448	12.580	9.867	0.007	7.162	0.484	31.548
Land converted to		-	0.079	-	-	0.003	0.004	

Annual Matrix 2011-2012		2012						Total 2011
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2011	Forest Land	1.448	-	-	-	-	-	1.448
	Cropland	-	12.580	-	-	-	-	12.580
	Grassland	-	0.079	9.781	-	0.003	0.004	9.867
	Wetland	-	-	-	0.007	-	-	0.007
	Settlement	-	-	-	-	7.162	-	7.162
	Other Land	-	-	-	-	-	0.484	0.484
Total 2012		1.448	12.659	9.781	0.007	7.165	0.488	31.548
Land converted to		-	0.079	-	-	0.003	0.004	

Annual Matrix 2012-2013		2013						Total 2012
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2012	Forest Land	1.448	-	-	-	-	-	1.448
	Cropland	-	12.659	-	-	-	-	12.659
	Grassland	-	0.079	9.695	-	0.003	0.004	9.781
	Wetland	-	-	-	0.007	-	-	0.007
	Settlement	-	-	-	-	7.165	-	7.165
	Other Land	-	-	-	-	-	0.488	0.488
Total 2013		1.448	12.738	9.695	0.007	7.168	0.492	31.548
Land converted to		-	0.079	-	-	0.003	0.004	

Annual Matrix 2013-2014		2014						Total 2013
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2013	Forest Land	1.448	-	-	-	-	-	1.448
	Cropland	-	12.738	-	-	-	-	12.738

	Grassland	0.014	2.662	**9.052**	-	0.069	0.068	11.865
	Wetland	-	-	-	**0.007**	-	-	0.007
	Settlement	-	-	-	-	**7.034**	-	7.034
	Other Land	-	-	-	-	-	**0.426**	0.426
Total 2014		1.448	12.827	9.600	0.007	7.171	0.496	**31.548**
Land converted to:		**0.014**	**2.662**	**0.548**	**0.000**	**0.137**	**0.071**	

20 Years Matrix 1996-2015		2015						Total 1996
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1996	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	0.004	**10.161**	0.548	-	0.056	0.002	10.772
	Grassland	0.014	2.755	**8.952**	-	0.064	0.067	11.852
	Wetland	-	-	-	**0.007**	-	-	0.007
	Settlement	-	-	-	-	**7.053**	-	7.053
	Other Land	-	-	-	-	-	**0.431**	0.431
Total 2015		1.452	12.916	9.500	0.007	7.174	0.500	**31.548**
Land converted to:		**0.018**	**2.755**	**0.548**	**0.000**	**0.120**	**0.069**	

20 Years Matrix 1997-2016		2016						Total 1997
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1997	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	0.004	**10.161**	0.548	-	0.045	0.002	10.760
	Grassland	0.014	2.843	**8.857**	-	0.059	0.066	11.839
	Wetland	-	-	-	**0.007**	-	-	0.007
	Settlement	-	-	-	-	**7.072**	-	7.072
	Other Land	-	-	-	-	-	**0.436**	0.436
Total 2016		1.452	13.004	9.405	0.007	7.176	0.504	**31.548**
Land converted to:		**0.018**	**2.843**	**0.548**	**0.000**	**0.104**	**0.068**	

20 Years Matrix 1998-2017		2017						Total 1998
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1998	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	0.004	**9.854**	0.848	-	0.037	0.006	10.749
	Grassland	0.014	2.843	**8.857**	-	0.051	0.061	11.826
	Wetland	-	-	-	**0.007**	-	-	0.007
	Settlement	-	-	-	-	**7.091**	-	7.091
	Other Land	-	-	-	-	-	**0.441**	0.441
Total 2017		1.452	12.698	9.705	0.007	7.179	0.508	**31.548**
Land converted to:		**0.018**	**2.843**	**0.848**	**0.000**	**0.088**	**0.067**	

20 Years Matrix 1999-2018		2018						Total 1999
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1999	Forest Land	**1.434**	-	-	-	-	-	1.434
	Cropland	0.004	**9.548**	1.147	-	0.028	0.010	10.738
	Grassland	0.014	2.843	**8.857**	-	0.044	0.055	11.813

	Grassland	-	0.089	**9.600**	-	0.003	0.004	9.695
	Wetland	-	-	-	**0.007**	-	-	0.007
	Settlement	-	-	-	-	**7.168**	-	7.168
	Other Land	-	-	-	-	-	**0.492**	0.492
Total 2014		1.448	12.827	9.600	0.007	7.171	0.496	**31.548**
Land converted to		**-**	**0.089**	**-**	**-**	**0.003**	**0.004**	

Annual Matrix 2014-2015		2015						Total 2014
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2014	Forest Land	**1.448**	-	-	-	-	-	1.448
	Cropland	0.004	**12.823**	-	-	-	-	12.827
	Grassland	-	0.093	**9.500**	-	0.003	0.004	9.600
	Wetland	-	-	-	**0.007**	-	-	0.007
	Settlement	-	-	-	-	**7.171**	-	7.171
	Other Land	-	-	-	-	-	**0.496**	0.496
Total 2015		1.452	12.916	9.500	0.007	7.174	0.500	**31.548**
Land converted to		**0.004**	**0.093**	**-**	**-**	**0.003**	**0.004**	

Annual Matrix 2015-2016		2016						Total 2015
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2015	Forest Land	**1.452**	-	-	-	-	-	1.452
	Cropland	-	**12.916**	-	-	-	-	12.916
	Grassland	-	0.089	**9.405**	-	0.003	0.004	9.500
	Wetland	-	-	-	**0.007**	-	-	0.007
	Settlement	-	-	-	-	**7.174**	-	7.174
	Other Land	-	-	-	-	-	**0.500**	0.500
Total 2016		1.452	13.004	9.405	0.007	7.176	0.504	**31.548**
Land converted to		**-**	**0.089**	**-**	**-**	**0.003**	**0.004**	

Annual Matrix 2016-2017		2017						Total 2016
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2016	Forest Land	**1.452**	-	-	-	-	-	1.452
	Cropland	-	**12.698**	0.300	-	0.003	0.004	13.004
	Grassland	-	-	**9.405**	-	-	-	9.405
	Wetland	-	-	-	**0.007**	-	-	0.007
	Settlement	-	-	-	-	**7.176**	-	7.176
	Other Land	-	-	-	-	-	**0.504**	0.504
Total 1990		1.452	12.698	9.705	0.007	7.179	0.508	**31.548**
Land converted to		**-**	**-**	**0.300**	**-**	**0.003**	**0.004**	

Annual Matrix 2017-2018		2018						Total 2017
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2017	Forest Land	**1.452**	-	-	-	-	-	1.452
	Cropland	-	**12.391**	0.300	-	0.003	0.004	12.698
	Grassland	-	-	**9.705**	-	-	-	9.705

	Wetland	-	-	-	0.007	-	-	0.007
	Settlement	-	-	-	-	7.110	-	7.110
	Other Land	-	-	-	-	-	0.447	0.447
Total 2018		1.452	12.391	10.004	0.007	7.182	0.512	31.548
Land converted to:		0.018	2.843	1.147	0.000	0.072	0.066	

20 Years Matrix 2000-2019		2019						Total 2000
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2000	Forest Land	1.387	-	-	-	0.042	0.004	1.434
	Cropland	0.004	9.192	1.147	-	0.325	0.057	10.726
	Grassland	0.014	2.843	8.247	-	0.536	0.160	11.800
	Wetland	-	-	-	0.007	-	-	0.007
	Settlement	-	-	-	-	7.129	-	7.129
	Other Land	-	-	-	-	-	0.452	0.452
Total 2019		1.405	12.036	9.394	0.007	8.033	0.674	31.548
Land converted to:		0.018	2.843	1.147	0.000	0.904	0.222	

20 Years Matrix 2001-2020		2020						Total 2001
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2001	Forest Land	1.341	-	-	-	0.084	0.008	1.434
	Cropland	0.004	8.837	1.147	-	0.623	0.105	10.715
	Grassland	0.014	2.843	7.637	-	1.028	0.265	11.787
	Wetland	-	-	-	0.007	-	-	0.007
	Settlement	-	-	-	-	7.148	-	7.148
	Other Land	-	-	-	-	-	0.457	0.457
Total 2020		1.359	11.680	8.784	0.007	8.883	0.835	31.548
Land converted to:		0.018	2.843	1.147	0.000	1.735	0.378	

20 Years Matrix 2002-2021		2021						Total 2002
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2002	Forest Land	1.341	-	-	-	0.084	0.008	1.434
	Cropland	0.004	8.837	1.136	-	0.623	0.105	10.704
	Grassland	0.014	2.843	7.641	-	1.031	0.268	11.797
	Wetland	-	-	-	0.007	-	-	0.007
	Settlement	-	-	-	-	7.148	-	7.148
	Other Land	-	-	-	-	-	0.458	0.458
Total 2021		1.359	11.680	8.777	0.007	8.886	0.839	31.548
Land converted to:		0.018	2.843	1.136	-	1.738	0.381	

20 Years Matrix 2003-2022		2022						Total 2003
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2003	Forest Land	1.341	-	-	-	0.084	0.008	1.434
	Cropland	0.004	9.405	1.136	-	0.623	0.105	11.273
	Grassland	0.014	2.275	7.634	-	1.034	0.271	11.228
	Wetland	-	-	-	0.007	-	-	0.007

	Wetland	-	-	-	0.007	-	-	0.007
	Settlement	-	-	-	-	7.179	-	7.179
	Other Land	-	-	-	-	-	0.508	0.508
Total 2018		1.452	12.391	10.004	0.007	7.182	0.512	31.548
Land converted to		-	-	0.300	-	0.003	0.004	

Annual Matrix 2018-2019		2019						Total 2018
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2018	Forest Land	1.405	-	-	-	0.042	0.004	1.452
	Cropland	-	12.036	-	-	0.308	0.047	12.391
	Grassland	-	-	9.394	-	0.500	0.110	10.004
	Wetland	-	-	-	0.007	-	-	0.007
	Settlement	-	-	-	-	7.182	-	7.182
	Other Land	-	-	-	-	-	0.512	0.512
Total 2019		1.405	12.036	9.394	0.007	8.033	0.674	31.548
Land converted to		-	-	-	-	0.851	0.161	

Annual Matrix 2019-2020		2020						Total 2019
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2019	Forest Land	1.359	-	-	-	0.042	0.004	1.405
	Cropland	-	11.680	-	-	0.308	0.047	12.036
	Grassland	-	-	8.784	-	0.500	0.110	9.394
	Wetland	-	-	-	0.007	-	-	0.007
	Settlement	-	-	-	-	8.033	-	8.033
	Other Land	-	-	-	-	-	0.674	0.674
Total 2020		1.359	11.680	8.784	0.007	8.883	0.835	31.548
Land converted to		-	-	-	-	0.851	0.161	

Annual Matrix 2020-2021		2021						Total 2020
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2020	Forest Land	1.359	-	-	-	-	-	1.359
	Cropland	-	11.680	-	-	-	-	11.680
	Grassland	-	-	8.777	-	0.003	0.004	8.784
	Wetland	-	-	-	0.007	-	-	0.007
	Settlement	-	-	-	-	8.883	-	8.883
	Other Land	-	-	-	-	-	0.835	0.835
Total 2021		1.359	11.680	8.777	0.007	8.886	0.839	31.548
Land converted to		-	-	-	-	0.003	0.004	

Annual Matrix 2021-2022		2022						Total 2021
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2021	Forest Land	1.359	-	-	-	-	-	1.359
	Cropland	-	11.680	-	-	-	-	11.680
	Grassland	-	0.000	8.770	-	0.003	0.004	8.777
	Wetland	-	-	-	0.007	-	-	0.007

	Settlement	-	-	-	-	**7.148**	-	*7.148*
	Other Land	-	-	-	-	-	**0.460**	*0.460*
Total 2022		*1.359*	*11.680*	*8.770*	*0.007*	*8.889*	*0.843*	***31.548***
Land converted to:		***0.018***	***2.275***	***1.136***	**-**	***1.741***	***0.383***	

	Settlement	-	-	-	-	**8.886**	-	*8.886*
	Other Land	-	-	-	-	-	**0.839**	*0.839*
Total 2022		*1.359*	*11.680*	*8.770*	*0.007*	*8.889*	*0.843*	***31.548***
Land converted to		**-**	**0.000**	**-**	**-**	**0.003**	**0.004**	

6.4 FOREST LAND (CRF CATEGORY 4A)

6.4.1 CATEGORY DESCRIPTION

6.4.1.1 Woodland in Malta

Within the Mediterranean region, Malta has one of the lowest levels of forest coverage (FAO, 2014), presumably a combined result of the country's small size, extraordinary high population density, and long history of human habitation, leading to a large human footprint and extensive anthropicization of the land. The only remaining forest remnants occur in localized pockets, with four particular copses of significant age. It is thought that, prior to being settled by humans, the Maltese Islands would have supported relatively extensive tracts of Mediterranean sclerophyll forest, dominated by species such as the Holm Oak (Quercus ilex) and Aleppo Pine (Pinus halepensis). Fossil evidence of this theory has been cited by several authors (e.g. Zammit Maempel, 1977, 1982; Pedley, 1980; Hunt, 1997). Once the Islands were settled, however, extensive deforestation took place to make space for farmland and habitation, and to provide timber as fuel. Meantime, grazing by domestic animals made it extremely difficult for young tree growth to survive, with these factors resulting in a near complete loss of Maltese forests. Typically, Quercus ilex forests would normally support an undergrowth of smaller tree species and shrubs of various dimensions, many of which are also characteristic of maquis assemblages, while coniferous woodlands would tend to lack a significant understorey. Maquis assemblages, which, in the Maltese Islands, typically occur in somewhat sheltered environments such as valley slopes and boulder screes, do not constitute woodlands in the strict sense of the term, but consist of smaller trees and tall shrubs; these assemblages, which may occur naturally but also a result of secondary succession following deforestation and subsequent re-growth of woodlands (Cassar & Conrad, 2014).

Given the total woodland area of Malta and the forest/woodland areas considered for the compilation of the category Forest Land, none of these woodland areas are utilised for logging (MEAIM, 2009). In Malta there is no relevant harvest commercialized for material use, and wood for material use is currently imported from other countries. Furthermore, Malta addresses the conservation of trees and woodland sites strictly through the Trees and Woodland Protection Regulations (Legal Notice 12 of 2001). Additionally, FAOSTAT information sourced from the Forestry Production and Trade indicate that the production quantity has never been produced in Malta.

The only significant extent of mature woodland in the Maltese Islands now occurs within the Buskett region, the naturally occurring woodland was enlarged through afforestation efforts during the rule of the Knights of St. John. It was during the rule of Grand Master La Valette (1557-1568) that the Bosketto area began to be used for the rearing of local falcons in connection with an inpart fulfillment to a condition, laid by the Viceroy of Sicily, to present him with a falcon on an annual basis (Cassar & Conrad, 2014).

The Buskett area is found in the western part of Malta includes both a Special Area of Conservation (SAC) and a Special Protection Area (SPA). It is one of the largest SACs in the Maltese Islands supporting the highest concentration of riparian woodlands in the Maltese Islands. This SAC is also one of the most diverse and richest in biodiversity, supporting a variety of rare and endemic species. It also hosts the largest woodland in the Maltese Islands, at Buskett, which in turn supports the largest concentration of woodland-associated species of invertebrates and mycoflora in Malta. Land management at Il-Buskett is particularly unique for a SAC in Malta. It is one of a handful of sites that are actively managed by the Government.

The Buskett SAC comprises of habitat types which are described as according to the Annex 12 Habitat types and an assessment was carried out in the management plan. The relevant habitats for this report of the Buskett area are described as follows:

- Annex 1 Habitat – Arborescent matorral with Laurus nobilis (Code – 5230)
- Annex 1 Habitat – Salix alba and Populus alba galleries (Code – 92A0)
- Annex 1 Habitat – Olea and Ceratonia forests (Code – 9320)
- Annex 1 Habitat – Quercus ilex and Quercus rotundifolia forests (Code – 9340)
- Annex 1 Habitat – Mediterranean pine forests with endemic Mesogean pines (Code – 9540)

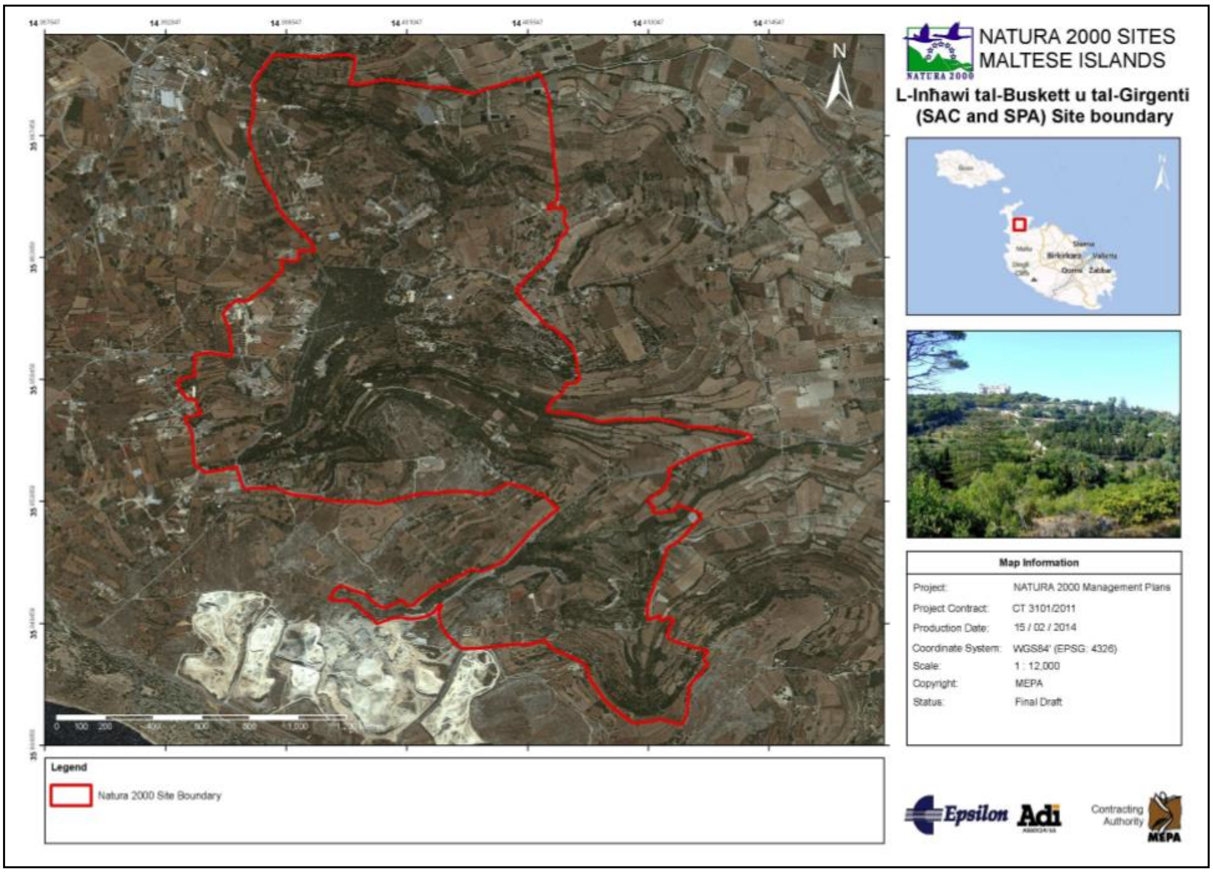


Figure 6-3 L-inhawi tal-Buskett u tal-Girgenti (SAC & SPA) Site boundary

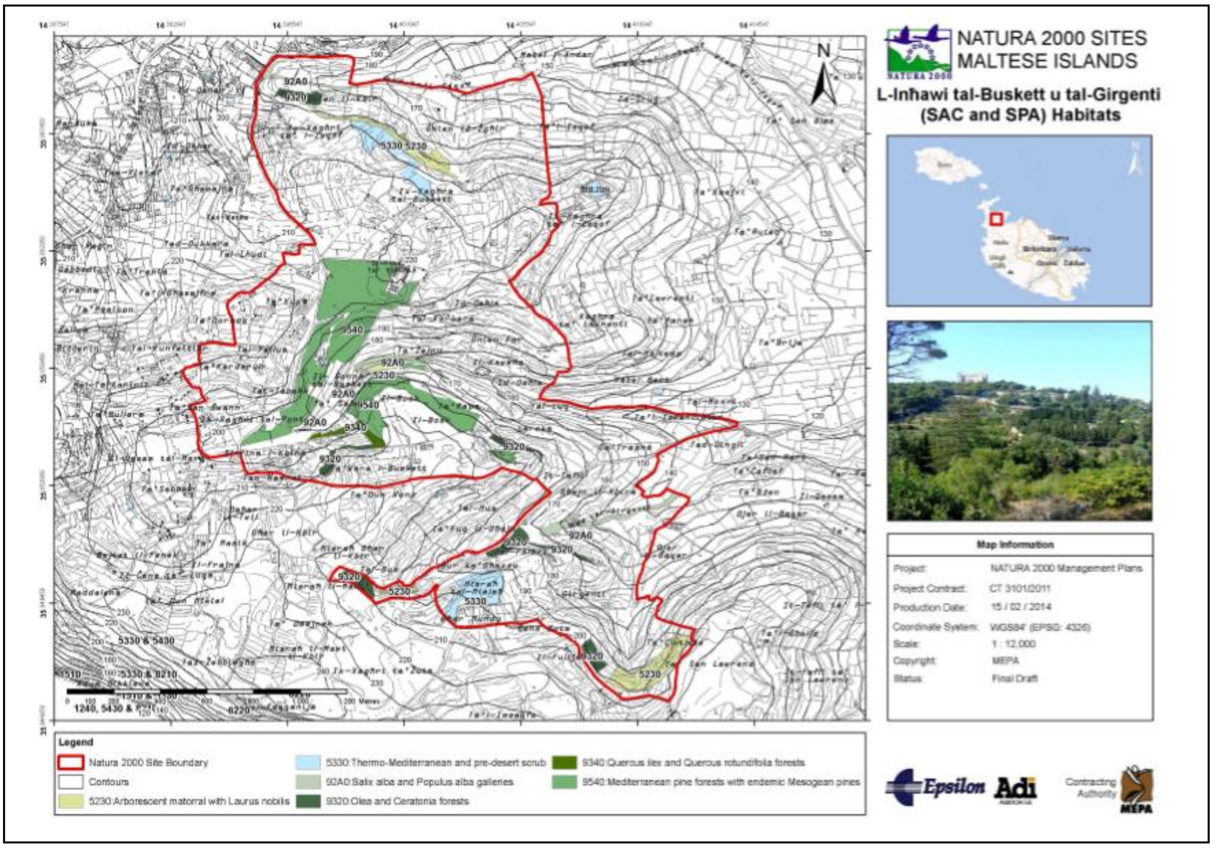


Figure 6-4 L-inhawi tal-Buskett u tal-Girgenti (SAC & SPA) Habitats

Il-Ballut tal-Wardija Special Area of Conservation (SAC) is found in the north-east coast of Malta. It is a small SAC that is characterised by a variety of woodland habitats, one of which is the most important Holm Oak woodlands in the Maltese Islands. The latter is a Holm Oak forest remnant supporting the oldest known population of such trees in the country. It also supports a self-regenerating coniferous woodland and an olive and carob maquis.

Most of the SAC is private land. The only government property that is found on site is limited to the path leading to the residential units, the south-western area and the north-eastern corner situated beneath the Wardija Village. There is evidence of land abandonment throughout the site. Land that was used for agricultural purposes in the 1950s and 1960s are now covered in scrub. A number of the Annex I habitats are actually occupying agricultural land that has since been abandoned. Throughout the SAC, there is evidence of habitat alteration by private individuals. This includes the planting of Eucalyptus trees in various pockets throughout the site by hunters.

The Wardija SAC comprises of habitat types which are described as according to the Annex 1 Habitat types and an assessment was carried out in the management plan. The relevant habitats for this report of the Wardija area are described as follows:

- Annex 1 Habitat – Olea and Ceratonia forests (Code – 9320)
- Annex 1 Habitat – Quercus ilex and Quercus rotundifolia forests (Code – 9340)
- Annex 1 Habitat – Mediterranean pine forests with endemic Mesogean pines (Code – 9540)

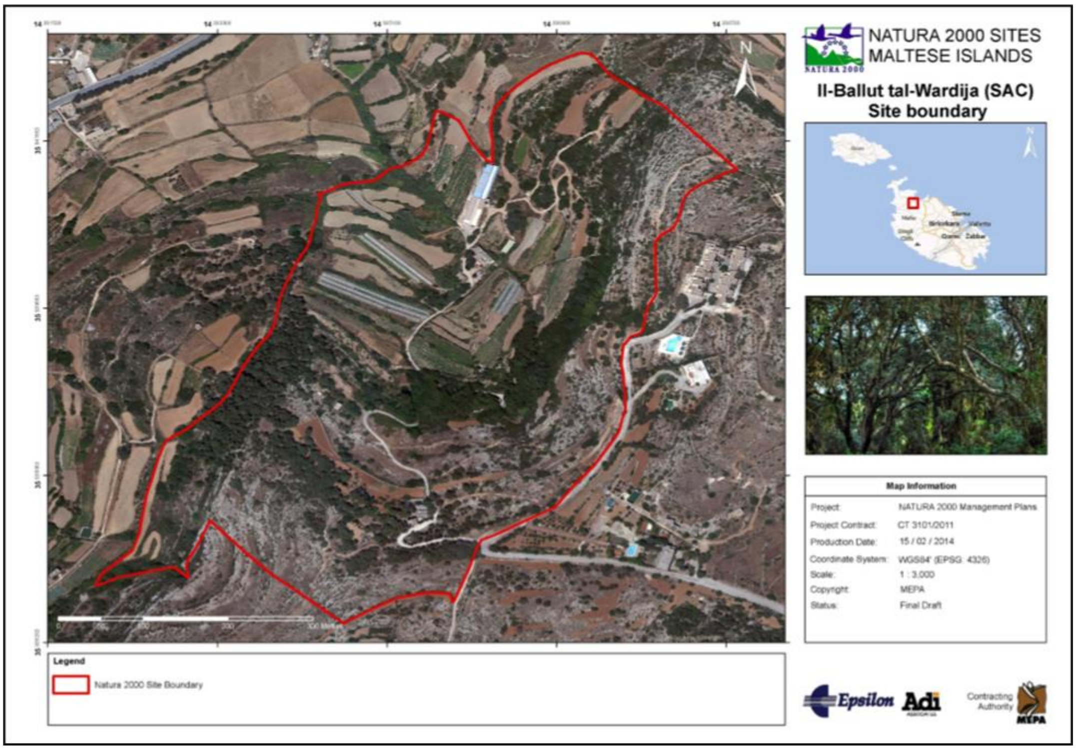


Figure 6-5 Il-Ballut tal-Wardija (SAC) Site boundary

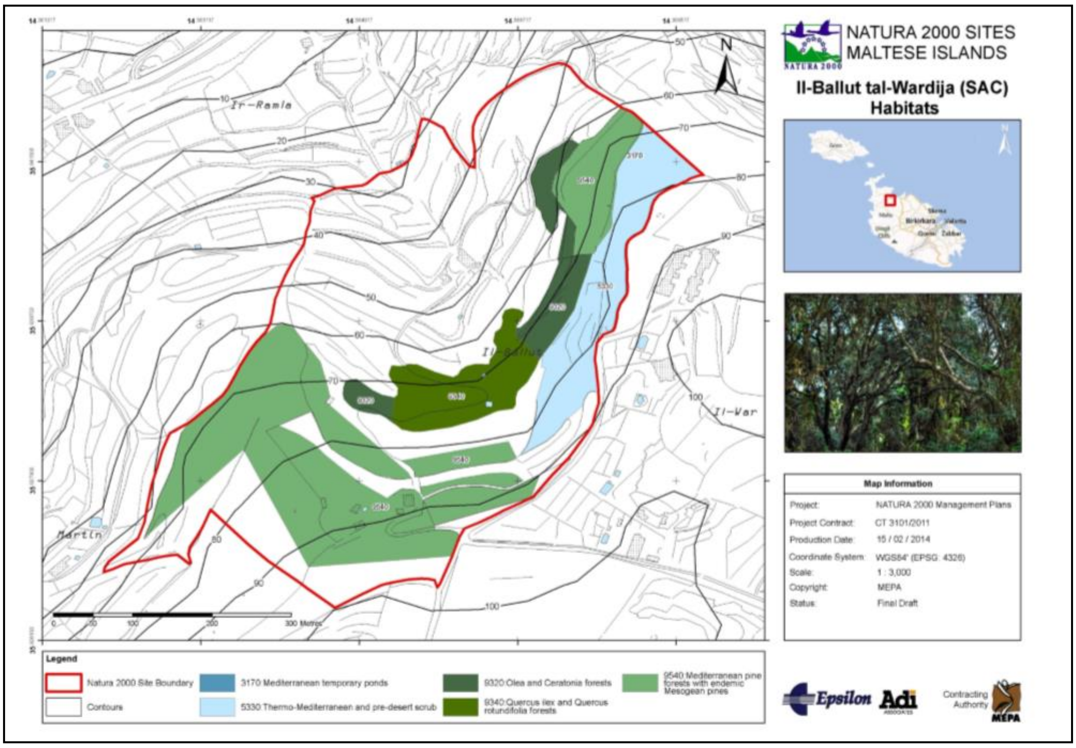


Figure 6-6 Il-Ballut tal-Wardija (SAC) Habitats

Mizieb is a woodland area in the north of Malta, managed by an organizing committee of the 'Federazzjoni Kaccaturi Nassaba u Konservazzjonisti' (FKNK; in English – Federation for Hunting and Conservation) since 1985. From general information, Mizieb constitutes both the mixed broad-leaved and conifer type of forests. Noting that no public information is available, the area from the Map server and the planting excel sheets provided by other local entities were referred for the area for this forest reserve and considered for the LULUCF sector reporting.

Foresta 2000 is an area of natural habitat which has been restored as a Mediterranean woodland. Foresta 2000 is a long-term project, commenced in 2003 with the aim to recover an area and plant a Mediterranean forest. The Foresta 2000 initiative involves the environmental improvement of a site, with the project aiming to establish a Mediterranean forest on site (Cassar & Conrad, 2014). Planting of tree species and shrubs in the Foresta 2000 afforestation site began in 2004, which up until now amounts to a total of 44 hectares of afforested land.

The project has benefited from contributions of external partners – the project website mentions, for example, that the Italian Corpo Forestale dello Stato have provided 8000 trees and shrubs over three years. As per details provided on the same website, the project has succeeded in planting some 20,000 trees and shrubs. The project has, however, unfortunately been subject to vandalism, with an early attack in 2004 involving the cutting down of some 100 trees, a second major attack in 2007 destroying around 3000 trees, and with further damage to 104 trees and saplings during a 2010 attack. (Cassar & Conrad, 2014). The entity responsible for the Foresta 2000 site reported that all trees were replaced, except for the attack which happened in 2010, when a number of olive trees were cut down, but the trees recovered.

Information pertaining to the tree species present and the trees which were planted through the years, was received from Ambjent Malta. The data sheets received were recorded from a Foresta 2000 warden through the years. A map of the Foresta 2000 reserve is indicated inFigure 6-7 below.

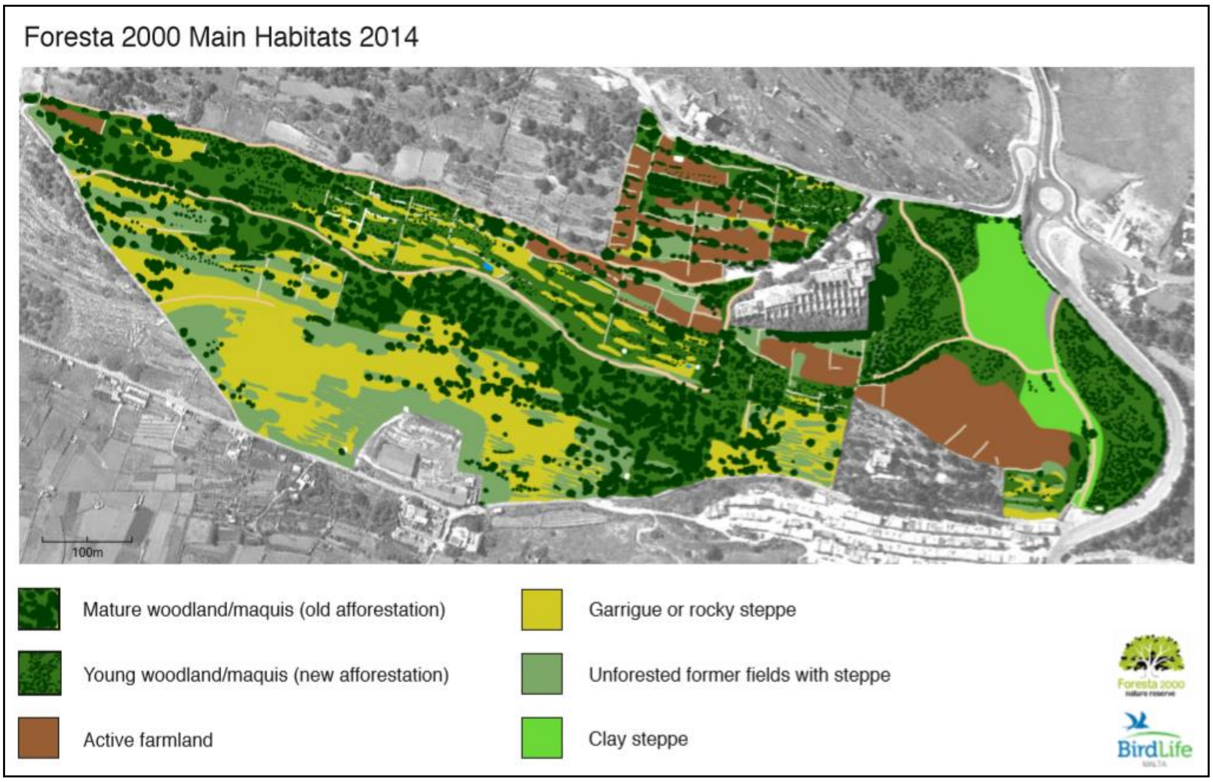


Figure 6-7 Foresta 2000 Main Habitats map

A work plan was carried out in Ġnien il-Mediterran garden which was rehabilitated whilst also planting a considerable amount of trees and shrubs in order for the site to return to its original state. Plans were in place for the planting of 500 trees and shrubs in the area, to replace dead plants but also to increase the biodiversity of the garden, which was very low (consisting just of a few tree species). Further Planting was extended to the previous 2 years.

The site project at Wied Fulija was announced in 2019, were a disused rubbish dump was earmarked to become a wooded park. The site was first used as a landfill in 1979 and stopped accepting waste in 1996. Around 45,000 plants – mostly indigenous shrubs – were planted in the site. The project included the planting of "hundreds" of three-metre trees will be included in the site. The landfill of Wied Fulija went through a rehabilitation transforming into a 95,000 sqm nature park

In 2019, an undeveloped area was set to be transformed into around a 3-hectare park with 8,000 trees. 8,000 endemic trees were planted on the site as part of the afforestation project will see the site in Benghajsa turned into an area which can be used for picnics, camping and tourism purposes. The new grove in Benghajsa was formed on a 15,000-metre-squared area of disturbed land, including planting over 300 aleppo pine trees, 350 olive trees, 260 holm oak trees, 220 sandaric gum trees (gharghar; Malta's national tree) and another 12 species of trees and shrubs such as judas trees, cypresses, carob trees, pomegranate trees, bay laurel and white mulberry trees.

6.4.1.2 Methodological description

During previous years, Malta was provided the assistance under the European Commission project 'Capacity building activities related to the establishment of Forest Reference Levels (FRLs) and improved inventories' (Task 1) through which experts provided by a consortium led by ICF Consulting limited (ICF) and including Aether Limited and the International Institute for Applied Systems Analysis (IIASA), to prepare and compile the National Forestry and Accounting Plan (NFAP). The Malta country team were assisted primarily through a capacity building in-country visit in October 2018 for the purpose to provide technical support to Malta in the preparation of the NFAP and Forest Reference Level (FRL) for the Compliance Period 2021-2025. The capacity building plan served to address issues that the Malta team were facing in preparing the NFAP and FRL and other issues that were identified by the visiting expert team during the visit, including discussions with relevant local stakeholders to identify and address better the national situation. The visit also served to aid in the development of the Forest Land category of the LULUCF sector. This in fact has benefited Malta, since new data and information on Forest Land was acquired from national stakeholders and entities, to be utilised in the development of estimations within the Forest Land category.

The area updates for Forest Land in the land area representation and eventually updates in the area land use matrix, were performed with the assistance of expert consultants from Aether Limited, thus, to develop the calculations of estimations in the Forest Land category. The below sections provide a description of the Forest Land category information, as well as the methodological description of the estimates.

The stratification of the forest/woodland areas of Malta was created and considered for the purpose of the reporting of the Forest Land sector, and eventually for the compilation of estimations. The stratification of these locations is documented by use of documents and maps which are provided from the national managing authorities and other national associations, which include the Environment Resources Authority (ERA), Ambjent Malta (AM), the Planning Authority (PA) and BirdLife Malta.

The stratification of the forest areas is based on the main criteria of distinguishing (i) 'forest in equilibrium' which are classified as forest land older than 100 years, as well as considers forests where these are not properly documented, or else no documentation is available; and (ii) 'age dynamic forest' which are classified as forest younger than 100 years. The dominant tree species in each of the forest areas is also considered. In addition, age classes were created by documenting the age for forests planted less than 100 years which are considered under the criteria for the 'age dynamic forests'. Furthermore, documentation on the afforestation criteria which occurred from the period 1990 to the latest reporting year is collected from the national authorities/associations, to be included in the dynamic evolution of the forest area.

In general, the primary data sources for the different forest areas considered for the Forest Land category are the management plans with respect to the Buskett, Wardija sites. For the Foresta 2000 site the management plan considers the area as part of a larger site. The Management Plans for the Buskett, Wardija and Foresta 2000 site were compiled by the Environment Resources Authority, and these are sites forming part of the Natura 2000 network. The inventory compilers also made use of the areas developed from the LUC maps by the collaboration project with MCAST, as described earlier.

With regards to the Mizieb, information on areas were gathered from excel sheets. For the sites of Gnien il-Mediterran, Wied Fulija and Benghajsa, information from news articles as well as planting excel sheets were utilised thus to acquire the rate of plantings for the relevant years.

The use of spreadsheets to process the information and data sources received from the various authorities and associations were important to record the data and ultimately to document the modelling framework. The spreadsheets used were delivered from the relevant national authorities and associations to input the data and information related to the tree characteristics and forest/woodland areas. Moreover, available historic maps from the Planning Authority were also utilised in instances to confirm the area from the geoportal, utilising the orthophotos for certain years that are available.

As a result of the information and documentation received from the entities involved, the areas for Forest Land were updated. The actions which have resulted in the improvement in the documentation of the forest/woodland areas were verified from the national authorities and associations such as ERA, Ambjent Malta and BirdLife. The PA geoportal also assisted to document the area or surface which are covered by the relevant forests, as a means to integrate better the area to the previous areas, confirming that the forests are in line with the national definition of Forest Land.

The majority of trees in Maltese woodland/forests constitute tree types classified as Mediterranean broadleaves and Conifers. Most of the forest areas were planted in historic times, more specifically during the time of the Knights Hospitaller, and are considered as woodland remnants or ancient copses of semi natural woodland. As a result of this, these woodland remnants are protected by the Maltese laws. Logging activities are also prohibited by national laws. Due to this, in Malta there is scarce differentiation of managements in the forest reserves.

From the yield tables and growth functions for similar species, indicated from other countries having similar land conditions to Malta, it is evident that the equilibrium between biomass growth and loss is reached when the forest is grown for periods longer than 100 years (Montero et al. 2001, Shater et al. 2011).

During discussions at the capacity-building support visit tasks it was analysed that some of the area of forest land remaining forest land under consideration, was actually planted during the last century (1900-2000). For this reason, a better representation had to be developed for the aging classes of the Maltese forests by assigning different growth according to the different ages of strata. According to the information and data gathered from the different data providers the following stratification criteria was proposed and developed for the estimations in Forest Land:

- Maturity:
    - Forest land older than 100 years and forests for which planting time cannot be properly documented are assigned to the stratification criteria or class of 'forest in equilibrium'.
    - Forest land which are younger than 100 years, with appropriate documentation of the planting year, are assigned to the stratification criteria or class of 'age dynamic forest'.
- Dominant species: distinguished in order to classify forests in the strata described above, as
    - 'Conifer dominated' forests
    - 'Broadleaved dominated' forests.

Dominant species are especially considered in the stratification for the 'age dynamic forest', and if possible, also for the 'forests in equilibrium'.

Table 6-15 and Table 6-16 below indicate the stratifications according to the criteria as proposed above.

Table 6-15 Stratification of Forest Management

Forest remaining Forest (Forest Management)				
Location	Habitat	Dominant tree species	Conifer or Broad-leaved dominant	Age (years)
Buskett Woodland (Natura 2000 site)	9340 – Oak Forests	Querces ilex	Broad-leaved	500+
	9540 – Mediterranean pine forests	Pinus halepensis	Conifer	100+
	9320 – Olive & Carob forests	Ceratonia siliqua & Olea europaea	Broad-leaved	100+ and ~50
	92A0 – Poplar & Willow galleries	Salix alba, Populus alba & Fraxinus angustifolia	Broad-leaved	~300-400
	5230 – Arborescent matorral with Bay laurel	Laurus nobilis	Broad-leaved	Unidentified (area difficult to assess)
	9540 – Mediterranean pine forests	Pinus halepensis	Conifer	50+
	9320 – Olive & Carob forests	Ceratonia siliqua & Olea europaea	Broad-leaved	100+
Mizieb	Unidentified	Unidentified	Unidentified	

Table 6-16 Stratification of Afforestation

Afforestation			
Location	Habitat	Dominant tree species	Age (years)
Foresta 2000	Conifer Dominated	Pinus halapensis Tetraclinus articulata	Planted around 2004
	Broad-leaved dominated	Arbutus unedo Quercus ilex Quercus coccifera Tamarix sp. Ceratonia siliqua Olea europea	
Buskett	Conifer Dominated	Pinus halapensis	Planted 2015-2017
	Broad-leaved dominated	Ceratonia siliqua Salix alba, Populus alba & Fraxinus angustifolia Querces ilex Laurus nobilis	
Gnien il-Mediterran	Conifer Dominated	Only number of planted species was provided thus considered a mix of conifer and broad-leaved dominated	Planted 2019
	Broad-leaved dominated		
Mizieb	Conifer Dominated	Cupressus sempervirens	Planted 2020
	Broad-leaved dominated	Querces ilex Rhamnus alaternus Prunus dulcis Pistacia lentiscus Myrtus communis	
Wied Fulija	Mix of Conifer and broad-leaved dominated	Indigenous species	Planted 2020
Benghajsa	Mix of Conifer and broad-leaved dominated	Pinus halapensis Olea europea Querces ilex Tetraclinus articulata Cercis siliquastrum Cupressus sempervirens Ceratonia siliqua Punica granatum Laurus nobilis Morus alba	Planted 2020

For the ‘age dynamic forests’ documentation on the planting decade was sourced from documents such as management plans and local plans/reports as well as data sheets, where relevant, whereas when not documented, ‘expert judgement’ was carried out from ERA and Ambjent Malta following the ‘elicitation protocol’ as recommended from the IPCC Guidelines, as well as the Technical guidance. An assessment of areas (i.e. in term of hectares, or tree numbers in case that the area is not known or cannot be retrieved) belonging to the different strata was collected. Information was collected also, where data was available, for documenting the ‘afforested land’ or afforestation, for plantings which occurred for the time-series from 1990 to 2022. The Afforestation will be considered also in the transition matrix of the GHG Inventory, to account for the land transitions to Forest Land.

6.4.2 *FOREST LAND - FOREST LAND REMAINING FOREST LAND (4.A.1) & LAND CONVERTED TO FOREST LAND (4.A.2)*

6.4.2.1 Methodological Issues

The approach for modelling the above-ground biomass pool is based on a spreadsheet model, which includes the age dynamic forest areas in the different forest strata. The evolution of forest areas is linked to the age specific growth and eventual losses of biomass due to eventual forest management practices, thus, to develop an age dynamic model. The choice of methodology in the spreadsheet model is based on the 'Biomass Gain-Loss Method' approach as evaluated in Section 4.2.1.1 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

None of these woodland areas are utilised for logging (MEAIM, 2015). FAOSTAT information sourced from the Forestry Production and Trade indicate that the production quantity has never been produced in Malta. As a result, since harvesting and logging is not occurring in Malta, the Harvested Wood Products (HWP) carbon pool is omitted.

There were no "deadwood pool" measurements performed previously in the country and the modelling of this pool, and therefore a projection is developed for the above-ground biomass pool due to the strong linkage between the two pools. For this reason, Malta selected the mortality rates (gains) and decay functions (losses) appropriate to the above-ground biomass development. Given the relatively lower relevance of this pool, compared to the above-ground biomass, the modelling of the above-ground biomass pool variation was prioritized. Malta has not experienced a significant increase of harvest levels which would have altered the deadwood pool. Therefore, the pool is not expected to become a source of emissions in the future, and the pool variation could be retained as minor.

An assessment, of such pool for similar forest conditions was provided in the Greek NIR 2018 submission and it was based on values of deadwood pools variations for Mediterranean forests in Central-South Italy (see Figure 9.5 on page 440). However, for the 'forests in equilibrium', it is justified that also the deadwood has no significant variation over time. In the future, in the case that more accurate modelling of above-ground biomass is established, and parameters are obtained for the deadwood, the reviewers encouraged to improve the estimation of the deadwood pool and base it on a spreadsheet simulation linked to the above-ground biomass pool variations. This will ultimately depend on the level and capacity of data collection from the national stakeholders.

The dynamic age structure module for the above-ground biomass pool is based on the stratification of the Maltese forests, which are explained above. The dynamic development of areas assigned to each age class are dynamically propagated from year throughout the time series. For the stratum of 'forests in equilibrium', it is assumed that an equilibrium has been reached between growth and decay of biomass and the carbon pool variation is zero. For the strata belonging to the 'age dynamic forests', a classification of the area in age classes is established, the width of each class is based on the accuracy of information on the planting time of the forests (e.g., 5 years, 10 years, etc.). For each successive year, starting from the year 1990, the age of each forest area is recalculated by adding 1 year to the documented age. The simulation is then propagated to the end of the time series, where the simulation is able to provide the age structure in the period. The annual volume of increments for determining the net growth of each stratum and age class is collected for yield tables/growth functions from countries with similar climate and species. Specifically, for conifers, the standing volume and above-ground volume current annual increment is retrieved from Montero et al. (2001) representing the growth functions for Pinus halepensis in south of Spain. The increment function is selected according to the fertility conditions of the national attributes. For Mediterranean broadleaves, above-ground biomass standing volume and current annual increments of volume for the different age classes are retrieved from the Italian National Forest Inventory (INFC 2005), considering the category of 'schlerophylls' forests in the Sicily Region. From the MALSIS (2004) and a report by Sultana (2017) on the soil quality change in the Maltese Islands, it can be assumed that Maltese forests belong to a medium to low classes of fertility.

The current annual increments from the growth functions/tables are consistent to the net annual increments by taking into account the mortality rates of the different species or compared to the ones of thinned forests. Yearly rate of mortality for similar species were retrieved from Ruiz-Benito et al (2013). The 'gains' of biomass above-ground biomass during each year were obtained by multiplying the net annual increment by the respective age class area. The biomass 'losses' were not included, since biomass due to the harvesting (cleaning, safety cutting) was not estimated to be relevant. Thus, it can be concluded that in the modelling approaches, the assessment of the biomass loss in the harvest module is not considered due that harvest is not proportional to the above-ground biomass growth. As a result, the projection of biomass losses due to harvest assumes a fixed amount.

In the carbon pool variation module, the variation of above-ground biomass is converted, measured in tonnes CO_2. The sum of gains for each year provides the annual net variation of the above-ground biomass volume. The average variation of above-ground volume (m^3) is converted in tonnes of CO_2 according to the conversion coefficients of IPCC 2006 for each forest type (following the recommended conversions from m^3 to oven dry tonnes and from oven dry tonnes to tonnes Carbon in Tables in section 4.5 of IPCC 2006 report). The conversion from tonnes C into CO_2 is obtained by applying a multiplier of 3.67 (or 44/12). The algebraic sum of the FRL for the 'forests in equilibrium', the 'age dynamic forests' and the 'afforested land' provides the total final increment for the above-ground biomass pool.

The model approach developed in the spreadsheet model considers the above-ground biomass pool including estimations in the 'age dynamic forest' pools for the forest sites which are less than 100 years. As stated earlier the model is based on the 'gains and losses' approach as indicated in the IPCC 2006 Guidance. The estimations for the biomass pool are calculated based on the stratification classes of 'forest in equilibrium' and 'age dynamic forest', as well as considering the stratification of the dominant tree species for each stratification class, which are divided into conifer dominated and broad-leaved dominated, with tree species being younger than 100 years respectively, and also considering the afforestation criteria. The estimations include the calculations for dynamic growth for the 'age dynamic forests' and for the afforestation criteria. As explained earlier, for the stratum of 'forests in equilibrium' no dynamic is included, as for these forests, it is assumed that an equilibrium has been reached between growth and decay of biomass and the carbon pool variation is zero.

The dynamic age structure module for the above-ground biomass pool is estimated for the strata belonging to the 'age dynamic forests', by assessing the classification of the area for the time series in the age classes for the dominant tree species of each forest site. As abovementioned, the annual volume of increments for determining the net growth of each strata and age class, is collected from yield tables/growth functions for countries with similar climate and species to that of Malta. The yield tables for the 'conifer dominated' are retrieved from Montero et al. (2001), considering the fertility class Q14. The age classes shown are the last value of the age class in terms of increment e.g. 20 means less than or equal to 20, 30 means from 21 to 30 years old, etc. Table 6-17 below show the increments for the 'conifer dominated' and 'broad-leaved dominated' stratum, as adopted from the mentioned reports.

Table 6-17 Q14 (fertility class). Moderate thinnings, columns from the "Main crop after moderate thinning" (in order to account already for mortality). Adopted from Montero et al. (2001)

Age class (years)	Standing volume (m^3/ha)	Current Annual Increment (m^3/ha/year)	Density (trees/ha)	Tree size (m^3/tree)
20	25	1.24	1482	0.02
30	52	2.74	1342	0.04
40	77	2.53	1006	0.08
50	106	2.85	997	0.11
60	124	1.77	797	0.16
70	138	1.43	684	0.20
80	150	1.16	608	0.25
90	159	0.94	554	0.29
100	167	0.76	515	0.32
110	173	0.63	486	0.36
120		0.00		

The Mean Annual Increment for the Q14 class (m^3/ha/year) is calculated by dividing the last significant age class (110 years) to the standing volume to acquire the mean value of 1.57m^3/ha/yr. This value is based on medium to low fertility, soil depth 20-40 cm and maximum height of trees 13m.

Figure 6-8 Current annual increment for 'conifer dominate' based on the Q14 Fertility class

A simulation for natural mortality effect for the 'conifer dominated' stratum was created to verify the mortality for "pinus halepensis", where the tree density of the forest for which increment were provided was compared to a forest where light thinnings were performed (considering a silvicultural management similar to natural mortality). The yearly mortality rate as number of trees was adopted from Ruiz-Benito et al. (2013). The density was recalculated to verify that the "moderate thinnings" is enough to represent the mortality in the stand as the "natural mortality", since the stand has the same density. Indeed, the density of the Q14 fertility is quite similar to the density values as adopted from Ruiz-Benito et al. (2013), thus a moderate thinning represents well already net increments (net of mortality). The exercise was done relative to a 10-year time step. Table 6-18 indicates the simulation of natural mortality effect.

Table 6-18 Simulation of natural mortality effect for ‘conifer dominated’ based on Q14 class. Adopted from Ruiz-Benito et al. (2013)

Age (years)	Density (trees/ha after mortality)	Mortality rate (from Ruiz-Benito et al. 2013)	Dead trees (trees/ha)
20	1586	0.0150	
30	1348	0.0150	238
40	1159	0.0140	189
50	997	0.0140	162
60	867	0.0130	130
70	755	0.0130	113
80	664	0.0120	91
90	598	0.0100	66
100	538	0.0100	60
110	484	0.0100	54
120			

The yield increments for the ‘broad-leaved dominated’ were retrieved from the tables indicating the mixed Mediterranean broadleaves forest "schlerophylls" in age classes from Sicily according to the Italian National Inventory of Forests and Carbon stock (INFC, 2005). Table 6-19 indicates the values for the ‘broad-leaved dominant’ species.

Table 6-19 Increment for mixed Mediterranean broadleaves forest "sclerophylls" in age classes. Adapted from Sicily according to NFI Italy tables (CFS-CRA 2005. Italian National Inventory of Forests and Carbon stock (INFC 2005)

Age class (years)	Middle in age class (year)	Current Annual Increment (m3/ha/year)	Standing volume (m3/ha)	Density (trees/ha)	tree size (m3/tree)
11-20	15	0.70	10.50	1800	0.01
21-30	25	3.90	49.50	1600	0.03
31-40	35	3.70	86.50	1400	0.06
41-80	60	3.60	176.50	1200	0.15
81-120	100	1.20	224.50	800	0.28
>120		0.00			

It is to note that for the Current annual increment it is assumed to be net of mortality, since it was collected in forests also eventually managed where the deadwood was inventoried separately. The density of trees indicated in the table is only indicative, based on mixed Mediterranean forests in Palahí, et al. (2008). Furthermore, the tree size is indicative as well, which is calculated and based on the standing volume and density. The Mean Annual Increment was calculated using the same method as for Table 6-17, with a mean value of 2.2 m^3/ha/yr. For the broadleaves, as recommended by the Expert reviewers, information on the type of management (tree density) was not directly linked to the increments, thus it was more difficult to verify if mortality was excluded from the increments. Nevertheless, this forest should be at least partly managed and therefore, the increments exclude some of the mortality from the gross increment.

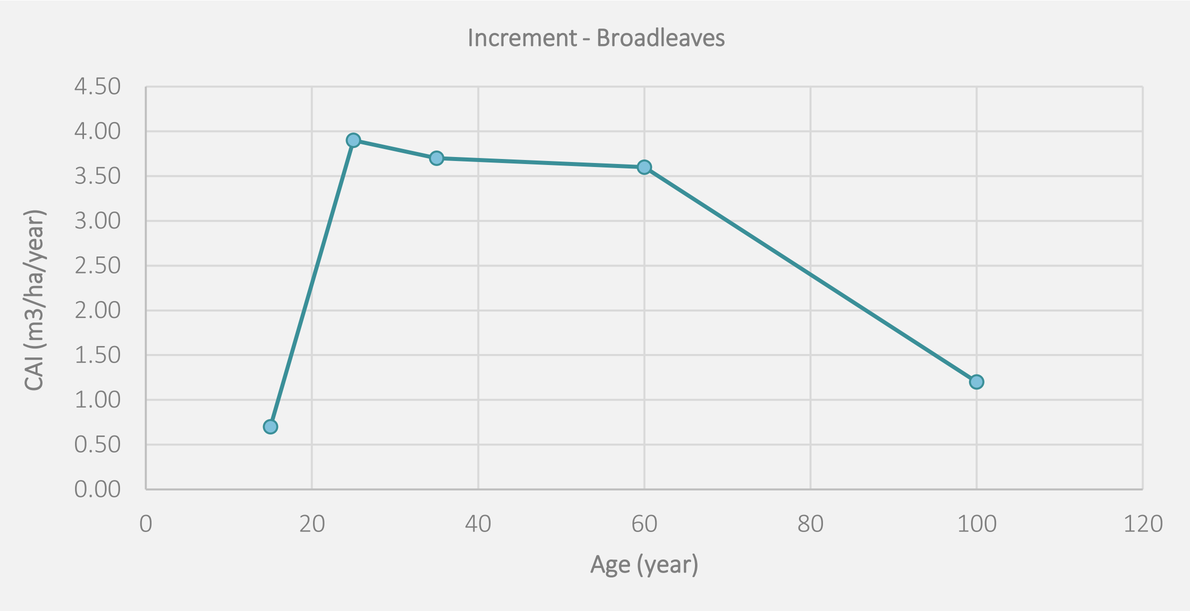


Figure 6-9 Annual increment for 'broad-leaved dominated' based on the Italian National Inventory of Forests and Carbon stock

With regards to tree mortality and cuttings, the information received relates only to cuttings which occurred in Foresta 2000. Relevant information on the other sites was not occurring or was not received. The information received indicates that few types of species underwent tree cutting due to vandalism in specific years only. It is to note, as Ambjent Malta and BirdLife confirmed, that all the species were very young when these were vandalised (less than 10 years old), and their removal is not due to 'prescribed management' but to external factors. In addition, this area has been recently afforested and it was not planned to be harvested. Therefore, the expert reviewers suggested to not take an average or dynamic harvest of the area, because these have been exceptional events not included in the management of the area. As a result, the dynamic simulation for the harvest was not evaluated.

The estimations of the above-ground biomass carbon pool are calculated in the model spreadsheet, where the estimations are presented in the tables below. The calculated increments for the stratification classes related to the forest sites are based on the dynamic growth simulation evaluated in the model spreadsheet. The harvest dynamic simulation is not evaluated, the reason was provided in previous sections.

The estimations of the above-ground biomass carbon pool are calculated in the model spreadsheet, where the calculations were estimated for the whole time-series. The calculated increments for the stratification classes related to the forest sites were computed using the values from the yield table/curves for current annual increment (CAI in m^3/ha/year) at net of mortality for the pine dominated class and broadleaved dominated class in Table 6-17 and Table 6-19. Since data was only available for the ages in intervals, as indicated in the age classes, an interpolation exercise was performed thus to gap fill the increment for all the remaining years. The values are based on the dynamic age specific value of the forest classes when these reach the specific age during the time series. The Biomass Expansion Factor (BEF) from stemwood to whole aboveground biomass is assumed to be "1".

The increment values for the respective tree species and locations were multiplied by the Default biomass conversion and expansion factors (BCEF) for the conversion from m^3 to tonnes dry matter of increments, multiplied by the Carbon Fraction of aboveground forest biomass for the conversion from tonnes dry matter to tonnes Carbon, and finally multiplied by 3.67 (as sourced from the 2006 IPCC Guidelines, Section 2.2.3, page 2.11) for the conversion from tonnes Carbon to tonnes CO_2. Table 6-20 and Table 6-21 indicate the default values utilised for the increment conversions, as retrieved from the IPCC Guidelines:

Table 6-20 Carbon fraction of aboveground forest biomass

Domain	Part of tree	Carbon Fraction, (DF) [tonne C (tonne d.m.)-1]	Source
Temperate & Boreal	Broad-leaved	0.48	2006 IPCC Volume 4 Part 1 – Table 4.3
	Conifers	0.51	

Table 6-21 Default biomass conversion and expansion factors (BCEF) [tonnes biomass (m^3 of wood volume)$^{-1}$]

Climatic Zone	Forest type	BCEF	Growing stock level (m3) 41-100	Source
Mediterranean	Hardwoods	$BCEF_I$	0.55	2006 IPCC Volume 4 Part 1 – Table 4.5
	Conifers	$BCEF_I$	0.45	

As a final step, to calculate the total increment in the stratification classes the annual increment per ha was multiplied by the area of each age class. The specific ages are retrieved from Table 6-15 and Table 6-16 accordingly.

Table 6-22 represents the biomass estimations in category 4.A.1 Forest Land remaining Forest Land from 1990-2022.

Table 6-22 Biomass estimations in Forest Land

Year	Biomass (kt CO_2 eq.)
1990	-0.013
1991	-0.013
1992	-0.012
1993	-0.012
1994	-0.011
1995	-0.011
1996	-0.010
1997	-0.010
1998	-0.009
1999	-0.009
2000	-0.008
2001	-0.008
2002	-0.008
2003	-0.008
2004	-0.008

2005	-0.007
2006	-0.007
2007	-0.007
2008	-0.007
2009	-0.007
2010	-0.007
2011	-0.007
2012	-0.006
2013	-0.006
2014	-0.006
2015	-0.006
2016	-0.006
2017	-0.006
2018	-0.006
2019	-0.006
2020	-0.005
2021	-0.005
2022	-0.005

The same methodology was considered and produced for estimations in conversions to Forest Land.

The calculations of Dead Organic Matter (DOM) in Land converted to Forest Land are estimated as according to Chapter 2 of the 2006 IPCC Guidelines, conversion to Forest Land results in build-up of litter and dead wood carbon pools starting from zero carbon in those pools. A Tier 1 approach was considered to calculate the estimates of DOM using Equation 2.23 from Chapter 2 of the 2006 IPCC Guidelines, where, the conceptual approach to estimating changes in carbon stocks in dead wood and litter pools is to estimate the difference in C stocks in the old and new land-use categories and to apply this change in the year of the conversion (carbon losses), or to distribute it uniformly over the length of the transition period (carbon gains).

For the area undergoing conversion from old to new land-use category in the equation the 20-year area period was considered. For the litter stock under the new land-use category C_n, the Tier 1 default values for litter C stock for Broadleaf deciduous of 28.2 tonnes C ha^{-1}, and 20.3 tonnes C ha^{-1} for Needleleaf evergreen forest types were utilised, considering the Warm Temperate, dry climate parameters. It is to note that the default values for dead wood carbon stocks are not available in the IPCC Guidelines, thus only the carbon stocks for litter were calculated for the DOM pool. For the litter stock under the old land-use category C_o the default value of 0 was utilised, as per the 2006 IPCC Guidelines. The default value of 20 was utilised for the time-period of the transition from old to new land-use category. For the conversion of Cropland to Forest Land and Grassland to Forest Land both the broadleaf deciduous and needleleaf evergreen species types are present, thus the appropriate factor was applied to the area of the species type present. To acquire the annual change in carbon stocks in litter, the area is multiplied by subtracting the litter stocks C_n to C_o and dividing by the time-period of the transition. Table 6-23 below indicates the emission factors used for the calculation of DOM in conversions to Forest Land.

Table 6-23 Default Emission Factors for litter carbon stocks

Parameter	Parameter description	Emission Factor	Identifier	Source
Land conversion to Forest Land - Litter carbon stocks of mature forests	Warm Temperate, dry - Broadleaf deciduous	28.2 tonnes C ha^{-1}	Default value for litter C stock	Table 2.2 IPCC 2006
	Warm Temperate, dry - Needleleaf evergreen	20.3 tonnes C ha^{-1}		

Table 6-24 represents the biomass and DOM estimates in category 4.A.2 Land converted to Forest Land from 1990-2022.

Table 6-24 Biomass and DOM estimations in conversions to Forest Land

Year	Biomass (kt CO_2 eq.)	DOM (kt CO_2 eq.)
1990	-	-
1991	-	-
1992	-	-
1993	-	-
1994	-	-
1995	-	-
1996	-	-
1997	-	-
1998	-	-
1999	-	-
2000	-	-
2001	-	-
2002	-	-
2003	-	-
2004	-0.001	-0.072
2005	-0.002	-0.072
2006	-0.003	-0.072
2007	-0.003	-0.072
2008	-0.004	-0.072
2009	-0.005	-0.072
2010	-0.005	-0.072
2011	-0.006	-0.072
2012	-0.006	-0.072
2013	-0.007	-0.072
2014	-0.008	-0.072
2015	-0.009	-0.093
2016	-0.010	-0.093
2017	-0.010	-0.093
2018	-0.013	-0.093
2019	-0.017	-0.093
2020	-0.036	-0.093

2021	-0.044	-0.093
2022	-0.051	-0.093

6.4.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty for the Forest Land category biomass calculations was very difficult to determine, noting that Emission factors from studies other than the IPCC Guidelines were chosen and utilised to perform the estimates. To this end, the studies did not reveal any information on uncertainty analysis, thus this was unavailable. Moreover, the EFs chosen and indicated in the IPCC Guidelines were also being referred from other studies carried out. Nevertheless, the uncertainty of 9% was acquired for the carbon fraction of aboveground forest biomass acquired from the 2006 IPCC Volume 4 Part 1 – Table 4.3, which was referenced from the study in which the emission factor was acquired from.

On the other hand, the uncertainty for the DOM calculations was calculated based on the emission factors utilised to estimate the emissions and expressed as percentages. The uncertainties of the default litter C stocks emission factors to estimate the annual change in carbon stocks in litter were calculated by estimating the average between the difference of the 5th and 95th percentiles (from simulations of inventory plots) of the default factors gathered from Table 2.2 of the 2006 IPCC Guidelines, using the equations: ((5th or 95th percentiles - EF) / percentile range)*100 or ((EF - 5th or 95th percentiles) / EF)*100. Table 6-25 below indicates the uncertainly levels for the Emission Factors used:

Table 6-25 Uncertainty in Forest Land category

Category / sub-category	Parameter	Uncertainty (%)	Source	Remark
Land conversion to Forest Land - Litter carbon stocks of mature forests	Warm Temperate, dry - Broadleaf deciduous	18%	Table 2.2 IPCC 2006	5th and 95th % - range from 23.4 - 33.0 (Calculated as an average between the difference of the percentile range estimates of the default factors)
	Warm Temperate, dry - Needleleaf evergreen	15%		5th and 95th % - range from 17.3 - 21.1 (Calculated as an average between the difference of the percentile range estimates of the default factors)

As a result of this assessment, the total uncertainty in Forest Land for CO_2 estimates is 14%.

Further information on the respective trends in the uncertainties for all the categories are presented in the Uncertainty section in Chapter 1 and separate detailed information on uncertainties being submitted with this report.

6.4.4 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

Data that is input in the working spreadsheet such as the activity data and the emissions factors are double-checked to ensure accuracy with the data entry, and moreover, the methodology is checked with the IPCC Guidelines data. When possible, the areas were verified when utilising different sources, such as datasheets, management plans, certain expert judgement and the map server, thus, to maintain accuracy with the areas in Forest Land throughout the time-series.

Please refer to Table 6-11 for the complete list of QA/QC checks produced, which is relevant for the Activity Data and Emissions Factors of all categories.

6.4.5 CATEGORY-SPECIFIC RECALCULATIONS

Recalculations for the Forest Land category are relevant only for the years 2004-2021 due to the updates in the land areas and the land use matrix.

Table 6-26 Recalculations in Cropland category

Year	Forest Land (kt CO2 eq.) as reported in the previous inventory report (AR5 GWPs)	Forest Land (kt CO_2 eq.) as reported in this inventory report (AR5 GWPs)	Percentage change in reported emissions (%)	Change in kt CO_2 eq.
2004	-0.07	-0.08	0.15%	-0.01
2005	-0.07	-0.08	0.15%	-0.01
2006	-0.07	-0.08	0.15%	-0.01
2007	-0.07	-0.08	0.14%	-0.01
2008	-0.07	-0.08	0.14%	-0.01
2009	-0.07	-0.08	0.14%	-0.01
2010	-0.07	-0.08	0.14%	-0.01
2011	-0.07	-0.08	0.14%	-0.01
2012	-0.07	-0.09	0.14%	-0.01
2013	-0.08	-0.09	0.14%	-0.01
2014	-0.08	-0.09	0.14%	-0.01
2015	-0.10	-0.11	0.12%	-0.01
2016	-0.10	-0.11	0.12%	-0.01
2017	-0.10	-0.11	0.12%	-0.01
2018	-0.10	-0.11	0.12%	-0.01
2019	-0.14	-0.12	-0.17%	0.02
2020	-0.29	-0.13	-0.53%	0.15
2021	-0.29	-0.14	-0.52%	0.15

6.4.6 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

Improvements will continue to be made following the collaboration project together with the Malta College of Arts, Science & Technology (MCAST), for the generation of land-use and land coverage mapping of the Maltese Islands, thus, to achieve a complete and more accurate spatial explicit representation of land use and tracking changes over time in Malta.

6.5 CROPLAND (CRF CATEGORY 4B)

6.5.1 CATEGORY DESCRIPTION

Agriculture is the largest land user on the island (47% of total land surface). Other land use categories are natural areas (23%) and woodland at less than 1%. The majority of agricultural holdings in Malta and Gozo are relatively small, where, around 75% of the agricultural holdings have a Utilised Agricultural Area (UAA) of less than 1 hectare each. Medium-sized agricultural holdings made up of around 25% of the total; such holdings comprise between 1 and 5 hectares of UAA. Around 200 are landless indoor livestock holdings which are likely to include some of Malta's largest farm businesses, along with some of the largest and more specialised horticultural farms and vineyards. Most small farms in Malta grow predominantly fruit and vegetables, fodder crops, with some permanent cropping (citrus, olives, vines) (MEAIM, 2015).

Agricultural landscape is one of very small parcels of land, frequently arranged in terraces, and surrounded by dry-stone ('rubble') walls along which grow a variety of wild flora. In the widest valleys, fields are somewhat larger & there is a notable occurrence of horticulture under plastic or glass – most commonly using polytunnels. Prickly pear and other shrubs frequently grow up along boundaries between cultivated surfaces, and landscape bears the marks of both historic and current water management systems, with rock-bounded channels to direct rainwater down, across slopes and valleys, as well as frequent top-structures of wells which were the traditional subterranean rainwater reservoirs. There is also evidence of partial land abandonment, where former terraces are breaking down slowly as the land has ceased to be actively farmed, and steppe vegetation may re-establish across the land surface if there is sufficient soil depth to encourage it.

Land use on Malta's farms is classified into 3 broad categories, according to the Rural Development Programme 2014-2020 (MEAIM, 2015):

- Arable land – accounts for the larger land-based farms which grow fruit and vegetables as well as having forage crops and/or fallow land;

- Permanent crops – cover citrus, olives, vines;

- Kitchen gardens – much smaller holdings that grow a wide range of horticultural crop types.

According to the Agriculture and Fisheries survey of 2014 released by NSO (NSO, 2016) the definitions considered for land use covered by cropland and farms are the following:

- Agricultural holding: single unit which has a single management, and which produces agricultural products. A holding may have agricultural land in different localities and hence, all information related to it is taken at the holder's residence.
- Utilised agricultural area (UAA): all the land used by the holding for agricultural production, whether rented or family owned. This includes arable land and permanent cropping.
- Arable land: land which is worked regularly, generally under a system of crop rotation such as potatoes, vegetables, fodder and fallow land. The area under greenhouses is included under this heading.
- Fallow land: land which is included in the crop rotation system but is not producing a harvest and is left to recover for the duration of the crop year.
- Permanent crops: land cultivated with crops that occupy the land for long periods and need not be replanted after each harvest.
- Kitchen Gardens: include those areas devoted to the cultivation of agricultural products mainly intended for consumption by the holder and his household.

The average soil organic matter level in the sampled top soils in Malta ranges from 0.4% to 2.3%, and just above the 2% soil organic carbon threshold, below which potentially serious decline in soil quality is expected to occur. The soils' suitability for agronomic purposes is limited by a number of factors, predominantly the unfavourable soil chemical status as a result of alkalinity and the calcareous nature of the soils, shallow depth to bedrock, low soil organic matter, high soil stoniness, and unfavourable water regime as a result of an impermeable surface crust. Soils with a carbonate and bicarbonate content greater than 25% occupy approximately 91% of the total country area. Very shallow soils (<25cm) and shallow soils (> 25cm and < 50cm) occupy 58% of the country's area. 40% of soils are estimated to contain more than 15% coarse fragments (MALSIS, 2004).

Liming of agricultural soils is not applicable to Malta as soils have large calcium carbonate content (MRAE, 2004). Maltese soil types are classified as Leptosols, Vertisols, Calcisols, Luvisols, Cambisols, Regosols or Arensols (data from the MALSIS database sourced through (MEPA, 2006)). Of these, Calcisols occupy approximately 27% of total country area, whereas Luvizols and Leptosols are the most common groups. Calcisols are calcareous (lime-rich) soils with significant accumulation of secondary calcium carbonates, generally developed in dry areas. The Maltese soils are now relict soils since it has developed under different climatic conditions from the more recent one.

For inventory purposes, local cropland was split into two types:

- Annual crops which are harvested each year, so there is no long-term storage of carbon in biomass; and,

- Perennial woody crops which constitute vegetation in orchards, vineyards and agroforestry systems capable of storing significant carbon in long-lived biomass.

Under this category, CO_2 removals from living biomass and soil carbon from sub-category Cropland remaining Cropland and sub-category Land converted to Cropland have been reported. Field burning of agriculture residues estimates are reported as Not Occurring in the CRF. In accordance with B2 of the first set of national Good Agriculture and Environment Conditions (GAEC) adopted for Malta, stubble and vegetable residue should not be burnt in field or on site (Sammut, 2015).

Activity data on Cropland area coverage as available from the 2001 Agriculture Census (NSO, 2003) was used for the years 1970 to 1983, whereas for some of the years starting from 2001and onwards activity data on these two categories as published by the National Statistics Office has been used such as the Agriculture and Fisheries statistics as well as Farm Structure Surveys in some instances. It is to note that for some years the areas were not available in the NSO census or statistics, as a result, these were extrapolated or interpolated as necessary to gap fill the years in the whole time-series. Moreover, the areas developed from the LUC maps were also integrated with the time-series.

6.5.2 Cropland - Cropland remaining Cropland (4.B.1)

6.5.2.1 Methodological Issues

The methodology applied to assess the changes in carbon in cropland biomass was a Tier 1 method based on the aggregation of area estimates for perennial crops. This methodology was applied with the help of the Joint Research Centre (JRC). As vines are the most abundant crop in Malta, only values relating to vineyards are considered. In the absence of country-specific values, it was suggested by the experts during the capacity building support that

Malta considers using the values estimated by other countries. Since Malta has characteristics such as typology and climate similar to the Mediterranean, it was recommended to consider improving the current applied factors using new sets of parameters available through the LIFE Project MediNet.

From expert judgement from LULUCF experts, it was recommended to use the values available from the LIFE Project MediNet. The same methodology was maintained as in previous submissions, established with the help of the JRC. It is strongly encouraged not to use the IPCC default value of 63 t C/ha^{-1}, since it is not appropriate for most Maltese conditions. In this case, the factors adopted by the LIFE Project MediNet report 'Biomass Data on Cropland and Grassland in the Mediterranean Region' from Table 27 (Canaveira et al., 2018) were taken into consideration for Malta and will thus be utilised, which considers the value of 9.9 tonnes C. ha^{-1} for vineyards. According to the report the type of perennial crop, which in this case for the crop vineyard, achieves the carbon stock at maturity 20 years after the date of planting. The areas for the years utilised for these calculations were taken from the land use matrix.

For the calculation of biomass changes in the land use conversion, different biomass stock factor values were used to acquire the value for the C stock in biomass (ΔC). The main values required were for annual and perennial Cropland, as well as for maquis and other Grassland. The values for Maquis and Other Grassland were required to estimate the conversions coming from Grassland. For Annual Cropland and Other Grassland the default values were used since the carbon stock in biomass is after one year as indicated in Table 6-27. On the other hand, for Perennial Cropland and maquis Grassland the values from the LIFE Project MediNet were used, since conditions are similar to those in Malta, thus the values are deemed to be appropriate for the Maltese case. These are also presented in below table.

The value as above for the perennial Cropland of 9.9 t. C. ha^{-1} was acquired from the default carbon stocks at maturity for vineyards stock for Perennial Cropland, and this was divided by the 20 years maturity cycle to acquire the biomass C accumulation rate value of 0.50 t C ha^{-1} y^{-1} (also present in report 'Biomass Data on Cropland and Grassland in the Mediterranean Region' from Table 30). For Annual Cropland, the default biomass C stock present on land converted to Cropland in the year following conversion was revised from the 2019 Refinement Guidelines for this year, thus considering the value of 4.7 tonnes C ha^{-1} from the updated Table 5.9 of 2019 Refinement to the 2006 IPCC Guidelines. For the Maquis Grassland value of 18.8 t. C. ha^{-1} acquired from the same report Table 27 for the category 'Shrublands' and divided by the 20 years maturity cycle to acquire the biomass C accumulation rate value of 0.94 t C ha^{-1} y^{-1} (also present in Table 30 from same report). For the Other Grassland sub-category the default value of 6.1 t.d.m. ha^{-1} from Table 6.4 of the 2006 IPCC Guidelines is multiplied by default expansion factor of the ratio of below-ground biomass to above-ground biomass for Woodland of 0.5 from Table 6.1 of the 2006 IPCC Guidelines to acquire the value of 3.05 t C ha^{-1} as a result.

Table 6-27 Average biomass stock values and Carbon stock values for biomass estimations

Sub-sector	Parameters		Reference
	Average biomass stock	Carbon stock in biomass	
Annual Cropland	NA	4.7 t C ha^{-1}	Table 5.9 (updated) 2019 Refinement to the 2006 IPCC Guidelines
Perennial Cropland (vineyards)	9.9 t C ha^{-1}	0.50 t C ha^{-1} y^{-1}	LIFE Project MediNet - Biomass Data on Cropland and Grassland in the Mediterranean Region - Table 27 & Table 30

Maquis Grassland	18.8 t C ha^{-1}	0.94 t C ha^{-1} y^{-1}	LIFE Project MediNet - Biomass Data on Cropland and Grassland in the Mediterranean Region - Table 27 & Table 30
Other Grassland	6.1 t d.m. ha^{-1}	3.05 t C ha^{-1}	Table 6.4 & Table 6.1 2006 IPCC guidelines

The conversion occurring within the category Cropland are Annual Cropland converted to Perennial Cropland and vice-versa. For these conversions, the net biomass stock was calculated using Equations 2.15 and 2.16 in Chapter 2 of the '2006 IPCC Guidelines for National GHG Inventories'. Table 6-28 below indicates the rationale for calculations of living biomass (LB) in these conversions:

Table 6-28 Calculation rationale of living biomass (LB) in Cropland remaining Cropland

Land conversion	LOSS				GAINS			
	Loss	t C/ha	years	area to use	Gain	t C/ha	years	area to use
Conversions in Cropland								
Perrennial Cropland to Annual Cropland	Mature LB in Perennial CL	9.9	1	annual	Annual CL LB in the year following conversion	4.7	1	annual
Annual Cropland to Perrenial Cropland	LB in Annual CL	4.7	1	annual	Accumulation rate (OR maximum LB in perennial/years to reach maturity)	0.50	20	cumulative

For the soil organic content changes in land conversions within Cropland, Equation 2.25 of the '2006 IPCC Guidelines for National GHG Inventories' was used. For Other Grassland default parameters were used which were taken from the 2006 IPCC Guidelines, since neither country specific values are present, nor in the LIFE MediNet project reports. As stated above, the values for Maquis and Other Grassland were required to estimate the conversions coming from Grassland. The soil organic carbon stock (SOC) for sub category Other Grassland was computed by multiplying the land use (F_{LU}) and tillage (F_{MG}) from Table 6.2 of the 2006 IPCC Guidelines (input F_I factor value was excluded since it only applies to improved grassland, thus it's not present) by the default reference soil organic C stock (SOC_{REF}) value of 24 t C ha^{-1}, taken from the updated Table 2.3 of 2019 IPCC Refinement Volume 4 AFOLU, which is that of the high activity clay soils (HAC soils) for Maltese soils, and choosing the appropriate climatic region for Malta which is the warm temperate, dry. The value of 24 t C ha^{-1} in the updated Table 2.3 from the IPCC 2019 Refinement was chosen over the 2006 IPCC guidelines, was mainly due that the uncertainty in the 2019 IPCC refinement was significantly less (±5%) when compared to the 2006 IPCC value (±90%), thus considered to be more accurate.

For Annual Cropland, Perennial Cropland and Maquis Grassland the values taken from the 'LIFE Project Medinet - Soil Carbon Data in Cropland and Grassland in the Mediterranean Region' were considered. For Annual and Perennial Cropland the average SOC stock resulting from the consolidated MediNet database (M+L) were considered from Table 34 and Table 35 choosing the appropriate soil and climate conditions for Malta - 'HAC+WTdry'. For Maquis Grassland it was recommended to use the SOC stock value in Shrubland from Table 74 of the same report, for the country of Italy since it represents closest conditions to that of Malta. Based on the LUCAS database for countries as indicated in Table 74 of the report, the average value for Italy is 48.9 t C ha^{-1} (standard error of 4.2). If the lowest value for Italy is considered, based on the standard error (48.9 (Av) - 4.2 (SE) = 44.7 t C ha^{-1}) then the value would be 44.7 t C ha^{-1}.

The 20-year transition cumulative areas were utilised in the estimation. Table 6-29 below indicates the default parameters used to calculate the SOC changes in the conversions.

Table 6-29 Cropland and Grassland emission factors for SOC changes calculation

Parameters	Values	Reference
Climate region	Warm temperate dry	Figure 3A.5.1 – 2006 IPCC Guidelines
Soil type	High activity clay soils - HAC soils	Table 2.3 (updated) of 2019 IPCC Refinement Volume 4 AFOLU
Default Soil Organic C stock (SOCref)	24 t C ha^{-1}	Table 2.3 (updated) of 2019 IPCC Refinement Volume 4 AFOLU
Annual Cropland stock change factors (t C ha^{-1})		
HAC+WTdry – high activity clay soils + warm temperate dry Consolidated MediNet database – (M+L)	44.2	LIFE Project Medinet - Soil Carbon Data in Cropland and Grassland in the Mediterranean Region - Table 34
Perennial Cropland stock change factors (t C ha^{-1})		
HAC+WTdry – high activity clay soils + warm temperate dry Consolidated MediNet database - Vineyard (M+L)	35.2	LIFE Project Medinet - Soil Carbon Data in Cropland and Grassland in the Mediterranean Region - Table 35
Other Grassland stock change factors (t C ha^{-1})		
F_{LU}	1	Table 6.2 – 2006 IPCC guidelines
F_{MG}	1	Table 6.2 – 2006 IPCC guidelines
F_I (applied only to improved grassland)		Table 6.2 – 2006 IPCC guidelines
Other Grassland SOC (t C ha^{-1})	24	
Maquis Grassland stock change factors (t C ha^{-1})		
Average SOC stocks (t C ha-1) in Shrubland - Italy value (based on standard error of the mean of 4.2 t C ha^{-1})	44.7	LIFE Project Medinet - Soil Carbon Data in Cropland and Grassland in the Mediterranean Region - Table 74

For the calculation of the Mineralised N resulting from loss of soil organic C stocks in mineral soils through land-use change or management practices to acquire the F_{SOM} value, equation 11.8 was used from the 2006 IPCC Guidelines. The cumulated 20-year transition areas in the conversions were used for these estimations. For the *R* in the equation 11.8, the default values for C:N ratio of the soil organic matter, which are indicated in the equation, were utilised for the calculation of FSOM values from the conversions to Cropland. For the C:N ratio, the default value of 15 was used for the land-use change from Grassland to Cropland, while the default value of 10 was used for the management changes on Cropland Remaining Cropland. The F_{SOM} input was calculated further to estimate the direct and indirect N_2O emissions from soil, and finally converted to kt N_2O equivalent. It is to note that the estimates within the Cropland reaming Cropland conversions are included in the Agriculture sector in section '3.D.1.5. Mineralisation/Immobilisation associated with Loss/Gain of Soil Organic Carbon', thus in the LULUCF CRF these are indicated as IE in section '4.B.2.2 4(III) Direct N_2O emissions from N Mineralisation/Immobilisation'. Estimations accounted in the LULUCF sector related to direct N_2O emissions from N mineralization/immobilization are reflected in the land use conversions from one category to another occurring in the sector, specifically in Cropland, Settlements and Other Land.

Table 6-30 represents the estimations in category 4.B.1 Cropland remaining Cropland from 1990-2022 by carbon pool.

Table 6-30 Emissions/removals in Cropland remaining Cropland

Year	Biomass (kt CO_2 eq.)	SOC (kt CO_2 eq.)
1990	-0.640	0.709
1991	-1.862	0.709
1992	-2.302	0.690
1993	-2.302	0.690
1994	-2.281	0.690
1995	-2.145	0.664
1996	-2.107	0.664
1997	-2.048	0.635
1998	-2.026	0.635
1999	-1.975	0.617
2000	-1.975	0.672
2001	-1.975	0.672
2002	-1.616	0.734
2003	-1.616	0.741
2004	-1.557	0.643
2005	-1.585	0.546
2006	-0.203	0.573
2007	-0.126	0.600
2008	-1.048	0.456
2009	-1.342	0.312
2010	-1.109	0.167
2011	-1.078	0.167
2012	-0.977	0.167
2013	-0.984	0.167
2014	-0.992	0.167
2015	-1.000	0.167
2016	-1.029	0.167
2017	-1.416	0.167
2018	-1.416	0.167
2019	-1.416	0.167
2020	-1.416	0.167
2021	-1.057	0.167
2022	-1.057	0.167

6.5.3 CROPLAND - LAND CONVERTED TO CROPLAND (4.B.2)

6.5.3.1 Category Description

Land converted to Cropland is assumed to come from Grassland and Settlements.

6.5.3.2 Methodological Issues

The land conversion areas were used to calculate the biomass stocks occurring in the land use conversions in Cropland for the whole time-series through the annual changes in areas. Equations 2.15 and 2.16 of the '2006 IPCC Guidelines for National GHG Inventories' were used to calculate the biomass stocks. The emission factors used to compute the estimates were taken from Table 6-27, where the different emission factors were utilised according to and corresponding to each of the conversions. Table 6-31 below indicates the rationale for calculations of living biomass (LB) in these conversions:

Table 6-31 Calculation rationale of living biomass (LB) in land converted to Cropland

Land conversion	LOSS				GAINS			
	Loss	t C/ha	years	area to use	Gain	t C/ha	years	area to use
Conversions to Cropland								
Other Grassland to Annual Cropland	LB in Other GL	3.05	1	annual	Annual CL LB in the year following conversion	4.7	1	annual
Perennial Cropland to Annual Cropland	Mature LB in Perennial CL	9.9	1	annual	Annual CL LB in the year following conversion	4.7	1	annual
Maquis Grassland to Annual Cropland	Maximum LB in Maquis GL	18.8	1	annual	Annual CL LB in the year following conversion	4.7	1	annual
Annual Cropland to Perennial Cropland	LB in Annual CL	4.7	1	annual	Accumulation rate (OR maximum LB in perennial/years to reach maturity)	0.50	20	cumulative
Maquis Grassland to Perennial Cropland	Maximum LB in Maquis GL	18.8	1	annual	Accumulation rate (OR maximum LB in perennial/years to reach maturity)	0.50	20	cumulative
Other Grassland to Perennial Cropland	LB in Other GL after 1 year	3.05	1	annual	Accumulation rate (OR maximum LB in perennial/years to reach maturity)	0.50	20	cumulative

For the soil organic content changes in land conversions to Cropland, Equation 2.25 of the '2006 IPCC Guidelines for National GHG Inventories' was used. Default parameters were used which were taken from the 2006 IPCC Guidelines. The same method used in Section 6.5.2.1 was applied here for land converted to Cropland to calculate the SOC changes. The 20-year transition cumulative areas were utilised in the estimation. Moreover, factors were also used from Table 6-27 for the calculations of estimations.

For the N_2O emissions in the conversions to Cropland, the same method as in the previous section was used here, where the N estimations were performed using the SOC stock change values. The estimates of N emissions in the Cropland conversions are included in the Agriculture sector in section '3.D.1.5. Mineralisation/Immobilisation associated with Loss/Gain of Soil Organic Carbon', thus in the LULUCF CRF these are indicated as IE in section '4.B.2.2 4(III) Direct

N_2O emissions from N Mineralisation/Immobilisation'. Table 6-32 represents the estimations in category 4.B.2 Land converted to Cropland from 1990-2022 by carbon pool.

Table 6-32 Emissions/removals in Land Converted to Cropland

Year	Biomass (kt CO_2 eq.)	SOC (kt CO_2 eq.)	Non-CO_2 – N_2O (kt CO_2 eq.)
1990	-0.133	-1.534	0.015
1991	-0.133	-1.534	0.015
1992	-0.133	-1.534	0.015
1993	-0.038	-1.262	0.013
1994	-	-0.785	0.009
1995	-	-0.785	0.009
1996	-	-0.603	0.005
1997	-	-0.603	0.005
1998	-	-0.603	0.005
1999	-	-0.603	0.005
2000	-	-0.550	0.004
2001	-	-0.550	0.004
2002	25.630	-0.406	0.015
2003	25.518	-0.295	0.025
2004	-	-0.295	0.025
2005	-	-0.295	0.025
2006	1.531	-0.270	0.029
2007	1.476	-0.244	0.032
2008	16.145	-0.425	0.034
2009	16.158	-0.605	0.037
2010	16.170	-0.785	0.039
2011	2.897	-0.827	0.040
2012	2.892	-0.869	0.041
2013	2.887	-0.911	0.042
2014	3.478	-0.938	0.044
2015	3.627	-0.966	0.047
2016	3.427	-0.993	0.049
2017	-0.033	-0.993	0.049
2018	-0.033	-0.993	0.049
2019	-0.033	-0.993	0.049
2020	-0.033	-0.993	0.049
2021	-0.033	-0.993	0.049
2022	-0.036	-0.846	0.015

6.5.4 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

This section will address the uncertainty analysis in the category of Cropland, which was calculated based on the emission factors utilised to estimate the emissions and expressed as percentages. The information presented here will be relevant also for the other categories since these made use of the same emission factors for the emission estimations. Table 6-33 below indicates the uncertainly levels for the Emission Factors used:

Table 6-33 Uncertainty analysis in the Cropland category

Category / sub-category	Parameter	Total uncertainty (%)	Source	Remark
Cropland remaining Cropland	Default Carbon Stocks at Maturity for vineyards	13%	LIFE Project MediNet - Biomass Data on Cropland and Grassland in the Mediterranean Region - Table 27	Systematic quantitative review of the available information from scientific literature and other publications + elicitation protocol
Annual Cropland	C biomass stocks	±75%	Table 5.9 (updated) IPCC 2019 Refinement	
Perennial Cropland	C biomass stocks	16%	LIFE Project MediNet - Biomass Data on Cropland and Grassland in the Mediterranean Region - Table 27 & Table 30	Average of uncertainty of the 2 values - Proposed Default Carbon Stocks at Maturity for Total Biomass (13%) & Coefficients for Net Carbon Gains - Biomass Carbon Accumulation Rate (18%)
Annual Cropland	Management activities	2%	LIFE Project Medinet - Soil Carbon Data in Cropland and Grassland in the Mediterranean Region - Table 34 & Table 32	
Perennial Cropland	Management activities	5%	LIFE Project Medinet - Soil Carbon Data in Cropland and Grassland in the Mediterranean Region - Table 35 & Table 32	
C:N ratio of the soil organic matter	C:N ratio for Cropland	30%	Equation 11.8 of 2006 IPCC Volume 4 AFOLU – default uncertainty range	Calculated as an average between the difference of the high and the low range estimates of the default factors - *((low or high range - EF) / low or high range) * 100 or ((EF - low or high range) / EF) * 100*
Direct N_2O emissions from managed soils	N mineralised from mineral soil as a result of loss of soil carbon	70%	Table 11.1 of 2006 IPCC Volume 4 AFOLU – default uncertainty range	Calculated as an average between the difference of the high and the low range estimates of the default factors - *((low or high range - EF) / low or high range) * 100 or ((EF - low or high range) / EF) * 100*

As a result of this assessment, the total uncertainty in Cropland for CO_2 estimates is 21%, while for the N_2O estimates 50%.

Further information on the respective trends in the uncertainties for all the categories are presented in the Uncertainty section in Chapter 1 and separate detailed information on uncertainties being submitted with this report.

The spikes that are occurring in the estimations in the sector, in particular to category Land Converted to Cropland in some of the years, are due to the big annual changes occurring in Annual Cropland, where in some of the years, national statistics for 2001, 2003, 2005, 2007 and 2010 etc. are present, while assuming a linear interpolation for the years without data.

Unfortunately, this presents an issue and is very challenging to solve, since getting rid of these spikes would mean changing national statistics data. Nevertheless, work is ongoing to acquire an improved land use representation data, and thus update the land use time series as necessary.

6.5.5 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

Wherever area data for Cropland is not available, this data has to be gap filed through linear interpolation, thus this presents a certain degree of uncertainty in the values. However, interpolation is a justified method to represent areas for the time-series, where unavailable. Due to this, at times these areas cannot be checked and compared with other documents and as a result has to be based on assumption to ensure consistency throughout the time-series.

Data that is input in the working spreadsheet such as the activity data and the emissions factors are double-checked to ensure accuracy with the data entry, and moreover, the methodology is checked with the IPCC Guidelines data.

Please refer to Table 6-11 for the complete list of QA/QC checks produced, which is relevant for the Activity Data and Emissions Factors of all categories.

6.5.6 CATEGORY-SPECIFIC RECALCULATIONS

Recalculations for the Cropland category are due to the updates in the land areas and the land use matrix.

Table 6-34 Recalculations in Cropland category

Year	Cropland (kt CO2 eq.) as reported in the previous inventory report (AR5 GWPs)	Cropland (kt CO_2 eq.) as reported in this inventory report (AR5 GWPs)	Percentage change in reported emissions (%)	Change in kt CO_2 eq.
1990	-1.892	-1.583	-0.16%	0.310
1991	-1.932	-2.805	0.45%	-0.873
1992	-1.970	-3.264	0.66%	-1.295
1993	-1.645	-2.900	0.76%	-1.255
1994	-1.153	-2.368	1.05%	-1.215
1995	-1.082	-2.258	1.09%	-1.176
1996	-0.906	-2.042	1.25%	-1.136
1997	-0.914	-2.011	1.20%	-1.097
1998	-0.932	-1.989	1.13%	-1.057
1999	-0.939	-1.956	1.08%	-1.017
2000	-0.871	-1.849	1.12%	-0.978
2001	-0.910	-1.849	1.03%	-0.938
2002	24.546	24.357	-0.01%	-0.189
2003	24.526	24.373	-0.01%	-0.153
2004	-1.029	-1.184	0.15%	-0.155
2005	-1.162	-1.309	0.13%	-0.147
2006	1.720	1.660	-0.03%	-0.060
2007	1.712	1.739	0.02%	0.027

2008	15.049	15.162	0.01%	0.113
2009	14.357	14.558	0.01%	0.201
2010	14.193	14.482	0.02%	0.288
2011	0.831	1.199	0.44%	0.368
2012	0.824	1.254	0.52%	0.430
2013	0.810	1.201	0.48%	0.391
2014	-1.954	1.759	-1.90%	3.713
2015	-1.769	1.875	-2.06%	3.644
2016	-1.953	1.622	-1.83%	3.575
2017	-2.409	-2.226	-0.08%	0.183
2018	-2.370	-2.226	-0.06%	0.144
2019	-2.330	-2.226	-0.04%	0.104
2020	-2.290	-2.226	-0.03%	0.065
2021	-1.891	-1.867	-0.01%	0.025

6.5.7 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

Improvements will continue to be made following the collaboration project together with the Malta College of Arts, Science & Technology (MCAST), for the generation of land-use and land coverage mapping of the Maltese Islands, thus, to achieve a complete and more accurate spatial explicit representation of land use and tracking changes over time in Malta.

6.6 GRASSLAND (CRF CATEGORY 4C)

6.6.1 CATEGORY DESCRIPTION

Grassland in Malta is an area of high biodiversity importance protected under the Habitats Directive (Directive 92/43/ECC). As reported in the National Rural Development Strategy 2007-2013 (MEAIM, 2009) the extensive permanent grass areas or pastures that are typical of most European countries are non-existent in Malta. This is mainly due to the prevailing semi-arid climate, geology of the island, relatively shallow depth of soil and small agricultural land parcels. The closest to such land is the 'xaghri', characterised by a variety of low aromatic shrubs. Effectively, in the past grazing was practiced on such land, as well as on steppe, and this resulted in further degradation of 'xaghri' or maquis areas as well as abandoned fields. With the transition from extensive goat and sheep herds to cattle in the 1950s, following outbreaks of Maltese fever, grazing eventually diminished and is now not practised, whilst the dairy industry has become mostly reliant on forage harvested as the main cereal crop (MEAIM, 2009).

The RDP 2014-2020 (MEAIM, 2015) reports that, Malta is notable in having no grassland area within the UAA, & thus no land which would qualify as classic High Nature Value farmland exists. The garigue & maquis, which are highly prioritised habitats in Malta, represent habitats of national & international importance for biodiversity, as signified by the designation of around 13.5% of the country as Natura 2000 sites. In recognition of its fragility in current conditions, there is a prohibition on the grazing of livestock on all areas of garrigue, although this habitat was probably subject to very low levels of grazing by sheep or goats in previous centuries. This is also indicated on the basis of Legal Notice 321 of 2011 (Nitrates Action Programme Regulations, as amended) which requires that animals are housed under roofed structures at all times, thus considers grazing as not taking place in Malta. Furthermore, the Trees and Woodland Protection Regulations (Legal Notice 12 of 2001) states that no person shall allow or attempt to allow animals to graze in any tree protection area or other protected area.

For inventory purposes the Grassland category is split into Other Grassland and Maquis Grassland. The data of this category was derived from the Corine Land Cover (CLC) 1996, 2000, 2006 and 2012 under the description classes of sclerophyllous vegetation and sparsely vegetated areas. Since the CLC covers only the specific years as aforementioned, for the other years the areas were gap filled through the land use representation exercise described in Section 6.3.1. Moreover, the areas developed from the LUC maps were also integrated with the time-series.

6.6.2 GRASSLAND - GRASSLAND REMAINING GRASSLAND (4.C.1)

6.6.2.1 Methodological Issues

The biomass stock changes were estimated using Equation 2.16 of the '2006 IPCC Guidelines for National GHG Inventories' in the Cropland conversions. The appropriate emission factor taken from Table 6-27 above were used for each conversion. Table 6-35 below indicates the rationale for calculations of living biomass (LB) in these conversions:

Table 6-35 Calculation rationale of living biomass (LB) in Grassland remaining Grassland

Land conversion	LOSS				GAINS			
	Loss	t C/ha	years	area to use	Gain	t C/ha	years	area to use
Conversions to Cropland								
Other Grassland to Maquis Grassland	LB in other grassland	3.05	1	annual	Accumulation rate (OR maximum LB in Maquis/years to reach maturity)	0.94	20	cumulative
Maquis Grassland to Other Grassland	maximum maquis grassland LB	18.8	1	annual	LB in other grassland	3.05	1	annual

For the soil organic content changes in land conversions to Grassland, Equation 2.25 of the '2006 IPCC Guidelines for National GHG Inventories' was used. The same method used in the Cropland sections was followed here for land converted to Grassland to calculate the SOC changes.

Table 6-36 represents the estimations in category 4.C.1 Grassland remaining Grassland from 1990-2022 by carbon pool.

Table 6-36 Emissions/removals in Grassland remaining Grassland

Year	Biomass (kt CO_2 eq.)	SOC (kt CO_2 eq.)
1990	-	-
1991	-	-
1992	-	-
1993	-	-

1994	-	-
1995	-	-
1996	-	-
1997	-	-
1998	-	-
1999	-	-
2000	-	-
2001	0.014	-0.007
2002	-0.006	-0.007
2003	-0.006	-0.007
2004	-0.006	-0.007
2005	-0.006	-0.007
2006	-0.006	-0.007
2007	-0.006	-0.007
2008	-0.006	-0.007
2009	-0.006	-0.007
2010	-0.006	-0.007
2011	-0.006	-0.007
2012	-0.006	-0.007
2013	-0.006	-0.007
2014	-0.006	-0.007
2015	-0.006	-0.007
2016	-0.006	-0.007
2017	-0.006	-0.007
2018	-0.006	-0.007
2019	-0.006	-0.007
2020	-0.006	-0.007
2021	-	-
2022	-	-

6.6.3 *GRASSLAND - LAND CONVERTED TO GRASSLAND (4.C.2)*

6.6.3.1 Category Description

Land converted to Grassland is assumed to come from Cropland and Settlements categories.

6.6.3.2 Methodological Issues

The biomass stock changes were estimated using Equation 2.16 of the '2006 IPCC Guidelines for National GHG Inventories' in the Cropland conversions. The appropriate emission factor taken from Table 6-27 above were used for each conversion. Table 6-37 below indicates the rationale for calculations of living biomass (LB) in these conversions:

Table 6-37 Calculation rationale of living biomass (LB) in land converted to Grassland

Land conversion	LOSS				GAINS			
	Loss	t C/ha	years	area to use	Gain	t C/ha	years	area to use
Conversions to Cropland								
Perennial Cropland to Maquis Grassland	Mature LB in Perennial CL	9.9	1	annual	Accumulation rate (OR maximum LB in Maquis/years to reach maturity)	0.94	20	cumulative
Settlements to Maquis Grassland	zero, assumed no LB in SL	0	1	annual	Accumulation rate (OR maximum LB in Maquis/years to reach maturity)	0.94	20	cumulative
Annual Cropland to Other Grassland	LB in CL annual	4.7	1	annual	LB in Other GL	3.05	1	annual
Maquis Grassland to Other Grassland	Maximum LB in Maquis GL	18.8	1	annual	LB in Other GL	3.05	1	annual

For the soil organic content changes in land conversions to Grassland, Equation 2.25 of the '2006 IPCC Guidelines for National GHG Inventories' was used. The same method used in the Cropland sections was followed here for land converted to Grassland to calculate the SOC changes. For the N2O emissions in the conversions to Grassland, the same method as in the previous section was used here, where the N estimations were performed using the SOC stock change values. Moreover, factors from Table 6-29 were used for the estimations.

Table 6-38 represents the estimations in category 4.C.2 Land converted to Grassland from 1990-2022 by carbon pool.

Table 6-38 Emissions/removals in land converted to Grassland

Year	Biomass (kt CO_2 eq.)	SOC (kt CO_2 eq.)	Non-CO_2 – N_2O (kt CO_2 eq.)
1990	-10.769	-0.494	0.181
1991	-13.683	-0.404	0.181
1992	-9.858	0.146	0.127
1993	-9.858	0.146	0.127
1994	-9.858	0.146	0.127
1995	-9.140	0.043	0.117
1996	-9.140	0.043	0.117

1997	-9.090	0.045	0.117
1998	-8.633	0.018	0.112
1999	-8.633	0.018	0.112
2000	-8.633	0.018	0.112
2001	-4.927	-0.085	0.065
2002	-5.276	-0.085	0.065
2003	-5.276	-0.085	0.065
2004	-0.997	0.327	0.066
2005	-0.737	0.688	0.063
2006	-4.252	0.588	0.054
2007	-3.509	0.487	0.045
2008	-2.843	0.398	0.037
2009	-2.177	0.310	0.029
2010	-1.614	0.238	0.022
2011	-1.614	0.238	0.022
2012	-1.614	0.238	0.022
2013	-1.614	0.238	0.022
2014	-1.614	0.238	0.022
2015	-1.614	0.238	0.022
2016	-1.614	0.238	0.022
2017	3.928	0.209	0.033
2018	2.892	0.246	0.049
2019	-3.356	0.246	0.049
2020	-3.356	0.246	0.049
2021	-3.317	0.260	0.049
2022	-3.317	0.260	0.049

6.6.4 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The category analysis for the Grassland category was calculated based on the emission factors utilised to estimate the emissions and expressed as percentages. The uncertainty analysis for Grassland is presented in Table 6-39. Methods to calculate the uncertainty are similar to the ones calculated for the Cropland category. The total uncertainty for the Grassland estimates is 36%.

Further information on the respective trends in the uncertainties for all the categories are presented in the Uncertainty section in Chapter 1 and separate detailed information on uncertainties being submitted with this report.

Table 6-39 Uncertainty in Grassland category

Category / sub-category	Parameter	Uncertainty (%)	Source	Remark
Other Grassland	C biomass stocks	±75%	Table 6.4 of 2006 IPCC Volume 4 AFOLU	

Maquis Grassland	C biomass stocks	25%	LIFE Project MediNet - Biomass Data on Cropland and Grassland in the Mediterranean Region - Table 27 & Table 30	Average of uncertainty of the 2 values - Proposed Default Carbon Stocks at Maturity for Total Biomass (13%) & Coefficients for Net Carbon Gains - Biomass Carbon Accumulation Rate (36%)
Soil C stock	Default Reference soil Organic C stocks for Mineral soils (SOCREF)	±5%	Table 2.3 (updated) of IPCC 2019 Refinement	
Other Grassland	Management activities	5%	Table 6.2 of 2006 IPCC Volume 4 AFOLU – default uncertainty	
Maquis Grassland	Management activities	11%	LIFE Project Medinet - Soil Carbon Data in Cropland and Grassland in the Mediterranean Region - Table 74	Based on Standard error of the mean of 4.2 t C ha^{-1}
C:N ratio of the soil organic matter	C:N ratio for Grassland	75%	Equation 11.8 of 2006 IPCC Volume 4 AFOLU – default uncertainty range	Calculated as an average between the difference of the high and the low range estimates of the default factors.
Direct N_2O emissions from managed soils	N mineralised from mineral soil as a result of loss of soil carbon	70%	Table 11.1 of 2006 IPCC Volume 4 AFOLU – default uncertainty range	Calculated as an average between the difference of the high and the low range estimates of the default factors.

6.6.5 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

Wherever area data is not available, this data has to be gap filed through linear interpolation, thus this presents a certain degree of uncertainty in the values. However, interpolation is a justified method to represent areas for the time-series, where unavailable. Due to this, at times these areas cannot be checked and compared with other documents and as a result has to be based on assumption to ensure consistency throughout the time-series. Data that is input in the working spreadsheet such as the activity data and the emissions factors are double-checked to ensure accuracy with the data entry, and moreover, the methodology is checked with the IPCC Guidelines data.

Please refer to Table 6-11 for the complete list of QA/QC checks produced, which is relevant for the Activity Data and Emissions Factors of all categories.

6.6.6 CATEGORY-SPECIFIC RECALCULATIONS

Recalculations for the Grassland category are due to the updates in the land areas and the land use matrix.

Table 6-40 Recalculations in Grassland category

Year	Grassland (kt CO2 eq.) as reported in the previous inventory report	Grassland (kt CO_2 eq.) as reported in this inventory report	Percentage change in reported emissions (%)	Change in kt CO_2 eq.
1990	-8.82	-11.08	0.26%	-2.262
1991	-8.17	-13.91	0.70%	-5.735
1992	-5.02	-9.59	0.91%	-4.561
1993	-5.26	-9.59	0.82%	-4.326
1994	-5.50	-9.59	0.74%	-4.090
1995	-5.13	-8.98	0.75%	-3.853
1996	-5.36	-8.98	0.67%	-3.616
1997	-5.55	-8.93	0.61%	-3.379
1998	-5.39	-8.50	0.58%	-3.115
1999	-5.63	-8.50	0.51%	-2.877
2000	-5.86	-8.50	0.45%	-2.638
2001	-2.91	-4.95	0.70%	-2.040
2002	-4.64	-5.30	0.14%	-0.653
2003	-4.64	-5.30	0.14%	-0.653
2004	-0.65	-0.60	-0.06%	0.041
2005	-0.72	0.01	-1.02%	0.731
2006	-4.72	-3.61	-0.23%	1.107
2007	-4.46	-2.98	-0.33%	1.484
2008	-4.27	-2.41	-0.44%	1.862
2009	-4.08	-1.84	-0.55%	2.240
2010	-3.97	-1.35	-0.66%	2.619
2011	-3.74	-1.35	-0.64%	2.384
2012	-3.50	-1.35	-0.61%	2.148
2013	-3.27	-1.35	-0.59%	1.911
2014	-3.03	-1.35	-0.55%	1.675
2015	-2.79	-1.35	-0.51%	1.438
2016	-2.55	-1.35	-0.47%	1.200
2017	2.712	4.170	0.54%	1.459
2018	2.059	3.186	0.55%	1.127
2019	-3.357	-3.061	-0.09%	0.295
2020	-3.118	-3.061	-0.02%	0.056
2021	-2.818	-3.008	0.07%	-0.190

6.6.7 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

Improvements will continue to be made following the collaboration project together with the Malta College of Arts, Science & Technology (MCAST), for the generation of land-use and land coverage mapping of the Maltese Islands, thus, to achieve a complete and more accurate spatial explicit representation of land use and tracking changes over time in Malta.

6.7 WETLANDS (CRF CATEGORY 4D)

6.7.1 CATEGORY DESCRIPTION

For the purpose of defining Wetlands, the Ramsar Convention was taken into consideration, with two sites, l-Għadira and is-Simar, being designated as such. As from past years, two management plans were issued on these sites to conserve and improve the area. Both sites do not have any aquaculture, salt production, peat extraction, drainage or rewetting.

For centuries the Għadira reserve was used as a saltpan by the residents of neighbouring Mellieħa. Use dwindled in the 1500s when the new saltpans at Salinas were constructed, and so the site fell into disuse. The area became silted up, and the construction of a road separated the area from the beach, leading to seasonal pools forming which attracted waterfowl. Proposals for a new inland road almost destroyed the site in the 1960's but the plans were stopped. But the dry lakebed was still used a summer car park for beach goers. Għadira was declared a bird sanctuary in 1978 and has been protected since. In 1980 the government adopted BirdLife's plans to restore the lake and saltmarsh habitat and turn the site into a proper wardened nature reserve.

Throughout the past 40 years various works have been carried out on site, starting from the early excavation works to create the saline lagoons. Thanks to various habitat modification works and planting of indigenous trees and shrubs, the site today has matured into a salt marsh ecosystem with lush Tamarix groves and adjacent sand dune and maquis habitats. The wetland of Għadira is designated as a Council of Europe Biogenetic Reserve, and a Mediterranean Protection Area. This reserve is now bordering more on a hyper saline wetland (once used for salt production) of varying water level and salinity, bordered by dunes. The high levels of salinity and further increases in salinity are due to the accumulation of salts in the Għadira lagoon over these past years. This may be due to several factors however the lack of precipitations in the Maltese Islands is a significant one (BirdLife, 2018). Several rare plant species, salt-resistant vegetation, and a diverse invertebrate fauna are supported.

The Simar nature reserve is a human-made coastal wetland consisting of a saltmarsh, a central pool with islets supporting dense salt-resistant vegetation, shrubs, Acacia trees and Aleppo pines. Water levels are maintained by precipitation run-off, and saltwater seepage through the porous substratum (source: RSIS). Before the conversion into a nature reserve in 1992, is-Simar was an abandoned area primarily due to human disturbance. The original marshland vegetation was completely degraded where only a small remnant remained. Work had begun with a network of pools, canals and islands created, hundreds of trees planted, restoring the site to the thriving wetland sanctuary it is today. A working plan was later drafted to strike a balance between reedbed, open water, open shorelines and reed fringes. The plan focused mainly on the creation of permanent zones of water, island management, control of invasive and alien vegetation, and the management of reedbed and associated habitats. Following these habitat management works carried out in previous years the wetland became more settled. Only minimal intervention was needed, and works were carried out only few days a year so as to minimise disturbance. Owing to the decrease in rainfall registered in recent years, the mean salinity of the water at Simar has risen steadily and has now reached levels that are unprecedented since records began being taken at this site (BirdLife, 2018). ERA scheduled Is-Simar as an Area of Ecological Importance and Site of Scientific Importance as per Government Notice No. 1070/06 in the Government Gazette dated 19 December 2006, followed by a minor revision in 2008 (G.N. No. 371/08).

6.7.2 WETLANDS - WETLANDS REMAINING WETLANDS (4.D.1)

6.7.2.1 Methodological Issues

Since the 2006 IPCC guidelines lack the methodologies related to the specific lands of wetlands as described above, the methodologies chosen for Wetlands remaining Wetlands follow Chapter 4 for Coastal Wetlands of the 2013 Wetlands Supplement to the 2006 IPCC Guidelines. From an analysis based upon the decision tree in Figure 4.1 of Chapter 4, on the decisions to estimate GHG emissions and removals in coastal wetlands, the methodologies for CO_2 calculations in carbon pools of biomass and soil carbon follow Section 4.3.2 of Chapter 4 of the 2013 Wetland Supplement Rewetting, revegetation and creation.

The methodology referred for the calculation of biomass in Wetland remaining Wetland is equation 2.9 of the 2006 IPCC Guidelines. For Coastal Wetlands having shrubs within the site, the coefficient for shrubs was utilised, and since no country specific value is available, the default Coefficient of 0.94 tdm ha^{-1} yr^{-1} for Net Carbon Gains in Shrublands in the Mediterranean Region from the biomass data report of the LIFE Project Medinet was chosen. For coastal wetlands containing grassy vegetation, the default value of 6.1 t.d.m. ha^{-1} from Table 6.4 of the 2006 IPCC Guidelines is multiplied by default expansion factor of the ratio of below-ground biomass to above-ground biomass for Woodland of 0.5 from Table 6.1 of the 2006 IPCC Guidelines to acquire the value of 3.05 t C ha^{-1} as a result. To note that for the area under Wetland remaining Wetland, 75% of area in the site is assumed shrubs, whereas 25% of the area assumed grass, thus the correct factors was multiplied by the percentage of the area to acquire the biomass estimations. To calculate the biomass under wetlands, the biomass stock value is multiplied by the area. Table 6-41 below indicates the emission factors used for the calculation of biomass in Wetland remaining Wetland.

Table 6-41 Wetland emission factors for biomass calculation

Parameter	Emission Factor	Identifier	Source
Average annual aboveground biomass growth for Shrubland	0.94 t C ha^{-1} yr^{-1}	Proposed Default Coefficients for Net Carbon Gains in Shrublands in the Mediterranean Region	LIFE Project MediNet - Biomass Data on Cropland and Grassland in the Mediterranean Region - Table 30
Other Grassland - C stock in biomass after one year (ΔC)	3.05 t C ha^{-1}	Default Biomass stock present on Grassland, after conversion from other land use	Table 6.4 IPCC 2006 (multiply by R of Woodland Table 6.1 IPCC 2006)

The methodology referred for the calculation of soil carbon in Wetland remaining Wetland is equations 4.7 of the 2013 IPCC Wetlands Supplement. To calculate the equation the area under wetlands is multiplied by the annual EF associated with rewetting on aggregated soils (EF_{REWET}). The EF_{REWET} of -0.91 t C ha^{-1} yr^{-1} for tidal marshes was acquired from Table 4.12 of the

2013 Wetlands Supplement. According to the 2013 Wetlands Supplement the EF is only applied if direct reseeding or planting occurs within the specific wetland, otherwise if re-establishment of vegetation is expected to occur by recolonization the EF_{RE} is equal to 0.

Table 6-42 Wetland emission factors for soil carbon calculation

Parameter description	Emission Factor	Identifier	Source
Annual EF associated with rewetting on aggregated soils	-0.91 t C ha^{-1} yr^{-1}	EF_{REWET} - Tidal Marsh	Table 4.12 2013 Wetlands Supplement

Table 6-43 represents the estimations in category 4.D.1 Wetlands Remaining Wetlands from 1990-2022 by carbon pool.

Table 6-43 Removals in Wetlands remaining Wetlands

Year	Biomass (kt CO_2 eq.)	SOC (kt CO_2 eq.)
1990	-0.009	0.005
1991	-0.009	0.005
1992	-0.009	0.005
1993	-0.009	0.005
1994	-0.009	0.005
1995	-0.009	0.005
1996	-0.009	0.005
1997	-0.009	0.005
1998	-0.009	0.005
1999	-0.009	0.005
2000	-0.009	0.005
2001	-0.009	0.005
2002	-0.009	0.005
2003	-0.009	0.005
2004	-0.009	0.005
2005	-0.009	0.005
2006	-0.009	0.005
2007	-0.009	0.005
2008	-0.009	0.005
2009	-0.009	0.005
2010	-0.036	0.022
2011	-0.036	0.022
2012	-0.036	0.022
2013	-0.036	0.022
2014	-0.036	0.022
2015	-0.036	0.022
2016	-0.036	0.022
2017	-0.036	0.022
2018	-0.036	0.022

2019	-0.036	0.022
2020	-0.036	0.022
2021	-0.036	0.022
2022	-0.036	0.022

6.7.3 *Wetlands - Land converted to wetlands (4.D.2)*

6.7.3.1 Methodological Issues

Conversion in Wetlands occur from Other Land. The methodology referred for the calculation of biomass and soil carbon follow the same equations as in the previous section of Wetland remaining Wetland.

Table 6-44 represents the estimations in category 4.D.2 Land Converted to Wetlands from 1990-2022 for biomass and SOC.

Table 6-44 Removals in Land converted to Wetlands

Year	Biomass (kt CO_2 eq.)	SOC (kt CO_2 eq.)
1990	-0.056	0.017
1991	-0.056	0.017
1992	-0.056	0.017
1993	-0.056	0.017
1994	-0.056	0.017
1995	-0.056	0.017
1996	-0.056	0.017
1997	-0.056	0.017
1998	-0.056	0.017
1999	-0.056	0.017
2000	-0.056	0.017
2001	-0.056	0.017
2002	-0.056	0.017
2003	-0.056	0.017
2004	-0.056	0.017
2005	-0.056	0.017
2006	-0.056	0.017
2007	-0.056	0.017
2008	-0.056	0.017
2009	-0.056	0.017
2010	-	-
2011	-	-
2012	-	-
2013	-	-
2014	-	-
2015	-	-
2016	-	-
2017	-	-
2018	-	-
2019	-	-

2020	-	-
2021	-	-
2022	-	-

For non-CO_2 calculations, more specifically for CH_4 in Land conversions to Wetland, Section 4.3.1 Rewetted soils of Chapter 4 of the 2013 Wetland Supplement, was followed. The methodology referred for the calculation of CH_4 emissions from rewetted soils in land converted to Wetlands is equation 4.9 of the 2013 IPCC Wetlands Supplement. To calculate the equation the area under wetlands is multiplied by the EF associated with drainage on aggregated soils (EF_{REWET}), then the sum is divided by 1000. The EF_{REWET} of 193.7 kh CH4 ha^{-1} yr^{-1} for tidal freshwater and brackish marsh and mangrove was acquired from Table 4.14 of the 2013 Wetlands Supplement. According to the 2013 Wetlands Supplement the EF is associated with salinity and applied when the salinity in the wetland site is <18 ppt, otherwise if the salinity is >18 ppt the EF_{REWET} is 0. Noting that the salinity levels in the Ghadira site (Wetland remaining Wetland) are high and considered to be bordering more on a hyper saline wetland – salinity levels vary from 35-60 ppt in wet periods; 50-100 ppt in dry periods - (BirdLife, 2018), the EF_{REWET} is 0 thus no calculations are estimated for this site. On the other hand, from the recent BirdLife report (BirdLife, 2018) the mean salinity levels of the water in Simar (Other Land converted to Wetland) have risen steadily through time owing to the decrease in rainfall registered in recent years, and from 2009 then on the level registered was greater than 18 ppt. In view of this the calculation for CH_4 emissions from rewetted soils in category Land converted to Wetlands was calculated from 1990-2009, whereas from 2010 onwards, noting that the EF_{REWET} is applied as 0, as a result, the calculations are estimated as 0 as well. Table 6-45 below indicates the emission factor used for the calculation of CH_4 emissions from rewetted soils in Land converted to Wetlands.

Table 6-45 Wetland emission factors for CH4 emissions from rewetted soils calculation

Parameter description	Emission Factor	Identifier	Source
EF associated with drainage on aggregated soils	Salinity <18 ppt: 193.7 kh CH_4 ha^{-1} yr^{-1} Salinity >18 ppt: 0 kh CH_4 ha^{-1} yr^{-1}	EF_{REWET}	Table 4.14 2013 Wetlands Supplement

Table 6-46 represents the estimations in category 4.D.2 Land Converted to Wetlands from 1990-2022 for non-CO_2 CH_4 emissions from rewetted soils.

Table 6-46 CH_4 emissions from rewetted soils in Land converted to Wetlands

Year	Non-CO_2 CH_4 (kt CO_2 eq.)
1990	0.027
1991	0.027
1992	0.027
1993	0.027
1994	0.027
1995	0.027

1996	0.027
1997	0.027
1998	0.027
1999	0.027
2000	0.027
2001	0.027
2002	0.027
2003	0.027
2004	0.027
2005	0.027
2006	0.027
2007	0.027
2008	0.027
2009	0.027
2010	-
2011	-
2012	-
2013	-
2014	-
2015	-
2016	-
2017	-
2018	-
2019	-
2020	-
2021	-
2022	-

6.7.4 *UNCERTAINTIES AND TIME-SERIES CONSISTENCY*

The category analysis for the Wetlands category was calculated based on the emission factors utilised to estimate the emissions and expressed as percentages. The uncertainty analysis for Wetland is presented in Table 6-47. Methods to calculate the uncertainty are similar to the ones calculated for the previous category. The total uncertainty for the Wetland estimates is 34%.

Further information on the respective trends in the uncertainties for all the categories are presented in the Uncertainty section in Chapter 1 and separate detailed information on uncertainties being submitted with this report.

Table 6-47 Uncertainty in Wetlands category

Category / sub-category	Parameter	Uncertainty (%)	Source	Remark
Coastal wetland with woody	Average annual aboveground biomass growth for Shrubland	36%	LIFE Project MediNet – Biomass Data on Cropland and Grassland in the	

perennial biomass			Mediterranean Region – Table 30	
	Other Grassland – C stock in biomass after one year (ΔC)	±75%	Table 6.4 IPCC 2006 (multiply by R of Woodland Table 6.1 IPCC 2006)	
Coastal wetland soil carbon	Annual EF associated with rewetting on aggregated soils	24%	Table 4.12 2013 Wetlands Supplement	95% CI – range from 0.7 to 1.1 – Calculated as an average between the difference of the high and the low range estimates of the default factors.
CH4 emissions from rewetted soils	EF associated with drainage on aggregated soils	70%	Table 4.14 2013 Wetlands Supplement	95% CI – range from 99.8 to 358 – Calculated as an average between the difference of the high and the low range estimates of the default factors.

As a result of this assessment, the total uncertainty in Wetlands for CO_2 estimates is 45%, while for the CH_4 estimates 70%.

6.7.5 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

Where area data for Wetlands is derived from the Ramsar datasheets and the map server, this is checked for accuracy of the areas for the time-series.

Data that is input in the working spreadsheet such as the activity data and the emissions factors are double-checked to ensure accuracy with the data entry, and moreover, the methodology is checked with the IPCC Guidelines data.

Please refer to Table 6-11 for the complete list of QA/QC checks produced, which is relevant for the Activity Data and Emissions Factors of all categories.

6.7.6 CATEGORY-SPECIFIC RECALCULATIONS

Recalculations for the Wetlands category are not relevant for this submission, noting that the values did not change from the previous submission.

6.7.7 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

Improvements will continue to be made following the collaboration project together with the Malta College of Arts, Science & Technology (MCAST), for the generation of land-use and land coverage mapping of the Maltese Islands, thus, to achieve a complete and more accurate spatial explicit representation of land use and tracking changes over time in Malta.

6.8 SETTLEMENTS (CRF CATEGORY 4E)

6.8.1 Settlements - Settlements remaining settlements (4.E.1)

6.8.1.1 Category Description

Settlements are defined as all developed land, including transportation, infrastructure and human settlements of any size, unless they are already included under other categories. The land-use category Settlements includes all classes of urban tree formations, namely trees grown along roads and streets, in public and private gardens, and in cemeteries, airports, construction sites, dumpsites, industrial or commercial units, port areas and sport and leisure facilities.

The data for this category was derived from the Corine Land Cover (CLC) 1996, 2000, 2006 and 2012 under the description classes of continuous urban fabric, discontinuous urban fabric, industrial and commercial units, port areas, airports, green urban areas, and sports and leisure facilities. Since the CLC covers only the specific years as aforementioned, for the other years the areas were gap filled through the land use representation exercise described in Section 6.3.1. Moreover, the areas developed from the LUC maps were also integrated with the time-series.

6.8.1.2 Methodological Issues

Tier 1 assumes no change in carbon stocks in live biomass in Settlements Remaining Settlements, in other words, that the growth and loss terms balance.

6.8.2 Settlements - Land converted to Settlements (4.E.2)

6.8.2.1 Category Description

Land converted to Settlement is assumed to come from Forest Land, Cropland and Grassland.

6.8.2.2 Methodological Issues

The biomass stock changes from land conversions to Settlement were calculated using Equations 2.15 and 2.16 of the '2006 IPCC Guidelines for National GHG Inventories'. The appropriate emission factors from Table 6-27 were considered for the conversions to Settlements. Table 6-48 below indicates the rationale for calculations of living biomass (LB) in these conversions:

Table 6-48 Calculation rationale of living biomass (LB) in land converted to Settlements

Land conversion	LOSS				GAINS			
	Loss	t C/ha	years	area to use	Gain	kt C/ha	years	area to use
Conversions to Cropland								
Annual Cropland to Settlements	LB in Annual CL	4.7	1	annual	zero	0	1	annual

Perennial Cropland to Settlements	LB in Perennial CL after 1 year	0.50	1	annual	zero	0	1	annual
Other Grassland to Settlements	LB in Other GL after 1 year	3.05	1	annual	zero	0	1	annual
Maquis Grassland to Settlements	LB in Maquis GL after 1 year	0.94	1	annual	zero	0	1	annual
Forest Land to Settlements	LB in FL	0.47	1	annual	zero	0	1	annual

For the soil organic content changes in land conversions to Settlements, Equation 2.25 of the '2006 IPCC Guidelines for National GHG Inventories' was used. The same method used as in the previous sections was used here for land converted to Settlement to calculate the SOC changes. Moreover, factors from Table 6-29 were considered for the calculations of estimations. For conversions to Settlements, it is assumed that settlements contain 20% of the soil organic content of the previous use (based on the percentage of the soil that is not disturbed in the conversion to settlements), thus in the equation the SOC factor was multiplied by 0.8.

The calculations of Dead Organic Matter (DOM) in Forest Land converted to Settlements are estimated as according to Chapter 2 of the 2006 IPCC Guidelines, The Tier 1 assumption for land converted from forest to another land-use category is that all DOM carbon losses occur in the year of land-use conversion. A Tier 1 approach was considered to calculate the estimates of DOM using Equation 2.23 from Chapter 2 of the 2006 IPCC Guidelines, where the conceptual approach to estimating changes in carbon stocks in dead wood and litter pools is to estimate the difference in C stocks in the old and new land-use categories and to apply this change in the year of the conversion (carbon losses).

For the litter stock under the new land-use category C_n, the Tier 1 default values for litter C stock for Broadleaf deciduous of 28.2 tonnes C ha^{-1}, and 20.3 tonnes C ha^{-1} for Needleleaf evergreen forest types were utilised, considering the Warm Temperate, dry climate parameters as per Table 6-23. It is to note that the default values for dead wood carbon stocks are not available in the IPCC Guidelines, thus only the carbon stocks for litter were calculated for the DOM pool. For the litter stock under the old land-use category C_o the default value of 0 was utilised, as per the 2006 IPCC Guidelines. The default value of 20 was utilised for the time-period of the transition from old to new land-use category. For the conversion the broadleaf deciduous species types are present, thus the appropriate factor was applied to the area present. To acquire the annual change in carbon stocks in litter, the area is multiplied by subtracting the litter stocks C_n to C_o and dividing by the time-period of the transition.

For the N_2O emissions in the conversions to Settlements, the same method as in the previous categories was used here, where the N estimations were performed using the SOC stock change values.

Table 6-49 represents the estimations in category 4.E.2 Land converted to Settlements from 1990-2022 by carbon pool.

Table 6-49 Emissions/removals in land converted to Settlements

Year	Biomass (kt CO_2 eq.)	SOC (kt CO2 eq.)	Non-CO_2 – N_2O (kt CO_2 eq.)	DOM (kt CO_2 eq.)
1990	1.152	0.897	0.082	-
1991	0.141	0.921	0.084	-
1992	0.141	0.945	0.086	-
1993	0.141	0.969	0.089	-
1994	0.141	0.993	0.091	-
1995	0.141	1.017	0.094	-
1996	0.141	1.038	0.096	-
1997	0.141	0.996	0.091	-
1998	0.141	1.020	0.093	-
1999	0.141	0.480	0.052	-
2000	0.141	0.504	0.054	-
2001	-	0.504	0.054	-
2002	-	0.504	0.054	-
2003	-	0.504	0.054	-
2004	-	0.504	0.054	-
2005	-	0.504	0.054	-
2006	-	0.482	0.052	-
2007	0.010	0.470	0.050	-
2008	0.010	0.416	0.044	-
2009	0.010	0.361	0.037	-
2010	0.010	0.257	0.025	-
2011	0.010	0.238	0.023	-
2012	0.010	0.219	0.021	-
2013	0.010	0.199	0.019	-
2014	0.010	0.180	0.017	-
2015	0.010	0.161	0.015	-
2016	0.010	0.142	0.013	-
2017	0.049	0.123	0.011	-
2018	0.049	0.103	0.009	-
2019	7.175	1.373	0.123	-0.218
2020	7.175	2.643	0.238	-0.436
2021	0.032	2.646	0.238	-0.436
2022	0.032	2.648	0.238	-0.436

6.8.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The same emissions factors used for the other categories to estimate the calculations of emissions were used for this category. As a result, to compile the uncertainty in this category, an approach to take the averages of the uncertainty values of the categories Cropland and Grassland were considered. The total uncertainty value for this category is thus, 20% for CO_2 and 63% for N_2O.

Further information on the respective trends in the uncertainties for all the categories are presented in the Uncertainty section in chapter 1 and separate detailed information on uncertainties being submitted with this report.

6.8.4 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

Since the data for Settlements is only available for few specific years, data on areas which are unavailable has to be gap-filled and produced through assumptions, thus this presents a certain degree of uncertainty in the values. However, since this data is not available the assumption method ensures that the data is filled for whole-time series. Due to this, since from the assumptions these areas cannot be checked and compared with other documents, consistency can be ensured throughout the time-series.

Data that is input in the working spreadsheet such as the activity data and the emissions factors are double-checked to ensure accuracy with the data entry, and moreover, the methodology is checked with the IPCC Guidelines data.

Please refer to Table 6-11 for the complete list of QA/QC checks produced, which is relevant for the Activity Data and Emissions Factors of all categories.

6.8.5 CATEGORY-SPECIFIC RECALCULATIONS

Recalculations for the Settlements category are due to the updates in the land areas and the land use matrix.

Table 6-50 Recalculations in Settlements category

Year	Settlements (kt CO2 eq.) as reported in the previous inventory report (AR5 GWPs)	Settlements (kt CO_2 eq.) as reported in this inventory report (AR5 GWPs)	Percentage change in reported emissions (%)	Change in kt CO_2 eq.
1990	2.13	2.13	0.0%	0.00
1991	1.34	1.15	-0.1%	-0.19
1992	1.38	1.17	-0.1%	-0.20
1993	1.41	1.20	-0.1%	-0.21
1994	1.44	1.23	-0.2%	-0.22
1995	1.48	1.25	-0.2%	-0.23
1996	1.51	1.28	-0.2%	-0.23
1997	1.47	1.23	-0.2%	-0.24
1998	1.50	1.25	-0.2%	-0.25
1999	0.93	0.67	-0.3%	-0.26
2000	0.97	0.70	-0.3%	-0.27
2001	0.64	0.56	-0.1%	-0.08
2002	0.64	0.56	-0.1%	-0.08
2003	0.64	0.56	-0.1%	-0.08
2004	0.64	0.56	-0.1%	-0.08
2005	0.64	0.56	-0.1%	-0.08
2006	0.61	0.53	-0.1%	-0.08
2007	0.61	0.53	-0.1%	-0.08
2008	0.55	0.47	-0.1%	-0.08
2009	0.49	0.41	-0.2%	-0.08
2010	0.37	0.29	-0.2%	-0.08
2011	0.34	0.27	-0.2%	-0.07
2012	0.31	0.25	-0.2%	-0.06

2013	0.28	0.23	-0.2%	-0.06
2014	0.26	0.21	-0.2%	-0.05
2015	0.23	0.19	-0.2%	-0.04
2016	0.20	0.16	-0.2%	-0.03
2017	0.207	0.183	-0.12%	-0.024
2018	0.178	0.162	-0.09%	-0.016
2019	8.455	8.454	0.00%	-0.001
2020	9.613	9.620	0.00%	0.007
2021	2.479	2.480	0.00%	0.000

6.8.6 Category-specific planned improvements

Improvements will continue to be made following the collaboration project together with the Malta College of Arts, Science & Technology (MCAST), for the generation of land-use and land coverage mapping of the Maltese Islands, thus, to achieve a complete and more accurate spatial explicit representation of land use and tracking changes over time in Malta.

6.9 OTHER LAND (CRF CATEGORY 4F)

6.9.1 Other Land - Other land remaining other land (4.F.1)

6.9.1.1 Category Description

This section includes bare soil, rock, and all unmanaged land areas that do not fall into any of the other five categories. It allows the total sum of identified land areas to match the total national area. Change in carbon stocks and non-CO_2 emissions and removals are not considered, assuming that there is no C stock. Mineral extraction sites in Malta are included under this land-use category. Only land area is reported in the CRF tables.

The data for this category was derived from the Corine Land Cover (CLC) 1996, 2000, 2006 and 2012 under the description classes of mineral extraction sites, dump sites and construction sites. Since the CLC covers only the specific years as aforementioned, for the other years the areas were gap filled through the land use representation exercise described in Section 6.3.1. Moreover, the areas developed from the LUC maps were also integrated with the time-series.

6.9.1.2 Methodological Issues

The default assumption for the Tier 1 calculation is that all carbon in biomass is released to the atmosphere immediately (i.e., in the first year after conversion) through decay processes either on- or off-site, thus it is assumed that the entire biomass is removed in the year of conversion.

6.9.2 Other Land - Land converted to other land (4.F.2)

6.9.2.1 Category Description

Land converted to Other Land is assumed to come from Forest Land, Cropland, Grassland and Settlements.

6.9.2.2 Methodological Issues

The biomass stock changes from land conversions to Other Land were calculated using Equations 2.15 and 2.16 of the '2006 IPCC Guidelines for National GHG Inventories'. The appropriate emission factors from Table 6-27 were considered for the conversions to Other Land. For the conversion from Settlements to Other Land it is assumed that no carbon stock changes currently occur here, thus the biomass stocks are considered to be zero. Table 6-51 below indicates the rationale for calculations of living biomass (LB) in these conversions:

Table 6-51 Calculation rationale of living biomass (LB) in land converted to Other Land

Land conversion	LOSS				GAINS			
	Loss	kt C/ha	years	area to use	Gain	kt C/ha	years	area to use
Conversions to Cropland								
Maquis Grassland to Other Land	maximum maquis grassland LB	18.8	1	annual	zero	0	1	annual
Settlements to Other Land	zero	0	1	annual	zero	0	1	annual
Annual Cropland to Other Land	LB in CL annual	4.7	1	annual	zero	0	1	annual
Other Grassland to Other Land	LB in Other GL after 1 year	3.05	1	annual	zero	0	1	annual
Perennial Cropland to Other Land	LB in Perennial CL after 1 year	0.50	1	annual	zero	0	1	annual
Forest Land to Other Land	LB in FL	0.47	1	annual	zero	0	1	annual

For the soil organic content changes in land conversions to Other Land, Equation 2.25 of the '2006 IPCC Guidelines for National GHG Inventories' was used. The same method used in previous sections was used here for land converted to Other Land to calculate the SOC changes. Moreover, similar parameters were also used from Table 6-29 for the calculations of estimations. The assumption that Settlements contains 20% of the SOC of the previous use was considered for Settlements converted to Other Land.

The calculations of Dead Organic Matter (DOM) in Forest Land converted to Settlements are estimated as according to Chapter 2 of the 2006 IPCC Guidelines. The same method used in Settlements section was used here for land converted to Other Land to calculate the DOM using Equation 2.23. For the litter stock under the new land-use category C_n, the Tier 1 default values for litter C stock were utilised, as per Table 6-23. For the litter stock under the old land-use category C_o the default value of 0 was utilised. The default value of 20 was utilised for the time-period of the transition from old to new land-use category.

For the N_2O emissions in the conversions to Other Land, the same method as in the previous categories was used here, where the N estimations were performed using the SOC stock change values.

Table 6-52 represents the estimations in category 4.F.2 Land converted to Settlements from 1990-2022 by carbon pool.

Table 6-52 Emissions/removals in land converted to Other Land (kt CO2 eq.)

Year	Biomass (kt CO_2 eq.)	SOC (kt CO2 eq.)	Non-CO_2 – N_2O (kt CO_2 eq.)	DOM (kt CO_2 eq.)
1990	0.178	0.435	0.044	-
1991	0.018	0.470	0.047	-
1992	0.018	0.513	0.050	-
1993	0.018	0.557	0.053	-
1994	0.018	0.600	0.056	-
1995	0.018	0.639	0.059	-
1996	0.018	0.639	0.059	-
1997	0.018	0.645	0.059	-
1998	0.018	0.689	0.062	-
1999	0.018	0.689	0.062	-
2000	0.018	0.690	0.062	-
2001	0.013	0.695	0.062	-
2002	0.004	0.704	0.063	-
2003	0.004	0.714	0.064	-
2004	0.020	0.723	0.065	-
2005	0.020	0.733	0.066	-
2006	0.004	0.699	0.062	-
2007	0.014	0.689	0.059	-
2008	0.014	0.679	0.057	-
2009	0.014	0.669	0.055	-
2010	0.014	0.618	0.048	-
2011	0.014	0.608	0.047	-
2012	0.014	0.597	0.046	-
2013	0.014	0.586	0.045	-
2014	0.014	0.576	0.044	-
2015	0.014	0.565	0.043	-
2016	0.014	0.554	0.043	-
2017	0.069	0.543	0.043	-
2018	0.069	0.532	0.043	-
2019	1.244	1.725	0.148	-0.021
2020	1.244	2.918	0.252	-0.043
2021	0.023	2.941	0.254	-0.043
2022	0.021	2.961	0.256	-0.043

6.9.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Please refer to the uncertainty section of category Settlements since the same approach was assumed for the category Other Land, thus same uncertainty values were reported, 20% for CO_2 and 63% for N_2O.

Further information on the respective trends in the uncertainties for all the categories are presented in the Uncertainty section in chapter 1 and separate detailed information on uncertainties being submitted with this report.

6.9.4 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

Since the data for Other Land is only available for few specific years, data on areas which are unavailable has to be gap filed and produced through assumptions, thus this presents a certain degree of uncertainty in the values. However, since this data is not available the assumption method ensures that the data is filled for whole-time series. Due to this, since from the assumptions these areas cannot be checked and compared with other documents, consistency can be ensured throughout the time-series.

Data that is input in the working spreadsheet such as the activity data and the emissions factors are double-checked to ensure accuracy with the data entry, and moreover, the methodology is checked with the IPCC Guidelines data.

Please refer to Table 6-11 for the complete list of QA/QC checks produced, which is relevant for the Activity Data and Emissions Factors of all categories.

6.9.5 CATEGORY-SPECIFIC RECALCULATIONS

Recalculations for the Other Land category are due to the updates in the land areas and the land use matrix.

Table 6-53 Recalculations in Other Land category

Year	Other Land (kt CO2 eq.) as reported in the previous inventory report (AR5 GWPs)	Other Land (kt CO_2 eq.) as reported in this inventory report (AR5 GWPs)	Percentage change in reported emissions (%)	Change in kt CO_2 eq.
1990	0.61	0.66	0.1%	0.05
1991	0.56	0.53	-0.1%	-0.03
1992	0.61	0.58	0.0%	-0.03
1993	0.66	0.63	0.0%	-0.03
1994	0.71	0.67	0.0%	-0.03
1995	0.75	0.72	0.0%	-0.03
1996	0.75	0.72	0.0%	-0.03
1997	0.76	0.72	0.0%	-0.04
1998	0.80	0.77	0.0%	-0.04
1999	0.81	0.77	0.0%	-0.04
2000	0.85	0.77	-0.1%	-0.08
2001	0.79	0.77	0.0%	-0.02
2002	0.79	0.77	0.0%	-0.02
2003	0.80	0.78	0.0%	-0.02
2004	0.82	0.81	0.0%	-0.02
2005	0.83	0.82	0.0%	-0.02
2006	0.78	0.77	0.0%	-0.02
2007	0.78	0.76	0.0%	-0.02

2008	0.77	0.75	0.0%	-0.02
2009	0.75	0.74	0.0%	-0.02
2010	0.70	0.68	0.0%	-0.02
2011	0.68	0.67	0.0%	-0.01
2012	0.67	0.66	0.0%	-0.01
2013	0.66	0.65	0.0%	-0.01
2014	0.65	0.63	0.0%	-0.01
2015	0.63	0.62	0.0%	-0.01
2016	0.62	0.61	0.0%	-0.01
2017	0.66	0.66	0.0%	-0.01
2018	0.65	0.64	0.0%	-0.01
2019	3.10	3.10	0.0%	0.00
2020	4.38	4.37	0.0%	0.00
2021	3.176	3.176	0.00%	0.000

6.9.6 Category-specific planned improvements

Improvements will continue to be made following the collaboration project together with the Malta College of Arts, Science & Technology (MCAST), for the generation of land-use and land coverage mapping of the Maltese Islands, thus, to achieve a complete and more accurate spatial explicit representation of land use and tracking changes over time in Malta.

6.10 HARVESTED WOOD PRODUCTS (CRF CATEGORY 4G)

6.10.1 Category Description

This category does not occur in Malta. In the CRF this is reported as Not Occurring (NO).

6.10.2 Methodological Issues

Not applicable.

6.10.3 Uncertainties and time-series consistency

Not applicable.

6.10.4 Category-specific QA/QC and verification

Not applicable.

6.10.5 Category-specific recalculations

Not applicable.

6.10.6 Category-specific planned improvements

Not applicable.

6.11 OTHER (CRF CATEGORY 4H)

6.11.1 Category Description
Not applicable.

6.11.2 Methodological Issues
Not applicable.

6.11.3 Uncertainties and time-series consistency
Not applicable.

6.11.4 Category-specific QA/QC and verification
Not applicable.

6.11.5 Category-specific recalculations
Not applicable.

6.11.6 Category-specific planned improvements
Not applicable.

CHAPTER 7 WASTE

SOLID WASTE DISPOSAL - BIOLOGICAL TREATMENT OF SOLID WASTE - INCINERATION & OPEN BURNING OF WASTE - WASTEWATER TREATMENT & DISCHARGE

7.1 OVERVIEW OF SECTOR

In this Chapter, emissions generated from waste management practices between the period 1990 (base year) and 2022 are presented. The direct Greenhouse Gas emissions generated from the Waste sector include carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) from the following categories; CH_4 from Solid Waste Disposal (CRF 5A) both from managed (CRF 5A1) and unmanaged waste disposal (CRF 5A2), both CH_4 and N_2O from Biological Treatment of Solid Waste (CRF 5B), CO_2, CH_4 and N_2O from Incineration and Open Burning of Waste (CRF 5C), and both CH_4 and N_2O from Wastewater Treatment and Discharge (CRF 5D) (refer to As described, GHG emissions in the waste sector are generated from the treatment and disposal of solid and liquid waste.

The waste chapter is organised as follows; it starts with an overview of the waste sector and its categories which also includes a description of waste management in Malta. Then, the remainder of section 7.1 presents the waste generation trends, an overview on methodology such as the emission factors, the source of activity data required, QA/QC and verification checks, tackled improvements and a summary of the recalculations occurred. Then, the waste categories are further described into more detail between sections 7.2 and 7.6 where a category description, methodological issues, uncertainties, QA/QC and verification, recalculations and planned improvements are reported.

As explained in Chapter 2, emissions from the Waste sector are mainly attributable to Solid Waste Disposal (SWD), specifically disposal on land. In fact, a relatively large proportion of emissions reported are emitted from landfill operations. The second largest source category after SWD is Wastewater Treatment and Discharge (CRF 5D), followed by Waste Incineration (CRF 5C) and Biological Treatment of Waste (CRF 5D).

Table 7-1 Summary table.

		GHG emissions reported/generated			
Waste Categories Included	5A: Solid Waste Disposal		CH4		
	5B: Biological Treatment of Solid Waste		CH4	N2O	
	5C: Incineration and Open Burning of Waste	CO2	CH4	N2O	

	5D: Wastewater Treatment and Discharge		**CH4**	**N2O**	
Gases Reported	Direct Gases	**CO2**	**CH4**	**N2O**	
	Indirect Gases	**NOx**	**CO**	**NMVOC**	**SO2**
Key Categories	Solid Waste Disposal		**CH4**		

The emissions given in this chapter are calculated using the AR5 GWPs as we have fully migrated to AR5 from AR4.

An overview of waste management in Malta

A brief overview of current solid waste management practices is provided to put the approaches utilised in the preparation of estimates of emissions from waste-related activities in context.

Solid Waste Disposal category is split into unmanaged and managed waste disposal sites. Unmanaged landfilling in Malta lasted till year 2004, in a number of landfilling sites which developed over the years (Magħtab and Wied Fulija in Malta and Qortin in Gozo), with unmanaged landfilling eventually being concentrated in two sites towards the end (Qortin and Magħtab). Eventually, waste deposition in unmanaged landfills was stopped, driven largely by requirements of European Union law. The shift to managed landfilling started in 2004 and is still operating till present with waste being deposited in the Għallis non-hazardous engineered managed landfill. Municipal and industrial solid waste and sewage sludge are treated in the Għallis landfill.

Waste incineration include clinical, industrial and municipal incineration while open burning of waste does not occur. Composting in Malta operated between 1993 and early 2007 while anaerobic biodigestion started in 2010 and remains in operation at present. The final waste category refers to Wastewater treatment and discharge where the sewerage infrastructure in Malta consists of two main geographically separate networks that collect both domestic and industrial wastewaters, as well as a portion of storm-water runoff.

Further details regarding each waste category are described in their specific chapter (sections between 7.2 and 7.6).

Current solid waste facilities in Malta

The various forms of existing waste facilities, separation, collection and disposal in Malta are briefly summarised below.

Sant Antnin Waste Treatment Plant (SAWTP)

The SAWTP is essential in increasing waste separation, recover recyclable materials for export, which reduces the use of landfill site, producing compost/stabilised digestate and produce electricity from waste. The plant consists of two main areas; the Mechanical Treatment Plant and the Materials Recovery Facility (further information is provided in section 7.3.2).

Organic waste

Besides the door-to-door household collection of mixed and recyclable waste, a third collection was introduced for the separation of domestic organic waste. The separation and collection of organic waste will improve the performance of Mechanical and Biological management facilities (MBT) and in reducing biodegradable municipal waste (BMW) going to landfill. Organic waste is the material that is biodegradable and comes from either an animal or a plant. This is normally broken down by micro-organisms over time to produce methane, which can be used as a fuel, and compost, which can be used to fertilise the soil.

Between 2015 and 2016, pilot projects commenced whereby a number of localities across Malta were chosen for the separation and collection of organic waste. From October 2018, the separation and collection of organic waste was extended to all localities in the Maltese Islands.

Currently, organic waste that is collected is sent to the Sant Antnin Waste Treatment Plant (SAWTP) for processing for landfill capping.

Thermal Treatment Facility

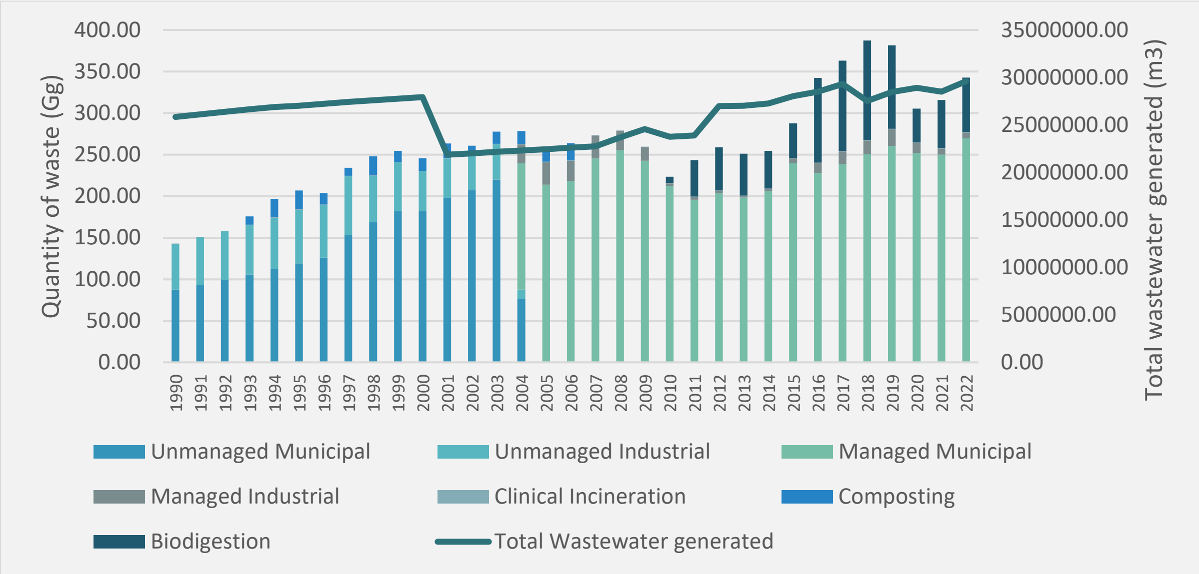
The Thermal Treatment Facility was inaugurated in December 2007. This incinerator treats abattoir waste, clinical waste and other hazardous waste streams. The commissioning of this facility resulted in the decommissioning of older incineration facilities, including those at St Luke's Hospital and at the Gozo General Hospital. Please refer to section 7.4 for further information regarding waste incineration.

7.1.1 WASTE GENERATION TRENDS

A general look at the local waste generation trends is illustrated in Figure 7-1 below. As presented in the figure, unmanaged landfilling (both municipal and industrial) was stopped in year 2004 due to requirements under European Union law while managed landfilling (both municipal and industrial) started operating in 2004. As displayed, managed landfilling started to increase throughout the years and is still operating till present. Another category is waste incineration including clinical, industrial and municipal incineration. Clinical incineration shows a stability throughout the years while industrial started to increase and municipal decreased. Moreover, composting in Malta started operating at Sant' Antnin Solid Waste Treatment Plant in 1993 and stopped in early 2007. In 2010, the process of biodigestion started and is still operating till present with an increase in activity data. The final category is wastewater where when wastewater generation volumes are compared with the base year (1990), data illustrates an increase in generation.

Correlations between the activity and resulting emissions, also through a description of the measures implemented that affect this correlation are described in the overview of the specific sectors.

Figure 7-1 Waste disposal trends; amount of MSW generated by year.



Municipal solid waste generation in Malta has seen an increase in trend throughout the years. In 2022, as reported by the European Commission (February 2024), the amount of municipal waste generated per person in Malta was 618kg while that for EU Member States was 513kg per person.

Landfilling in Malta remains an important destination of a significant portion of collected waste until alternative disposal solutions are brought into operation.

According to NSO, during 2021, municipal waste generation has decreased by 4.4% over the previous year. Also, during 2021, the total amount of municipal waste treatment increased by 4.7% and the share of landfilling from the total municipal waste treated stood at 82.9%, which is lower than the previous year (NSO, 2022).

It is worth noting that waste generation in Malta is strongly influenced by other factors apart from the waste generation and management tendencies of the local population.

In particular, tourism, which reached 2.8 million inbound tourists in 2019 and has seen continuous increases over the years, a 5.9% increase from the previous year (NSO, 2020), should be given due consideration when analysing trends in waste generation in Malta.

7.1.2 Methodology Overview

7.1.2.1 Methodology and Emission Factors

The methodologies and emission factors used to estimate emissions in the waste sector are summarised in the table below including the default value, Tier 1 and Tier 2 approach from the 2006 IPCC Guidelines and some country specific emission factors.

Table 7-2 A summary of the methodologies and emission factors used in the waste sector.

	GHG					
	CO2		CH4		N2O	
Waste sector category	Method	EF	Method	EF	Method	EF
5. Waste	T1	D	D,M,T1,T2	CS,D,M	D,T1	D
5.A Solid Waste Disposal	NA	NA	M, T2	M	NO	NO
5.A.1 Managed Waste Disposal Sites	NA	NA	T2	M	NO	NO
5.A.1.a Anaerobic	NA	NA	T2	M	NO	NO
5.A.1.b Semi-aerobic	NA	NA	NA	NA	NO	NO
5.A.2 Unmanaged Waste Disposal Sites	NA	NA	M	M	NO	NO
5.A.3 Uncategorized Waste Disposal Sites	NA	NA	NA	NA	NO	NO
5.B Biological Treatment of Solid Waste	NO	NO	T1	D	NA	NA
5.B.1 Composting	NO	NO	NA	NA	NA	NA
5.B.1.a Municipal Solid Waste	NO	NO	NA	NA	NA	NA
5.B.1.b Other (please specify)	NO	NO	NA	NA	NA	NA
5.B.2 Anaerobic Digestion at Biogas Facilities	NO	NO	T1	D	NA	NA
5.B.2.a Municipal Solid Waste	NO	NO	T1	D	NA	NA
5.B.2.b Other (please specify)	NO	NO	NA	NA	NA	NA
5.C Incineration and Open Burning of Waste	T1	D	T1	D	T1	D
5.C.1 Waste Incineration	T1	D	T1	D	T1	D
5.C.1.1 Biogenic	T1	D	NA	NA	NA	NA
5.C.1.1.a Municipal Solid Waste	NA	NA	NA	NA	NA	NA
5.C.1.1.b Other (please specify)	T1	D	NA	NA	NA	NA
Industrial Solid Waste	T1	D	NA	NA	NA	NA
5.C.1.2 Non-biogenic	T1	D	T1	D	T1	D
5.C.1.2.a Municipal Solid Waste	NA	NA	NA	NA	NA	NA
5.C.1.2.b Other (please specify)	T1	D	T1	D	T1	D
Clinical Waste	T1	D	T1	D	T1	D
Industrial Solid Wastes	T1	D	T1	D	T1	D
5.C.2 Open Burning of Waste	NA	NA	NA	NA	NA	NA

5.C.2.1 Biogenic	NA	NA	NA	NA	NA	NA
5.C.2.1.a Municipal Solid Waste	NA	NA	NA	NA	NA	NA
5.C.2.1.b Other (please specify)	NA	NA	NA	NA	NA	NA
5.C.2.2 Non-biogenic	NA	NA	NA	NA	NA	NA
5.C.2.2.a Municipal Solid Waste	NA	NA	NA	NA	NA	NA
5.C.2.2.b Other (please specify)	NA	NA	NA	NA	NA	NA
5.D Wastewater Treatment and Discharge	NO	NO	D	CS	D	D
5.D.1 Domestic Wastewater	NO	NO	D	CS	D	D
5.D.2 Industrial Wastewater	NO	NO	NA	NA	NA	NA
5.D.3 Other (please specify)	NO	NO	NA	NA	NA	NA

Abbreviations: D= 2006 IPCC Guidelines default, T1 = 2006 IPCC Guidelines Tier 1, T2 = 2006 IPCC Guidelines Tier 2, M= Model, NA= not applicable, CS = country specific, PS = Plant-specific

7.1.2.2 Activity Data

The data used for the compilation of the waste sector report is collected from a number of data providers and sources. The data providers, sources and descriptions are reported in the below table.

Table 7-3 Activity Data for the Waste sector.

Description		Source
Waste generated and treated data by type for landfilling and incineration;		Environment & Resources Authority (ERA)
Solid Waste:	-Municipal Waste (Għallis landfill)	
	-Industrial Waste: (Għallis landfill)	
Managed solid waste:	-Sewage sludge from treatment of urban wastewater	
Municipal Incineration:	-Total amount of Municipal waste containing non-biogenic carbon	
	-Total amount of Municipal waste containing biogenic carbon	
Industrial Incineration:	-Total amount of Industrial waste containing non-biogenic carbon	
	-Total amount of Industrial waste containing biogenic carbon	

Clinical Incineration:	-Amount of clinical waste incinerated	
Anaerobic Digestion:	-Total annual amount treated by biological treatment facilities	
Unmanaged SWDS landfill: amount of CH4 recovered through the RTO Managed SWDS: amount of CH4 recovered and used for energy production The average % of CO2 and CH4 in landfill gas Total annual amount treated by biological treatment facilities		Wasteserv Malta Ltd.
Sewage Treatment; • Total wastewater treated • Total wastewater untreated • Percentage of wastewater treated • Total load entering sewerage system (BOD/year)		Water Services Corporation (WSC)
Swine manure nitrogen going to sewers		Agriculture sector at the Inventory Agency (MRA)
Total population		National Statistics Office (NSO)
Protein Consumption per capita		FAOSTAT

7.1.2.3 Sector-specific QA/QC & Verification

The table below presents the QA/QC checks and verifications performed in the Waste sector.

Table 7-4 QA/QC Checks performed for the Waste sector.

Item		**Check**
EMISSION DATA QUALITY CHECKS		
1	Are emission comparisons for historical data source performed	Yes
2	Are emission comparisons for significant sub-source categories performed	Yes
3	If applicable, are checks against independent estimates or estimates based on alternative methods performed	N.A.
4	Are reference calculations performed	Yes
5	Is completeness check performed	Yes
6	Other (detailed checks)	Yes
EMISSION FACTOR QUALITY CHECKS		

IPCC default emission factors		
7	Are the national conditions comparable to the context of the IPCC default emission factors study	No
8	Are default IPCC factors compared with site or plant-level factors	No
Comparisons		
19	Are country-specific factors compared with IPCC default factors	No
20	Is comparison between countries, including historical trends, min and max value, base and most recent year value, IEF performed	No
21	If applicable, is comparison to plant-level emission factors performed	N.A.
22	Other (detailed checks)	No
ACTIVITY DATA QUALITY CHECKS		
National level activity data		
23	Are alternative activity data sets based on independent data available	No
24	Were comparisons with independently compiled data sets performed	Independently compiled data is difficult to find
25	Were the national data compared with extrapolated samples or partial data at sub-national level	Yes
26	Was a historical trend check performed	Yes
27	Are any sharp increases/decreases detected and checked for calculation errors	Yes
28	Are any sharp increases/decreases explained and documented	Yes
CALCULATION RELATED QUALITY CHECKS		
36	Are checks of the calculation algorithm (duplications, unit conversion, calculation errors) performed	Yes
37	Are the calculations reproducible	Yes
38	Are all calculation procedures recorded	Yes
39	Other (please specify)	Cross checking calculations for verification

7.1.2.4 Sector-specific Planned Improvements

A number of improvements have been already addressed during the past inventory submissions from identified issues made in previous review reports both from ESD and UNFCCC reviews.

7.1.2.5 Sector-specific Recalculations

Recalculations for the Solid Waste Disposal and Wastewater categories occurred throughout the reporting of the Waste sector.

The below table refers to the Waste sector categories in which a correction or improvement were carried out throughout the specified year or years. Further information on the recalculations is provided under the mentioned category, in Chapter 10 and in recalculations template.

Table 7-5 Waste sector recalculations carried out in the NIR.

Waste Category - Recalculation	Correction or Improvement	Years Affected
Solid Waste Disposal	Total CH4 emissions (Gg CO2 eq.)	2011-2022
Wastewater	Total N2O emissions (Gg CO2 eq.)	2010-2021

On the other hand, the below table represents a summary of recalculations carried out throughout the timeseries by referring to the current and previous submissions. A percentage change is provided as to illustrate the change between the two submissions.

Kindly note that the ‘previous submission’ row refers to March 2023 submission in AR5.

Table 7-6 summary of recalculations carried out in the Waste sector throughout the timeseries.

		1990	1995	2000	2005	2010	2015	2021
Current submission: Total waste	Gg CO2 eq.	75.22	113.97	153.99	196.73	123.28	150.61	184.21
Previous submission: Total waste	Gg CO2 eq.	75.22	113.97	153.99	196.73	123.81	149.77	200.94
Percentage change	%	0.00%	0.00%	0.00%	0.00%	-0.43%	0.56%	-8.33%
Solid Waste Disposal	Gg CO2 eq.	46.48	78.86	119.46	162.54	94.33	137.34	167.71
	Gg CO2 eq.	46.48	78.86	119.46	162.54	94.33	136.45	182.90
	%	0.00%	0.00%	0.00%	0.00%	0.00%	0.66%	-8.31%
Biological Treatment of Solid Waste	Gg CO2 eq.	0.00	4.01	2.72	2.81	0.17	0.93	1.30
	Gg CO2 eq.	0.00	4.01	2.72	2.81	0.17	0.93	1.30
	%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Incineration and Open Burning of Waste	Gg CO2 eq.	0.43	0.43	0.41	0.32	0.71	0.71	0.58
	Gg CO2 eq.	0.43	0.43	0.41	0.32	0.71	0.71	0.58
	%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Gg CO2 eq.	28.31	30.67	31.41	31.07	28.07	11.62	14.62
	Gg CO2 eq.	28.31	30.67	31.41	31.07	28.61	11.68	16.17

Wastewater Treatment and Discharge	%	0.00%	0.00%	0.00%	0.00%	-1.88%	-0.50%	-9.57%

7.1.3 KEY CATEGORY

According to the IPCC 2006 Guidelines, a key category is defined as ''one that is prioritised within the national inventory system because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level, the trend, or the uncertainty in emissions and removals'' (IPCC 2006 Guidelines, Volume 1, Chapter 4, page 4.5).

Within the Waste sector, the methane emissions of the Solid Waste Disposal category (5.A) is determined to be one of the key categories, including and not including LULUCF emissions.

7.1.4 CATEGORY SPECIFIC QA/QC PROCEDURES AND VERIFICATION PROCESS

The following were further included in the report's section 'Overview of sector'; the GHG emissions of the Waste sector, a summary of the methodologies and emission factors used, a table presenting the required activity data to the Inventory Agency and its source/data provider, a summary of the recalculations carried out in this submission and the key category.

Moreover, some of the QA/QC procedures and Verification processes tackled during the compilation of the waste sector inventory report comprise of;

- verification of activity data which was performed by;
- ➢ reviewing and comparing the activity data from the data providers with previous years' data;
- ➢ reviewing and comparing the activity data between one data provider and another data provider;
- ➢ upon reviewing and comparing the activity data, some inconsistencies were observed, and so, additional clarifications were requested to the data provider;
- consistency checks between the waste spreadsheets of the Inventory Agency and the CRF reporter inventory software data during the inventory compilation cycle;
- recommendations from the findings during the UNFCCC in-country review held in October 2016;
- recommendations carried out from the review by Ing. Eva Krtková, from the ESD review team, in August 2018 regarding the Waste sector;
- recommendations from the Senior Consultant Richard Claxton throughout Aether's support (Aether Ltd. (UK)), including also in-country visits in 2018, 2019 and 2020; world experts in environmental data analysis and interpretation;
- recommendations carried out during the ESD review of the January 2019 submission;
- recommendations carried out during the UNFCCC review between July and September 2019 (Assessment report, Preliminary and Centralized reviews);
- recommendations carried out during the ESD review of the 2020 submission;
- meetings were organised in July 2019 between the Inventory Agency and the data provider to discuss waste data and its timeliness;
- an overview of waste management and current solid waste facilities in Malta are reported under the 'Overview of sector' category.

7.2 SOLID WASTE DISPOSAL (CRF 5A)

7.2.1 Category Description

Table 7-7 Summary table.

Waste sector category	Solid Waste Disposal (SWD)
2006 IPCC Guidelines category number	4A
CRF category number	5A
GHG emissions reported/generated Direct gases	CH_4
Key category	Yes
Method	M (Model) T2 (2006 IPCC Guidelines Tier 2)
Emission Factor	M (Model)
Operation: Unmanaged landfilling Managed landfilling	 1990 – 2004 2004 – till present
Landfill in operation	Ghallis Engineered non-hazardous managed landfill

Introduction

The Solid Waste Disposal category is split into unmanaged and managed waste disposal sites as is further explained below. Unmanaged landfilling in Malta lasted till year 2004 while managed landfilling is still operating till present with waste being disposed of in the Għallis non-hazardous managed landfill (refer to the below table).

The disposal of solid waste in land-based solid waste disposal sites leads to CH_4 emissions through anaerobic decomposition of organic matter into waste.

Table 7-8 Solid waste disposal throughout the years.

Landfill		Years
Unmanaged	Wied Fulija (Malta)	1990 - 1996
	Magħtab (Malta) and Qortin (Gozo)	1990 - 2004
Managed	Ta' Żwejra (engineered landfill)	2004 - 2006
	Għallis non-hazardous landfill (engineered landfill)	2006 - till present

7.2.2 Unmanaged waste disposal sites (CRF 5A2)

As presented in Table 7-8 above and as illustrated in Figure 7-3 further below, between 1990 to 1996, solid waste (both municipal and industrial) was deposited into one of the three unmanaged landfills; Magħtab and Wied Fulija in Malta and Qortin in Gozo. In 1997, waste stopped being deposited at Wied Fulija and all the waste generated between the years 1997 to 2004 was deposited at Magħtab and Qortin, with the vast majority of waste entering Magħtab. Eventually, from 2004, due to requirements under European Union law, waste deposition in unmanaged landfills was stopped.

Prior to 1997, no weighing bridges were available at the Maltese landfills. Hence, the available solid waste statistics prior to 1997 may, at best, be considered as indicative. The quantities of industrial waste deposited in landfills decreased gradually over the years because of improved recycling practices. As shown in above, a significant decrease in the amount of municipal and industrial waste being landfilled is visible from 2009 onwards.

To fill the gap in activity data between 1990 and 1997 a conservative back extrapolation exercise was undertaken, using available data on GDP, population, waste/capita and waste/GDP. The data was back extrapolated to 1950 as indicated in the IPCC 2006 guidelines (IPCC, 2006) (Volume 5, Chapter 3, page 3.12) for the implementation of the Tier 2 First Order Decay Model in order to ensure completeness and time series consistency. An explanation of the back extrapolation of activity data is presented in Annex 3.

Wied Fulija

Following the Wied Fulija landfill closure, plans have recently been developed to restore and rehabilitate the landfill which include primarily for the regrading, reprofiling and capping of the waste mass. In order to provide environmental betterment, the wastes are to be capped with a one-metre-deep capping layer comprising a combination of 250mm fine crushed rock material above the waste, a 500mm crushed rock layer and a 250mm top layer of soil type material that will include a mix of soils, crushed rock and compost. The capping layer is intended to reduce air and water ingress into the waste mass and limit landfill gas emissions from within it. The deposited wastes currently vary in age between 21 and 38 years old and gas production will be well advanced. Peak production will have occurred in 1996 when waste disposal ceased, and the gas production curve will have gradually declined over the past 21 years. In the absence of capping and gas control measures, any gases produced within the site will have remained in-situ, migrated into the fractured limestone or dispersed to atmosphere. Combustion within the waste mass will also have reduced the residual gas volume within the site as fires within the waste will have thermally oxidised the methane to carbon dioxide.

The volume of residual landfill gas at the site is deemed to have declined to levels whereby active gas extraction and flaring is considered uneconomical. Furthermore, with the on-going issue of combustion within the waste mass, it is considered environmentally and technically inappropriate to drill wells into the waste which are likely to exacerbate the ingress of air into the waste mass and increase the potential for in-waste fires to spread. For these reasons the installation of both active gas extraction and passive gas venting control measures are considered inappropriate at Wied Fulija. In developing the site restoration plan, it has been concluded that the most appropriate environmentally sensitive and technically achievable solution to control gas at Wied Fulija is to provide a capping layer that is resourced from locally available materials and can be placed at the landfill surface to limit water ingress into the waste and minimise both air ingress into the wastes and emissions of landfill gas from it. The proposals are considered to be a low-risk strategy in terms of gas migration control (gas yields are in steady decline; the site is remote from receptors and public access onto the main landfill area will be limited to perimeter footpaths). Furthermore, the proposals are intended to minimise air ingress into the waste and thereby help manage and gradually reduce combustion within the site. In addition, it is also proposed to use locally sourced compost material mixed with suitable soil-forming materials to form the upper surface layer across the landfill (personal communication, Wasteserv Malta Ltd, September 2019).

Magħtab

The Magħtab dump site started receiving an increasing amount of waste in 1978 and was then closed in 2004, forming a man-made hill, due to Malta's accession into the European Union, as previously mentioned.

During the mentioned years, the dump site, which was originally a valley, received a variety of waste streams including municipal solid waste, industrial waste, electronic waste, hazardous waste and a substantial amount of construction and demolition waste. As a result, accidental fires used to take place since air was being trapped between the rocks and other inert waste. Waste was functioned as a fuel and high temperatures were generated (Wasteserv Press Release, 5th June 2015).

When the Magħtab dump site was closed a system of gas wells, pipe works and gas treatment plants were installed to extract, treat and burn landfill gases (Adi Associates Environmental Consultants Ltd, 2011).

7.2.3 Managed waste disposal sites (CRF 5A1)

From 2004, all solid waste started to be deposited in engineered landfills. Engineered landfills consist of protective layers at the sides and bottom which are covered with impermeable liners and have a leachate collection system to protect the surrounding environment.

Ta' Żwejra

The first engineered landfill opened in Malta was Ta' Żwejra Engineered managed landfill which operated from year 2004 till year 2006. Here, only mixed waste (black bag) was to be deposited, thereby avoiding inert waste from the construction industry, domestic recyclable materials, household bulky waste being diverted to the engineered landfill (Wasteserv Press Release, 5th June 2015).

Għallis

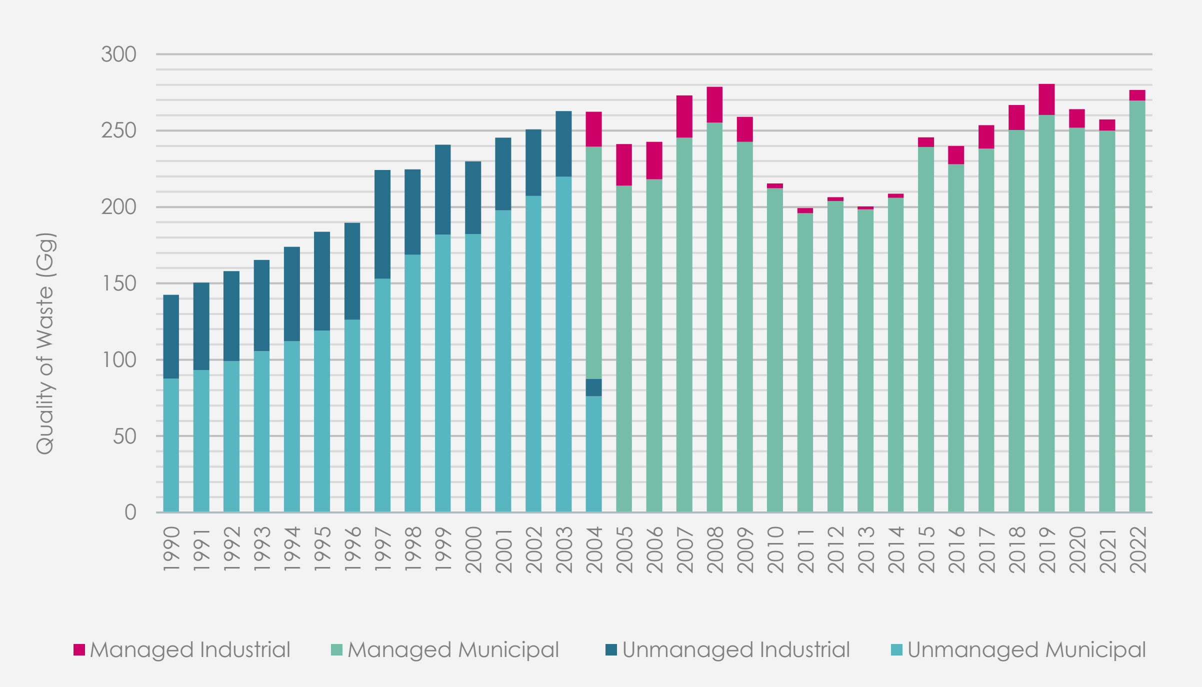
Subsequently, due to limited space available at the Ta' Żwejra Engineered managed landfill, the Għallis non-hazardous managed landfill (an engineered landfill) became operational in 2006 and is still running till present. However, the Għallis non-hazardous managed engineered landfill is set to reach its waste capacity within a few years. In fact, it was recently proposed that a Waste-to-Energy plant will be built in Malta to reduce the amount of municipal solid waste disposed into the landfill (refer to section 7.4.3 with regards to the Waste-to-Energy plant).

The Magħtab, Wied Fulija, Qortin, Ta' Żwejra and Għallis landfills are under the responsibility of one operator, namely Wasteserv Malta Ltd. The operator is a state-owned company responsible for permitting, reporting on the closed sites and operation of the active sites. Sites operating post-2004, like Għallis and Ta' Żwejra, have operated under an Integrated Pollution Prevention and Control (IPPC) permit.

Moreover, the below reflects how the above-described changes in Solid Waste Disposal are reflected by activity data classifications under CRF category 5A.

A clear increase in industrial waste is evident from year 2011. This increase is due to rejects from waste treatment of municipal waste at other plants. The waste enters the landfill under the EWC code 19 12 12, an industrial heading, where most of the rejects are of domestic origin.

Figure 7-2 Amounts of waste deposited in SWD sites by SWD type.



Regenerative Treatment Oxidiser (RTO) and Combined Heat Power (CHP)

The Magħtab, Ta' Żwejra and Għallis landfills form part of the Magħtab complex and are geographically adjacent to one another and also share facilities including a Regenerative Treatment Oxidiser (RTO) and Combined Heat and Power (CHP) generation facilities.

The RTO gas compound at the Magħtab environmental complex became operational in 2008. Following this, a CHP generation facility was also installed in the same area to generate energy from the landfill oxidised gases. Methane generated in the Magħtab landfill is directed to the RTO. Characteristically, gas from this landfill is too poor in methane to be burnt for energy purposes. So much so, that it actually requires the input of energy (through the RTO's electric heaters or gas-boosting from the nearby managed landfills) for successful combustion. The RTO facility has affected the overall composition of landfill gas by exerting negative pressure on the landfill mass, increasing oxidation. This effect has created the need to correct MCF annually since it alters radically the characteristics of the landfill mass.

Gases from other landfills in the complex are directed to the CHP for energy production purposes. The quantities of methane oxidised to carbon dioxide during operation at the RTO and CHP have been provided for each year of operation. In addition, a smaller amount of CH_4 was oxidised to CO_2 via flaring at the Qortin Landfill.

In 2012, Wasteserv Malta Ltd. scaled up the collection of gas from the Għallis engineered landfill, through the closure of the first landfill cell, which increased drastically the amount of gas being oxidised on site. This was the main reason why emissions from the sector reduced considerably as from 2012. The savings from the reported annual methane emissions from the same landfills has thus been calculated. No significant gas extraction volumes have been reported for the other local landfills.

7.2.4 Uncategorized Waste Disposal Sites (CRF 5A3)

Uncategorized Waste Disposal Sites are referred to as not occurring (NO).

7.2.5 Methodological Issues

A First Order Decay (FOD) spreadsheet model has been used to work out methane emissions from the solid waste category. This model method uses default parameters from the IPCC 2006 Guidelines, as well as country-specific activity data. This method assumes that the degradable organic component in the waste decays slowly over the course of a few decades. The emissions are highest in the first few years after waste deposition, and then gradually decline as the degradable carbon in the waste is consumed by the bacteria responsible for the decay.

7.2.5.1 Parameters

The table below displays the parameters that have been selected to represent Malta in the IPCC Waste model together with its source.

Table 7-9 Waste sector Parameters.

Parameters:		Source:
Country	Malta	
Region	Southern Europe	
Climate	Dry Temperate	
Starting Year for Waste Deposition	1950	
% waste going to SWDS	100%	
Delay Time for methane emissions to start being generated	six months	IPCC 2006 Guidelines default value, Volume 5, Chapter 3, Page 3.19
Degradable Organic Carbon (DOC) in waste: (weight fraction, wet basis)		
Food waste	0.15	IPCC 2006 Guidelines default value, Volume 5, Chapter 2, Table 2.4, Page 2.14
Garden	0.2	
Paper	0.4	
Wood and straw	0.43	
Textiles	0.24	
Disposable nappies	0.24	
Sewage sludge	0.05	IPCC 2006 Guidelines default value, Volume 5,

		Chapter 2, Paragraph 2.3.2, Page 2.15
Industrial waste	0.15	IPCC 2006 Guidelines default value, Volume 5, Chapter 2, Table 2.5, Page 2.16
DOC_f (fraction of Degradable Organic Carbon dissimilated)	0.5	IPCC 2006 Guidelines default value, Volume 5, Chapter 3, Page 3.13
Methane Correction Factor (MCF):		IPCC 2006 Guidelines, Volume 5, Chapter 3, Table 3.1, Page 3.14
• unmanaged shallow landfill (1977 – 1987)	0.4	
• unmanaged deep landfill (1988 – 2004)	0.8 (rectified[2])	
• managed deep landfill (2004 onwards)	1.0	
Methane Generation Rate Constant (k):		
Food waste	0.06	IPCC 2006 Guidelines, Volume 5, Chapter 3, Table 3.3, Page 3.17
Garden	0.05	
Paper	0.04	
Wood and straw	0.02	
Textiles	0.04	
Disposable nappies	0.05	
Sewage sludge	0.06	
Industrial waste	0.05	
Fraction of methane (F) in developed gas	0.5	IPCC 2006 Guidelines default value, Volume 5, Chapter 3, Page 3.15
Conversion factor, C to CH_4	$\frac{16}{12}$	IPCC 2006 Guidelines default value, Volume 5, Chapter 3, Page 3.9
Oxidation Factor (OX) (unmanaged)	0	IPCC 2006 Guidelines default value, Volume 5, Chapter 3, Table 3.2, Page 3.15
Oxidation Factor (OX) (managed)	0.1	IPCC 2006 Guidelines default value, Volume 5, Chapter 3, Table 3.2, Page 3.15
Parameters for carbon storage:		
• % content of paper in industrial waste	14.14%	Country-specific
• % content of wood in industrial waste	5.4%	Country-specific

Aeration Factor • % CO2 • % CH4 Total Aeration Factor	4.100% 0.264% 0.121%	Country-specific
Sewage sludge from treatment of urban wastewater	33.80 Gg	Country-specific

7.2.5.2 Region and Climate

As described in Chapter 1, the Maltese Islands are situated in the central Mediterranean and consist of a typically Mediterranean climate, with hot, dry summers and relatively mild winters with fluctuating rain patterns. Therefore, the parameter of a dry temperate climate was used for the methodology.

7.2.5.3 Starting year

In the waste model, 1950 was chosen as the starting year for waste deposition into landfills. As previously mentioned, the data was back extrapolated to 1950 as indicated in the IPCC 2006 guidelines (IPCC, 2006) (Volume 5, Chapter 3, page 3.12) for the implementation of the Tier 2 First Order Decay Model.

7.2.5.4 Delay Time

When waste is disposed in Solid Waste Disposal Sites the production of methane would not initiate instantly. Therefore, the IPCC Guidelines provides a default value of six months for the delay time before anaerobic decay begins. Moreover, according to the IPCC Guidelines, choosing a delay time of between zero and six months is a good practice. A default value of six months was used for Malta.

7.2.5.5 Degradable Organic Component (DOC)

According to the IPCC Guidelines, Degradable organic carbon (DOC) is one of the main parameters affecting the CH_4 emissions from solid waste disposal. The IPCC default value of the DOC content in percentage of wet waste for different MSW components was used to estimate CH_4 emissions from and carbon stored in SWDS.

7.2.5.6 DOCf (fraction of Degradable Organic Carbon dissimilated)

The IPCC Guidelines (Volume 5, Chapter 3, Page 3.13) describes DOCf as “an estimate of the fraction of carbon that is ultimately degraded and released from SWDS and reflects the fact that some degradable organic carbon does not degrade, or degrades very slowly, under anaerobic conditions in the SWDS”.

The DOCf value reported is recommended by the IPCC 2006 Guidelines, default value of 0.5. The mentioned value is reported in the CRF under the unmanaged waste category between years 1990 and 2004 since unmanaged landfilling in Malta lasted till year 2004. From year 2004 till present, the DOCf for managed landfilling is reported.

7.2.5.7 Methane Correction Factor (MCF)

It is notable that the MCF for unmanaged waste deposition sites is variable for years in which the RTO is in operation. This modification is based on the findings of a study carried out on behalf of the operator following the installation of the RTO plant at Magħtab, which claimed that more than 50% of the landfill gas produced is actually treated by the RTO and 90% of the methane treated is actually destroyed (Scott Wilson, 2004 and 2010). Additionally, the findings in the above-mentioned study are in line with the findings in (Oonk, 2012), where the RTO collection efficiency varies between 45-75%.

The MCF for unmanaged landfilling between 1950 and 1987 was 0.4 and the MCF from 1988 till 2004 was 0.8. In fact, the MCF for unmanaged landfilling in the CRF is reported as 0.8 between 1990 and 2004, using the IPCC default values.

For the managed landfilling, using the IPCC default values on the IPCC Waste Model, the MCF value from year 2004 till present is 1, also reported on the CRF, (as stated in the IPCC Guidelines Table 3.1).

The above explanation was asked by the ERT during the UNFCCC 2022 Review as to specify the MCF applied during the whole period.

7.2.5.8 Methane Generation Rate Constant (k)

The IPCC recommended default value of dry temperate climate zone was used to calculate the methane generation rate (k) of different type of waste; slowly, moderately and rapidly degrading waste.

7.2.5.9 Fraction of methane in developed gas

The value used for the fraction of methane in landfill gas, 0.5, is encouraged by the default value of the IPCC 2006 Guidelines.

7.2.5.10 Conversion factor, C to CH4

The fraction $\frac{16}{12}$,which is equal to 1.333…, refers to the molecular weight ratio of methane and carbon, CH_4/C (ratio).

7.2.5.11 Oxidation factor

The oxidation factor, OX, reflects the amount of methane from SWDS that is oxidised in the soil or other material covering the waste. An oxidation factor of 0.1 was used which is the default value recommended by the IPPC 2006 Guidelines both for managed and unmanaged SWDS (Volume 5, Chapter 3, Table 3.2, Page 3.15).

7.2.5.12 Parameters for carbon storage

Both the percentages content data of paper and wood in industrial waste are country-specific values provided by the data provider Wasteserv Malta Ltd.

7.2.5.13 Municipal waste composition

Municipal waste composition data used in the FOD model prior years 2018 was obtained from the ''Household Waste Composition'' surveys carried out by the National Statistics Office (NSO, 2012).

The below table shows the types of waste material, in percentage, recorded in the 2002 and 2011/2012 NSO surveys. Results show that food remains made up over 50% of the daily household waste generation. Both surveys were then implemented in the current FOD models. The 2002 survey is reported in the managed model for years after 2002 while the 2011/2012 survey started to be reported in year 2011 till 2018.

From year 2019 till present, the waste composition survey from the Environment and Resources Authority is being used since it is the most recent survey (refer to the below table). Results from this survey show that food remains have decreased by more than half when compared with previous surveys. The reason for this result is due to the introduction of nationwide organic waste collection.

Table 7-10 Municipal solid waste composition surveys.

Year of Survey	Waste material, %						
	Food remains	Garden	Paper and cardboard	Wood	Textile	Nappies	Plastics and Other inert (Glass, Metal, Hazardous and Other)
2002	59.50	0.00	12.70	0.00	1.70	1.70	24.30
2011/2012	52.10	0.00	17.60	0.25	2.30	0.00	27.75
2019	22.25	0.00	7.25	0.56	4.74	0.00	65.20

Note: In the 2002 survey, nappies accounted for half the textiles category while in the 2011/2012 survey, nappies were re-classified to form part of the 'Other' category.

In the 2002 survey, it is stated that nappies accounted for half the textiles category. Therefore, since the percentage of textile for the 2002 survey is reported as 3.40%, nappies account to 1.7% of the total household waste generation back in 2002. The term household waste generation in the surveys refers to the generation of organics, recyclables and residual waste and excludes other waste streams that may be generated by households such as bulky waste. On the other hand, in the 2011/2012 survey, it is stated that 'nappies' were re-classified to form part of the 'Other' category.

The data provider confirmed [personal communication, July 2020] that from the results that are presented in the News Release, the 'Other' category amounted to 6.7% of the total in the 2011/2012 survey. This is made up of 0.25% 'Wood' and 6.45% 'Other'. According to the waste sorting personnel, the 'Other' category is made up 'mainly of nappies and other unclean material'. One should keep in mind that this wood represents the wood items that were normally disposed in the black bag and so did not include any other wood items that were disposed in other ways (e.g. through the bulky refuse collection system). Garden waste was not included in the surveys.

7.2.5.14 Methane Recovery

The following description explains the method used to quantify and estimate CH_4 recovery:

The oxidised value from the FOD managed model is multiplied by the proportion used for energy production. The value is then multiplied with the molecular weight of CO_2 ($\frac{44}{16}$). This results into the total emissions to be transferred to energy (Gg CO_2). The later value is then divided by the GWP of CH_4 (GWP 25) and results into the total emissions to be transferred to energy (Gg CH_4).

The oxidised value from the FOD managed model and the amount of methane oxidised from the unmanaged model are provided by the data provider Wasteserv Malta Ltd.

Therefore, for year 2022, methane recovery was calculated as follows:

i. Total emissions to be transferred to energy (Gg CO2) = oxidation from the FOD managed model * proportion used for energy production * (molecular weight of CO2);

= 0.14 * 0.80 * (44/16) = 0.32

= 0.32/28 = **0.01**

ii. Total Emissions to be transferred to Energy (Gg CH4) = Total emissions to be transferred to energy (Gg CO2) / GWP of CH4 in AR5;

Moreover, the below calculations refer to the quantity of methane recovered, and method used to quantify CH_4 for all years in which recovery is reported.

Hence, keeping in mind the method previously presented:

For year 2021, methane recovery was calculated as follows:

= 0.20 * 0.80 * (44/16) = 0.43

=0.43/28 = **0.02**

For year 2020, methane recovery was calculated as follows:

= 0.20 * 0.80 * (44/16) = 0.43

= 0.44/28 = **0.02**

For year 2019, methane recovery was calculated as follows:

= 0.20 * 0.80 * (44/16) = 0.44

=0.44/28 = **0.02**

For year 2018, methane recovery was calculated as follows:

= 0.23 * 0.80 * (44/16) = 0.50

=0.50/28 = **0.02**

For year 2017, methane recovery was calculated as follows:

= 0.19 * 0.80 * (44/16) = 0.42

=0.42/28 = **0.02**

For year 2014, methane recovery was calculated as follows:

= 0.34 * 0.80 * (44/16) = 0.75

=0.75/28 = **0.03**

For year 2013, methane recovery was calculated as follows:

= 0.41 * 0.80 * (44/16) = 0.90

=0.90/28 = **0.04**

EWC code

In the current FOD model, the landfilling of industrial waste and wastewater sludge from aerobic treatment of waste is also included. It is important to note that the sludge being referred to in the FOD managed model refers to sludge from urban wastewater treatment. In fact, the activity data received from the data provider is EWC code 19 08 05.

Additionally, once the landfill data is provided from the data provider according to the EWC code, the data is then further sorted into municipal and industrial waste. Based on personal communication with the data provider in February 2024, it was recommended that the 19 12 and 20 EWC codes should be classified under municipal waste. As a result, the landfill data has been revised accordingly to include the 19 12 EWC codes under municipal waste rather than industrial waste or inert waste. The recalculation is provided in section 7.2.7.

7.2.5.15 Unmanaged Landfill MCF rectifications

Aeration factor

In the landfill of Magħtab a mixture of municipal solid waste and demolition waste was deposited, resulting in a relative porous waste material. In 2008, landfill gas was extracted, to minimise diffuse emissions. Gas was extracted using relatively high suction pressures on the gas wells, resulting in a system that resembles active aeration, using over extraction (e.g. refer to Duurzaam Storten 'Braambergen Landfill', Netherlands).

The composition of gas extracted is closely monitored. Concentrations of methane are very low (< 2 vol%), the ratio of CO_2/CH_4 is significantly higher compared to the normal composition of greenhouse gases and this is consistent with composition of extracted gas at another aeration (Heyer, K., Hupe, K., Koop, A., Ritzkowski, M., & Stegmann, R., 2003). As discussed during the in-country review held in 2016, the effect on methane emissions, is best described as a decreased actual MCF upon start of gas-collection/over-extraction.

The high ratio of CO_2/CH_4 is a clear indication that large part of biodegradation proceeds in aerobic decomposition. In this respect it is not important whether solid organic material (DOC) is directly aerobically degraded, or whether solid organic material first degrades anaerobically and produces methane, which is subsequently oxidised. The ratio of anaerobic and aerobic processes can be estimated from the ratio of methane and carbon dioxide in the extracted gas.

Assumption: Generally, degradable organic material has the molecular composition of cellulose $(CH_2O)_n$.

(Note: this is an assumption that is used often, e.g. in the determination of DOC in waste).

Anaerobic degradation goes as:

$$(CH_2O)_n \rightarrow {}^{1}/_{2}\, n\, CH_4 + {}^{1}/_{2}\, n\, CO_2$$

Aerobic degradation goes as:

$$(CH_2O)_n + n\, O_2 \rightarrow n\, CO_2 + n\, H_2O$$

In case landfill gas contains x% of CH_4 and y% of CO_2, the actual MCF (the fraction of DOC removed through anaerobic processes) can be estimated as follows:

$$2 * {}^{x}/_{x+y}$$

For the Magħtab landfill a substantially reliable time series of the composition of collected gas (CH_4, CO_2, O_2-content) is available. This time series is used to correct the MCF with the aeration factor upon over extraction.

The aeration factor was included in the unmanaged model since the model (the 2006 IPCC Guidelines Waste FOD model) was not providing the real situation of the total methane generated and the total methane emissions in unmanaged waste (Magħtab landfill).

The aeration factor is used in the calculation of the MCF, specific to the unmanaged landfills, where historic data analysis shows that the default MCF does not represent reality. This is due to the specific composition of the unmanaged landfills in question, with a major component of construction waste, which helps the oxygenation of the landfill mass, and thus the aerobic digestion of waste in the landfill mass. This change to MCF is measured by proportional comparison of the CO_2 and CH_4 content in the gas and its deviation from the expected gas composition. The higher CO_2 as compared to CH_4 means a lower MCF.

This methodology regarding the aeration factor was suggested during the in-country visit at the beginning of August 2016. The experts discussed that the oxidation factor (OX) should not be used in the unmanaged model. It was then considered to start using the aeration factor in the unmanaged model since the oxidation factor had a high oxidation rate of landfills with a value of 0.6 (60%). The mechanism regarding the aeration factor was provided by one of the experts, which is the proportion between carbon dioxide and methane from landfill gas (unmanaged landfill; Magħtab landfill) and is calculated by dividing twice the average percentage of methane in landfill gas with the sum of both the average percentage of methane and carbon dioxide in landfill gas; $\frac{(2 * \%\, CH4)}{(\%\, CH4 + \%\, CO2)}$

The time series values of the aeration factor and $\%CH_4$ and $\%CO_2$ to estimate the aeration factor to are provided in the below table to improve transparency, as suggested during the UNFCCC 2021 Review.

Table 7-11 Aeration factor.

Year	Aeration factor	Average % of CO_2	Average % of CH_4
2022	0.098	4.115	0.213
2021	0.107	3.612	0.204
2020	0.127	3.947	0.268
2019	0.121	4.100	0.264
2018	0.120	4.700	0.300
2017	0.118	6.400	0.400
2016	0.167	6.900	0.630
2015	0.192	4.700	0.500
2014	0.184	5.440	0.550
2013	0.150	5.440	0.440
2012	0.217	4.590	0.560
2011	0.194	4.480	0.480
2010	0.133	5.600	0.400
2009	0.380		
2008	0.390		

Hence, for year 2022, the aeration factor was calculated as follows;

Aeration Factor = (2*%CH4)/(%CH4 + %CO2)

Aeration Factor = (2*0.213)/(0.213+4.115)

Aeration Factor = **0.098**

7.2.5.16 Uncertainties and time-series consistency

Uncertainty is estimated using IPCC good practice guideline (IPCC, 2006). The main component of uncertainty is related to the emission factor and specifically to the use of default methane generation rate constant (k) as per IPCC 2006. It is understood that all activity (waste entering sites) is weighed at the gate. Uncertainty levels are presented in the below.

Table 7-12 Uncertainty levels for category Solid Waste Disposal.

Uncertainty issues for SWD	Managed	Unmanaged
% MSW sent to SWDS	5.00%	10.00%
Total uncertainty in waste composition	60.00%	200.00%
DOC Value	20.00%	20.00%
Percentage of DOC decomposed	20.00%	20.00%

MCF	10.00%	50.00%
Fraction of CH_4 generated at Landfill	5.00%	5.00%
OX factor	NA	NA
Half life	20.00%	20.00%
Totals	24.87%	76.10%

For activity data, an uncertainty of ±10% has been used.

Data collected spans back to 1997, prior to which, as previously explained, no weighbridges were used, thus no activity data was collected. International data on such a small economy scale, is, in this case, considered inadequate. This is why back extrapolation based on common drivers was the preferred option.

7.2.5.17 Long-term storage of carbon and Harvested wood Products (HWP)

During the 2017 review report of the annual submission of Malta, the ERT noted that no data was reported in CRF table 5 on the long-term storage of carbon at waste disposal sites, annual change in long-term carbon storage, and annual change in carbon storage in HWP waste.

The waste sector checked with the LULUCF sector, and it was confirmed that harvesting in forests in Malta does not occur. In fact, HWP in the LULUCF sector, both in the NIR (section 6.10) and CRF (category 4G), is reported as NO. Also, after assistance from Aether UK ltd., it was agreed that the notation key should be changed from NE to NO and be consistent with the LULUCF sector.

7.2.6 *CATEGORY-SPECIFIC QA/QC AND VERIFICATION*

QA/QC checks were carried out in the past between the Inventory Agency and the data provider to improve the quality related to landfills by ensuring accuracy and consistency in this chapter. Data provided through the operator, Wasteserv Malta Ltd., is also provided under IPPC permitting and reporting, and reviewed accordingly. Verification of activity data used for estimating municipal solid waste disposed to solid waste disposal sites was performed by comparing the activity data with previous year's data.

UNFCCC Review 2021

Further description has been included regarding MCF under section 7.2.5.7 where the MCF for unmanaged landfilling is reported as 0.8 between years 1990 and 2004 while for managed landfilling, the MCF is reported as 1 as from year 2004. Also, the methane recovery for years in which recovery is reported is now included and reported in the NIR under section 7.2.5.14.

Also, the ERT suggested to provide the values of the aeration factor and the percentage CH4 and percentage CO2 to estimate the aeration factor to improve transparency. This is included under section 7.2.5.15.

ESD Review 2020

With regards to the household survey, the Inventor Agency asked the data provider whether there has been an update since the 2011/2012 survey was released. However, the data provider confirmed that no updates have been made and neither future updates are expected to such study. Moreover, with regards to the waste composition, communication with the data provider was conducted as to include further explanations in the NIR in section 7.2.5 as recommended during the ESD 2020 Review. Years between 2005 and 2018 in the FOD managed model have been corrected according to the NSO survey (MT-5A-2020-0004).

Moreover, further improvements have been applied with regards to the ESD 2020 Review (MT-5A-2020-0003). Such improvements refer to the oxidation factor of the IPCC Waste model for managed model. The oxidation factor (OX) value applied has been updated from OX=0 to OX=0.1 as indicated in Table 3.2 of Volume 5, Chapter 3 of the 2006 IPCC Guidelines when managed landfills are covered with oxidising material. Also, due to lack of transparency, the methodology used to estimate methane recovery is explained in detail in section 7.2.5 as suggested during the ESD 2020 Review (MT-5A-2020-0005).

Furthermore, a meeting was organised between the Inventory Agency and the data provider (the Authority) in July 2019 to discuss waste data and its timeliness due to lack of data available in previous submissions. During this meeting it was agreed that provisional data regarding solid waste disposal and waste incineration can be provided earlier so that data would be included in the 2020 submission reports.

Additionally, during the waste data meeting, the procedure between the Authority with the operators was also discussed:

One of the major issues encountered with regards to the Waste sector emissions inventory is the timely availability of activity data. The Environment and Resources Authority (ERA) is responsible for monitoring any establishments or undertakings carrying waste treatment operations. Permitting requirements include obligations on the operators to provide data on a yearly basis to ERA for regulatory purposes, which data, once verified and aggregated by ERA, is made available to the Inventory Agency, Malta Resources Authority (MRA). Instances of late submission of data by operators has led ERA to implement regulations setting a daily fine for late submissions of data, so as to improve the timeliness of data gathering. That being said, at present, the ERA opted to impose administrative fines for late submission rather than daily fines as the former are more substantial, with the intention deter further late submissions. Furthermore, data received by ERA is thoroughly checked, including via clarifications sought from the waste operators. While this ensures higher reliability of the data received, it may also lead to further delays in the finalization of waste data inventory by ERA and submission to MRA for inventory purposes. Discussions between MRA and ERA are ongoing to seek further ways to improve the timeliness and robustness of waste sector data. Please refer to the subsidiary legislation on the Daily Penalty Regulations (Subsidiary Legislation, 2018).

The deadline for submission of the Annual Environmental Report by the Waste Operators is end of March of the following year (i.e. 2019 waste data shall be submitted by end of March 2020). That being said, when taking into consideration late submissions and the duration of data verification process (based on the priorities), the entire process would extend several months.

ESD Review 2019

With regards to the aeration factor data from unmanaged landfill, the equation used in the model has been updated according to discussions during the ESD Review 2019 since an incorrect equation was being applied and calculated.

Furthermore, improvements in this category are also presented within the text according to questions asked during the UNFCCC Centralised Review 2019 regarding solid waste disposal such as the managed and unmanaged sections represents the landfills into more detail. Moreover, during the UNFCCC Centralised Review 2019, the Emission Factor (EF) for methane Plant Specific (PS) for the anaerobic managed waste disposal sites (CRF 5.A.1.a) was discussed. However, the emission factor PS has been updated to M (Model) since the FOD model is being used to calculate the solid waste disposal category. This has been updated both in the CRF and also in parameters table.

ESD Review 2018

From the review that was carried out by the ESD review team Ing. Eva Krtková in August 2018, Ing. Eva Krtková suggested that section '7.2.5 Methodological Issues' should be inputted in a table so that the parameters of the methodological issues could be better classified and understood. Moreover, the source of the parameters was also included in the table to identify whether the parameter's value is either from the IPCC Guidelines or is a country-specific value. This was also recommended by the UNFCCC expert review team of 2017 inventory submission report (Table 3; ID# W.5, W.6 and W.7 and Table 4; ID# W.5 and W.6). Similarly, the description of estimating methane recovery was also a recommendation (Table 3; ID# W.3 and W.4 and Table 4; ID# W.3) which is included in section 7.2.5.15.

Furthermore, during the visit, Ing. Eva Krtková suggested to include in the NIR the reason regarding the increase of industrial waste in the Għallis landfill from year 2011. This was included in the 'Category Description' of this chapter.

ESD Review 2017

The ERT recommended in the 2017 submission report that Malta replace the "IE" notation key for unmanaged waste disposal reported in CRF table 5.A with actual MCF and DOCf values. This has been updated in the 2021 submission.

7.2.7 CATEGORY-SPECIFIC RECALCULATIONS

The reason for the recalculation for the Solid Waste Disposal category is due to the classification of municipal and industrial waste in landfill according to the EWC codes and also due to the update of municipal waste composition, as explained previously in the 'methodological issues' section. The recalculation is presented in the below table for CH4 emissions in AR5.

Table 7-13 Recalculation for category Solid Waste Disposal – Total CH4 emissions (Gg CO_2 eq).

Year	Total CH4 emissions from SWD (Gg CO2 eq.)	Total CH4 emissions from SWD (Gg CO2 eq.)	Percentage change in reported emissions (%)	Change in Gg CO2 eq.

	as reported in the previous inventory report	as reported in this inventory report		
1990	46.48	46.48	0.00%	0.00
1991	52.63	52.63	0.00%	0.00
1992	58.96	58.96	0.00%	0.00
1993	65.44	65.44	0.00%	0.00
1994	72.05	72.05	0.00%	0.00
1995	78.86	78.86	0.00%	0.00
1996	85.92	85.92	0.00%	0.00
1997	93.00	93.00	0.00%	0.00
1998	101.83	101.83	0.00%	0.00
1999	110.36	110.36	0.00%	0.00
2000	119.46	119.46	0.00%	0.00
2001	127.51	127.51	0.00%	0.00
2002	136.14	136.14	0.00%	0.00
2003	144.71	144.71	0.00%	0.00
2004	153.60	153.60	0.00%	0.00
2005	162.54	162.54	0.00%	0.00
2006	169.82	169.82	0.00%	0.00
2007	176.79	176.79	0.00%	0.00
2008	88.03	88.03	0.00%	0.00
2009	108.18	108.18	0.00%	0.00
2010	94.33	94.33	0.00%	0.00
2011	106.96	106.92	-0.04%	-0.05
2012	115.17	115.49	0.28%	0.32
2013	113.42	114.06	0.57%	0.65
2014	125.38	126.30	0.73%	0.92
2015	136.45	137.34	0.66%	0.90
2016	148.41	149.70	0.87%	1.29
2017	146.95	148.30	0.91%	1.34
2018	155.48	156.90	0.91%	1.42
2019	165.46	166.97	0.91%	1.50

2020	175.67	168.52	-4.07%	-7.15
2021	182.90	167.71	-8.31%	-15.19
2022	NA	168.57	NA	NA

7.2.8 *CATEGORY-SPECIFIC PLANNED IMPROVEMENTS*

There are no planned improvements.

7.3 BIOLOGICAL TREATMENT OF SOLID WASTE (CRF 5B)

Table 7-14 Summary table.

Waste sector category	Biological Treatment of Solid Waste
2006 IPCC Guidelines category number	4B
CRF category number	5B
GHG emissions reported/generated Direct gases	CH_4, N_2O
Key category	No
Method	T1 (2006 IPCC Guidelines Tier 1)
Emission Factor	D (2006 IPCC Guidelines default)
Operation: Composting Anaerobic biodigestion	 1993 - 2006 2010 – till present

Introduction

The category Biological Treatment of Solid Waste consist of two categories; Composting (CRF 5B1) and Anaerobic digestion (CRF 5B2) where composting in Malta stopped operating in early 2007 while anaerobic biodigestion has started its operation since 2010.

7.3.1 *BIOLOGICAL TREATMENT OF SOLID WASTE - COMPOSTING (CRF 5B1)*

7.3.1.1 Category Description

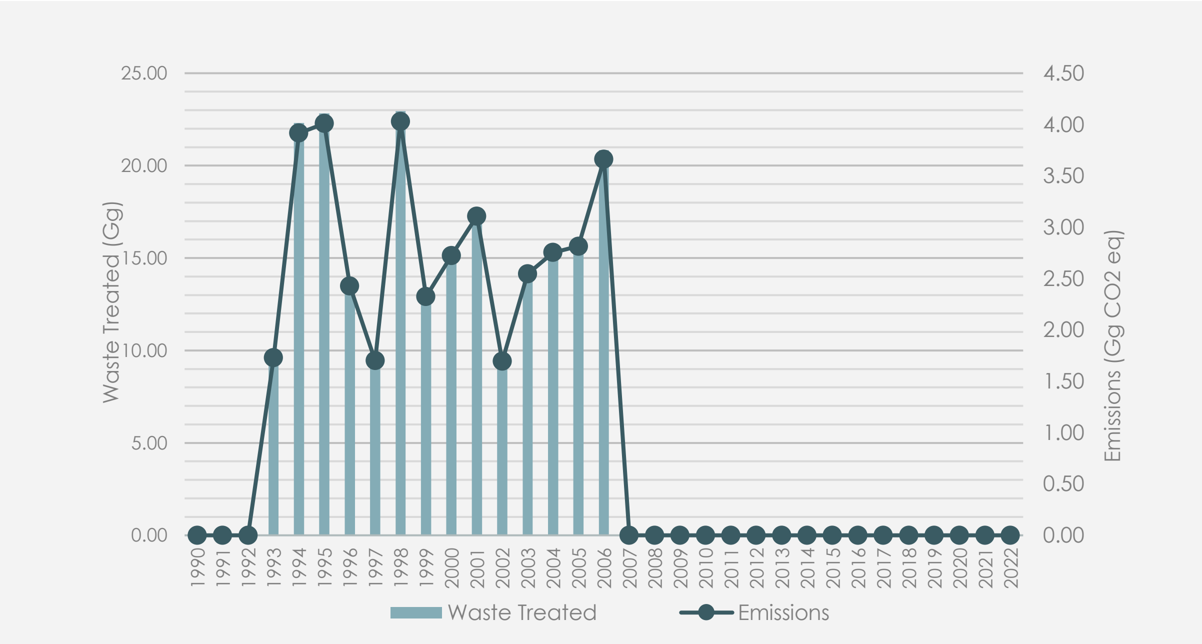
The Sant'Antnin Solid Waste Treatment Plant started operating in 1993. Waste arriving at the plant was either mixed waste or waste separated at source. Mixed wastes were separated mechanically, and the biodegradable fraction was composted. Some non-biodegradable materials such as metals and plastics were channelled into recycling, whilst the rejects from mechanical separation were landfilled.

The organic fraction was composted using the open window system with the product raw compost being refined and left in the open to mature. No abatement measures were ever installed at the Sant'Antnin Solid Waste Treatment Plant (personal communication, Wasteserv Malta Ltd, October 2007). The composting plant stopped operating in early 2007 and was replaced by a mechanical biological anaerobic treatment plant, the activity of which is accounted for. Between the decommissioning of this plant, in 2007, and the commissioning of the new plant, in 2010, no plant scale biological treatment of solid waste was operational in Malta, as confirmed in Figure 7-3 below.

7.3.1.2 Methodological Issues

Data on biological solid waste treated at the Sant'Antnin Solid Waste Treatment Plant has been provided by Wasteserv Malta Ltd. for the operating years 1993 to 2006. Default IPCC 2006 Tier 1 emission factors were used for CH_4 (on a dry weight basis - 10g CH_4/kg waste composted) and N_2O (on a dry weight basis - 0.6g N_2O/kg waste composted). These values were updated from wet to dry weight basis as recommended during the ESD Review 2020 (MT-5B-2020-0001) because in the CRF table, Activity Data (AD) should be expressed on a dry weight basis and not on wet weight basis. This observation had no impact on emissions but deals with the transparency of the CRF tables.

Figure 7-3 Waste treated and emissions from composting.



The above figure illustrates the different quantities of waste composted. The quantities of waste accepted at the Sant' Antnin plant decreased progressively during the mid-1990s and, again, in 2002, in attempts to keep odour emissions within control. The resultant emissions from composting reflect the quantities of degradable municipal waste received at the compost plant.

The notation key 'NE' is reported in the CRF for composting as requested during the ESD/ESR reviews. The reason for this notation key, which is also reported in table 9, is because as urban population is about 95% of total population in Malta, the TERT considers that emissions from backyard composting are likely negligible and encourages Malta to report "NE'.

As reported previously in the NIR in section 7.3.1, the Sant'Antnin Solid Waste Treatment Plant started operating in 1993 and stopped operating in early 2007. Data for composting is reported under 5.B.1 in the CRF. This plant was then upgraded and replaced by a mechanical biological anaerobic treatment plant (refer to NIR section 7.3.2) to operate as an Anaerobic Digestor plant in 2010. Data for the anaerobic plant is reported under 5.B.2 in the CRF as from year 2010 till present.

There is in place a national waste collection system that provides for tri-weekly collection of organic waste from all households which is reported under AD.

7.3.1.3 Uncertainty and time series consistency

Not applicable.

7.3.1.4 Category-specific QA/QC and verification

Not applicable.

ESD 2020 Review

Default IPCC 2006 Tier 1 emission factors were used for CH_4 (on a dry weight basis - 10g CH_4/kg waste composted) and N_2O (on a dry weight basis - 0.6g N_2O/kg waste composted). The values for the default IPCC 2006 Tier 1 emission factors for CH4 and N2O emissions from composting were updated to dry weight basis: 10g CH_4/kg waste and 0.6g N_2O/kg. This was recommended during the ESD Review 2020 (MT-5B-2020-0001) since in the CRF table, Activity Data should be expressed on a dry weight basis and not on wet weight basis. This observation had no impact on emissions but deals with the transparency of the CRF tables.

7.3.1.5 Category specific recalculations

No recalculations were required. Compost stopped operating in early 2007.

7.3.1.6 Category specific planned improvements

No improvements are planned in this specific category. Compost stopped operating in early 2007.

7.3.2 BIOLOGICAL TREATMENT OF SOLID WASTE - ANAEROBIC BIODIGESTION OF WASTE (CRF 5B2)

7.3.2.1 Category Description

The process of biodigestion expedites the process of decomposition of organic waste through controlled conditions (e.g. temperature moisture and pH) within a reaction vessel. In the conditions set, methane is generated and, contrary to landfilling, it can easily be directed into a combustion system to be used for energy or else flared.

Since 2010, Malta has one plant operating this process (Sant'Antnin Waste treatment plant following upgrading). The operator of the plant (Wasteserv Malta Ltd.) is the same operator of the landfills. The plant consists of a Mechanical & Biological Treatment Plant (MBT), which separates the biological fraction of waste from the remainder and this part is sent for anaerobic treatment. The remaining fractions are either recovered or treated elsewhere. The

Malta North Mechanical and Biological treatment Plant has started its operation in 2016 by treating municipal solid waste (MSW) and animal manure. The MBT addresses waste management issues through three different sections: the Mechanical Treatment Plant (MTP) where MSW is segregated into five fractions (organic waste, ferrous and non-ferrous metals, refuse derived fuel (RDF) and rejects); the Materials Recovery Facility (MRF) where the recyclable items from bring-in-sites and recycling bags are separated to be sold abroad for recycling; and Anaerobic Digestion Plant (AD Plant)/Biogas Plant in which the organic waste (from MTP) undergoes a fermentation process in closed vessels, and gas is produced.

This plant processes organic waste and then uses bacteria to produce methane gas, which is used as fuel to produce heat and electricity. The first step in this process is mixing the organic waste with water to convert it into a pulp which is then fed to the digesters within the Anaerobic Digestion Plant. This breaks down the pulp through bio-kinetic processes taking place within the digestors to produce a 'digestate'.

One of the most important bio-kinetic process taking place is that of the methane forming bacteria. These bacteria convert the acids produced into methane and carbon dioxide. The methane is then used as fuel in the Combined Heat and Power (CHP) machine to produce heat and electricity. The heat is used to sustain the Anaerobic Digestion process itself while the electricity generated is fed to the national grid. The stabilised digestate is ultimately dewatered and used for landscaping and other projects such as landfill rehabilitation (Wasteserv, 2020).

7.3.2.2 Methodological Issues

The calculation consists of multiplying the annual activity data provided by the operator (wet weight) with the default emission factor for CH_4 on a wet weight basis for anaerobic digestion, as corrected under point three of the ninth corrigenda for the 2006 IPCC Guidelines – i.e. 0.8 g CH_4/kg. Then, the value is divided by 1000 which results into Net CH_4 Emissions (Gg CH_4) and then multiplied by the Global Warming Potential, GWP of CH_4 in AR5 (28) which results into Gg CO_2 eq. On the other hand, the N_2O Emission Factor of anaerobic digestion at biogas facilities are assumed to be negligible (2006 IPCC Guidelines, Volume 5, Chapter 4, Table 4.1, Page 4.6).

The following calculation refers to the anaerobic digestion for the latest year, 2022:

CH_4 tonnes = Activity Data (Gg) * CH_4 Emission Factor

= 65.87 * 0.80

= 52.70 CH_4 tonnes

Net CH_4 emissions (Gg CH_4) = CH_4 tonnes / 1000

= 52.70/1000

= 0.05 Gg CH_4

Net CH4 emissions (Gg CO_2 eq.) = Net CH4 emissions (Gg CH4) * Global Warming Potential of methane in AR5

= 0.05 * 28

= 1.48 Gg CO_2 eq.

7.3.2.3 Uncertainty and time series consistency

The time series of this sector contains a number of gaps mainly due to inconsistent operation of biological plants in the country. Two main periods of no operation are identified: between 1990 and 1992 and between 2007 and 2009. The periods in which no operation was occurring can be easily explained with the inexistence or unavailability of infrastructure due to the decommissioning and subsequent upgrades of the Sant' Antnin plant.

In terms of uncertainty, specifically, in recent inventory years for anaerobic bio-digestion, the use of gas monitoring data decreases the uncertainty of emission (Activity Data (AD) x Emission Factor (EF)) to ±10%. This uncertainty can be fully attributed to AD, since the EF in direct measurement is equal to 1 with no uncertainty.

7.3.2.4 Category-specific QA/QC and verification

UNFCCC Review 2022

During the review, the ERT asked that the amount of CH4 flared in anaerobic digestion at biogas facilities is reported as NE in the CRF in table 5.B and an explanation is not presented in the NIR or in CRF Table 9.

Malta treats a small proportion of its waste in the Mechanical and Biological Treatment Plant (MBT) facility at Sant' Antnin which has organic processing and Anaerobic Digestion stages. Our assumption is of negligible emissions from flaring which is in line with the 2006 IPCC Guidelines, Volume 5 Chapter 4 which states that "Where technical standards for biogas plants ensure that unintentional CH4 emissions are flared, CH4 emissions are likely to be close to zero". Hence, the NE.

UNFCCC Review 2021

The calculation/method used to calculate anaerobic digestion from the biological treatment of solid waste category is worked out in detail and reported under section 7.3.2.2.

ESD 2018 Review support

As pointed out by Ing. Eva Krtková during the 2018 ESD review support regarding the anaerobic digestion at biogas facilities, an explanation about the default emission factor for N_2O was included in section '7.3.2.2 Methodological Issues' to reflect the current methodology being followed. Moreover, the ERT recommended that the notation key of the amount of methane for energy recovery in anaerobic digestion reported in the CRF table 5.B.2.a, ''NO'', is not appropriate and should be replaced with ''IE'' if the IPCC default emission factor of methane is applied. The reason for this is because the default IPCC value for CH_4 emissions from anaerobic digestion (0.8 g CH4/kg) already takes account of CH_4 recovery. The notation key has been updated.

7.3.2.5 Category specific recalculations

Not applicable.

7.3.2.6 Category specific planned improvements
There are no planned improvements.

7.4 INCINERATION AND OPEN BURNING OF WASTE (CRF 5C)

Table 7-15 Summary table.

Waste sector category	Incineration and Open Burning of Waste
2006 IPCC Guidelines category number	4C
CRF category number	5C
GHG emissions reported/generated	
Direct gases	CO_2, CH_4, N_2O
Indirect gases	NO_x, CO, NMVOC, SO_2
Key category	No
Method	T1 (2006 IPCC Guidelines Tier 1)
Emission Factor (EF)	D (2006 IPCC Guidelines default)
Operation:	
Waste Incineration	1990 – till present
Open Burning of Waste	Not Estimate (NE)

The types of waste incineration described in this chapter include municipal, industrial and clinical incineration. Open burning of waste does not take place in Malta. In fact, open burning is reported as NO (Not Occurring) in the CRF category 5.C.2.

7.4.1 Waste Incineration (CRF 5C1)

7.4.1.1 Category Description

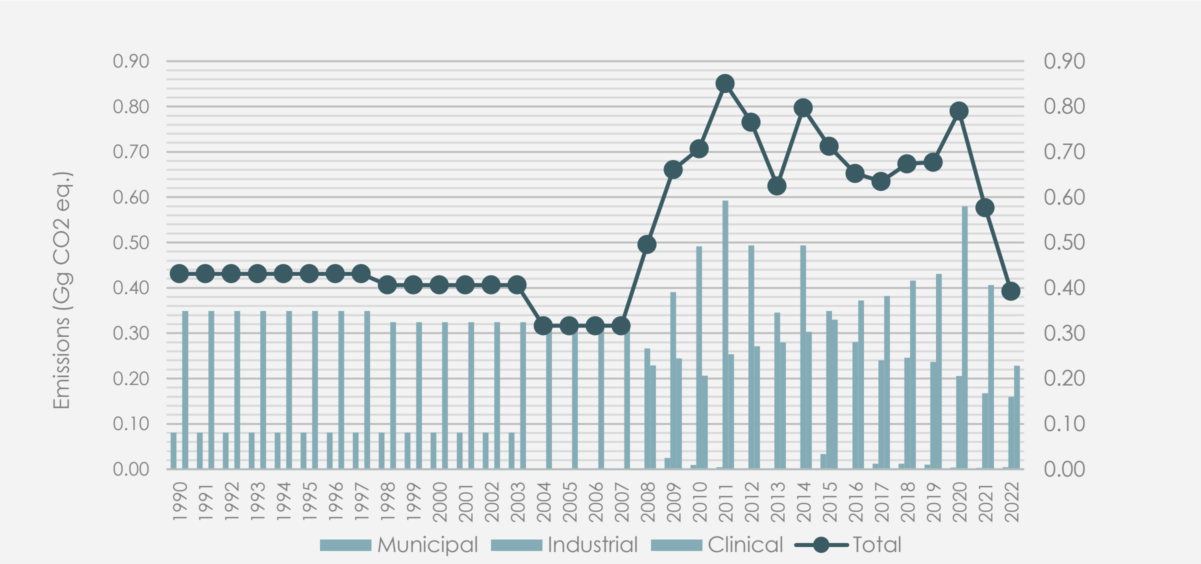
Waste incineration is defined as the combustion of solid and liquid waste in controlled facilities. In Malta, to date, the emissions from waste incineration are minimal (<5% of the total emissions in the waste sector). This category includes emissions from municipal, clinical and industrial waste incineration, leading to carbon dioxide, methane and nitrous oxide emissions; as well as emissions of the indirect greenhouse gases, nitrogen oxides (NO_x), carbon monoxide (CO), non-methane volatile organic compounds (NMVOC) and sulphur dioxide (SO_2).

Between 1990 and 2007, no regulated/licensed facilities existed for waste incineration in Malta. The facilities in operation at the time were basic and without combustion control. As a precautionary measure, their emissions are considered with open burning of waste rather than as waste incineration. A major improvement took place in early 2008 with the commissioning of a thermal treatment facility, in line with the European Union Incineration Directive (Directive 2000/76/EC). This incinerator allowed for the decommissioning of old non-compliant local incinerators.

Figure 7-4 below shows the emissions in CO_2 equivalents from the combustion of municipal, clinical and industrial waste. The major source of emissions until 2007 was combustion of clinical waste, whereas from 2008, industrial waste incineration has the highest share of emissions in this category. Municipal waste combustion is being reported for the years 1990 to 2003 and intermittently from 2008 onwards. The gap between the latter sets is due to the unavailability of such waste treatment facilities, thus this type of incineration was not operational.

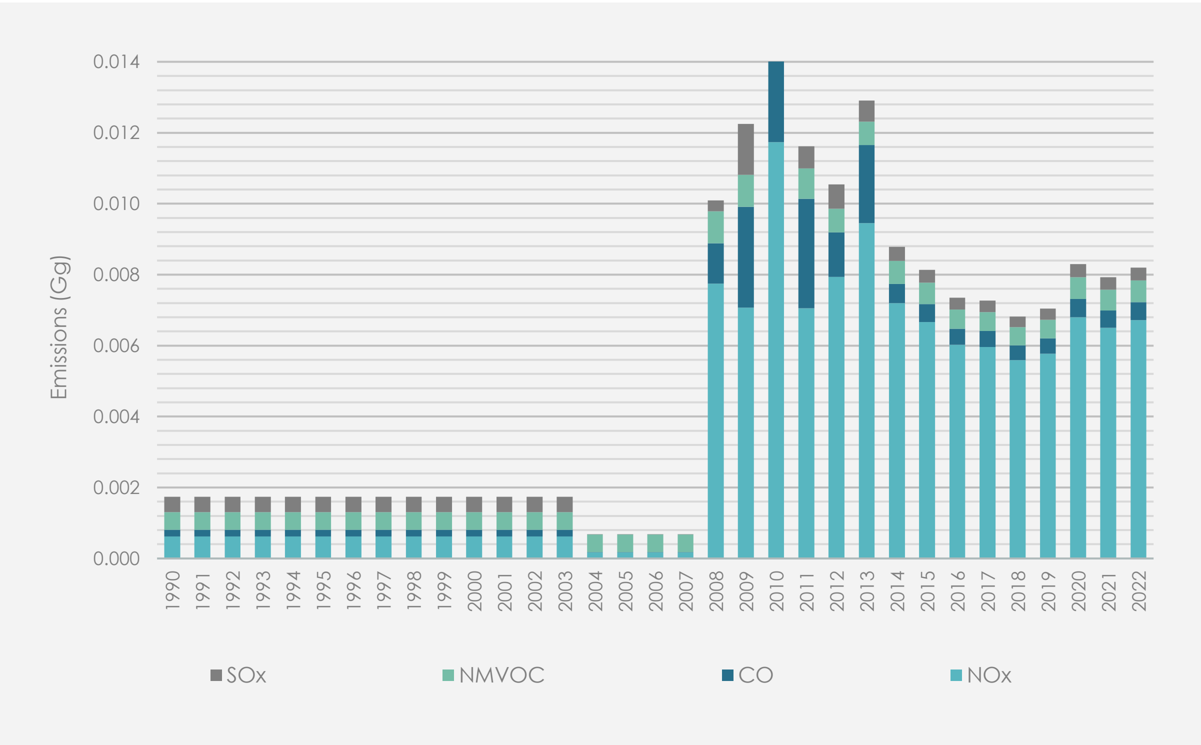
Incineration in Malta is treated at the Thermal Treatment Facility.

Figure 7-4 Direct GHG emissions from category Incineration.



The below Figure 7-5, includes the indirect emissions from the combustion of municipal, clinical and industrial waste.

Figure 7-5 Indirect GHG emissions from category Incineration.



7.4.2 METHODOLOGICAL ISSUES

7.4.2.1 Municipal Waste Incineration (CRF 5C1)

Under this section the following points are to be considered:

- Shipboard kitchen waste reported under Municipal Waste Incineration was previously incinerated at the Malta Shipyards. Shipyard wastes (sediments or paints) were never incinerated.
- Municipal waste incineration is being reported for the years 1990 to 2003, when the incinerator at the Malta Shipyards was operational.
- An average of 0.25Gg of waste between 1990 and 2003, 85% of which is considered to be of biogenic origin, used to be incinerated at the shipyards. It is to be noted that the incinerator coped easily with one tonne of waste daily and had no abatement measures fitted.
- During 2004-2007, no plants incinerating MSW were operational. In fact, activity data is reported as NO; Not Occurring.
- For the year 2008, emissions from the incineration of about 0.1tonnes (0.0001Gg) of paper and cardboard, at the Thermal Treatment Facility, have been included.
- Data for the remainder inventory years is provided annually by the data provider.

CO_2 emissions from municipal waste incineration were calculated using the default IPCC 2006 method, as presented in Annex 3 for the year 1990 as an exemplar. EFs for CH_4 and N_2O used in this section prior to 2007 were equivalent to EFs specified for open burning of waste. This has been done in order to take due account of the lacking and unregulated infrastructure which was in place at the time. Details of EFs used can be found in Annex 3.

The fraction of carbon in dry matter (CF) for MSW used to be reported as 0.38 *(Food waste, 2006 IPCC Guidelines (vol. 5, Chap. 2, Table 2.4))*. However, during the UNFCCC in-country review of year 2021, the ERT noted that this is not in accordance with the 2006 IPCC Guidelines *(vol. 5 chap. 5, equation 5.2 and vol. 5, chap.2, Table 2.4)* because the Party did not calculate CO2 emissions for waste incineration by applying different CO2-EFs for each waste type separately. Hence, the CF value was updated to improve accuracy depending on the EWC code such as for codes 20 01 25 and 20 01 28.

7.4.2.2 Clinical Waste Incineration (CRF 5C1)

Two clinical waste incineration facilities existed in the Maltese Islands between 1990 and 2007. During this period, the St. Luke's Hospital incinerator provided services for all public and private healthcare institutions on the island of Malta. From a clinical waste survey carried out in 2001 (personal communication, Ministry of Health, 2007) it was found that approximately one tonne of clinical waste was produced daily in Malta. In 2006, the St. Luke's Hospital incinerator was processing, on average, approximately 910kg of clinical waste per day. No abatement measures were present at the St. Luke's Hospital incinerator. The total clinical waste processed by the St. Luke's Hospital incinerator in 2006 was estimated at approximately 330 tonnes per year (excluding Gozo).

A second clinical waste incinerator was also operating at the Gozo General Hospital. During the early 1990s, approximately 180kg of contaminated waste per day was incinerated at the

Gozo Hospital. This quantity of waste amounts to an estimated 65.7 tonnes of waste incinerated annually. This figure of waste incineration at the Gozo General Hospital was used for the inventory years 1990 to 1997. For the years 1998 till 2003, a figure of 37.6 tonnes of waste incinerated per year, as reported in the 1998 MEPA report (SOER) was used. For the years 2004 till 2007, a figure of 27.5 tonnes of waste incinerated, as reported from waste audits (personal communication, Ministry of Health, 2007), carried out in 2004, was used. For the year 2008, emissions from the incineration of about 0.26Gg clinical waste at the thermal treatment facility have been reported. Data for the remainder inventory years is provided annually by the data provider.

CO_2 emissions from clinical waste incineration are calculated using the default IPCC 2006 method, as presented in Annex 3 for the year 1990 as an exemplar.

7.4.2.3 Industrial Waste Incineration (CRF 5C1)

Under this category, incineration of paper waste at a local industrial establishment is reported for the inventory years 1990 to 2007. 99% of this is considered as waste of biogenic origin. As indicated by the operator of this facility, the incinerator was more than three decades old and was of a self-burning configuration, that is, no other fuel was used during the burning process. During the years 1990 to 2007, about 0.066Gg of paper waste was incinerated annually (personal communication, private industry representatives, October 2007). Details of this private facility are not listed for reasons of data protection. Data for the remainder inventory years is provided annually by the data provider.

CO_2 incineration emissions are calculated using the default IPCC 2006 method, as presented in Annex 3 for the year 1990 as an exemplar.

7.4.3 ECOHIVE

ECOHIVE is the largest ever investment in the waste management sector that will drive Malta towards a circular economy. This project will process waste in the most sustainable and resource-efficient way possible while also turning it into precious resources into energy and agricultural compost (Ecohive, 2020).

The name ECOHIVE refers to as the following: “ECO” ties to the environment and sustainability, while “HIVE” reminds us of a beehive which is constantly active. Four new waste management plants will form part of the ECOHIVE project: energy, recycling, organic and hygienics.

Since the Għallis non-hazardous managed landfill is set to reach its waste capacity within a few years, it was recently proposed that a 5,000 square meter Waste-to-Energy (WtE) plant will be built in Malta to reduce the amount of municipal solid waste disposed into the landfill. It was proposed that the WtE facility should be built in the Magħtab complex since part of the infrastructure is already available at the site.

The ECOHIVE project is divided as the following:

Energy

The plant will be treating around 40% of non-recyclable waste generated in the Maltese Islands. The capacity of the plant is 192,000 tonnes and will generate 126GWh per year to the grid (Ecohive, 2021).

Recycling

The new Material Recovery Facility will be receiving and processing co-mingled recyclables – namely paper, plastic and metal – through an automated sorting process. Waste will undergo a series of procedures that refine the material stream, extracting specific materials that can be recycled leading to higher quality materials for recycling.

Organic

Using the heat generated by the Waste-to-Energy Facility for pasteurization, the Organic Processing Plant will convert waste into biogas and agricultural compost. The aim is to reduce the volume of biodegradable waste going to the landfill and turning waste into a resource.

Hygienics

This facility will process hazardous waste such as clinical and pharmaceutical waste using environmentally sound technology. Energy in the form of heat will also be generated in the process.

7.4.4 UNCERTAINTY AND TIME SERIES CONSISTENCY

Activity data uncertainty in the latest years is rather low due to the introduction of IPPC permitting and obligatory weighbridges at the entry of incineration plants. The same is not true for the earliest years of the time series. Due to the lack of available data, conservative assumptions on activity are included in the calculation of emissions for the period 1990-2007.

In earlier years, the EFs calculations for incineration include EFs from open burning due to the lack of infrastructure. However, following the introduction of IPPC regulated plants, much more reliable data on emissions was provided from facilities which fit the definition of 'controlled facility' in the IPCC 2006 guidelines.

The Waste Incineration category is the category with the highest uncertainty from the Waste sector. The emission factor uncertainty (%) of ± 100 percent is being used for both CH_4 and N_2O as described in the IPCC 2006 guidelines (Volume 5, Chapter 5, section 5.7.1 on page 5.23). The below table illustrates the quantified uncertainty for this category.

Table 7-16 Uncertainties for category Waste Incineration

Parameter	CO_2	CH_4	N_2O
Emission factor uncertainty (%)	60.00	100.00	100.00
Activity data uncertainty (%)	10.00		

7.4.5 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

2022 submission

During past reviews, the ERT recommended to provide information on all uses of the notation key 'IE' in CRF table 9.

Malta used to report CH4 and N2O emissions from 5.C.1.1.a (municipal biogenic) and 5.C.1.1.b (industrial other) as IE since the total emissions were being included under non-biogenic only. However, after communication and assistance from Aether, it was decided that as a best practice and to be more transparent, the CH4 and N2O emissions between the biogenic and non-biogenic subcategories are now being reported separately.

UNFCCC In-country Review 2021

The fraction of carbon in dry matter (CF) for MSW used to be reported as 0.38 *(Food waste, 2006 IPCC Guidelines (vol. 5, Chap. 2, Table 2.4))*. However, during the UNFCCC in-country review of year 2021, the ERT noted that this is not in accordance with the 2006 IPCC Guidelines *(vol. 5 chap. 5, equation 5.2 and vol. 5, chap.2, Table 2.4)* because the Party did not calculate CO2 emissions for waste incineration by applying different CO2-EFs for each waste type separately. Hence, the CF value was updated to improve accuracy.

ESD 2018 Review support

During the ESD review support in 2018, Ing. Eva Krtková suggested that the deNOx and desulphurisation emissions should be removed from the Waste sector Incineration category and should be included in the IPPU sector instead. Therefore, following the review, the amount of sodium bicarbonate used for desulphurisation (tonnes), amount of urea used for deNOx (m^3), CO_2 from desulphurisation (tCO_2/t) bicarbonate, CO_2 from deNOx (tCO_2/m^3) urea, CO_2 from desulphurisation (Gg CO_2) and CO_2 from deNOx (Gg CO_2) were removed from incineration and provided to the IPPU sector Inventory compiler in section '4.2 Mineral Products' and section '4.5 Non-Energy products from fuel and solvent use', CRF Category 2A and 2D respectively.

7.4.6 Category Specific Recalculations

Not applicable.

7.4.7 Category Specific planned improvements

A future improvement is to create a Waste-to-Energy model with assistance from experts to ensure that the appropriate data and methodologies are applied. In fact, this is currently ongoing. At present, there is no definite timeframe for conclusion of the support, as this will be subject to support logistics.

7.4.8 Open Burning of Waste (CRF 5C2)

Malta used to report emissions from the open burning of waste as 'NO'. However, during the UNFCCC review (2021), the ERT recommended to the Party to start estimating GHG emissions from unintentional open burning of waste in accordance with the 2006 IPCC Guidelines (vol. 5, chap. 5, section 5.2). It was also suggested to replace the notation key "NO" for open burning of waste in CRF table 5.C. with the notation key "NE".

In 2021, the Inventory Agency contacted potential data providers, including the operator of the landfills and the regulator for waste management operators (Wasteserv and the Environment and Resources Authority). However, it has been confirmed that no data is available regarding the amount of waste that may have burned in instances of accidental fires in landfills. The reason being is that accidental fires start through spontaneous combustion of the waste mass. Unfortunately, at this stage, we do not consider it possible to make an estimate for this category. As you identify, the guidance does not currently support countries to make a robust T1 estimate without significant expertise and/or data.

We consider that the decision to report 'NE' is appropriate at this stage and more accurate than 'NO' even though that would be justified in common with the approach of many reporting countries. For these reasons, we do not feel that it is feasible, or necessary to provide what would be a highly uncertain estimate as a comparison against the threshold significance. We provided this justification and reasoning in the NIR so that to be more transparent on this issue.

During the 2022 UNFCCC Review, the ERT recommended to report the notation key 'NO' since open burning of waste does not take place in Malta. Considering that a regenerative treatment oxidizer gas compound has been used since 2008, the notation key 'NE' was recommended to be used only for years before 2008. Please refer to the CRF table 5.C.2 and Table 9.

7.5 WASTEWATER TREATMENT AND DISCHARGE (CRF 5D)

Table 7-17 Summary table.

Waste sector category	Wastewater
2006 IPCC Guidelines category number	4D
CRF category number	5D
GHG emissions reported/generated	
Direct gases	CH_4, N_2O
Key category	No
Method	D (2006 IPCC Guidelines default)
Emission Factors (EF)	D (2006 IPCC Guidelines default) CS (Country Specific)

7.5.1 Wastewater Treatment and Discharge - Domestic and Industrial (CRF 5D1 and 5D2)

7.5.1.1 Category Description

Malta's sewerage infrastructure consists of two main geographically separate networks that collect both domestic and industrial wastewaters, as well as a portion of storm-water runoff. In addition, during the whole time series, slurry and liquid waste from animal husbandry is known to have been introduced in the wastewater system and, thus, it had to be accounted for.

During the inventory years 1990 up to 2007, a single sewage treatment plant was in operation and catered for only a fraction of the total wastewater generated on the Maltese Islands; around 10% or under of the wastewater generated was treated while the rest, around 90% or over, was discharged untreated to the marine environment i.e. disposed to sea.

The collection treatment and discharge system has undergone major upgrades with the building of three new sewage treatment plants to address all the wastewater generated on the Maltese Islands.

Two of the plants came into operation in 2008, and this is reflected in an increase in the percentage of treated sewage in the years after 2008. The third and largest plant came in operation in late 2010 and was fully operational in 2011. This is reflected in the reduction of methane emissions in 2011 compared to other years.

These infrastructural developments represent a decrease in untreated wastewater - under 30% of wastewater is untreated and an increase of treated wastewater – with over 70% of wastewater is treated of all wastewater generated - not considering exceptional events (accidental releases, overload due to storm runoff or plant breakdown) - resulting in minimal emissions of methane and nitrous oxide from this source category. Notwithstanding, a small fraction of wastewater remains untreated (disposed to sea) because of unintentional bypasses and plant process disruptions, stemming from the receipt of non-domestic discharges.

The quantification of emissions from domestic wastewater treatment and discharge does not include emissions from uncollected wastewater. Methane emissions from uncollected wastewater are negligible as the part of the population which is not connected to a sewer system is very low. Where remote hamlets are served by communal and individual cesspits, the local water and wastewater utility company periodically collects the wastewater from the cesspits using tankers and discharges it into the sewer network at designated discharge points for treatment at urban wastewater treatment plants, and those related emissions are thus included in the inventory *(text as recommended by the ERT in 2019)*.

The bulk of wastewater generated is treated aerobically. A small fraction is disposed to sea untreated because of unintentional bypasses and plant process disruptions, stemming from the receipt of non-domestic discharges.

The volume of untreated wastewater bypassed is progressively reducing by;

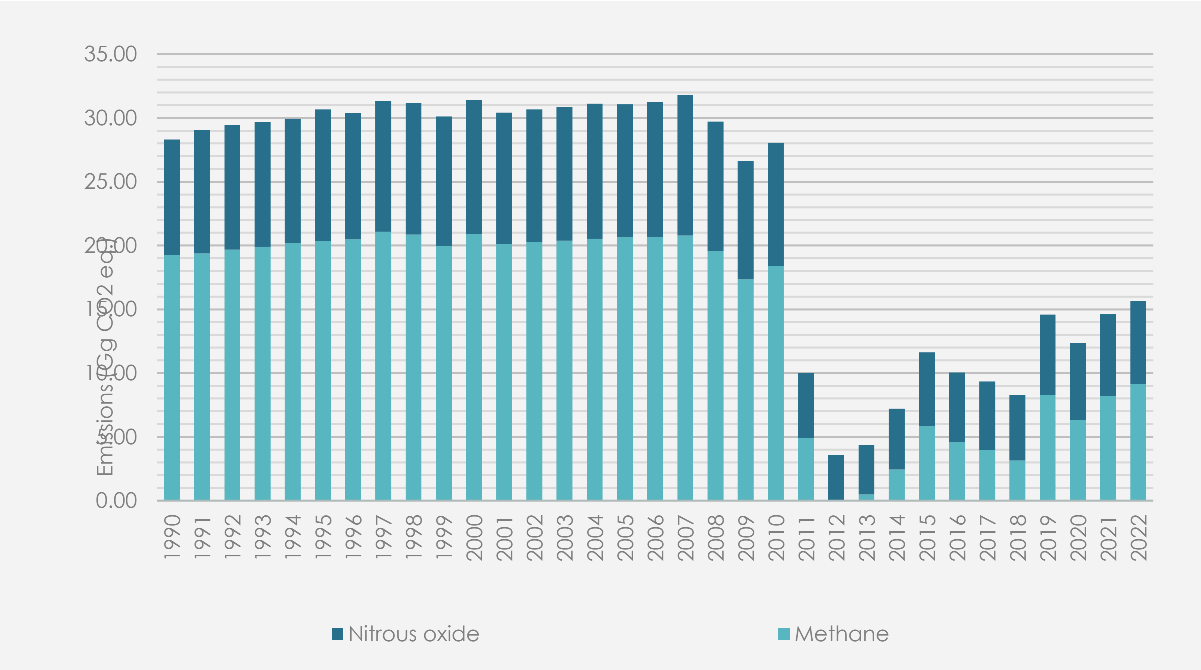
- investing in additional treatment capacity (Sant'Antnin Treatment Plant upgrade currently underway) and
- through the curbing of seawater infiltration, following a series of completed sewer rehabilitation interventions, with others in the pipeline.

The percentage of the population per type of wastewater treatment for aerobic WWTP is 100% (all agglomerations are connected to an UWWTP) and 0% for direct discharge.

Moreover, as the data provider clarified (Water Services Corporation), all wastewater generated in year 2012 was treated (100% treated wastewater in 2012) with no untreated wastewater (zero volume i.e. 0% untreated wastewater in 2012). Hence, methane emissions in the CRF are reported as Not Occurring in 2012 (notation key NO) (because zero is not an accepted value). Therefore, as already clarified, although wastewater emissions were estimated, there were no methane emissions emitted from wastewater because all wastewater was treated with no untreated wastewater. Hence, as illustrated in Figure 7-6 below, methane emissions could not be estimated for year 2012.

Furthermore, both CH_4 and N_2O emissions have declined throughout the years. A reason for this could be that currently, more wastewater is being treated while less wastewater is being untreated.

Figure 7-6 GHG emissions for category Wastewater Treatment.



7.5.2 METHODOLOGICAL ISSUES

For the period 1990 to 2000, the sewage generation rate for the year 1992 in m^3/capita/year has been used to calculate the total volume of sewage generated annually. For the years 2001 to 2006, the average rate of sewage generation for 2005/2006 has been used to calculate the total volume of sewage generated annually. This is because no data specific to this period is available. For the years 2007 onwards, annual wastewater generation and treatment data has been provided by the Water Services Corporation.

Moreover, a factor is applied to account for the N removal efficiency of wastewater treatment plants in the calculation of N_2O emissions from effluent. The removal capacity of plants is reported to be 70%. The value of 70% was suggested to the Inventory Agency by EU expert reviewers in accordance with EU legislation during the review held in 2016. The percentage value is applied to take account of N in nitrates dissolved in the wastewater treated leading to the emission of N gas.

The 70% is a ballpark figure used because the IPCC guidelines on this sector omit reference to this effect. Moreover, it was identified that in general, such plants have a 70% N removal capacity. However, further consultation in future submissions will be undertaken with the operator of the urban wastewater treatment system to identify whether the 70% value remains applicable to the Maltese situation or if this should be revised.

Sewage sludge from the treatment of urban wastewater is being included in the FOD managed model, with the activity data of an EWC code 19 08 05, as previously described in section 7.2.5.13. In fact, sludge in the CRF is referred to as included elsewhere, with the notation key IE, for both CH4 and N2O emissions.

In estimating emissions of methane from the treatment of wastewater in Malta's UWWTPs, the performance of the respective plants is taken into account. In the years [2016-2020], these plants far exceeded the performance standards for treatment of BOD, and on this basis, the plants are considered to be “well-managed”. This means that an MCF value of “0” (zero) is applied, resulting in overall “0” (zero) emissions of methane from the wastewater treatment plants.

Furthermore, the BOD g/person/day is being used for the whole timeseries, whereas before it used to be reported until year 2011 and then after year 2012 the total BOD load, as provided by the data provider, was used instead.

Additionally, with regards to domestic wastewater, the additional amount of N from manure managed in sewers was included in the quantity of N in effluent reported in CRF table 5.D. This started to be included, following the UNFCCC in-country review held in October 2016, for the whole timeseries, as from the 2017 submission.

The pig slurry entering wastewater treatment plants is used to estimate N2O emissions. The following methodology is used:

The swine manure nitrogen to sewers data is firstly being calculated in the N Effluent (kt N/year) which will affect the N_2O emissions.

Therefore, N Effluent = (population *in persons* * per capita protein consumption (kg/persons/year) * Fraction of Nitrogen in Protein kKg N/Kg protein) * Factor for non-consumed protein added to the wastewater * Factor for industrial and commercial co-discharged protein into the sewer system * 0.000001) + swine manure.

Then, the N Effluent total value is multiplied in the calculation to calculate the total Indirect N_2O emissions, the N removed by plants and the N remaining in Effluent. This will then affect the N_2O emissions where:

Indirect N2O emissions (Gg N_2O/year) = N Effluent * untreated fraction * EF Effluent * the conversion factor of kg N_2O-N into kg N_2O.

N removed by plants (assuming 70% removal by plants) = 0.7 * N Effluent * (1-untreated fraction)

N remaining in Effluent = N Effluent – (N Effluent * untreated fraction) - N removed by plants – N plants (Gg)

The Factor 44/28 is the conversion factor of kg N_2O-N into kg N_2O.

Furthermore, the ERT (in 2017 submission) (Table 5 ID# W.17) recommended that the activity data of the quantities of N from agricultural sources received at wastewater treatment plants should be included in the NIR (table below). The mentioned swine activity data is received from the Inventory Agency Agriculture sector as also explained in the Agriculture chapter under section 5.5.2.1.2.

Table 7-18 Activity data of Swine manure N going to sewers N (kt) (in 2 d.p.).

	Year								
	1990	1995	2000	2005	2010	2015	2020	2021	2022
Swine manure N going to sewers, N (kt)	0.93	0.95	0.73	0.64	0.65	0.44	0.39	0.39	0.29

During the UNFCCC Review 2019 (2019MLTQA104), the ERT requested to implement a balance check with manure management data under the Agriculture sector to ensure that there is no double counting or omission in the estimates of N between the wastewater category in the Waste sector (under the CRF category 5D) and Agriculture sector (under the CRF category 3B). The double-counting issue was consulted with an expert who was suggested by the capacity building support under the ESD review contract. The expert confirmed that nitrogen is correctly implemented hence, there is no double-counting from N_2O emissions occurring between the Agriculture and the Waste sector.

Furthermore, the end-of-year population data is provided by data from NSO, the National Statistics Office, which is the official government statistics in Malta. Population data may be obtained from;

- the 'Demographic Review 2014' as published by NSO in 2016 for inventory years between 1990 and 2006 *and*
- NSO's News Release entitled, 'World Population Day: 2020' and NSO's 'News Release 122/2021' for inventory years between 2007 and 2020 *and*
- for the inventory year 2021, from NSO's innfographic at *World Population Day (gov.mt)*
- for the inventory year 2022, from NSO's website at NSO Malta | World Population Day: 11 July 2023 - NSO Malta (gov.mt)

7.5.2.1 Methane Emissions

Methane is released where anaerobic conditions prevail. An important factor is the amount of degradable organic component (DOC) in the wastewater, of which a quantitative measure can be taken through the biological and chemical oxygen demand of the wastewater (BOD, COD). This DOC in anaerobic conditions will generate methane emissions and the existence of these conditions is subject to the treatment methodology used. From year 2012 onwards, estimates of the total BOD entering the system have been provided by the wastewater system operator. This includes all BOD (domestic and industrial) entering the wastewater handling system. It is important to note that the average BOD/capita/year calculated from BOD data submitted is higher than the range of the default factor provided in Table 6.4 of the IPCC 2006 guidelines Volume 5. An explanation for this could be that animal liquid waste has allegedly been introduced in the wastewater handling system. The average BOD/capita/year of the period 1990-2011 is back extrapolated as the average of the same between 2012 and 2013.

In Malta's case, only two treatment methods are relevant: aerobic treatment in wastewater treatment plants and direct disposal at sea. Through the data collected, it is possible to elucidate the amount of wastewater which was directed to both processes and thus the proportion of DOC going into the relevant process. Default emission factors as described in Table 6.3 of Volume 5 of the 2006 IPCC guidelines are used to calculate the emission from each process at this stage.

7.5.2.2 Nitrous Oxide

N_2O emissions also occur due to anaerobic conditions during handling or disposal of wastewater, where the nitrogenous molecules, mostly protein, is broken down by specific microorganisms. Aerobic treatment of wastewater reduces the amount of nitrogen available for the formation of N_2O.

Direct N_2O emissions from WWT

Wastewater treatment plants are a small but distinct source of N_2O, emanating from the nutrient removal mechanisms. Even though mainly aerobic, some anaerobic pockets do occur, creating N_2O emissions. Emissions are calculated using equation 6.9 found in Volume 5 of the 2006 IPCC guidelines, assuming, an EF_{PLANT} of 3.2g N_2O/person/year, and also including the default factor for industrial and domestic co-disposal of wastewater (1.25):

$$N_2OEmissions_{Plant} = P * F_{IND-COM} * T_{Plant} * EF_{Plant}$$

$$N_{WWT} = N_2OEmissions_{Plant} * {}^{28}/_{44}$$

Indirect N_2O emissions from Effluent

Effluent disposed in waterways, in this case, the sea, is a source of N_2O. The calculation of this emission is based on the nitrogen content of wastewater, which, in this case, is inferred from protein consumption/capita. This data was obtained through the FAOSTAT database 'Food Balance Sheets' (FAO) where the name of the country, elements, items aggregated, and years are selected.

An annual figure for the years between 1990 and 2020 is provided from the 'Food Balance Sheets'. However, the data used between years 1990 and 2009 is currently not available on the FAOSTAT website. The data reported in this submission refers to the data as reported in the January 2020 submission report (date accessed: November 2019).

The data currently available on the 'Food Balance Sheets' refer to years between 2010 and 2021 (latest update from FAOSTAT: October 27th, 2023; date accessed by the Inventory Agency: 16th February 2024).

For the remaining year, 2022, an extrapolation is being calculated (refer to Table 7-19). Therefore, the formula ''=TREND'' five-year moving average, was applied until an updated data is available from FAOSTAT.

Table 7-19 Protein Consumption (g/capita/day).

	Year							
	1990	1995	2000	2005	2010	2015	2020	2022
Per Capita Protein Consumption (g/capita/day)	93.34	103.87	109.34	110.15	109.08	113.34	105.93	98.17

Note: The value for year 2022, is an extrapolated value as data is not available on the FAOSTAT website.

Using the protein consumption data, as stated in the IPCC Guidelines default values (Volume 5, Chapter 6, Table 6.11, Page 6.27) and also in the 2017 UNFCCC Review, assuming 0.16 of that mass is nitrogen and assuming an additional 1.40 for non-consumed protein and 1.25 for industrial domestic co-disposal, with no nitrogen being retained as sludge, the nitrogen content of the effluent ($N_{EFFLUENT}$) is estimated. Included in this total there also is N_{Agri}, which is the total nitrogen originating from slurry and liquid waste from animal husbandry being introduced in the wastewater system. From this, N_{PLANT} (the amount of nitrogen resulting in direct emissions from WWT) is subtracted to obtain the net $N_{EFFLUENT}$. A default EF is used as highlighted in Table 6.11 of the 2006 IPCC guidelines and equation 6.7 of the same guidelines is used to calculate the N_2O emission.

$$N_{EFFLUENT} = \left(\left((P * Protein * F_{NPR} * F_{NON-CON} * F_{IND-COM}) - N_{Sludge} - N_{WWT}\right) + N_{Agri}\right)$$

$$N_2O\ Emissions_{Effluent} = N_{EFFLUENT} * EF_{EFFLUENT} * {}^{44}/_{28} * (1 - Efficiency_{plant})$$

$$N2O\ Emissions\ _{Total} = \ N2OEmissions_{Plant} + \ N2O\ Emissons_{Effluent}$$

The additional amount of N from manure managed in sewer is obtained from the compiler of the agriculture section of the inventory agency. Thus, section 5.3, Manure Management, provides more information on the AD, EFs, methodology and assumptions used to estimate N_2O emissions from animal husbandry.

7.5.3 *UNCERTAINTY AND TIME SERIES CONSISTENCY*

Uncertainty in both methane and nitrous oxide emissions are summarised in the below table. It is clear that the biggest uncertainty is at EF level especially for N_2O emissions.

Table 7-20 Uncertainty estimates for category Wastewater Treatment.

Uncertainty Source	Value (%)
Population	5.0
EF_j	10.0
BOD total	10.0
$T_{i,j}$	10.0
I	20.0
F_{NPR}	10.0
$EF_{Effluent}$	100.0
EF_{PLANTS}	200.0
Annual Protein Consumption	10.0
$F_{IND-COM}$	25.0
$F_{NON-CON}$	10.0
Total Uncertainties	
N_2O_{PLANT} uncertainty	100.9
$N_2O_{EFFLUENT}$ uncertainty	42.7
CH_4 uncertainty	17.5

7.5.4 *CATEGORY-SPECIFIC QA/QC AND VERIFICATION*

UNFCCC 2021 Review

The text regarding the wastewater from dwellings not connected to the sewer system has been corrected as proposed by the ERT in 2019.

2020 Review

The data regarding swine manure N going to sewers has been updated for the whole time series by the Agriculture sector. This is reflected also in the Wastewater category. This update has resulted from changes in the Methodology due to application of IPCC 2019 Refinements to reflect better the local situation and to improve estimates.

2019 review

The notation key NE (not estimated) in the CRF 5.D for sludge was replaced with IE (included elsewhere) as recommended during the 2019 review by the ERT (ID# W.24) since sewage sludge is included in the solid waste disposal category. The notation key is also explained in the CRF Table 9.

Furthermore, improvements in this category are also presented within the text according to questions asked during the UNFCCC Centralised Review 2019 regarding wastewater.

In-country review in 2018 from the ESD Review team

Ing. Eva Krtková suggested to include an explanation in the NIR regarding the factor (70%) applied to account for the N removal efficiency of wastewater treatment plants in the calculation of N_2O emissions from effluent. This was included in section '7.5.2 Methodological Issues'.

Moreover, the factor of non-consumed protein added to wastewater ($F_{NON-CON}$) and the factor of industrial and commercial co-discharged protein into the sewer system ($F_{IND-COM}$) have been changed to the IPCC default values of 1.40 and 1.25 respectively throughout the whole time series from the CRF Reporter Inventory Software Table 5.D. This finding was recommended during the review.

2017 submission

In line with the recommendation made by the ERT in Table 2 of the report of the review of the 2017 annual submission of Malta, dated 30th September 2017, regarding domestic wastewater, it can be confirmed that the additional amount of N from manure managed in sewer was included in the quantity of N in effluent reported in CRF table 5.D. This started to be included, following the UNFCCC review held in 2016, for the whole timeseries, as from the 2017 submission.

The activity data of the quantities of N from agricultural sources received at wastewater treatment plants was included in section '7.5.1.2 Methodological Issues' as recommended by the ERT in 2017 submission. Moreover, with regards to activity data, the data provider provided revised updates of figures since year 2012.

2016 submission

Moreover, as recommended by the Technical Expert Review Team (TERT) in the 2016 submission, in section 7.5.1.1 it was justified that methane emissions from uncollected wastewater are negligible.

The methodology for the pig slurry entering wastewater treatment plants, which is used to estimate N_2O emissions, is being provided in the methodological section (7.5) as proposed by the ERT during the 2016 submission (WAS.13).

7.5.5 *CATEGORY SPECIFIC RECALCULATIONS*

The cause for the recalculation for the Wastewater category for years between 2010 and 2021 is due to an update in the FAOSTAT website in the Food Balance Sheets for protein consumption. The recalculation is presented in the below table.

Kindly note that under the 'previous inventory' column, the values are from the March 2023 submission.

Table 7-21 Recalculation for category Wastewater – Total N2O emissions (Gg CO_2 eq).

Year	N2O emissions from Wastewater (Gg CO2 eq.) as reported in the previous inventory report	N2O emissions from Wastewater (Gg CO2 eq.) as reported in this inventory report	Percentage change in reported emissions (%)	Change in Gg CO2 eq.
1990	9.05	9.05	0.00%	0.00
1991	9.69	9.69	0.00%	0.00
1992	9.81	9.81	0.00%	0.00
1993	9.75	9.75	0.00%	0.00
1994	9.74	9.74	0.00%	0.00
1995	10.30	10.30	0.00%	0.00
1996	9.91	9.91	0.00%	0.00
1997	10.25	10.25	0.00%	0.00
1998	10.31	10.31	0.00%	0.00
1999	10.14	10.14	0.00%	0.00
2000	10.52	10.52	0.00%	0.00
2001	10.30	10.30	0.00%	0.00
2002	10.41	10.41	0.00%	0.00
2003	10.47	10.47	0.00%	0.00
2004	10.60	10.60	0.00%	0.00
2005	10.41	10.41	0.00%	0.00
2006	10.56	10.56	0.00%	0.00
2007	11.00	11.00	0.00%	0.00
2008	10.17	10.17	0.00%	0.00
2009	9.27	9.27	0.00%	0.00
2010	10.20	9.66	-5.27%	-0.54
2011	5.28	5.11	-3.19%	-0.17
2012	3.78	3.57	-5.58%	-0.21

2013	4.01	3.89	-3.03%	-0.12
2014	4.79	4.77	-0.51%	-0.02
2015	5.86	5.80	-0.99%	-0.06
2016	5.51	5.46	-0.92%	-0.05
2017	5.65	5.36	-5.14%	-0.29
2018	5.78	5.16	-10.62%	-0.61
2019	7.70	6.32	-17.91%	-1.38
2020	7.10	6.05	-14.82%	-1.05
2021	7.95	6.40	-19.46%	-1.55
2022	NA	6.52	NA	NA

CATEGORY SPECIFIC PLANNED IMPROVEMENTS

No improvements are planned.

7.6 BIOGENIC EMISSIONS FROM WASTE

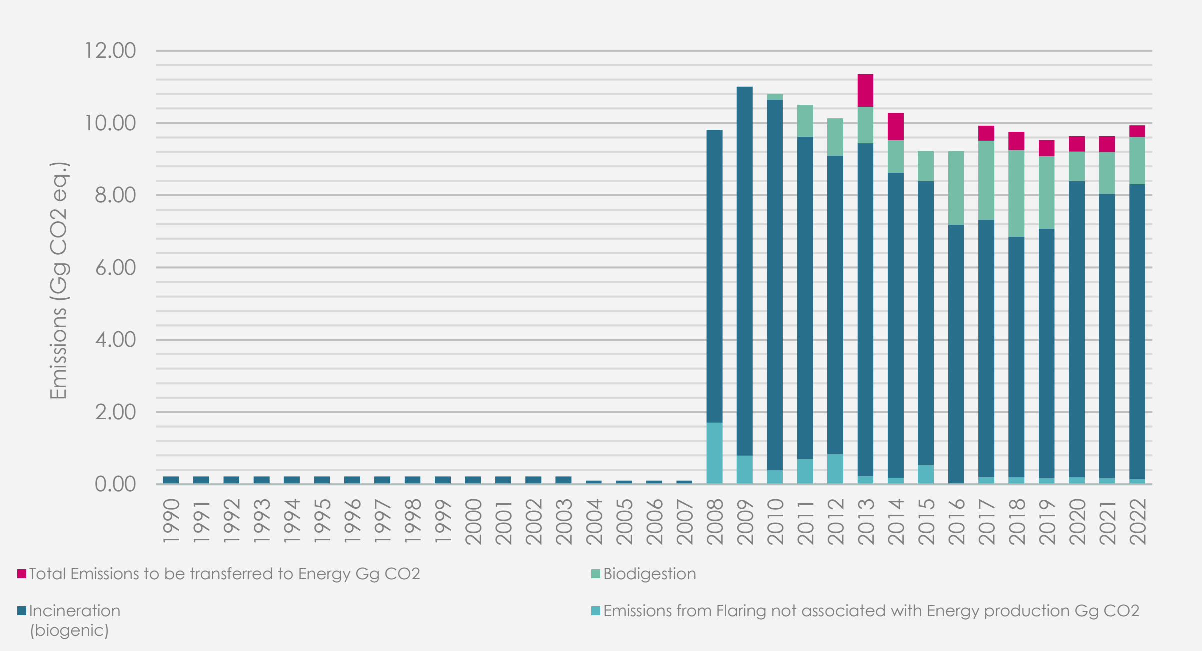
7.6.1 CATEGORY DESCRIPTION

A number of waste management practices currently implemented give rise to CO_2 that can be classified as biogenic, thus not being accounted as emissions in the totals estimated for the country. This is mainly because of the changes in waste management practices and implementation of flaring in closed landfills.

7.6.2 METHODOLOGICAL ISSUES

The major contributors of biogenic CO_2 in the waste sector are the incineration of non-fossil fractions of waste and flaring of methane from landfill gas and, or, biological processes. Only the CO_2 portion of emissions from these processes can be considered biogenic, other gases (CH_4 and N_2O) are accounted for in the previous sections of the specific sectors. Figure 7-7 below summarises the emissions of biogenic CO_2 from 1990.

Figure 7-7 CO_2 emissions of biogenic origin from a number of waste processes.



Between 1990 and 2006 the non-fossil fraction was assumed using the type of waste and obtained from tables 2.4 and table 2.5 of section 2.3 of the 2006 IPCC guidelines. From 2007 onwards, the estimation was done using the distribution and types of waste actually incinerated.

7.6.3 Uncertainty and time series consistency

Uncertainty in this category was not estimated.

7.6.4 Category-specific QA/QC and verification

Not applicable.

7.6.5 Category Specific Recalculations

Not applicable.

7.6.6 Category-specific planned improvements

No improvements are planned in this specific category.

CHAPTER 8 OTHER

No activities are reported under this section.

CHAPTER 9 INDIRECT CO2 & N2O EMISSIONS

Information on indirect N2O emissions may be found in Chapter 5, relating to source sector Agriculture, under Manure Management (Indirect N2O from volatilisation and runoff and leaching) and Agricultural Soils (Indirect N2O from volatilisation and leaching).

Table 9-1 Indirect emissions of NOx, NMVOC, SOx and CO from the agriculture sector.

	3B - Manure Management		3D - Managed soils		3F - Field burning of agricultural wastes			
	NOx	NMVOC	NOx	NMVOC	NOx	NMVOC	SOx	CO
1990	0.013	0.726	0.162	0.0069	0.000084	0.000038	0.000017	0.0025
1991	0.014	0.745	0.165	0.0062	0.000084	0.000048	0.000017	0.0025
1992	0.014	0.758	0.172	0.0062	0.000084	0.000047	0.000017	0.0025
1993	0.014	0.757	0.172	0.0061	0.000083	0.000044	0.000017	0.0025
1994	0.014	0.746	0.170	0.0061	0.000083	0.000040	0.000017	0.0025
1995	0.014	0.733	0.182	0.0060	0.000083	0.000038	0.000017	0.0024
1996	0.014	0.742	0.162	0.0055	0.000083	0.000051	0.000017	0.0025
1997	0.014	0.747	0.165	0.0056	0.000083	0.000036	0.000017	0.0024
1998	0.014	0.726	0.174	0.0057	0.000082	0.000037	0.000017	0.0024
1999	0.015	0.740	0.163	0.0055	0.000082	0.000038	0.000017	0.0024
2000	0.014	0.717	0.169	0.0054	0.000082	0.000038	0.000017	0.0024
2001	0.014	0.720	0.162	0.0052	0.000082	0.000033	0.000017	0.0024
2002	0.013	0.690	0.156	0.0050	0.000087	0.000038	0.000018	0.0025
2003	0.011	0.636	0.139	0.0054	0.000092	0.000040	0.000019	0.0027
2004	0.011	0.613	0.143	0.0052	0.000089	0.000041	0.000018	0.0026
2005	0.010	0.526	0.134	0.0049	0.000087	0.000039	0.000018	0.0026
2006	0.010	0.545	0.140	0.0048	0.000087	0.000037	0.000018	0.0026
2007	0.010	0.568	0.138	0.0049	0.000088	0.000039	0.000018	0.0026
2008	0.010	0.533	0.124	0.0051	0.000090	0.000038	0.000019	0.0027
2009	0.009	0.507	0.121	0.0053	0.000094	0.000039	0.000020	0.0027
2010	0.009	0.487	0.121	0.0056	0.000097	0.000040	0.000020	0.0029
2011	0.008	0.447	0.106	0.0056	0.000095	0.000039	0.000020	0.0028
2012	0.008	0.463	0.109	0.0057	0.000094	0.000039	0.000020	0.0028
2013	0.008	0.462	0.110	0.0054	0.000092	0.000039	0.000019	0.0027
2014	0.008	0.452	0.109	0.0054	0.000093	0.000039	0.000019	0.0027
2015	0.008	0.434	0.108	0.0053	0.000094	0.000039	0.000020	0.0028
2016	0.008	0.412	0.107	0.0056	0.000095	0.000040	0.000020	0.0028
2017	0.008	0.399	0.105	0.0057	0.000101	0.000041	0.000021	0.0030
2018	0.008	0.411	0.107	0.0056	0.000098	0.000040	0.000020	0.0029
2019	0.008	0.410	0.106	0.0057	0.000094	0.000040	0.000020	0.0028
2020	0.010	0.430	0.109	0.0054	0.000091	0.000039	0.000019	0.0027
2021	0.009	0.433	0.109	0.0054	0.000091	0.000039	0.000019	0.0027

Indirect emissions from manure management, managed soils and field burning of agricultural waste is calculated by the Environment and Resources Authority, following the EEA/EMEP guidebook. The results above are those presented in the March 2023 submission of the IIR. Indirect emissions for 3B. include cattle, sheep, swine, goats, horses, mules and asses, poultry, *and other animals. Indirect emissions for 3D. include inorganic N fertilisers and livestock manure applied to soils (*https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/4-agriculture/3-b-manure-management/view*,* https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/4-agriculture/3-d-crop-production-and/view*,* https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/4-agriculture/3-f-field-burning-of/view*,* https://cdr.eionet.europa.eu/mt/eu/nec_revised/iir/envykklyq/*)*.

CHAPTER 10 RECALCULATIONS

Information on recalculations and improvements is presented in the respective sectoral chapters. Furthermore, summary data is presented in a separate excel template being submitted with this report.

The below table shows the percentage change in 1990 and 2021 for the total national GHG emissions with and without LULUCF, for both previous and latest submissions, in AR5. As illustrated in the table, a change of -0.01% occurred for year 1990, while a percentage change of -1.64% occurred in year 2021, including LULUCF emissions.

Table 10-1 Total national GHG emissions recalculations for years 1990 and 2021 (in AR5).

	Total national GHG emissions with LULUCF		Total national GHG emissions without LULUCF		Total %age change with LULUCF	Total %age change without LULUCF
	Previous submission (Gg CO2 eq.)	Latest submission (Gg CO2 eq.)	Previous submission (Gg CO2 eq.)	Latest submission (Gg CO2 eq.)	Previous Submission	Latest Submission
1990	2618.43	2616.26	2626.43	2626.17	-0.08	-0.01
2021	2134.26	2099.35	2133.62	2098.72	-1.64	-1.64

Kindly refer to the below explanations for the recalculations for all gases for the base year period (1990) and for year X-3 (2021).

Table 10-2 Explanations for recalculations for year X-3 (2021)

Gas: CO2

Sector	***Category***	***Explanation for recalculation***
Energy	Manufacturing Industries	Update in activity data and worksheet updates.
	Transport	Updates in the activity data (Fuel Consumption). In addition an updated version of the COPERT model was used to estimate emissions from Road transport.
	Memo Items	Updates from the data provider (EUROCONTROL)

IPPU	Non-energy products from fuels and solvent use	Activity data "Gasoline consumption in motorcycles 1.A.3.b.iv" and "Emissions of CO2 from urea used in selective catalytic reduction in road transport" was updated.
LULUCF	Forestland	Updates in land use areas.
LULUCF	Cropland	Updates in land use areas.
LULUCF	Grassland	Updates in land use areas.

Gas: CH4

Energy	Transport	Updates in the activity data (Fuel Consumption). In addition, an updated version of the COPERT model was used to estimate emissions from Road transport.
Energy	Memo items	Updates from the data provider (EUROCONTROL)
Agriculture	Enteric fermentation	Correction in worksheet.
Agriculture	Manure management	Correction in worksheet.
Waste	Solid Waste Disposal	Recalculation is due to an update in waste composition.
Waste	Wastewater Treatment and Discharge	Recalculation is due to an update in the FAOSTAT website in the Food Balance Sheets for protein consumption.

Gas: N2O

Energy	Transport	Updates in the activity data (Fuel Consumption). In addition, an updated version of the COPERT model was used to estimate emissions from Road transport.
Energy	Memo Items	Updates from the data provider (EUROCONTROL)
Agriculture	Manure management	Correction in worksheet.
Agriculture	Agricultural soils	Correction in worksheet.
LULUCF	Cropland	Updates in land use areas.
LULUCF	Grassland	Updates in land use areas.
Waste	Wastewater Treatment and Discharge	Recalculation is due to an update in the FAOSTAT website in the Food Balance Sheet for the protein consumption.

Gas: F-gases (HFC)

IPPU	Refrigeration and air conditioning	- Inconsistencies in the estimation of stock and emissions in sub-category CRF 2.F.1.b Domestic Refrigeration were corrected. - Inconsistencies in the estimation of stock, emissions and recovery in sub-category CRF 2.F.1.f Stationary Air Conditioning were corrected. - The bulk imports of HFC-32 were updated for 2019 (activity data) (sub-category CRF 2.F.1.f Stationary Air Conditioning). - The estimated annual imports of split units (activity data) was updated for 2021 (sub-category CRF 2.F.1.f Stationary Air Conditioning). - The number of vehicles (activity data) for 2021 was updated (sub-category CRF 2.F.1.d Transport Refrigeration). - The number of vehicles (activity data) for 2021 was updated (sub-category CRF 2.F.1.e Mobile Air Conditioning). - The use of R1234yf in mobile air conditioning was included (sub-category CRF 2.F.1.e Mobile Air Conditioning). - Errors in the estimation of disposal emissions from HGVs and LGVs were corrected sub-category (CRF 2.F.1.e Mobile Air Conditioning). - The inclusion of R1234yf in mobile air conditioning has increased the mass of HFC-134a attributed to CRF 2.F.1.a (& .c) Commercial (& Industrial) Refrigeration. - Inconsistencies in the estimation in sub-category CRF 2.F.1.a (& .c) Commercial (& Industrial) Refrigeration were corrected. These changes have, inevitably, led to recalculations.

Gas: F-gases (SF6)

IPPU	Electrical equipment	The data for the year 2021 had not been received in time for the 2023 submission. However, this data was eventually received and included in the national GHG inventory.

Table 10-3 Explanations for recalculations for year base year (1990)

Gas: CO2

Sector	***Category***	***Explanation for recalculation***
Energy	Memo Items	Correction in calculations for CO_2 Emissions from Residual Fuel Oil.
LULUCF	Cropland	Updates in land use areas.
LULUCF	Grassland	Updates in land use areas.
LULUCF	Other land	Updates in land use areas.

Gas: CH4

Energy	Transport	Updates in the activity data (Fuel Consumption). In addition, an updated version of the COPERT model was used to estimate emissions from Road transport.
Agriculture	Enteric fermentation	Correction in worksheet.
Agriculture	Manure management	Correction in worksheet.

Gas: N2O

Energy	Transport	Updates in the activity data (Fuel Consumption). In addition, an updated version of the COPERT model was used to estimate emissions from Road transport.
Agriculture	Manure management	Correction in worksheet.
Agriculture	Agricultural soils	Correction in worksheet.
LULUCF	Grassland	Updates in land use areas.
LULUCF	Other land	Updates in land use areas.

Gas: F-gases (HFC)

IPPU	Refrigeration and air conditioning	not applicable – no recalculations for base year

Gas: F-gases (SF6)

IPPU	Electrical equipment	not applicable – no recalculations for base year

CHAPTER 11 KP-LULUCF REPORTING

This chapter is not relevant to this submission.

CHAPTER 12 INFORMATION ON KYOTO UNITS ACCOUNTING

This chapter is not relevant to this submission.

CHAPTER 13 INFORMATION ON CHANGES IN NATIONAL SYSTEM

An overview of the current system for the compilation of national GHG inventories and recent developments is provided in Chapter 1.

There have been no major changes to the national system for the reporting of greenhouse gas emissions by sources and removals by sinks since the previous submission of Malta's national GHG inventory.

It is worth noting that the ISO certification of the Malta Resources Authority with regards to its Quality Management System relating to the GHG inventory functions remains in effect. Compliance of the MRA Quality Management System to the requirements of SM EN ISO 9001:2015 is confirmed by Certificate No: S085, issued by the Malta Competition and Consumer Affairs Authority (MCCAA), Standards and Metrology Institute, dated 29 January 2021, and expired on 28 January 2024.

CHAPTER 14 INFORMATION ON CHANGES IN NATIONAL REGISTRY

The following changes to the national registry of Malta have occurred in 2023. Note that the 2023 SIAR confirms that previous recommendations have been implemented and included in the annual report.

Table 14-1 Changes to the National Registry of Malta in 2023.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	None
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No changes
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	There have been five new EUCR releases in production (versions 13.10, 13.10.2, 13.10.3, 13.10.4 and 13.11.2) after version 13.8.2 (the production version at the time of the last Chapter 14 submission). No changes were applied to the database, whose model is provided in Annex A. No change was required to the application backup plan or to the disaster recovery plan. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	The changes that have been introduced with versions 13.10, 13.10.2, 13.10.3, 13.10.4 and 13.11.2 compared with version 13.8.2 of the national registry are presented in Annex B. It is to be noted that each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and are carried out prior to the relevant major release of the version to Production (see Annex B). No other change in the registry's conformance to the technical standards occurred for the reported period.

15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	No changes regarding security were introduced.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	No change to the list of publicly available information occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No change to the registry internet address during the reported period.
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	No change during the reported period.

CHAPTER 15 INFORMATION ON MINIMISATION OF ADVERSE IMPACTS IN ACCORDANCE WITH ARTICLE 3, PARA 5 OF THE KYOTO PROTOCOL

This chapter is not relevant to this submission.

CHAPTER 16 OTHER INFORMATION

There is no other information to report under this chapter.

REFERENCES

Adi Associates Environmental Consultants Ltd, 2011. Master Plan for the Maghtab Environmental Complex. Environmental Impact Statement Update prepared in support of development permit Application No. PA 02342/06. San Gwann, September 2011; xxi + 386pp + 3 Appendices.

Agriculture and Fisheries 2014, National Statistics Office (NSO), 2016

APAT (2005). Methodologies used in Italy for the estimation of air emission inventory in the agriculture sector, p.16.

Bigi, D & Zanon, A. (2020). Atlante delle Autoctone

BirdLife Malta, 2018. Managing Land for Nature – Reserves report for 2017, Malta

Code of Good Agricultural Practice Microsoft Word - CoGAP.doc (gov.mt)

Canaveira, P., Manso, S., Pellis, G., Perugini, L., De Angelis, P., Neves, R., Papale, D., Paulino, J., Pereira, T., Pina, A., Pita, G., Santos, E., Scarascia-Mugnozza, G., Domingos, T., and Chiti, T. (2018). Biomass Data on Cropland and Grassland in the Mediterranean Region. Final Report for Action A4 of Project MediNet. http://www.lifemedinet.com/

CasaInginiera. (2012). Analysis of the potential to decrease the proportion of HFC Emissions in the Refrigeration and Air Conditioning sector. Malta.

Cassar, L. F., & E., C. (2014). An Outline Strategy for implementation of a National Restoration and Afforestation Project in the Maltese Islands. Malta.

CCC/PMF/2021/MLT Review of the 2021 annual submission of Malta Centralized review conducted remotely 4–9 October 2021

Census of Agriculture 1991, NSO, 1993

CFS-CRA 2005. Italian National Inventory of Forests and Carbon stock (INFC), 2005. https://www.sian.it/inventarioforestale/

Climate Action Act, 2015, Chapter 543; 7th July 2015.

Commission Implementing Regulation (EU) No 749/2014 of 30 June 2014 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0749&from=BG

Convention on Wetlands of International Importance especially as Waterfowl Habitat, Paris, 1994.

COPERT wiki : https://copert.emisia.com/w/Copert.

Cremona, E. (2019). A Note on Data Collection and Methodology in the Development of the EWA Heat-Pumps Model - Split Units. Malta: The Energy and Water Agency.

Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora

Directive, E. U. (2000). Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste. Official Journal of the European Communities L, 332, 91-111.

Don't waste waste (2016). Bulky Refuse Services. Retrieved from http://dontwastewaste.gov.mt/sort-it/bulky-refuse-services/

Don't waste waste (2016). Civic Amenity Site. Retrieved from

http://dontwastewaste.gov.mt/sort-it/civic-amenity-site/

Duurzaam Storten. (2011). Braambergen Landfill. Retrieved from

https://duurzaamstorten.nl/wp-content/uploads/2016/07/Braambergen_project_plan_2011-1.pdf

EC (1991). Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources

EEA & EMISIA, webinar notes and presentations.

ENVIRONMENT PROTECTION ACT (CAP. 348) Trees and Woodlands (Protection) Regulations, 2001, LEGAL NOTICE 12 of 2001

EPA. (2012). General Information on CATC Products. Retrieved 12 02, 2012, from http://www.epa.gov/ttn/catc/products.html#software.

Estimation of greenhouse gas emissions from agricultural activities for Malta 's Inventory, Sammut 2015

Estimation of greenhouse gas emissions from agricultural activities for Malta 's Inventory, Sammut 2015.

European Commission (2019). The Environmental Implementation Review 2019, Country Report Malta. Retrieved from https://ec.europa.eu/environment/eir/pdf/report_mt_en.pdf

European Parliament (2018). Waste management in the EU: infographic with facts and figures. Retrieved from https://www.europarl.europa.eu/news/en/headlines/society/20180328STO00751/eu-waste-management-infographic-with-facts-and-figures

EUROSTAT, (2018). Presentation of annual energy statistics in Eurobase: Changes in datasets in node [nrg_quanta]. European Commission.

EUROSTAT. (2023). Number of passenger cars, by age. Retrieved on 16th February 2024, from https://ec.europa.eu/eurostat/databrowser/view/ROAD_EQS_CARAGE__custom_9902441/default/table?lang=en last updated on 13th February 2024.

EUROSTAT. (2023). Number of mini buses and mini coaches. Retrieved on 16th February 2024, from https://ec.europa.eu/eurostat/databrowser/view/ROAD_EQS_BUSVEH__custom_9902453/default/table?lang=en last updated on 13th February 2024.

EUROSTAT. (2023). Number of buses. Retrieved on 16th February 2024, from https://ec.europa.eu/eurostat/databrowser/view/ROAD_EQS_BUSVEH__custom_9902462/default/table?lang=en last updated on 13th February 2024.

EUROSTAT. (2023). Number of motor coaches. Retrieved on 16th February 2024, from https://ec.europa.eu/eurostat/databrowser/view/ROAD_EQS_BUSVEH__custom_9902476/default/table?lang=en last updated on 13th February 2024.

EUROSTAT. (2023). Number of LGVs (<= 3.5 tonnes). Retrieved on 16th February 2024, from https://ec.europa.eu/eurostat/databrowser/view/ROAD_EQS_LORROA__custom_9902499/default/table?lang=en last updated on 13th February 2024.

EUROSTAT. (2023). Number of HGVs (> 3.5 tonnes). Retrieved on 16th February 2024, from https://ec.europa.eu/eurostat/databrowser/view/ROAD_EQS_LORROA__custom_9902521/default/table?lang=en last updated on 13th February 2024.

EUROSTAT. (2024). Municipal waste down by 19 kg per person in 2022. Retrieved in February 2024, from Municipal waste down by 19 kg per person in 2022 - Eurostat (europa.eu)

EWA (2018) Documentation on the Energy (transport) model.

IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

FAO (2014) State of Mediterranean Forests 2013. FAO and Plan Bleu.

Food and Agriculture Organization of the United Nations. (2017). Food Balance Sheets. Retrieved from http://www.fao.org/faostat/en/#data

FCCC/ARR/2017/MLT Report on the individual review of the annual submission of Malta submitted in 2017

FCCC/ARR/2018/MLT Report on the Centralised Review of the 2019 annual submission of MALTA

Forsell N, Korosuo A, Federici S, Gusti M, Rincón-Cristóbal J-J, Rüter S, Sánchez-Jiménez B, Dore C, Brajterman O and Gardiner J. (2018). Guidance on developing and reporting Forest Reference Levels in accordance with Regulation (EU) 2018/841. Available online at: https://ec.europa.eu/clima/policies/forests/lulucf_en.

Gauci, V. (2000). National Greenhouse Gas Emissions Inventory for Malta 1990 to 2000. Malta: Environment protection Department.

Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (GPG2000, IPCC, 2000).

Greenpak (2015). Batree. Retrieved from https://www.greenpak.com.mt/batree

Heyer, K. U., Hupe, K., Koop, A., Ritzkowski, M., & Stegmann, R. (2003). The Low Pressure Aeration of Landfills: Experience, Operation and Costs. (Proceedings Sardinia).

Hunt, C.O. (1997). Quaternary deposits in the Maltese Islands: a microcosm of environmental change in Mediterranean lands. GeoJournal 41 (2), 101-109.

I.Sempos (n.d)-Note on fossil carbon content in biofuels

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

IPCC (2019). 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

KPH (2018). Personal Communication with K. Tonna relating to livestock feed characterisation, weights, etc.

KIM (2021). Personal communication with Dr. Frendo relating to swine characterisation, life cycle, feeding etc.

Lanfranco, G. (n.d.). Vegetation of the Maltese Islands. www.maltawildplants.com

Legal Notice 321 of 2011 Environment and Development Planning Act (Cap. 504) - Nitrates Action Programme Regulations, 2011

Legal Notice 12 of 2001 Environment Protection Act (CAP. 348) Trees and Woodland (Protection) Regulations, 2001

Lutz, J.D., Hopkins, A., Letschert, V., Franco, V.H. and Sturges, A. (2011). Using national survey data to estimate lifetimes of residential appliances. HVAC&R Research, 17(5), pp.726-736.

MALSIS. Maltese Soil Information System. 2004. Soil geographic database of the Maltese Islands. National Soil Unit, Ministry for Rural Affairs and the Environment, Malta 2004.

Montero G, Cañellas I, Ruíz-Peinado R. 2001. Growth and Yield Models for Pinus halepensis Mill. Invest. Agr.: Sist. Recur. For. Vol. 10 (1), 2001.

MSDEC (2013). Rural Development Programme for Malta 2007 – 2013, Rural Development Department Ministry for Sustainable Development, the Environment and Climate Change, April 2013.

National Inventory Report 2018. Greece- Annual inventory submission of Greece under the convention Kyoto Protocol for greenhouse and other gases for the years 1990-2016. Ministry of Environment and Energy, April 2018. 545 pp. https://unfccc.int/documents/65722

NSO (2007). Gross Nitrogen Balance for Malta.

NSO (2012). News Release: Household waste composition survey.

NSO (2014). Demographic Review. Retrieved from https://nso.gov.mt/en/publicatons/Publications_by_Unit/Documents/C5_Population%20and%20Migration%20Statistics/Demographic_Review_2014.pdf

NSO (2018). News Release: World Environment Day.

NSO (2019). News Release: Solid Waste Management.

NSO (2019). News Release: World Population Day.

NSO (2020). News Release: Inbound Tourism.

NSO (2021). News Release: transport statistics.

NSO (2021). News Release Municipal Waste: 2020.

NSO Malta. (2012). Census of Agriculture 2010. Retrieved 06 22, 2013, from http://nso.gov.mt/statdoc/document_file.aspx?id=3360

NSO, (2018). *Business Demographics*. National Statistics Office, Malta.

NSO, (Q4, 2018). News Release 'Motor Vehicles'. National Statistics Office Malta.

NSO. (2012). Household Waste Composition Survey: 2012. Malta: National Statistics Office.

Nitrates Action Programme (2011). Annex V Nitrates Report (gov.mt)

Oonk, H. (2012). Efficiency of landfill gas collection for methane emission reduction. Greenhouse Gas Measurement and Management.

Pedley, M. (1980) The occurrence and sedimentology of a Pleistocene travertine in the Fiddien Valley, Malta. Proceedings of the Geologists' Association 91 (3), 762-767.

Planning Authority (2015). Soil types (gov.mt)

Ramsar Sites Information Service, Annotated List of Wetlands of International Importance

Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU

Ruiz-Benito P, Lines ER, Go´ mez-Aparicio L, Zavala MA, Coomes DA (2013) Patterns and Drivers of Tree Mortality in Iberian Forests: Climatic Effects Are Modified by Competition. PLoS ONE 8(2): e56843

Rural Development Programme for Malta: 2007 – 2013, Funds and Programmes Division – Ministry for European Affairs and the Implementation of the Electoral Manifesto (MEAIM), 2015

Rural Development Programme for Malta: 2014 – 2020, Funds and Programmes Division within the Ministry for European Affairs and the Implementation of the Electoral Manifesto (MEAIM), 2015

Said, A. (2019). National Forestry Accounting Plan containing Malta's Forest Reference Level. Malta Resources Authority on behalf of the Ministry for Environment, Sustainable Development and Climate Change.

Sammut, S. (2015). Estimation of greenhouse gas emissions from agricultural activities for Malta's inventory. Report prepared for the Malta Resources Authority, Climate Change Unit, Government of Malta. Sammut & Associates, October 2015.

Sanz, C. C., & Attard, M. (2015). Assess land use change through the use of map layering from the CORINE Land Cover data for the years 1996, 2000 and 2006. Malta: Institute for Climate Change and Sustainable Development, University of Malta.

Scerri, D., Inguanez, F., & Bonello, J. J. (2021). Maltese Region LULC. Malta: Malta College of Arts, Science and Technology.

Scott Wilson. (2004). Development of Rehabilitation Strategies Maghtab, Qortin and Wied Fulija Landfills. Malta: Wasteserv Malta Ltd.

Scott Wilson. (2010). Rehabilitation of Maghtab, Qortin and Wied Fulija Landfills in Malta Aerial Emissions Control Works CT 2586/2004. Malta: Wasteserv Malta ltd.

Shater Z., de-Miguel S., Kraid B., Pukkala T., Palahí M. 2011. A growth and yield model for even-aged Pinus brutia Ten. stands in Syria. Annals of Forest Science (2011) 68:149–157.

State of the Environment Report 2005, Malta Environment and Planning Authority, 2006.

State of the Environment Report, 2018, Summary Report; Environment & Resources Authority, 2018.

State of the Environment Report 2005, Malta Environment and Planning Authority, 2006.

Sustech (2008). Agricultural Waste Management Plan for the Maltese Islands. Final Report.

Sustech (2005). Agricultural Waste Management Plan for the Maltese Island.

Schwarz, W., Gschrey, B., Leisewitz, A., Herold, A., Gores, S., Papst, I., . . . Lindborg, A. (2011). Pedersen, P.H.; Colbourne, D.; Kauffeld, M.; Kaar, K.; Lindborg, A. *Preparatory study for a review of Regulation (EC) No. 842/2006 on certain fluorinated greenhouse gases*. Brussels: European Commission.

Sultana, D. (2017). Emergent Realities for Social Wellbeing - Environmental, Spatial and Social Pathways: Chapter 13 Soil Quality Change in the Maltese Islands: A 10-Year Assessment (2003-2013). Malta: University of Malta - Department of Criminology.

Transport Malta: Documentation on the exercise regarding data harmonisation with COPERT, for speed and road share.

Transport Malta: Documentation on the model developed by the entity.

Valletta, P. P. (2011). The establishment of the local sheep population as a breed.

Vassa. (2006). data.

Vella, S. (1997). The Nutritive Value of Forage Crops in the Maltese Islands. Dissertation in partial fulfillment of the Masters in Agricultural Sciences of the University of Malta. 13. Vella, S., 2003. Fertiliser use and nutrient management in potato growing in Malta A report compiled in relation to Eurepgap certification. (Unpublished manuale di concimazione in NS0 2017

Wasteserv (5 June 2015). Landfills: Past, present and future. [Press Release]. Retrieved from

https://www.wasteservmalta.com/articles/aba76517-5480-4330-997b-0106f40a5018

Wasteserv (2018). Organic. Retrieved from https://www.wasteservmalta.com/organic

Wasteserv (2019). Expired medicine collection – Pharmacies. Retrieved from https://www.wasteservmalta.com/expiredmedicine

Wasteserv (2019). Roadshow. Retrieved from https://www.wasteservmalta.com/roadshow

Wasteserv. Civic Amenity Sites. Retrieved from https://www.wasteservmalta.com/casites

Wasteserv. Construction waste. Retrieved from https://www.wasteservmalta.com/constructionwaste

Wasteserv. Sant Antnin Waste Treatment Plant. Retrieved from

https://www.wasteservmalta.com/santantnin

Wasteserv. Thermal Treatment Facility. Retrieved from https://www.wasteservmalta.com/ttf

WEEE Malta (2019). WEEE Malta increases the electrical material and electronics collection by 40%. Retrieved from

https://www.weeemalta.org/weee-malta-zzid-il-gbir-tal-materjal-tal-elettriku-u-l-elettronika-b40/

WEEE Malta (2019). Five years of collection and recycling of electronic waste

Retrieved from https://www.weeemalta.org/weee-malta-5-snin-ta-gbir-u-riciklagg-ta-skart-elettroniku/

Wilson, S (2004). Development of Rehabilitation Strategies: Maghtab, Qortin and Wied Fulija

Landfills. Summary report Final. (Derbyshire, UK).

Wilson, S (2010). Rehabilitation of Maghtab, Qortin and Wied Fulija Landfills in Malta - Aerial

Emissions Control Works CT2586/2004, Final Report. (Derbyshire, UK).

Zammit-Maempel, G. (1977). An Outline of Maltese Geology. Valletta, Malta: Progress Press.

CHAPTER 17 ANNEXES

1. KEY CATEGORIES – DETAILED ASSESSMENT

A summary of key categories as determined for this submission is provided in Chapter 1 of this report. A more detailed assessment of key categories is presented in the following tables for both Approach 1 and 2. Please note that only categories determined to be key categories according to the KCA rules (as explained in chapter 1 under section 1.5) are being presented in this annex.

1.1. Approach 1

Table 17-1 Key Category Level assessment (Base Year [1990] With LULUCF)

CRF Code	Category	Classification	GHG	Identification Criteria	
				Level %	Cumulative %
1A1	Public electricity and heat production	Liquid Fuels	CO2	40.94	40.94
1A1	Public electricity and heat production	Solid Fuels	CO2	27.69	68.64
1A3b	Road Transportation	Liquid Fuels	CO2	13.01	81.64
1A4a	Commercial/Institutional	Liquid Fuels	CO2	6.42	88.07
1A4b	Residential	Liquid Fuels	CO2	3.71	91.78
3A	Enteric Fermentation	Cattle	CH4	1.91	93.69
5A2	Unmanaged Waste Disposal Sites		CH4	1.81	95.50

Table 17-2 Key Category Level assessment (Base Year [1990] Without LULUCF)

CRF Code	Category	Classification	GHG	Identification Criteria	
				Level %	Cumulative %
1A1	Public electricity and heat production	Liquid Fuels	CO2	40.23	40.23
1A1	Public electricity and heat production	Solid Fuels	CO2	27.21	67.44
1A3b	Road Transportation	Liquid Fuels	CO2	12.78	80.22
1A4a	Commercial/Institutional	Liquid Fuels	CO2	6.31	86.53
1A4b	Residential	Liquid Fuels	CO2	3.65	90.18
1A2	Manufacturing industries and construction	Liquid Fuels	CO2	2.02	92.20
3A	Enteric Fermentation	Cattle	CH4	1.87	94.07
5A2	Unmanaged Waste Disposal Sites		CH4	1.78	95.85

Table 17-3 Key Category Level assessment (Latest Year [2022] With LULUCF)

CRF Code	Category	Classification	GHG	Identification Criteria	
				Level %	Cumulative %
1A1	Public electricity and heat production	Gaseous Fuels	CO2	38.09	38.09
1A3b	Road Transportation	Liquid Fuels	CO2	33.67	71.76
5A1	Managed Waste Disposal Sites (Anaerobic)		CH4	8.30	80.06
1A4a	Commercial/Institutional	Liquid Fuels	CO2	3.33	83.39
1A4c	Agriculture, forestry and fishing	Liquid Fuels	CO2	2.99	86.38
1A3d	Domestic navigation	Liquid Fuels	CO2	2.92	89.29
1A1	Public electricity and heat production	Liquid Fuels	CO2	2.49	91.79
1A4b	Residential	Liquid Fuels	CO2	1.64	93.43
3A	Enteric Fermentation	Cattle	CH4	1.54	94.97
5D1	Wastewater Treatment and Discharge – Domestic wastewater		CH4	0.47	95.44

Table 17-4 Key Category Level assessment (Latest Year [2022] Without LULUCF)

CRF Code	Category	Classification	GHG	Identification Criteria	
				Level %	Cumulative %
1A1	Public electricity and heat production	Gaseous Fuels	CO2	33.29	33.29
1A3b	Road Transportation	Liquid Fuels	CO2	29.43	62.72
2F1	Product Uses as Substitute for Ozone Depletion Substances – Refrigeration and Air Conditioning		HFC	8.97	71.69
5A1	Managed Waste Disposal Sites (Anaerobic)		CH4	7.25	78.95
1A2	Manufacturing industries and construction	Liquid Fuels	CO2	4.18	83.12
1A4a	Commercial/Institutional	Liquid Fuels	CO2	2.19	86.03
1A4c	Agriculture, forestry and fishing	Liquid Fuels	CO2	2.61	88.64
1A3d	Domestic navigation	Liquid Fuels	CO2	2.55	91.19
1A1	Public electricity and heat production	Liquid Fuels	CO2	2.18	93.38
1A4b	Residential	Liquid Fuels	CO2	1.43	94.81
3A	Enteric Fermentation	Cattle	CH4	1.35	96.16

Table 17-5 Key Category Trend assessment (latest year [2022] with LULUCF)

CRF Code	Category	Classification	GHG	Identification Criteria		
				Trend %	Contribution to trend %	Cumulative total %
1A1	Public electricity and heat production	Liquid Fuels	CO2	29.45	37.59	37.59
1A1	Public electricity and heat production	Solid Fuels	CO2	21.21	27.07	64.67
1A3b	Road Transportation	Liquid Fuels	CO2	15.83	20.20	84.87
1A4a	Commercial/Institutional	Liquid Fuels	CO2	2.37	3.03	87.90
1A4c	Agriculture, Forestry and Fishing	Liquid Fuels	CO2	2.17	2.77	90.67
1A3d	Domestic Navigation	Liquid Fuels	CO2	1.88	2.40	93.07
1A4b	Residential	Liquid Fuels	CO2	1.59	2.03	95.10

Table 17-6 Key Category Trend assessment (latest year [2022] without LULUCF)

CRF Code	Category	Classification	GHG	Identification Criteria		
				Trend %	Contribution to trend %	Cumulative total %
1A1	Public electricity and heat production	Liquid Fuels	CO2	32.76	38.56	38.56
1A1	Public electricity and heat production	Gaseous Fuels	CO2	23.43	27.57	66.13
1A3b	Road Transportation	Liquid Fuels	CO2	14.34	16.87	83.01
1A4a	Commercial/Institutional	Liquid Fuels	CO2	2.93	3.45	86.46
1A4c	Agriculture, Forestry and Fishing	Liquid Fuels	CO2	2.12	2.50	88.96
1A4b	Residential	Liquid Fuels	CO2	1.91	2.24	91.20
1A1	Public electricity and heat production	Solid Fuels	CO2	1.86	2.19	93.39
1A3d	Domestic Navigation	Liquid Fuels	CO2	1.81	2.13	95.51

1.2. Approach 2

Table 17-7 Key Category Level assessment (Latest Year [2022])

CRF Code	Category	Classification	GHG	Identification Criteria	
				Level %	Cumulative %
1A3b	Road Transportation	Liquid Fuels	CO2	33.67	24.75
5A1	Managed Waste Disposal Sites (Anaerobic)		CH4	8.30	47.87
1A1	Public electricity and heat production	Gaseous Fuels	CO2	38.09	60.39
3D1	Direct N2O emissions from Managed soils (inorganic)		N2O	0.44	65.01
1A4a	Commercial/Institutional	Liquid Fuels	CO2	3.33	69.51
1A4	Agriculture, Forestry and Fishing	Liquid fuels	CO2	2.99	73.55
3A	Enteric Fermentation	Cattle	CH4	1.54	76.35
5A2	Unmanaged Waste Disposal Sites		CH4	0.29	78.68

1A4b	Residential	Liquid Fuels	CO2	1.64	80.90
1A3d	Domestic Navigation	Liquid Fuels	CO2	2.92	83.04
3D2	Direct N2O Emissions from Managed soils (organic)		N2O	0.42	84.81
2D1	Non-Energy Products from Fuels and Solvent Use – Lubricant Use		CO2	0.22	85.99
3D1	Indirect N2O emissions from Managed soils		N2O	0.29	87.16

Table 17-8 Key Category Trend assessment (Latest Year [2022])

CRF Code	Category	Classification	GHG	Identification Criteria	
				Trend %	Cumulative %
1A3b	Road Transportation	Liquid Fuels	CO2	15.83	23.25
1A1	Public electricity and heat production	Liquid Fuels	CO2	29.45	42.60
5A2	Unmanaged Waste Disposal Sites		CH4	1.17	61.19
1A4a	Commercial/Institutional	Liquid Fuels	CO2	2.37	67.60
1A4c	Agriculture/Forestry/Fishing	Liquid Fuels	CO2	2.17	73.46
3D1	Direct N2O Emissions from Managed Soils		N2O	0.26	78.98
1A4b	Residential	Liquid Fuels	CO2	1.59	83.27
1A3d	Domestic Navigation	Liquid Fuels	CO2	1.88	86.04
4C2	Land Converted to Grassland		CO2	0.22	87.82
3A	Enteric Fermentation	Cattle	CH4	0.28	88.81
5D	Wastewater Treatment and Discharge - Domestic wastewater		CH4	0.22	89.73

2. ASSESSMENT OF UNCERTAINTY (ANNEX X OF IMPLEMENTING REGULATION (EU) 2020/1208)

A detailed assessment of uncertainty is presented in a separate excel template in accordance with Article 12 Annex X of the Implementing Regulation (EU) 2020/1208.

The overall uncertainty in the total inventory was of 6.07%, whereas the trend uncertainty was that of 6.32%.

3. DETAILED METHODOLOGICAL DESCRIPTIONS FOR INDIVIDUAL SOURCE OR SINK CATEGORIES

Detailed methodological descriptions for specific activity categories is provided in the respective sector chapters. Where deemed relevant, and for a more practical presentation of information in sector chapters, some additional methodological information is included in this annex.

Methodological descriptions relating to Union key categories (in accordance with Article 11, and Annex IX of Commission Implementing Regulation (EU) 2020/1208, are provided in a separate consolidated format coordinated by the European Commission, independent of this submission.

3.1. Energy: Transport

DOMESTIC AVIATION (CRF 1.A.3.A)

The methodology for estimating greenhouse gas emissions from civil aviation follows a fuel-based Tier 1 approach using the following formula:

$$Emissions = \sum_j (Fuel\ Consumption_j \cdot Emission\ Factor_j)$$

And default emissions factors (section 3.2.6.1)

The fuel used for domestic aviation in Malta includes Jet kerosene and aviation gasoline. We compared archived historic data (available for the period 1990-2015) that was collected through the Malta Resources Authority from the relevant Aviation Fuel Suppliers, data reported on EUROSTAT (available since 2005) and data provided from REWS which is the Regulator for Energy and Water services in Malta (available since 2015). Figure 17-1 illustrates the data under comparison.

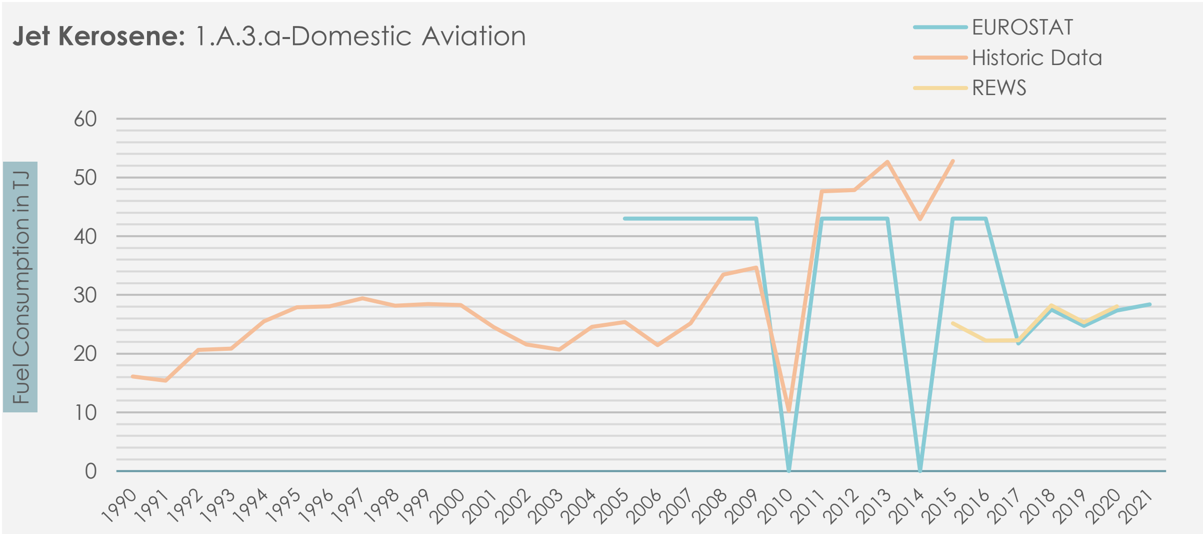


Figure 17-1 Jet Kerosene data from different sources. Category 1.A.3.a-Domestic Aviation.

For the period 1990-2008 archived national data collected through the Malta Resourced Authority were used. For the period 2009-2016 the aviation gasoline amount reported on EUROSTAT was the same. Although this data was not in line with any of the other sources, it was decided to be used as activity data because these values are official and it is assumed to be more accurate. From 2015 onwards EUROSTAT data are very close to those provided by REWS.

For the years 2010 and 2014 there was no data on EUROSTAT and thus we used the same value as in 2009,2011,2012 and 2013 (highlighted in red- Figure 17-2). Data on EUROSTAT include fuel used by military. As there were no clear indication that historic data include or exclude fuels used by military it was decided to take the more conservative approach and assume that military fuels are not included. Figure 17-3 presents the jet kerosene consumption including (blue line) and excluding (orange line) fuel used by military.

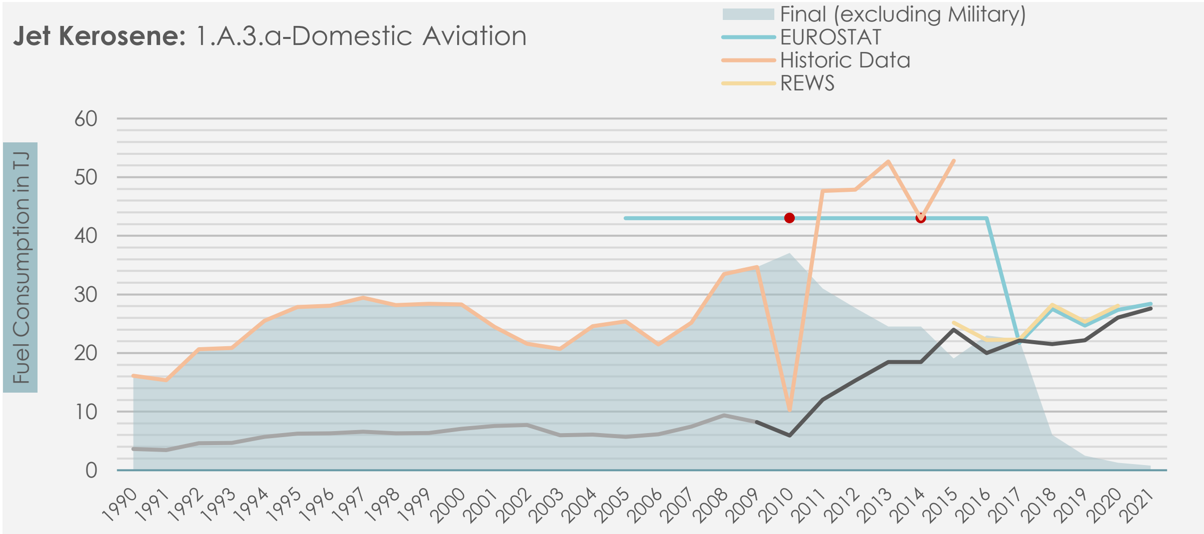


Figure 17-2 Final Jet kerosene consumption. Category 1.A.3.a-Domestic Aviation

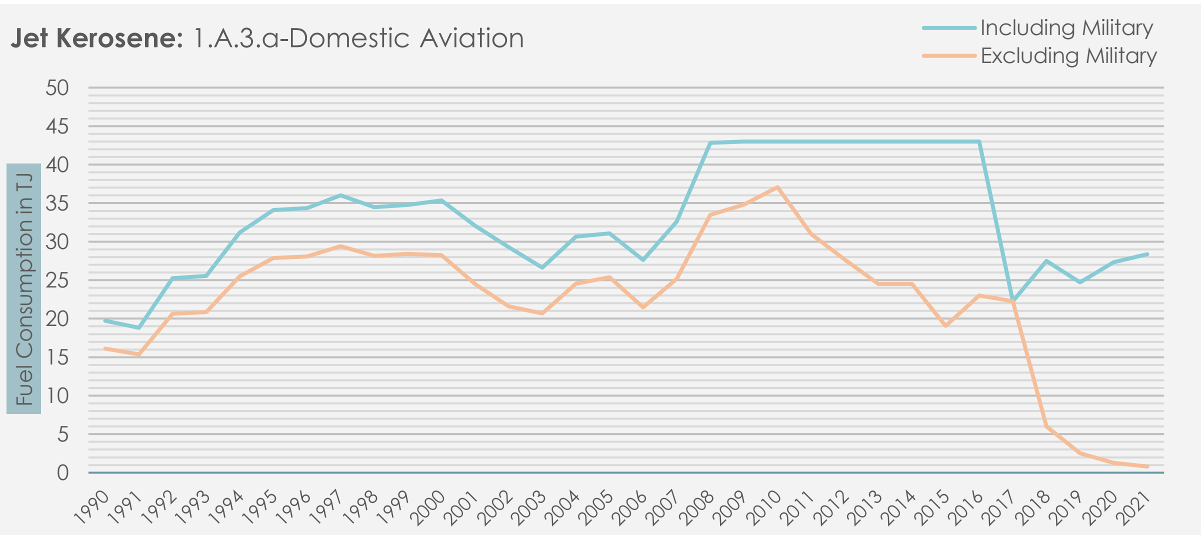


Figure 17-3 Jet kerosene consumption including military and excluding military.

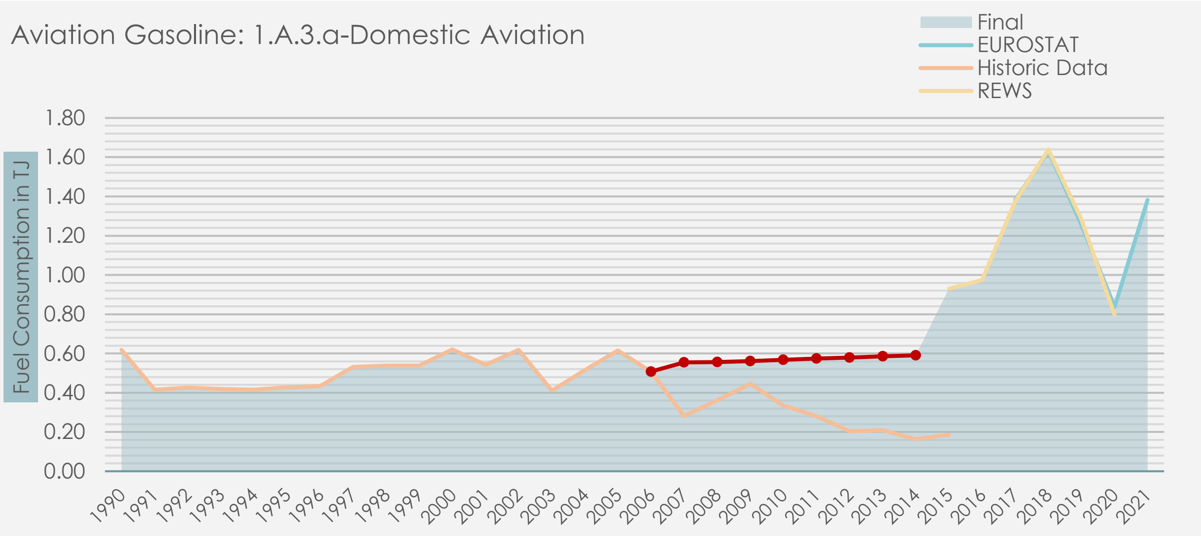


Figure 17-4 Final Jet kerosene consumption including military and excluding military.

Following a similar approach, we compared archived historic data (available for the period 1990-2015), data reported on EUROSTAT (available since 2017) and data provided from REWS (available since 2015) for aviation gasoline. For the period 1990-2006 archived national data collected through the Malta Resourced Authority. For the period 2007-2014 a forecast method was used to fill in the timeseries as the trend started to decrease and was not in line with future values. From 2015 onwards EUROSTAT data are very close to those provided by REWS and is used as activity data for the NIR. Data provided from the Armed Forces of Malta (military use) indicate that no aviation gasoline was used by military since 2015. However, archive data for military used were available and it is assumed that are not included in the timeseries for domestic aviation and are reported separately under category 1.A.5.

It was confirmed by the National Statistics Office (NSO) that the same questionnaires regarding the national oil balance are submitted to both EUROSTAT and IEA. During the UNFCCC review of 2022, the TERT suggested to address the inconsistencies identified between the IEA data and the aviation gasoline data reported in CRF tables. However, data regarding aviation gasoline for Malta was not available by IEA. The final fuel consumption by fuel type can be seen in Figure 17-5 and values are provided in Table 3-5.

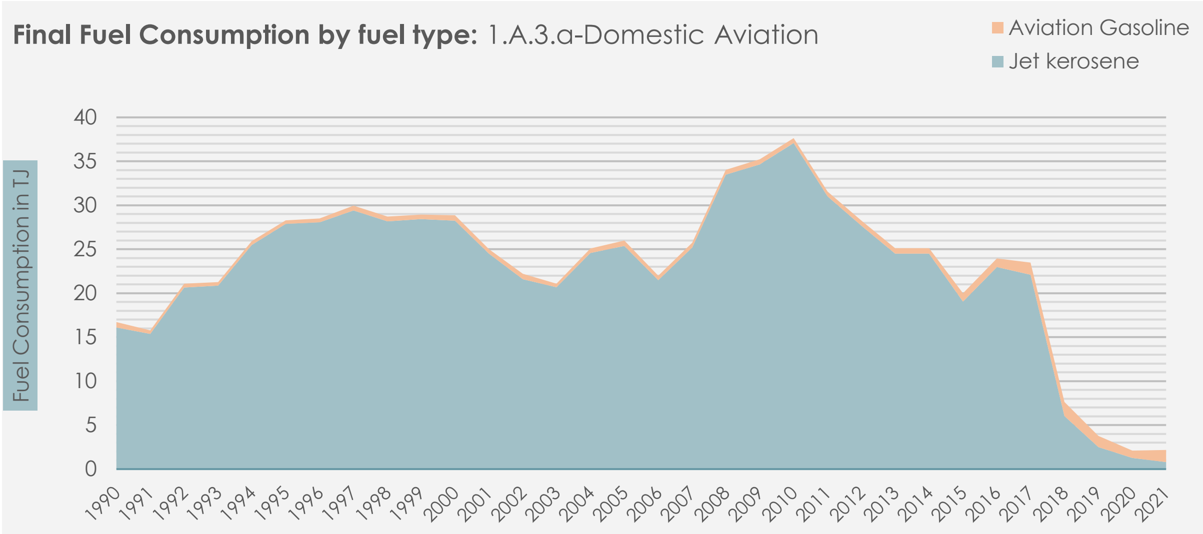


Figure 17-5 Final fuel consumption by fuel type. Category 1.A.3.a-Domestic Aviation.

Table 17-9 Fuel consumption for category 1.A.3.a-Domestic Aviation (1990-2021)

Total Fuel Consumption in TJ. Category 1.A.3.a-Domestic Aviation																
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Jet kerosene	16.115	15.376	20.649	20.859	25.495	27.871	28.078	29.427	28.179	28.414	28.264	24.488	21.59	20.675	24.559	25.369
Aviation Gasoline	0.619	0.416	0.426	0.42	0.417	0.427	0.433	0.532	0.538	0.539	0.621	0.542	0.619	0.411	0.515	0.614
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Jet kerosene	21.474	25.178	33.469	34.657	37.074	30.998	27.674	24.521	24.521	19.048	22.994	22.103	6.014	2.509	1.269	0.793
Aviation Gasoline	0.508	0.555	0.556	0.562	0.568	0.573	0.579	0.585	0.591	0.93	0.975	1.382	1.633	1.256	0.837	1.364

During the same review it was also suggested to make use of additional sources of information such as EUROCONTROL, as a supplementary QA activity to verify the fuel allocation for domestic and international uses. EUROCONTROL data was used in the past to report emissions for domestica aviation. However, Malta is no longer using EUROCONTROL data as part of the methodology to estimate any emissions arising from category 1.A.3.a-Domestic Aviation. In addition, such data were not satisfactory for verification purposes as the estimated fuel consumption was not comparable to the national oil balance. For example, in 2020 the total fuel consumption for domestic aviation as reported in the national oil balance was 28.184 TJ (including fuel used by military) while the EUROCONTROL estimate was 9.6 TJ. The following graph (Figure 17-6) compares the total fuel consumption as reported in the 2021, 2022 and 2023 submissions. Fuel consumption for the period 2005-2019 for the 2021 submission were obtained by EUROCONTROL.

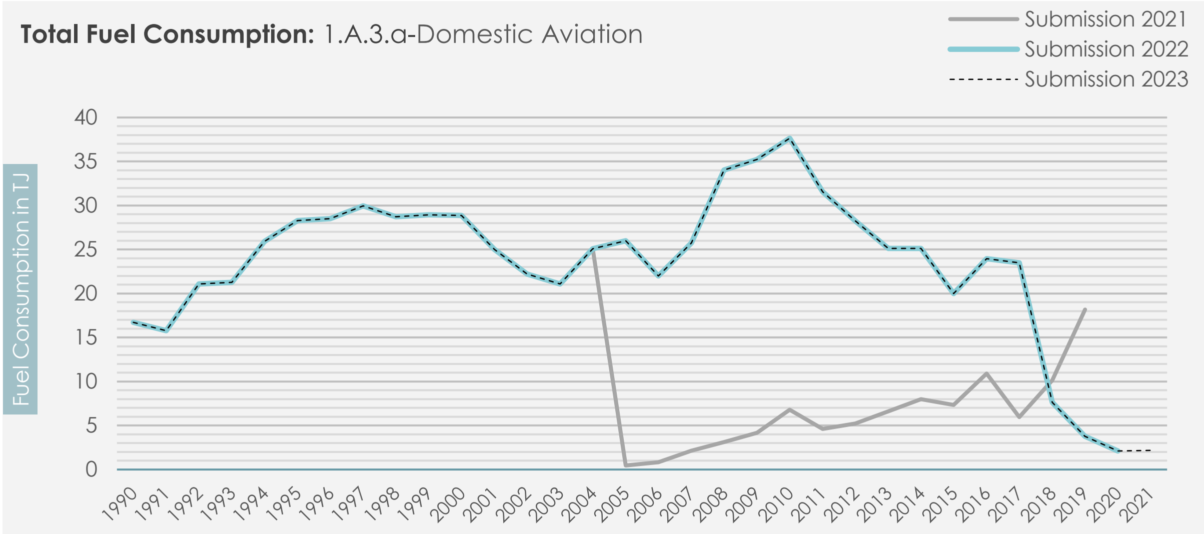


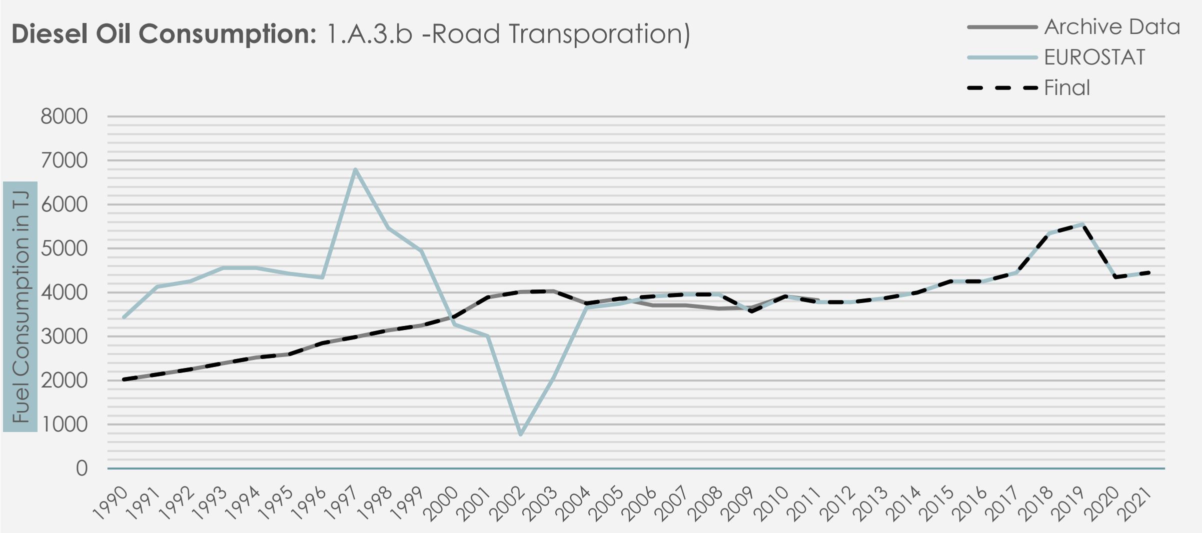
Figure 17-6 Total fuel consumption as reported in the 2021, 2022 and 2023 submissions. Fuel consumption for the period 2005-2019 for the 2021 submission were obtained by EUROCONTROL.

ROAD TRANSPORT (CRF 1.A.3.B)

The fuels used for road transport include Diesel oil, Motor Gasoline, LPG, and biodiesel, with the latter being sold pre-blended with diesel following the implementation of EN590 (diesel) and EN228 (petrol) in 2010. Carbon dioxide emissions are estimated following the IPCC 2006 Tier 1 methodology. Methane and nitrous oxide emission estimates are calculated using the COPERT V model, which follows a detailed Tier 3 method. During the 2022 UNFCCC it was recommended to ensure the time-series consistency of GHG emission estimates from liquid fuels in road transportation by using the same methodology, or to demonstrate that the use of two different methodologies does not introduce inconsistencies in the time series. In the current submission, the same methodology explained in chapter 3 is used for the whole timeseries.

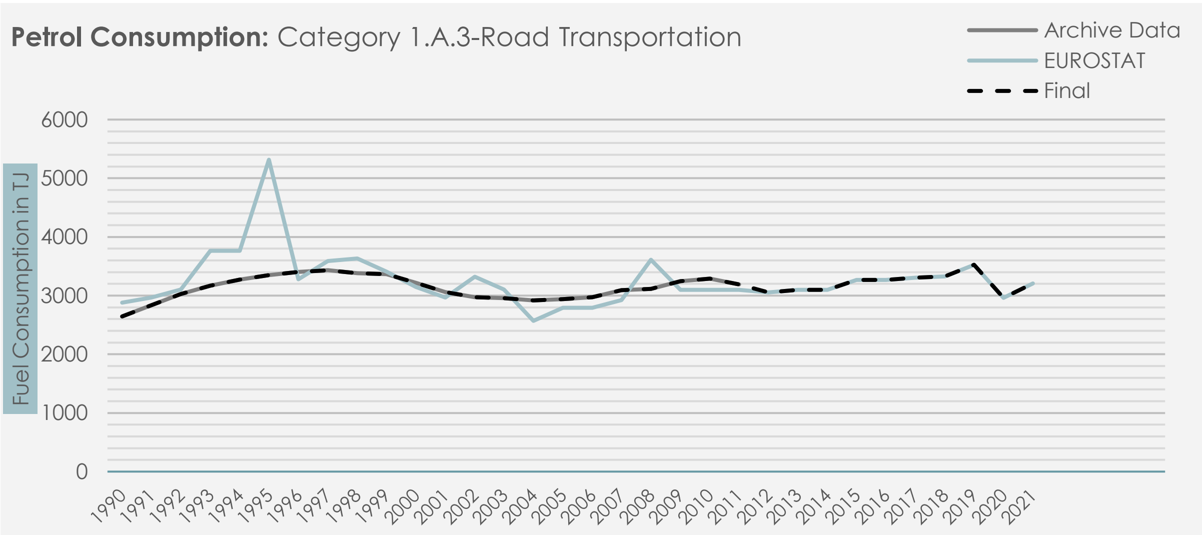
Fuel Consumption

Figure below, compares archive historic data for Diesel oil used for road transportation (available from 1990 to 2011), collected by the University of Malta through the relevant entities, with data reported on EUROSTAT (available for the period 1990-2021).

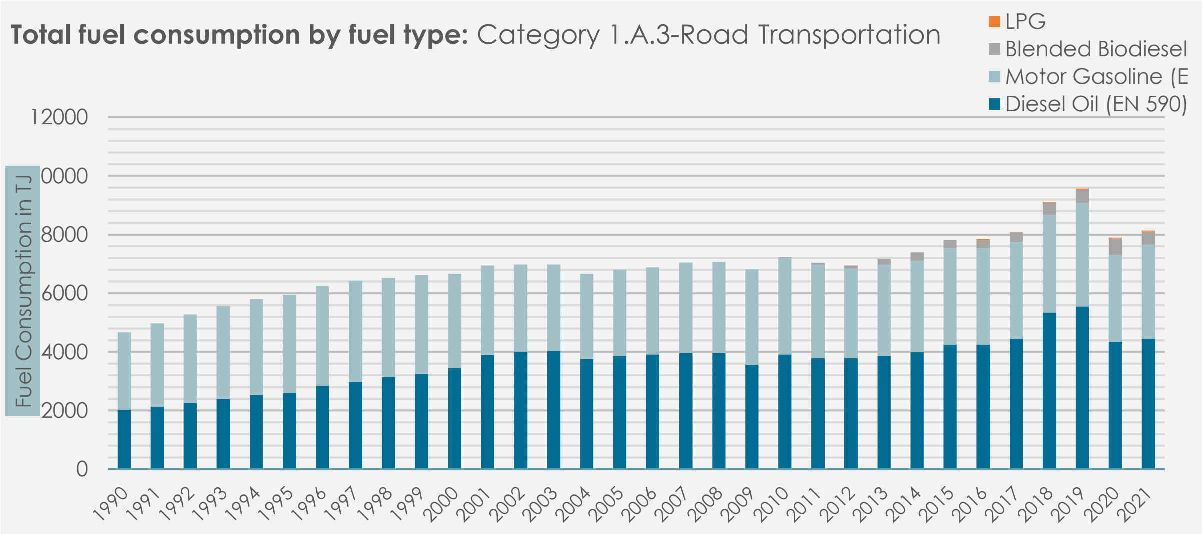


The timeseries obtained from EUROSTAT for the period 1990-2004 does not seem consistent and archived historic data was used for this period. The same source was used for 2005 as it was a bit higher than the value provided by EUROSTAT and more in-line with the rest of the timeseries. From 2006 onwards fuel consumption for diesel oil is obtained by EUROSTAT.

A similar exercise was performed for the motor gasoline used for road transportation. In this case, archive historic data was used for 1990-2011. From 2012 onwards, fuel consumption for motor gasoline is obtained by EUROSTAT.



Liquified Petroleum Gas (LPG) is used for road transportation since 2016 and data are only available by EUROSTAT. Biomass is also obtained by EUROSTAT. Figure below, presents the total fuel consumption by fuel type.



COPERT Input parameters

The table below, summarizes the main input parameters used by COPERT.

Table 17-10 Input parameters for the COPERT model

INPUT PARAMETER	UNIT	INPUT PARAMETER	UNIT
MIN_TEMPERATURE	[ºC]	URBAN_PEAK_ROAD_SLOPE	[%]
MAX_TEMPERATURE	[ºC]	RURAL_ROAD_SLOPE	[%]
HUMIDITY	[%]	HIGHWAY_ROAD_SLOPE	[%]
REID_VAPOR_PRESSURE	[kPa]	NO_OF_AXELS	[n]
TRIP_LENGTH	[km]	VEHICLES_WITH_AC	[%]
TRIP_DURATION	[hour]	AC_USAGE	[%]
STOCK	[n]	PRIMARY_FUEL_BIFUEL_SHARE	[%]
MEAN_ACTIVITY	[km]	SECONDARY_FUEL_BIFUEL_SHARE	[%]
LIFETIME_CUMULATIVE_ACTIVITY	[km]	FIRST_BLEND	[%]
URBAN_OFF_PEAK_SPEED	[km/h]	SECOND_BLEND	[%]
URBAN_PEAK_SPEED	[km/h]	FIRST_BLEND_ENERGY_SHARE	[%]
RURAL_SPEED	[km/h]	SECOND_BLEND_ENERGY_SHARE	[%]
HIGHWAY_SPEED	[km/h]	FIRST_TECHNOLOGY_SHARE	[%]
URBAN_OFF_PEAK_SHARE	[%]	SECOND_TECHNOLOGY_SHARE	[%]

URBAN_PEAK_SHARE	[%]	THIRD_TECHNOLOGY_SHARE	[%]
RURAL_SHARE	[%]	ENERGY_CONTENT	[MJ/kg]
HIGHWAY_SHARE	[%]	DENSITY	[kg/m3]
FUEL_TANK_SIZE	[l]	HC_RATIO	[-]
CANISTER_SIZE	[l]	OC_RATIO	[-]
FUEL_INJECTION	[%]	S_CONTENT	[ppm wt]
EVAPORATION_CONTROL	[%]	PB_CONTENT	[ppm wt]
URBAN_OFF_PEAK_EVAPORATION_SHA	[%]	CD_CONTENT	[ppm wt]
URBAN_PEAK_EVAPORATION_SHARE	[%]	CU_CONTENT	[ppm wt]
RURAL_EVAP_SHARE	[%]	CR_CONTENT	[ppm wt]
HIGHWAY_EVAP_SHARE	[%]	NI_CONTENT	[ppm wt]
URBAN_OFF_PEAK_LOAD	[%]	SE_CONTENT	[ppm wt]
URBAN_PEAK_LOAD	[%]	ZN_CONTENT	[ppm wt]
RURAL_LOAD	[%]	HG_CONTENT	[ppm wt]
HIGHWAY_LOAD	[%]	AS_CONTENT	[ppm wt]
URBAN_OFF_PEAK_ROAD_SLOPE	[%]	TOTAL_FUEL_SALES	[TJ]

Stock

For the period 1995-2005 stock was extracted from the national Vehicle Registration and Administrative System Database (VERA). VERA database is the only register that contains the complete details of all vehicles registered and licensed in Malta, since 1995. For 1990-1994 only the total number of vehicles was available.

Table 17-11 Number of Vehicles per category.

1.A.3.b: Road Transport												
Category		Number of vehicles per category (1990-2000)										
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total Number of Vehicle:		122444	132698	140141	177745	187611	198235	211600	219980	225442	232899	239814
Passenger C	Diesel	18885	20477	21151	26826	28315	30647	33905	36463	38354	41761	47415
	Petrol	76180	82601	87732	111274	117450	123542	129739	132997	135404	138364	138966
	LPG	0	0	0	0	0	0	0	0	0	0	0
	Total	95065	103078	108883	138100	145765	154189	163644	169460	173758	180125	186381
Light Duty Vehicles		14095	15283	16232	20588	21730	22873	25265	27254	27835	28161	28322
Heavy Dute Vehicles		6004	6442	6641	8423	8890	9358	10074	10403	10732	10913	11015
Buses and Coaches		794	861	915	1160	1225	1289	1346	1383	1468	1550	1571
Motorcycles		6486	7033	7470	9474	10000	10526	11271	11480	11649	12150	12525

1.A.3.b: Road Transport												
Category		Number of vehicles per category (2001-2011)										
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total Number of Vehicle:		246363	252533	259924	264311	269590	275604	281789	287573	295730	301639	308001
Passenger C	Diesel	52386	56955	60702	62338	62980	63685	64298	64640	65992	67835	71467
	Petrol	139709	140489	142872	144953	148674	152901	157137	161068	167492	171134	173134
	LPG	0	0	0	0	0	0	0	0	0	0	0
	Total	192095	197444	203574	207291	211654	216586	221435	225708	233484	238969	244601
Light Duty Vehicles		28566	28760	29115	29648	29929	30034	30408	30721	30733	30698	30780
Heavy Dute Vehicles		11296	11470	12039	12310	12775	13149	13378	13869	13756	13698	13666
Buses and Coaches		1576	1607	1654	1658	1682	1705	1730	1770	1776	1800	1830
Motorcycles		12830	13252	13542	13404	13550	14130	14838	15505	15981	16474	17124

1.A.3.b: Road Transport												
Category		Number of vehicles per category (2012-2022)										
		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Total Number of Vehicle:		310320	316836	327362	336617	347054	358629	368845	377312	378837	376160	
Passenger C	Diesel	74175	77396	81336	84253	86786	90564	93165	95075	94573	91928	89238
	Petrol	172620	174497	179114	184083	187566	191502	194952	197387	196864	194766	190841
	LPG	0	0	0	0	1726	1801	1862	1874	1867	1840	1844
	Total	246795	251893	260450	268336	276078	283867	289979	294336	293304	288534	281923
Light Duty Vehicles		30869	31422	31942	32475	32985	34197	35575	36927	37631	37754	37953
Heavy Dute Vehicles		13508	13526	13597	13676	13885	14272	14663	15131	15422	15401	16421
Buses and Coaches		1826	1841	1919	2090	2184	2259	2309	2582	2633	2648	2656
Motorcycles		17322	18154	19454	20040	21922	24034	26319	28336	29847	31823	34656

In order to have a consistent timeseries, an exercise has been carried out to categorise the vehicle fleet according to fuel type, segment and euro standards, for years 1990 to 1994. The vehicle fleet of year 1995 was used to calculate backwords such categorisations. The percentage of each vehicle subcategory was calculated and this was applied to the vehicle fleet for years 1990 to 1994. If a Euro standard that existed in 1995 was not introduced in a particular year during the four-year period of 1990-1994, the percentage of this category has been added to the previous one. For example, Euro 1 for petrol passenger cars was introduced in 1992.As these percentages are based on the year of 1995, a percentage for Euro 1 cars has already been established, therefore, this has been used to estimate the number of Euro 1 cars for all four years. However, in 1990 Euro 1 cars didn't exist. Hence, to keep the same total number of vehicles (as in historic data) this percentage was added to the previous category (ECE 15/04).

The VERA database includes information regarding several parameters such as the size of the vehicle, the year of manufacturing, EU category, National Description, Engine size, Body type and many other. For the inventory reporting only vehicles that are licensed are taken into account. A number of checks were performed to assess the accuracy of this database and it was found that for certain entries there was missing information or a number of misclassifications. In cases where such issues were easy to solve, they were updated.

The classification follows the EEA/ EMEP guidebook and is mainly based on the EU Category column, where each vehicle is classified according to the European Classifications (M1, M2,M3, N1, N2,N3, L etc). We assume that information found under the EU Category column is accurate and we base are classification to this column. If there are blanks under this column, we eliminate the entries (Note: The script is counting the number of blank entries under this category, and it eliminated them if only they are less than a certain number. All files 1995-2021 were checked for blank cells under the 'EUCAT' column and they were all less than 20).

General Eliminations:

For the inventory purposes we consider only internal Combustion Engine vehicles. Thus, all electric vehicles are eliminated. We also eliminate all entries that are agricultural tractors as we assume that they do not travel on roads. In addition, we eliminate all entries that are classified as machinery. It is also assumed that cranes are mostly stationary and thus they are removed as well. Similarly, it is assumed that caravans are mostly stationary and they are removed. Note that any military own vehicles are included at this stage.

Fuel Categories:

For entries were the fuel type was not available we assume the following:

- If the vehicle is a motorcycle it runs on petrol
- All Heavy Duty vehicles and Buses are more likely to run on Diesel
- For passenger Cars and Light Duty vehicles, we filled in the fuel type randomly based on the percentages of Petrol and Diesel consumed by these categories.

Due to the small distances in Malta, all Plug-in Hybrids are considered as electric and are not taken into account for the GHG Inventory.All LPG bi-fuel are considered as LPG vehicles.

Passenger Cars:

All vehicles classified as M1 and have less than nine seats, it is assumed to be passenger cars, except those that the "BODY" category is Bus, Coach, All Terrain Vehicle, Three Wheeler or Buggy. M1 vehicles that have more than nine seats are considered mini buses. For the classification required by the COPERT model, it is important to disaggregate passenger cars by segment. This disaggregation is based on the engine size as follows:

	Segment	Engine Size			
Passenger Cars	Mini	<	800cc		
	Small	≥	800cc	<	1400cc
	Medium	≥	1400cc	<	1800cc
	Large	≥	2000cc		

In cases where the engine size was not available and there was no other information to fill in the cell, it was assumed that the engine was "Large". For certain entries, the national Description was available and we took the following assumptions to fill in the blank cells:

- Passenger Cars up to 1300cc: 1300cc,
- Passenger Cars from 1301 to 1449cc: 1449,
- Passenger Cars from 1450 to 1500cc: 1500,
- Passenger Cars from 1501 to 1800cc: 1800,
- Passenger Cars from 1801 to 2000cc: 2000,
- Passenger Cars 2100cc and over: 2100

Light Commercial Vehicles

All vehicles classified as N1 and with gross weight less than 3.5 tonnes, belong to this category. Light Commercial vehicles that are heavier than 3.5 tonnes, even if the EU category is N1 are excluded from this category and they are included under the Heavy Duty Vehicles. LCVs are further dissagragated into N1-I, N1-II and N1-III catgories, based on their weight:

Light Commercial Vehicles	**N1-I**	Gross weight less or equal to 1305kg
	N1-II	Gross weight more than 1305kg and less or equal to 1760kg
	N1-III	Gross weight more than 1760kg

Heavy Duty Vehicles

This category includes all vehicles that are classified as N2 or N3. The model takes into consideration only HDVs with a Diesel engine. Any petrol HDVs were eliminated and all petrol is assumed to be used by passenger cars, LCVs and motorcycles.In addition, N1 vehicles that are heavier than 3.5 tonnes are also included here. HDVs are further dissagragated into Rigid and Articulated

Heavy Duty Vehicles	**Rigid (All except those that are listed as tractor units (TU))**	≤ 7.5 t
		7.5t - 12t
		12t - 14t
		14t - 20t
		20t - 26t
		26t - 28t
		28t - 32t
		> 32t
	Articulated (All HDVs listed as Tractor Units (TU))	14t - 20t
		20t - 28t
		28t - 34t
		34t - 40t
		40t - 50t
		50t - 60t

Buses

This category includes all vehicles that are classified as M2 or M3. In addition, M1 vehicles with more than nine seats or where the body type is coach/bus are also included here. Please note that as mentioned above, such vehicles are excluded from the passenger cars category.The model does not take into consideration Buses with a petrol engine. Any petrol buses were eliminated and all petrol is assumed to be used by passenger cars, LCVs and motorcycles. There are no articulated buses in Malta, however due to the bigger size of certain buses, we included them under the articulated buses category which are usually heavier, in order to have more realistic emission factors.

Buses	**Urban Buses Midi**	≤ 15t
	Uban Buses Standard	15t-18t

	Urban Buses Articulated	>	18t
	Coaches Standard	≤	18t
	Coaches Articulated	>	18t

Motorcycles

All entries classified as L, excluding L6 and L7 which are quads or All Terrain Vehicles, including also three wheelers from the M1 classification. Any Diesel motrorcycles were eliminated.Diesel is assumed to be used only by passenger cars, LCVs and HDVs. Motorcycles in COPERT are dissagragated by type of engine into 2-stroke and 4-stroke. The necessary parameters that indicate if a motorcycle is 2-stroke or 4-stroke were not available and we assume that all motorcycles, with an engine smaller than 50cc, are 2-stroke and any motorcycles with engines larger than 50cc are 4-stroke.

Motorcycles	Mopeds 2-stroke <50 cm³	We assume that all motorcycles, with an engine smaller than 50cc, are 2-stroke.
	Motorcycles 2-stroke >50 cm³	We assume that all motorcycles, with an engine larger than 50cc, are 4-stroke.
	Motorcycles 4-stroke <250 cm³	Based on the engine size
	Motorcycles 4-stroke 250 - 750 cm³	Based on the engine size
	Motorcycles 4-stroke >750 cm³	Based on the engine size

Quads and ATVs

All L6 and L7 vehicles.

Euro Standard Classification

All mentioned categories are further dissagragated according to the Euro Standard classifications. The VERA database does not include information on the Euro Standards. In order to solve this issue, we created a new column, which checks the year of manufacture of each vehicle and provides the Euro standard based on the following tables (according to the EEA/EMEP guidbook):

Euro Standards for Passenger Cars														
	Petrol Passenger Cars				Diesel Passenger Cars					LPG Passenger Cars				
	From		To			From		To			From		To	
PRE ECE			≤	1971	-	-	-	-	-	-	-	-	-	-
ECE 15/00-01	≥	1972	≤	1977	-	-	-	-	-	-	-	-	-	-
ECE 15/02	≥	1978	≤	1980	-	-	-	-	-	-	-	-	-	-
ECE 15/03	≥	1981	<	1985	-	-	-	-	-	-	-	-	-	-
ECE 15/04	≥	1985	<	1992	Conventional			<	1992	Conventional			≤	1991
EURO 1	≥	1992	<	1996	EURO 1	≥	1992	<	1996	EURO 1	≥	1992	<	1996
EURO 2	≥	1996	≤	1999	EURO 2	≥	1996	≤	1999	EURO 2	≥	1996	≤	1999
EURO 3	≥	2000	≤	2004	EURO 3	≥	2000	≤	2004	EURO 3	≥	2000	≤	2004
EURO 4	≥	2005	≤	2010	EURO 4	≥	2005	≤	2009	EURO 4	≥	2005	≤	2009
EURO 5	≥	2011	≤	2014	EURO 5	≥	2010	<	2014	EURO 5	≥	2010	<	2014
EURO 6 a/b/c	≥	2014	<	2018	EURO 6 a/b/c	≥	2014	<	2019	EURO 6 a/b/c	≥	2015	<	2016
EURO 6 d	≥	2019			EURO 6 d	≥	2019			EURO 6 d	≥	2017		

Light Commercial Vehicles									
Petrol LCVs					Diesel LCVs				
	From		To			From		To	
Conventional			<	1993	Conventional			<	1993
EURO 1	≥	1993	<	1997	EURO 1	≥	1993	<	1997
EURO 2	≥	1997	≤	2001	EURO 2	≥	1997	≤	2001
EURO 3	≥	2001	≤	2006	EURO 3	≥	2001	<	2006
EURO 4	≥	2006	≤	2010	EURO 4	≥	2006	<	2011
EURO 5	≥	2011	<	2015	EURO 5	≥	2011	<	2015
EURO 6 a/b/c	≥	2016	<	2017	EURO 6 a/b/c	≥	2015	≤	2017
EURO 6 d	≥	2018			EURO 6 d	≥	2018		

Heavy Duty Vehicles				
Diesel HDVs and Buses				
	From		To	
Conventional			<	1992
EURO I	≥	1992	≤	1995
EURO II	≥	1996	<	2000
EURO III	≥	2000	<	2005
EURO IV	≥	2005	<	2008
EURO V	≥	2008	<	2013
EURO VI D/E	≥	2013	<	2019
EURO VI A/B/C	≥	2019		

L- Category				
Motorcycles, Quads and ATVs				
	From		To	
Conventional			<	1999
EURO 1	≥	1999	<	2003
EURO 2	≥	2003	<	2006
EURO 3	≥	2006	<	2015
EURO 4	≥	2016	<	2020
EURO 5	≥	2020	<	2013

Environmental Parameters

Minimum Temperature																
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
January	10.6	9.5	9.1	9.4	10.5	9.3	11.6	10.9	9.7	10.0	7.7	11.4	8.6	10.9	9.4	8.1
February	10.6	9.4	8.8	8.5	10.2	10.6	9.7	9.5	9.6	8.6	8.5	10.1	11.2	7.9	9.7	8.0
March	10.8	12.5	11.0	9.6	10.8	9.9	10.5	9.9	10.0	10.2	10.5	13.2	12.4	9.8	10.9	9.8
April	13.3	11.6	12.5	12.0	12.2	11.6	11.8	11.1	13.5	12.3	13.1	12.6	13.0	12.4	12.8	11.9
May	15.7	13.4	14.9	15.4	16.4	15.0	15.7	15.4	15.7	16.6	16.8	16.7	15.7	16.0	14.5	15.4
June	19.2	18.2	18.3	19.8	19.0	19.6	19.1	20.9	19.6	20.4	19.0	19.0	19.8	21.5	18.6	19.5
July	21.7	21.1	20.5	20.9	22.1	22.3	21.0	21.4	22.2	21.4	21.7	22.2	22.8	23.9	21.5	22.2
August	21.9	22.1	22.7	22.3	23.7	23.5	23.3	22.4	22.7	23.9	22.1	22.7	22.6	24.0	22.6	21.9
September	21.7	21.9	20.4	21.0	21.6	20.9	20.6	20.4	20.8	21.8	20.9	21.3	20.7	21.2	19.8	21.2
October	20.0	19.0	19.8	19.0	18.4	17.2	16.2	17.7	18.6	18.7	17.4	19.2	18.0	19.2	18.5	18.5
November	15.4	13.9	15.9	14.7	14.9	13.7	14.9	14.8	12.9	15.0	15.5	15.3	16.1	14.8	14.2	15.2
December	10.3	9.3	11.7	11.7	11.4	13.1	12.3	11.9	10.2	12.1	12	10.3	11.9	11.38	12.76	11.77

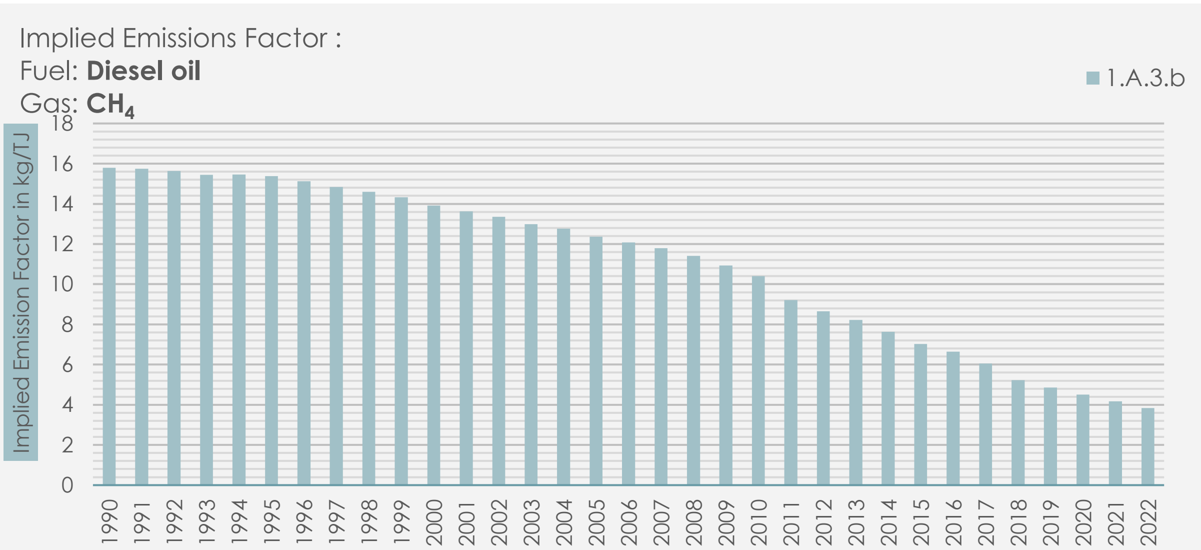
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
January	9.9	11.5	12.1	10.8	11.1	9.7	9.0	10.6	11.6	10.1	10.4	7.8	11.5	8.8	10.1	11.6
February	9.3	10.8	10.5	8.5	10.9	8.2	7.5	9.4	11.3	9.3	11.9	10.2	10.1	8.7	10.2	10.8
March	10.1	11.3	12.1	10.4	11.2	9.6	9.7	11.8	10.5	10.7	11.3	11.2	12.3	11.2	11.3	10.7
April	12.9	13.4	13.9	12.2	13.5	12.7	12.6	13.7	13.6	12.1	14.7	12.7	13.8	12.6	12.9	12.8
May	16.0	16.2	16.8	15.7	16.0	15.0	15.8	16.5	15.5	16.1	16.1	16.4	16.5	14.3	17.3	16.5
June	19.0	20.3	19.8	18.9	18.8	18.9	20.4	18.9	19.5	19.4	20.0	20.6	19.8	21.3	19.3	21.0
July	22.5	21.5	22.7	21.6	22.2	21.9	23.4	21.8	21.6	23.1	21.8	22.7	22.5	23.2	22.3	23.6
August	22.8	22.8	22.7	23.0	22.8	21.9	24.0	23.3	22.6	23.9	22.4	23.7	23.5	23.8	24.2	24.8
September	20.7	21.2	21.0	21.0	21.0	21.1	21.3	21.6	22.4	21.9	21.4	20.5	22.0	22.0	22.4	23.0
October	18.8	18.6	18.0	17.0	17.9	17.0	19.8	19.8	18.7	19.3	20.4	17.4	18.6	19.0	17.7	18.0
November	14.9	15.1	15.2	13.7	15.6	15.0	16.5	14.6	15.9	14.8	15.9	14.6	15.8	15.4	14.2	15.3
December	13.481	12.152	12.313	13.19	11.719	11.6	11.4	11.152	12.368	11.019	11.758	10.8	11.7	13.20	12.80	11.10

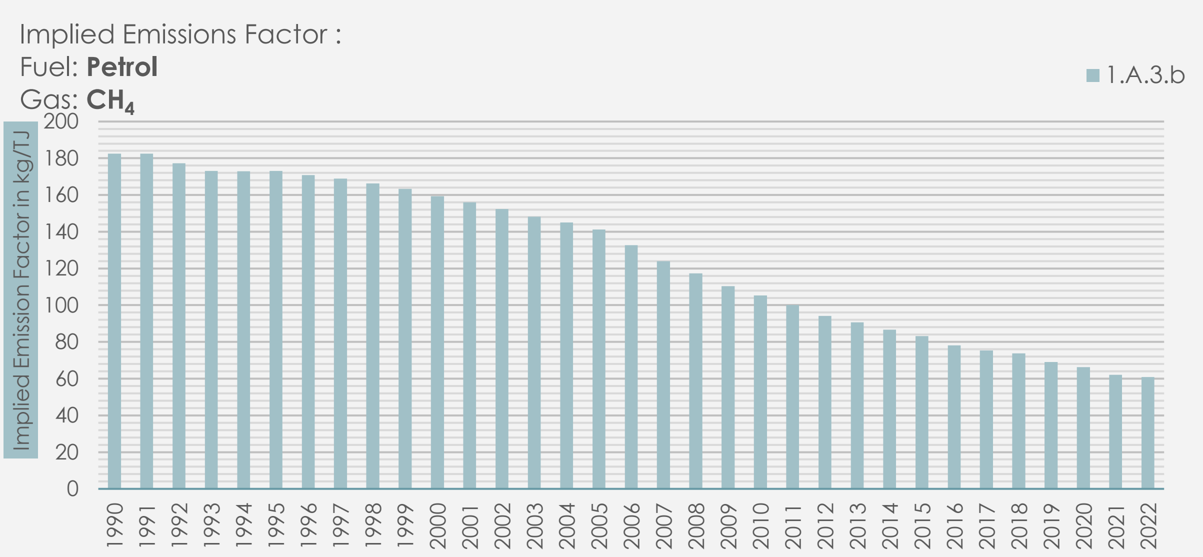
Maximum Averaged Monthly Temperature																
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
January	15.78	15.10	15.35	15.39	16.26	14.46	16.77	17.15	16.26	15.69	14.68	17.19	14.48	15.60	15.00	13.99
February	17.62	15.43	14.70	14.34	16.25	17.50	15.42	16.94	17.47	14.64	15.61	16.32	16.34	13.00	16.30	13.17
March	18.70	18.34	15.96	16.37	18.89	17.14	16.49	17.75	17.16	16.98	17.84	20.69	18.67	15.70	16.60	16.90
April	20.15	18.84	19.68	19.94	19.16	19.03	19.12	18.22	21.62	20.93	20.77	20.42	20.86	18.70	19.39	19.17
May	23.81	20.74	22.96	24.59	25.24	24.93	23.85	25.24	24.35	26.49	25.34	24.52	23.24	24.80	21.87	24.77
June	28.64	27.60	26.70	28.23	27.93	28.90	28.31	30.75	30.30	30.37	28.98	28.80	29.28	30.80	27.58	27.95
July	31.60	30.83	29.35	30.53	32.15	32.07	31.47	31.07	33.00	31.27	32.05	31.77	31.38	33.70	31.01	31.21
August	30.74	31.49	32.73	33.16	33.88	31.52	31.81	31.25	32.78	34.57	33.69	32.67	30.15	33.40	30.92	28.85
September	30.05	29.13	28.81	28.99	30.16	27.94	27.77	27.81	28.78	29.97	29.29	28.89	27.24	27.70	27.03	27.40
October	27.25	26.14	26.42	25.65	24.86	23.32	23.04	24.84	25.06	27.22	24.58	27.38	24.54	25.10	25.96	23.99
November	21.18	20.36	21.98	20.87	21.40	19.25	21.01	20.96	19.63	21.25	22.26	20.62	20.44	21.20	19.36	20.69
December	15.69	14.32	17.62	17.42	17.77	17.99	17.92	17.50	16.25	17.16	18.68	15.25	16.60	16.40	17.23	16.48
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
January	14.8	17.4	16.9	15.5	15.8	16.0	14.2	16.0	16.8	15.7	16.9	14.9	16.9	14.4	16.2	16.7
February	14.4	16.8	16.1	14.1	16.7	15.4	13.0	15.2	16.9	14.7	18.7	16.9	15.5	15.3	17.2	17.2
March	16.4	17.4	17.8	16.3	17.0	16.5	16.6	18.4	16.9	16.4	18.8	18.6	18.4	17.7	17.4	16.9
April	20.3	20.1	20.9	18.5	20.4	20.1	19.8	21.6	20.5	19.7	22.2	21.0	21.4	19.1	20.5	19.5
May	25.5	24.8	23.7	25.5	22.7	22.9	24.8	24.5	23.7	25.3	24.2	25.8	24.0	22.3	25.1	25.2
June	29.4	29.4	27.9	28.5	27.0	27.8	30.8	27.9	29.0	27.9	28.5	30.4	28.3	31.4	27.5	31.0
July	31.5	31.7	30.7	32.4	31.2	31.5	33.6	31.5	30.8	33.1	31.5	33.1	32.2	32.6	31.7	33.0
August	30.4	31.9	31.1	31.6	31.6	31.7	33.1	31.7	31.7	31.8	30.7	33.6	31.0	32.5	33.0	33.8
September	27.5	28.8	28.2	28.1	27.0	29.3	28.9	28.8	30.2	29.9	28.3	28.2	29.7	29.1	28.8	29.6
October	24.8	24.2	24.2	23.4	23.2	23.2	26.2	27.2	25.8	25.7	26.6	23.7	24.5	25.2	23.9	23.4
November	20.4	20.2	20.6	20.1	20.9	19.9	22.3	20.3	21.9	21.1	21.1	20.0	21.2	21.1	21.1	21.0
December	18.58	16.54	16.8	18.02	17.28	16.56	16.92	17.07	17.49	17.85	17.08	16.3	17.4	18.40	17.60	16.20

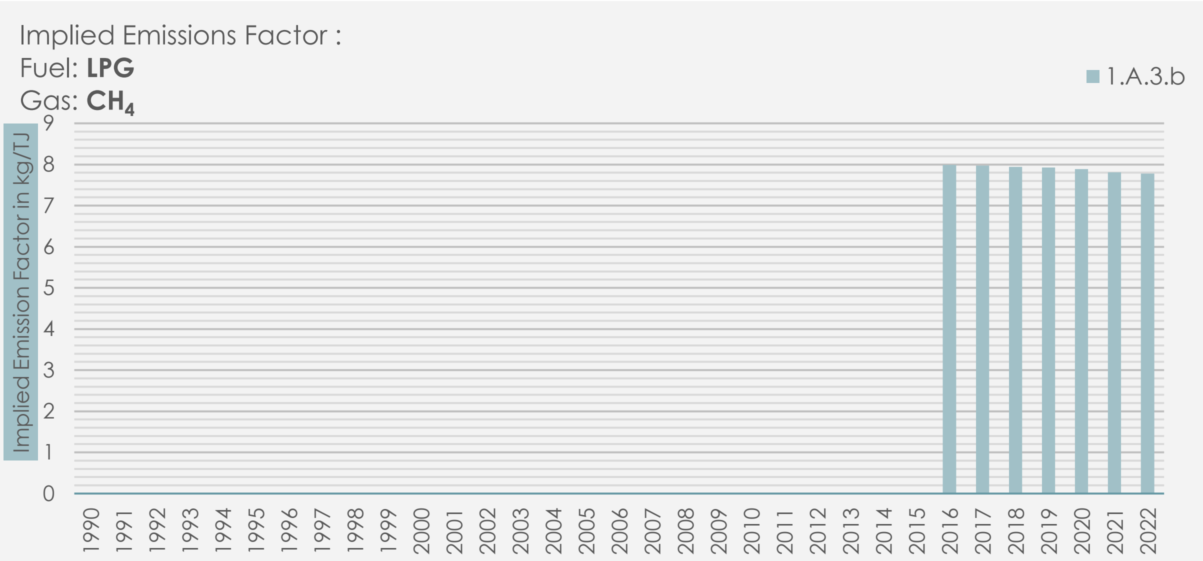
Humidity																
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
January	81%	81%	81%	83%	78%	80%	84%	83%	83%	81%	80%	81%	77%	78%	74%	73%
February	81%	79%	78%	78%	78%	83%	82%	80%	82%	79%	77%	77%	83%	73%	77%	72%
March	77%	73%	78%	79%	80%	74%	83%	77%	76%	81%	80%	77%	76%	80%	76%	77%
April	73%	75%	72%	80%	77%	76%	79%	73%	76%	77%	78%	76%	74%	82%	77%	75%
May	74%	73%	75%	79%	70%	68%	76%	69%	74%	76%	78%	75%	79%	76%	72%	68%
June	69%	68%	71%	78%	71%	68%	73%	68%	63%	71%	71%	68%	62%	64%	62%	70%
July	66%	62%	73%	69%	68%	70%	66%	70%	66%	69%	67%	72%	65%	63%	61%	62%
August	72%	72%	70%	66%	69%	72%	76%	72%	74%	68%	63%	72%	69%	68%	66%	70%
September	72%	76%	73%	73%	75%	78%	73%	81%	77%	80%	77%	77%	75%	79%	70%	75%
October	77%	75%	75%	81%	81%	81%	79%	83%	81%	77%	80%	80%	75%	80%	77%	79%
November	77%	73%	83%	78%	79%	71%	77%	83%	82%	79%	79%	70%	79%	78%	73%	73%
December	82%	73%	84%	89%	82%	82%	76%	81%	75%	78%	81%	72%	80%	73%	76%	74%
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
January	80%	77%	81%	84%	74%	84%	74%	75%	78%	78%	77%	70%	73%	70%	75%	74%
February	77%	76%	80%	75%	72%	79%	74%	75%	80%	75%	76%	81%	75%	74%	75%	77%
March	78%	81%	80%	77%	81%	80%	81%	76%	78%	82%	72%	75%	74%	77%	76%	75%
April	75%	82%	75%	82%	79%	76%	77%	75%	74%	76%	73%	73%	76%	78%	78%	75%
May	67%	71%	77%	68%	71%	72%	67%	67%	72%	67%	69%	65%	75%	70%	69%	68%
June	54%	68%	66%	67%	66%	70%	64%	62%	63%	73%	65%	61%	68%	58%	68%	59%
July	69%	60%	66%	57%	68%	62%	63%	66%	66%	67%	62%	56%	64%	63%	65%	61%
August	67%	71%	69%	70%	66%	65%	70%	70%	70%	72%	69%	59%	68%	67%	66%	64%
September	72%	71%	71%	73%	74%	71%	76%	75%	70%	71%	73%	69%	69%	74%	74%	73%
October	79%	79%	80%	75%	79%	72%	78%	75%	75%	75%	79%	73%	77%	78%	73%	77%
November	75%	76%	76%	79%	74%	79%	76%	72%	82%	79%	77%	74%	74%	73%	79%	81%
December	76%	76%	73%	73%	73%	76%	72%	76%	75%	80%	76%	67%	73%	79%	75%	75%

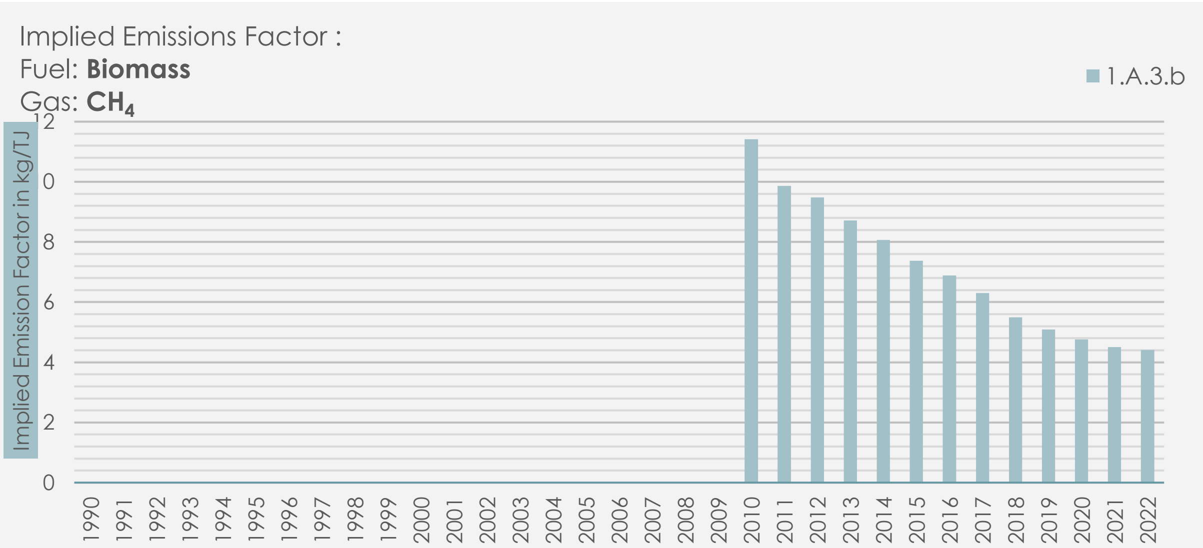
Implied Emission Factors

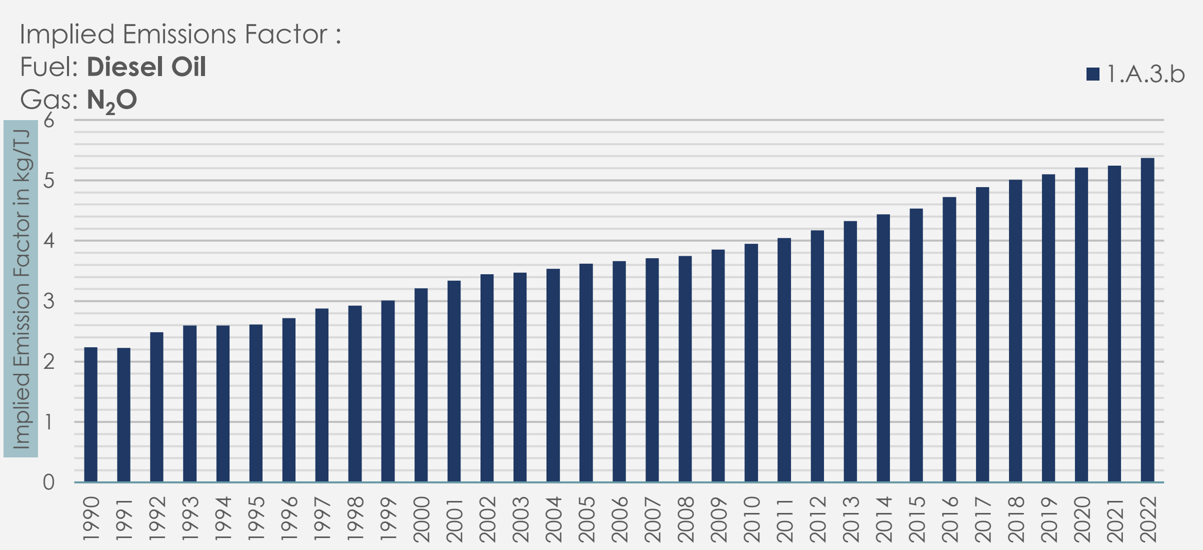
For CO_2 emissions the default emissions factors were used (Tier 1), while N_2O emissions were calculated with COPERT (Tier 3). The graphs below provide information on the methane and nitrous oxide implied emissions factors, per fuel type for category 1.A.3.b.

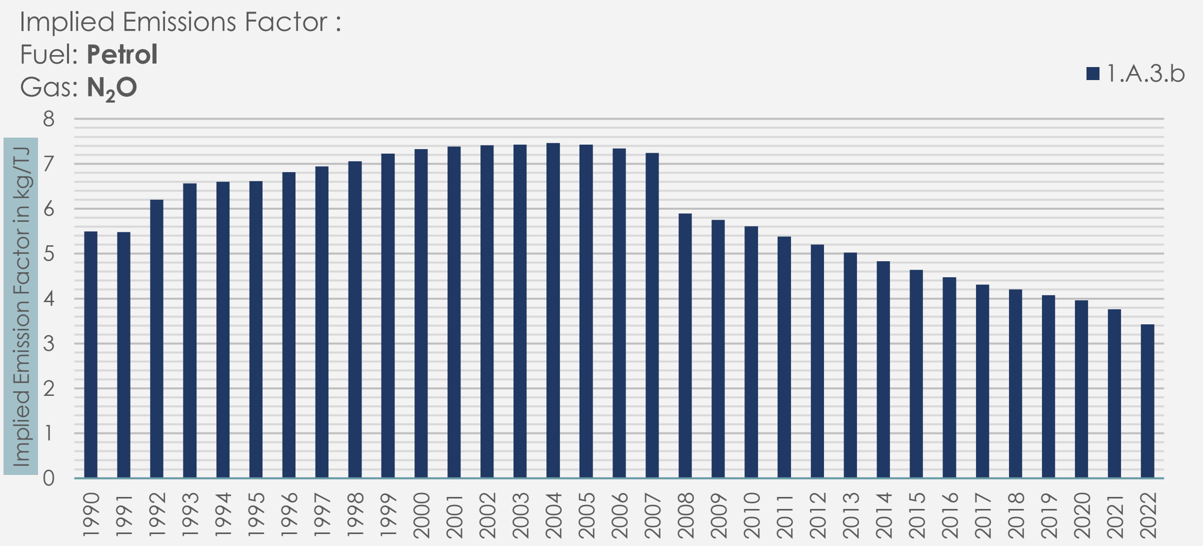


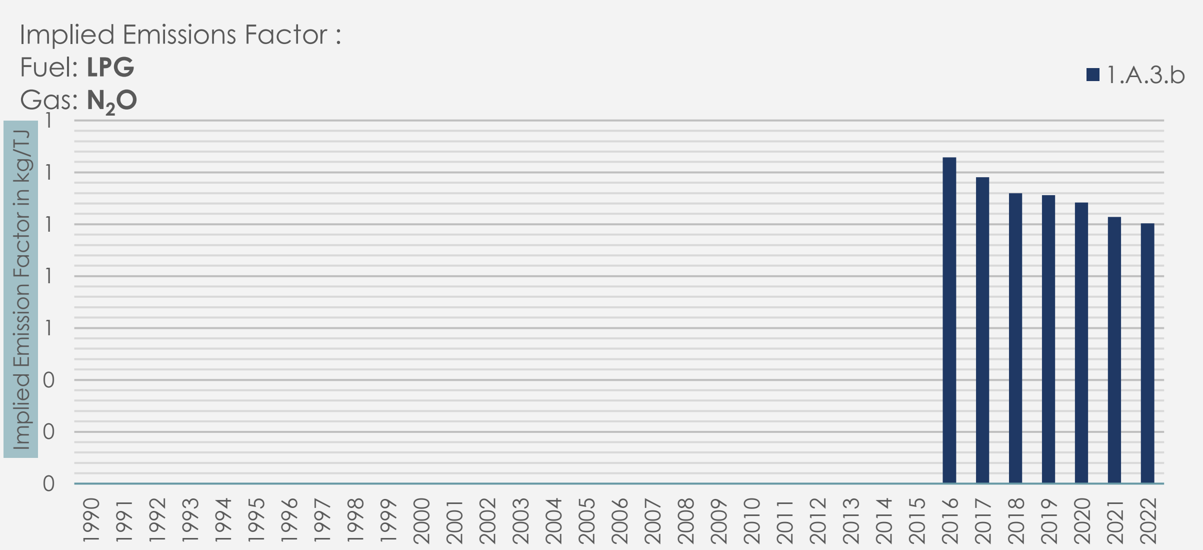

Implied Emissions Factor :
Fuel: Petrol
Gas: CH4
1.A.3.b
Implied Emission Factor in kg/TJ
200
180
160
140
120
100
80
60
40
20
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022

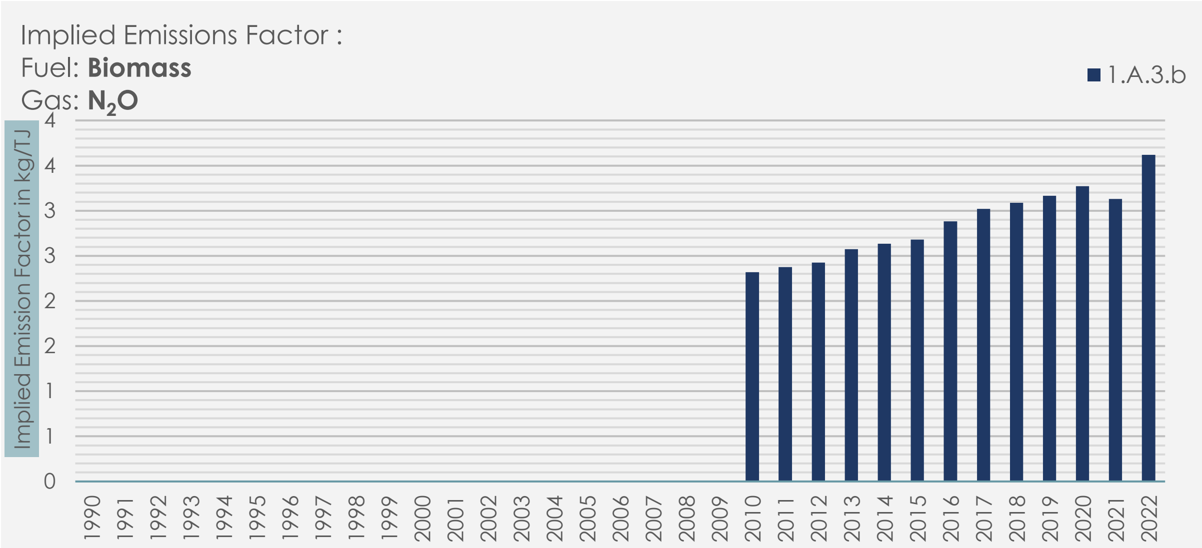

Implied Emissions Factor :
Fuel: LPG
Gas: CH4
1.A.3.b
Implied Emission Factor in kg/TJ
9
8
7
6
5
4
3
2
1
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022


Implied Emissions Factor :
Fuel: Biomass
Gas: CH4
1.A.3.b
Implied Emission Factor in kg/TJ
12
0
8
6
4
2
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022


Implied Emissions Factor :
Fuel: Diesel Oil
Gas: N2O
1.A.3.b
Implied Emission Factor in kg/TJ
0
1
2
3
4
5
6
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022


Implied Emissions Factor :
Fuel: Petrol
Gas: N2O
1.A.3.b
Implied Emission Factor in kg/TJ
0
1
2
3
4
5
6
7
8
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022


Implied Emissions Factor :
Fuel: LPG
Gas: N2O
1.A.3.b
Implied Emission Factor in kg/TJ
0
0
0
1
1
1
1
1
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022



It was noticed that there is a drop on the Implied Emission Factor of N_2O, fr category 1.A.3.b-Gasoline from 2007 t0 2008, as seen below.

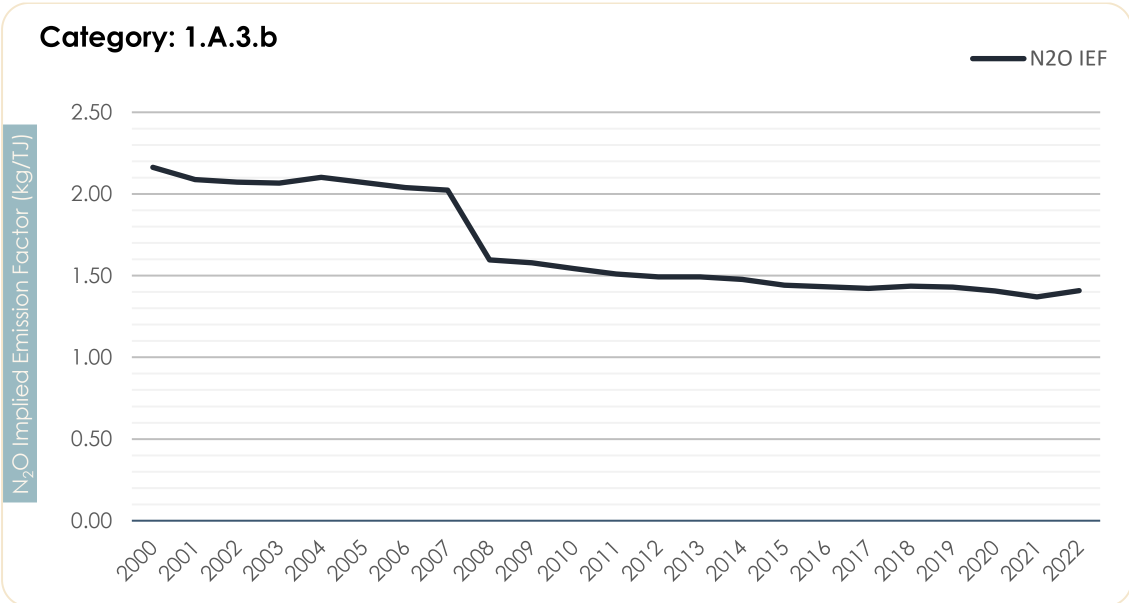


Figure 1: Implied Emission Factor for Nitrous Oxide emissions, Fuel: Gasoline, Category 1.A.3.b –Road Transportation.

As explained, Nitrous Oxide (N_2O) emissions for any fuel type are estimated via the COPERT V mode, based on specific emission factors (Tier 3 approach). All Emission factors for these gases are provided by the model. For petrol passenger cars and light commercial vehicles the following equation is used:

$$EF_{N_2O} = (a \times M_{cumulative} + b) \times \text{Emission Factor}_{BASE}$$

Where:
a,b, EF_{BASE} depend on the technology level
a,b, depend on fuel sulphur content
Different factors for cold urban, hot urban, rural and highway are used.

The observed decline can be primarily attributed to the following factors:

i.) Changes in petrol specifications concerning Sulphur content, as per revisions of the EN 228.

ii.) Improvements in vehicle technology, the introduction of more Euro 4 vehicles, and a reduction in ECE vehicles.

The change in historic sulphur content data between 2007 and 2008 was 7.38 ppm, which was the largest change observed between two years throughout the timeseries. This coincides with the sharp decrease in the N2O IEF which as noted above is also influenced by the S content.

Comparison of CO_2 emissions estimates (2006 IPCC guidelines (T1) & COPERT V (T1))

This section is dedicated to the comparison of CO_2 estimates derived using the COPERT V model and those estimated following the 2006 IPCC guidelines Tier 1 approach. Table 17-12 shows the difference in CO_2 estimates by sub-category for road transportation (year 2020). From this submission, the methodology to estimate CO_2 emissions from road transportation changed. The new methodology (explained in section 3.2.6.2) is based on the fuel consumption and default emission factors.

Table 17-12 CO_2 estimates by vehicle sub-category for category 1.A.3.b-Road Transport, year 2020.

Comparison of CO_2 estimates (IPCC Tier 1 & COPERT V): Road Transport (2020)			
CRF sub-category	**Fuel Consumption(excl biomass & Lubricants) estimated by COPERT in TJ**	**CO_2 Emissions in kt**	
		IPCC Tier 1	**COPERT V**
1.A.3.b.i-Cars	4952.911	352.811	361.200
1.A.3.b.ii-Light commercial Vehicles	981.150	72.629	72.801
1.A.3.b.iii-Heavy duty vehicles & Buses	1345.850	99.727	99.909
1.A.3.b.iv Motorcycles , Quads and ATVs	51.500	3.596	3.665
Total	**7331.41**	**528.76**	**537.58**

CO_2 emissions by COPERT are calculated using the following equation:

$$Emissions_{CO_2}^{CALC} = 44.011 \times \frac{Fuel\ Consumption^{CALC}}{12.011 \times 1.008 R_{H:C} + 16.000 R_{O:C}}$$

Assuming that all carbon in fuel is oxidised to CO_2.

The discrepancies are mainly due to the different emission factors used; information can be found in Table 17-13. In addition, COPERT V estimates emissions from the use of A/C, UREA and lube-oil.

Table 17-13 CO_2 emission factors for category 1.A.3.b-Road Transport.

Comparison of CO_2 emission factors used in COPERT to the default TPCC emission factors						
COPERT V				**IPCC**		**IPCC/COPERT**
Fuel Type	**EF CO_2 (kg/kg)**	**LHV (MJ/kg)**	**EF CO_2 (Kg/TJ)**	**LHV (MJ/kg)**	**Default CO_2 EF (kg/TJ)**	**Difference (%)**

Petrol	3.169	43.8	72 412	44.3	69 300	0.044%
Diesel	3.169	42.7	74 227	43.0	74 100	0.002%
LPG	3.020	46.6	64 938	47.3	63 100	0.029%

NATIONAL WATER-BORNE NAVIGATION (CRF 1.A.3.D)

The following section present the result of the analysis of the fuel consumption for all fuel types used in this category as mentioned in section 3.2.6.

Gas & Diesel Oil

The following graph (Figure 17-7) shows the total Gas & Diesel Oil consumption (for domestic navigation, including fuel consumed by military vessels) as reported in the submissions for 2012, 2017 and 2021. The blue line indicates the fuel consumption as reported on EUROSTAT. Since EUROSTAT data is audited, using the most up to date version is considered to be the most accurate approach, and thus from 2005 onwards it was decided to update the figures for Gas & Diesel Oil for domestic navigation in line with current EUROSTAT reporting.

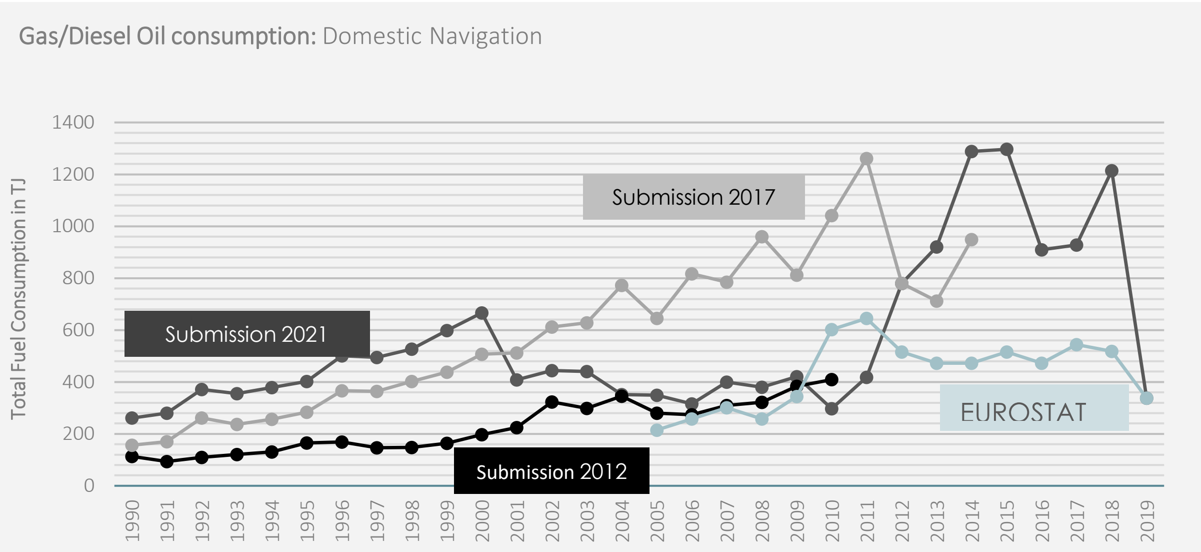


Figure 17-7 Gas and Diesel Oil consumption as submitted in 2012, 2017 and 2021. Category 1.A.3.d-Domestic Navigation.

EUROSTAT does not provide data for any year prior to 2005. The data prior to 2005 as submitted in 2012, with regards to Gas & Diesel Oil consumption, was found to be more in line with current EUROSTAT data for later years than that of other submissions, as the discrepancies for the common years of these two-time series were minimal. In addition, when projecting the figures reported in the 2012 submission, these projected figures were found to be fairly in line with current EUROSTAT figures (Figure 17-8).

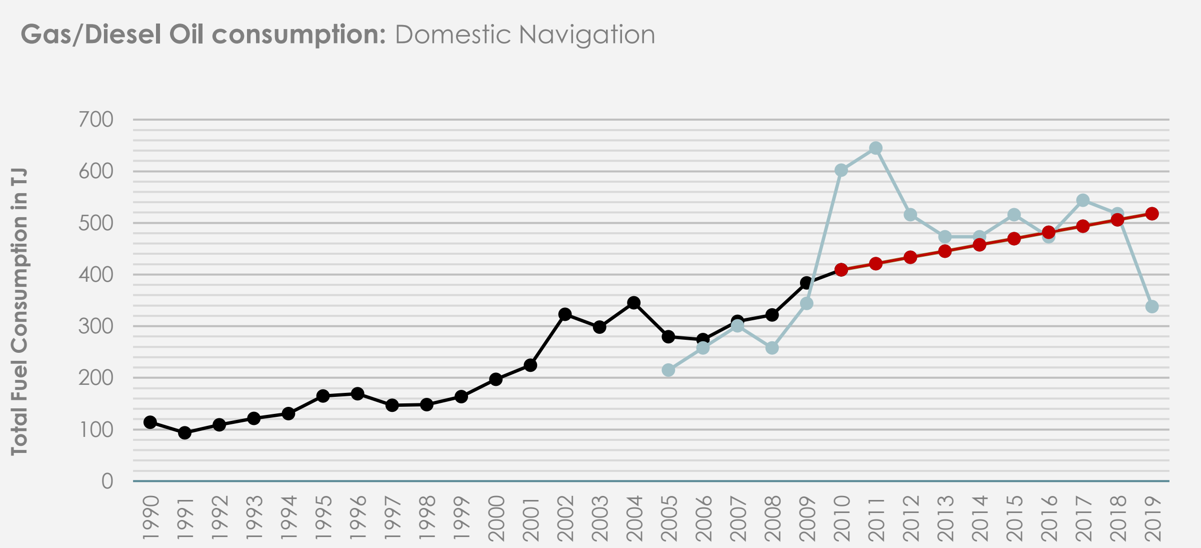


Figure 17-8 Gas and Diesel Oil consumption: projections (red line) based on the data submitted in 2012. Category 1.A.3.d-Domestic Navigation (incl military).

It was also decided to use a trend line for the years 2002, 2003 and 2004 (**Error! Reference source not found.**), as the available data was found to be inconsistent with the rest of the time series.

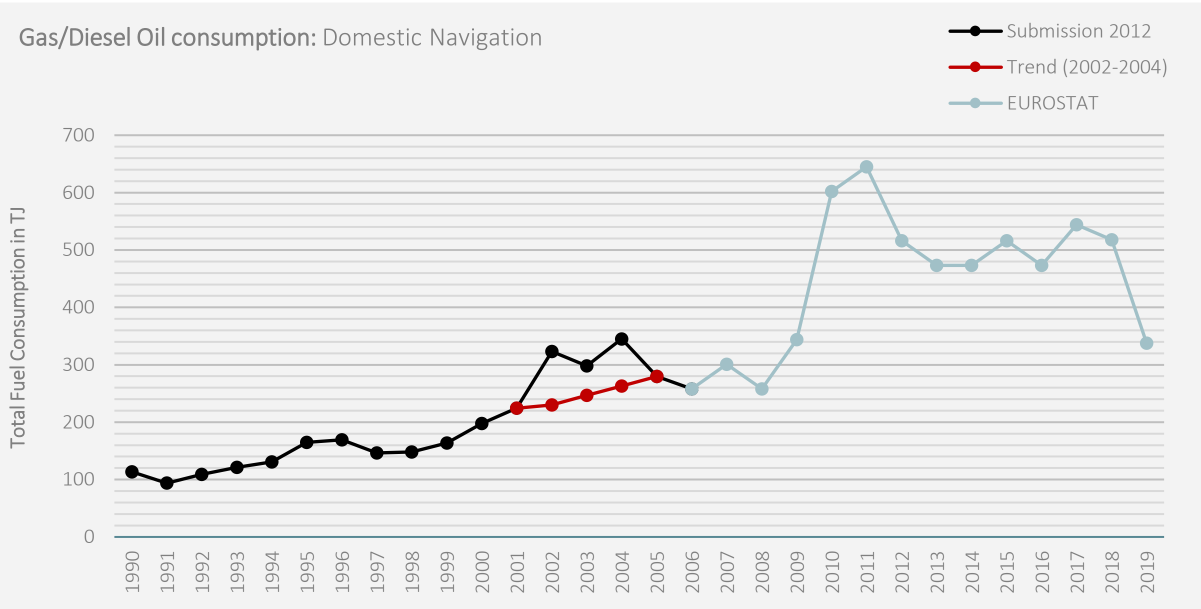


Figure 17-9 Gas and Diesel Oil consumption: trend (red line) based on the data submitted in 2012. Category 1.A.3.d-Domestic Navigation (incl military).

Motor Gasoline

Motor Gasoline data on EUROSTAT is only available since 2017. For the 2009 -2012 the data reported in the current submission were obtained from archived data from the Malta Resources Authority. The National Statistics Office provided us with data covering the period 2013-2016.

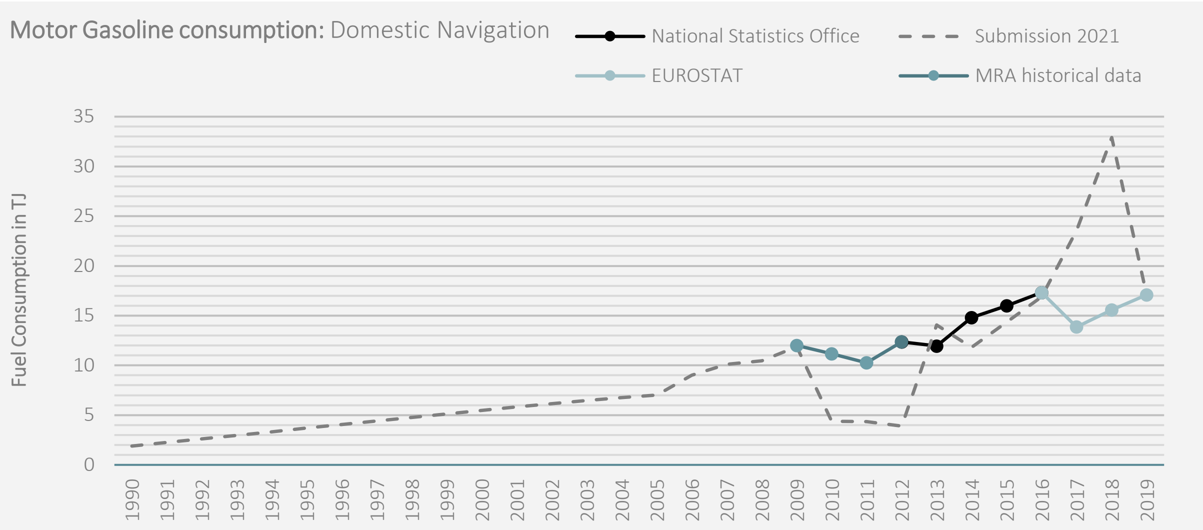


Figure 17-10 Motor Gasoline consumption for category 1.A.3.d-Domestic Navigation (incl military).

Residual Fuel Oil

In the case of Residual Fuel Oil, EUROSTAT data was not found consistent, thus it was decided to take the most conservative approach and use the higher values of the two data sources, for the years 2005-2012. For 2011, none of the available values was acceptable and a forecasted values was used instead. In addition, as it was confirmed from REWS, the used of Residual Fuel Oil in Malta was stopped in 2012.

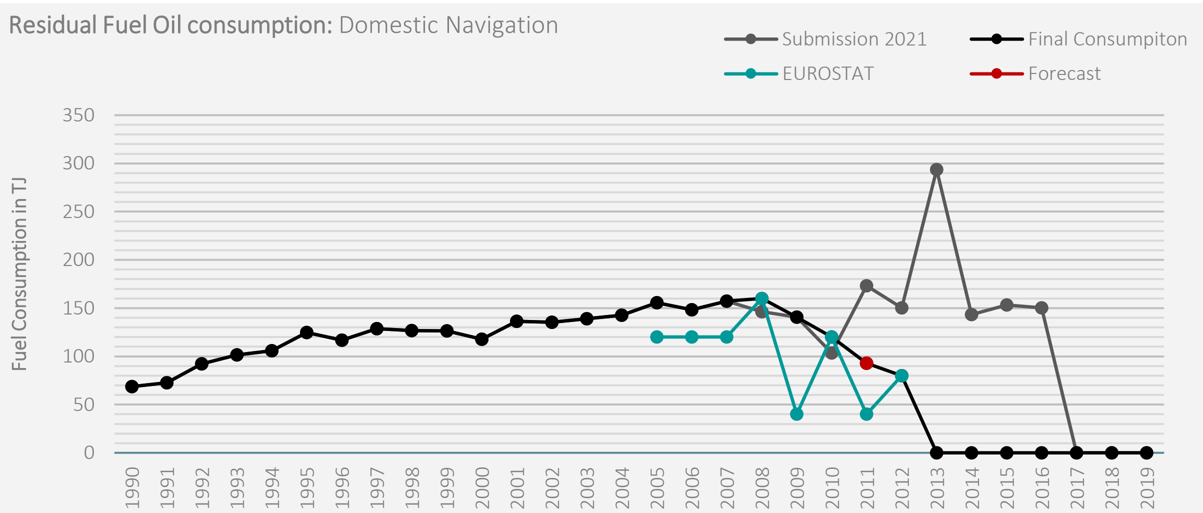


Figure 17-11 Residual Fuel Oil consumption for category 1.A.3.d-Domestic Navigation (incl military).

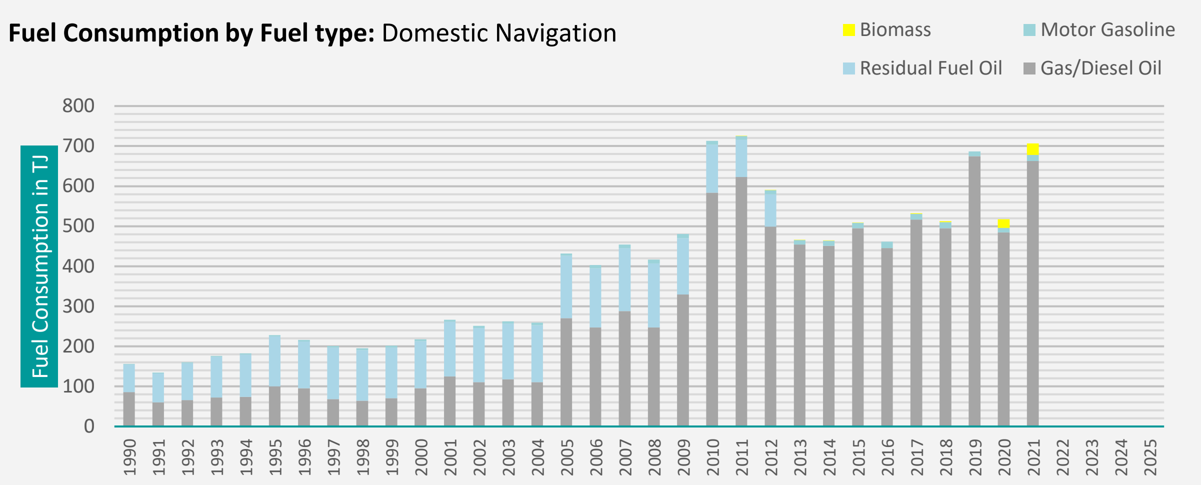


Figure 17-12 Fuel consumption by fuel type for the period 1990-2021. Category 1.A.3.d-Domestic Navigation.

NOTE: To estimate the marine bunkering fuels that are expected to be used within territorial waters (national navigation) and those outside Maltese waters (international navigation), a bottom-up methodological approach is used whereby the destination of the receiving vessel is, a priori, assumed. The total fuel sold to each receiving vessel is subsequently summed up and classified accordingly. This table lists the assumed destination of different types of receiving vessels, together with the source of the classification.

Table 17-14 Classification between National Navigation and International Navigation of sea-faring vessels.

Receiving Vessel Type	Classification	Source of Classification
Fishing Boat	Fishing Purposes	Transport Malta
Fishing Trawler	Fishing Purposes	Transport Malta
Fishing Vessel	Fishing Purposes	Transport Malta
Air Cushion Vessel	International Navigation	Transport Malta
Anchor Handling Vessel	International Navigation	Transport Malta
Asphalt Tanker	International Navigation	Assumed
Breakbulk Vessel	International Navigation	Transport Malta
Bulk Carrier	International Navigation	Transport Malta
Cable Layer	International Navigation	Transport Malta
Cargo Ship	International Navigation	Transport Malta
Catamaran	International Navigation	Transport Malta
Carrier	International Navigation	Transport Malta
Chemical Tanker	International Navigation	Transport Malta
Coast Guard Ship	International Navigation	Transport Malta
Combat Vessel	International Navigation	Assumed

Container Ship	International Navigation	Transport Malta
Crude Oil Tanker	International Navigation	Transport Malta
Cruise Liner	International Navigation	Transport Malta
DRILLING SHIP	International Navigation	Transport Malta
DRY CARGO VESSEL	International Navigation	Transport Malta
Gas Carrier	International Navigation	Transport Malta
Gas tanker	International Navigation	Transport Malta
General Cargo	International Navigation	Transport Malta
Live Stock Carrier	International Navigation	Transport Malta
LPG Tanker	International Navigation	Transport Malta
Military vessel	International Navigation	Transport Malta
Multi Purpose Offshore Vessel	International Navigation	Assumed
Naval Vessel	International Navigation	Transport Malta
Oil Products Tanker	International Navigation	Transport Malta
Passenger Ship	International Navigation	Transport Malta
Reefer	International Navigation	Transport Malta
Research/Survey Vessel	International Navigation	Transport Malta
Rig	International Navigation	Transport Malta
Ro-Ro Vessel	International Navigation	Transport Malta
Tanker Vessel	International Navigation	Transport Malta
Trawler	International Navigation	Transport Malta
Vehicle Carrier	International Navigation	Transport Malta
Warships	International Navigation	Transport Malta
Bunkering Tanker	National Navigation	Transport Malta
Comm	National Navigation	Transport Malta
Dive Vessel	National Navigation	Transport Malta
Ferry	National Navigation	Transport Malta
Floating Storage	National Navigation	Transport Malta
Motor Yacht	National Navigation	Transport Malta
Patrol vessel	National Navigation	Transport Malta
PILOT BOATS	National Navigation	Transport Malta
Pleasure Craft	National Navigation	Transport Malta
Pleasure Yacht	National Navigation	Transport Malta
Sailing Boat	National Navigation	Transport Malta

Sailing Vessel	National Navigation	Transport Malta
Supply Vessel	National Navigation	Transport Malta
Tourist Boat	National Navigation	Transport Malta
Towing Vessel	National Navigation	Transport Malta
Tug Boat	National Navigation	Transport Malta
Yacht	National Navigation	Transport Malta

3.3 REFRIGERATION AND AIR CONDITIONING – STATIONARY AIR CONDITIONING (CRF 2F1F)

Extracts from "A Note on Data Collection and Methodology", Cremona (2019), undertaken by The Energy and Water Agency in the Development of the EWA Heat-Pumps Model - Split Units

1. Data sources

1.1 Surveys

Data from surveys carried out between 2014 and 2016 were used to estimate the total stock of split unit heat pumps in Malta for 2014 in three sectors. Three surveys assessing the stock of heat pumps in Malta were undertaken:

- 2014 survey on households

A CATI survey was carried out in 2014, commissioned by EWA (then SEWCU) and carried out by NSO. The number of air-conditioning units in households, their capacity, age and other information was collected. The age of the air-conditioning units was based on whether they were 7 years or older in 2014.

- 2014 survey on enterprises employing less than 50 employees

EWA (then SEWCU) commissioned a survey in 2014 on the air-conditioning units in companies employing less than 50 employees, similar to that carried out on households.

- 2016 survey on enterprises employing more than 50 employees

EWA officials collected data on air-conditioning units installed in companies employing more than 50 employees in 2016. Data, where available, includes quantity, capacity, year of installation and coefficient of performance.

1.2 Import Data

Data on the number of heat pumps imported from 1995 to 2003 was received by EWA from NSO. This contains data on the number of units imported in Malta between these years. NSO informed that the number of units under both HS code 84151010 and 84151090 could be considered as split units in these years due to the practices at the time. Data on imports pre-1995 was manually collected by EWA from the NSO library.

Data on imports (from non-EU countries) of heat pumps from 2004 to 2018 was provided by Customs. This contains data on the number of units imported from outside the EU, including their weight and customs value.

Data on the total value (euro) and weight (kg) of heat pumps imported from 2004 to 2018 was received from NSO. This contains the total value and weight of heat pumps imported from within and outside the EU.

Data on the quantity of units imported from within the EU, including their weight, customs value and BTU range was extracted by EWA from the Intrastat database for the years 2016 - 2018; note that pre-2016, this information is not available as it was not mandatory for importers to report such data[11].

[11] Additional fields were included in the Intrastat declaration following a request made by the Agency.

Table 17-15 Overview of data sources and the information available

Data	Content
Imports pre-1995	Number of units
Imports 1995 – 2003	Number of units
Extra-EU imports 2004 – 2018	Number of units, value & weight
Intra-EU imports 2016 – 2018	Number of units, value, weight & BTU range
Total imports 2004 - 2018	Value and weight, divided by intra-EU and extra-EU imports

2. Methodology and Assumptions

2.1 Compiling the number of imported split units

Data supplied by NSO and Customs was used to estimate the number of heat pumps imported in Malta each year. The number of units imported from 1982 - 2003 were taken directly from those reported by NSO. The total number of units imported from 2004 to 2018 were sourced from NSO; for the years 2016 to 2018, this was validated against data reported by Customs (for extra-EU imports) and Intrastat (for intra-EU imports).

2.2 Calculating the Survival Rate of Heat Pumps

To calculate the total number of heat pumps still functional in a particular year (and therefore, the capacity in that year), a survival function was applied to the stock of heat pumps according to their year of installation. The Weibull function was used to estimate the survival curve of new units according to their year of import, and based on the following assumptions:

- the survival function does not change over time;
- the survival function is independent of other household factors;
- the survival function is consistent across different BTU ranges; and
- all surviving heat pumps are still in use.

The Weibull function with the parameters used in the study by Hopkins et al. (2011)[12] was applied; this study was selected as the values of all parameters required in the equation were available at the national level or, when unavailable, default parameters identified by the authors based on their data for the years 2001 to 2007 could be used. These values define a mean lifetime of 16.8 years for heat pumps.

The survival function was estimated using a modified Weibull distribution:

$$P(x) = e^{-Ln(2)\left(\frac{x-\theta}{M-\theta}\right)^{\beta}}$$

where:

P(x) is the probability that the appliance is still in use at age x;

[12] Lutz, J.D., Hopkins, A., Letschert, V., Franco, V.H. and Sturges, A., 2011. Using national survey data to estimate lifetimes of residential appliances. HVAC&R Research, 17(5), pp.726-736.

x is the appliance age. M is the median; Hopkins et al. (2011) estimate this is 14.6;

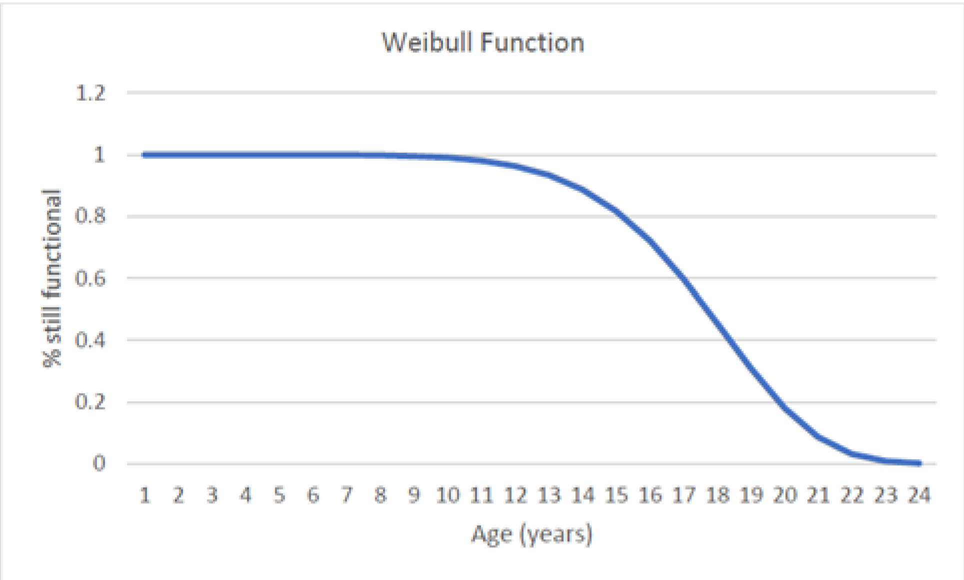
β is the shape parameter which determines the way in which the failure rate changes through time; Hopkins et al. (2011) estimate this is 1.525;

ϴ is the delay parameter which provides for a delay before any failures occur; Hopkins et al. (2011) estimate this is 0.

However, when these default parameters were applied, the survival curve generated did not fit the data as the curve overestimated the number of units which would no longer be alive after 5 years. The majority of heat pumps imported into Malta have a 5-year warranty and therefore a negligible number of units are expected to fail during the first five years. Furthermore, when the survival function was applied to the number of imports, the resulting figure for surviving units in 2014 (191,968 units) underestimated that reported by the surveys (a total of 219,691 in 2014).

Through a curve fitting exercise (modifying the median and shape of the survival function), a survival function was determined which, when applied to the number of imports, yields the number of heat pumps still functional, which tallies that reported by the survey. The median was set at 16.7, the delay at 0, and the shape at 7. This implies that the maximum age of split units in Malta is 24 years.

Figure 17-13 Weibull function



2.3 Calculating the annual stock of heat pumps

To calculate the annual stock of heat pumps, the year of installation of each heat pump must be known as the cumulative number of surviving heat pumps in Malta is based on an application of the Weibull function with the above parameters. For instance, a heat pump installed in 1982 would no longer be considered as part of the national stock as it would no longer be functional.

For the heat pump stock derived from the three aforementioned surveys (stock until end 2014), this method could not be directly applied as the year of installation was not specifically obtained through the surveys. For this purpose, a probabilistic approach was adopted, and using R Studio, the year of installation of each split unit reported in the households and SMEs surveys was estimated together with its corresponding capacity. The year of installation of heat pumps in large companies was collected by the 2016 survey, and therefore this step was not required.

2.3.1 Attributing a year to each split unit in 2014 stock

The programme R was used to attribute a random number to each BTU value in the input sheets, and then assign an age to that BTU according to the range in which that random number falls. These age ranges were determined based on the number of heat pumps imported each year, and the number of which have survived and are still functional in 2014, based on the Weibull function. This provided a distribution of surviving CAT 1 (heat pumps pre-2009) and CAT 2 (heat pumps 2009 onwards) heat pumps in 2014. This was then used to distribute the heat pumps reported by the surveys into particular years.

For example: the table below shows the percentage distribution of CAT 2 heat pumps according to their year of import. When R attributed a random number to a heat pump reported by the surveys that fell between 0 and 0.09553616, that heat pump was given 2009 as its year of installation. If the random value fell between 0.1877020 and 0.34993236, it was given 2011 as its year of installation. For statistical purposes, this process was repeated one thousand times, and the median year of installation generated for each heat pump reported in the surveys was used.

Table 17-16 The percentage distribution of CAT 2 heat pumps according to their year of import

Year	Units in 2014	Distribution	Cumlative
2009	9,230	0.10	0.09553616
2010	8,904	0.09	0.18770020
2011	15,674	0.16	0.34993236
2012	24,328	0.25	0.60173482
2013	17,238	0.18	0.78015934
2014	21,240	0.22	1.00000000

This was carried out for households and SMEs, CAT 1 and CAT 2 heat pumps. The resulting data allowed for each heat pump and its corresponding capacity to be allocated a year of installation. Therefore, the number of heat pumps functional each year can be calculated by applying the appropriate Weibull function.

2.3.2 Data validation of the 2016 survey of heat pumps in large companies

The following points describe the work undertaken to validate the results of the 2016 survey of heat pumps in large companies:

- All units with an age of 0 or 1, corresponding to an installation date of 2016 and 2015 respectively, were removed as the model uses 2014 stock as the baseline.
- All units with a BTU of more than 70,000 BTU were removed. In the survey on split units in SMEs, no heat pumps with a BTU of over 60,000 BTU were reported. Therefore, it was assumed that anything reported in large industries with a capacity over 70,000 BTU (10,000 BTU greater than the largest reported in SMEs, given that large industries may have split

units with a slightly larger capacity than the former) were incorrectly reported under the label of reversible split units, and were thus removed.

- Units with an age of 10+ were attributed an estimated age. A random number was generated for each unit and this corresponded to a year, according to the known distribution of heat pumps in large companies over 10 years old (similar to the method in section 2.3.1).
- In cases where the capacity was not reported, this was estimated in a similar manner to that described in the previous point.

3.4 AGRICULTURE

Parameters used in the characterisation of livestock described in Chapter 5 are given in the tables below. The Activity data tabulated below gives the livestock populations, typical animal mass (TAM), sometimes referred to as weight (kg), the milk yield of cattle and sheep, wool production (sheep), feed proportions fed, agriculture area data (including crop areas) and synthetic fertilizer application rates.

Table 17-17 Cattle population for the entire timeseries

	Cattle											
Population	Male Cattle <1yr	Female Cattle <1yr	Male Cattle 1-2yr	Females not yet mated 1-2yr	Heifers for slaughter 1-2yr	Other heifers 1-2yr	Male Cattle >2yr	Heifers for Slaughter Cattle >2yr	Other Heifers Cattle >2yr	Other Cows Cattle >2yr	Dairy Cows Cattle >2yr	Total
1990	2586	2949	1829	1270	116	1401	218	173	1233	50	9175	21000
1991	2713	3090	1914	1334	124	1486	226	180	1271	51	9609	22000
1992	2721	3093	1919	1349	128	1503	226	176	1242	50	9593	22000
1993	2672	3027	1891	1330	129	1487	228	167	1176	47	9345	21500
1994	2402	2763	1744	1257	103	1180	206	164	1279	42	8659	19800
1995	2273	2600	1583	1066	83	1200	192	168	1154	53	8128	18500
1996	2586	2953	1815	1210	121	1472	218	174	1206	52	9194	21000
1997	2613	2953	1820	1293	136	1523	204	161	1096	45	9155	21000
1998	2396	2687	1684	1251	130	1390	192	131	911	35	8194	19000
1999	2558	2843	1849	1301	147	1486	255	129	879	31	8523	20000
2000	1993	2556	1723	1428	0	15	174	222	2436	37	8796	19380
2001	2447	2701	1276	366	0	1820	189	264	881	141	8332	18417
2002	2348	2650	1721	1076	257	1935	199	60	491	0	8033	18770

2003	2383	2526	1586	1568	200	1584	95	66	325	0	7607	17940
2004	2635	2832	1940	1761	175	1496	238	47	449	0	7835	19408
2005	2733	2892	2260	1192	201	1592	552	72	416	0	7832	19742
2006	2659	2729	2186	1149	205	1567	614	46	391	193	7494	19233
2007	2619	2702	2209	1070	216	1476	778	169	429	229	7545	19442
2008	2055	2378	1956	1035	209	1410	708	166	415	198	7247	17777
2009	1988	2220	1565	869	179	1184	575	164	398	191	6931	16264
2010	1977	2395	1357	766	168	1043	259	143	358	126	6362	14954
2011	2070	2403	1100	1038	147	1209	180	142	370	107	6308	15074
2012	2262	2579	1276	1036	146	1210	164	136	364	100	6320	15593
2013	2076	2224	1232	1101	146	1284	222	136	372	94	6333	15220
2014	2024	2459	1008	937	134	1086	129	129	373	102	6502	14883
2015	2069	2103	1217	1055	128	1250	202	122	373	127	6374	15020
2016	1818	2064	1065	915	127	1084	176	117	377	115	6498	14356
2017	2011	2171	921	933	122	1106	159	122	365	136	6138	14184
2018	1981	2271	945	839	119	996	121	119	373	147	6214	14125
2019	1941	2062	1011	907	121	1071	132	115	360	137	6138	13995
2020	1987	2381	994	846	114	1018	109	117	371	299	6055	14291
2021	1999	2278	889	933	115	1130	119	114	348	217	5874	14016
2022	2015	2331	920	883	118	1045	114	110	360	185	6119	14200
Unit	heads	heads	heads	heads	heads	heads	heads	heads	heads	heads	heads	heads
Source	NSO	NSO	NSO	NSO	NSO	NSO	NSO	NSO	NSO	NSO	NSO	NSO
Uncertainty	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Frequency of data collection	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual

Table 17-18 Sheep and Goat population for the entire timeseries.

	Sheep						Goats					
Population	Female Lambs	Male Lambs	Ewe Lambs	Ewes	Male Sheep (ram)	Total	Female kids	Male kids	Goats mated for the first time	Goats that have already kidded	Male goats	Total
1990	2466	2420	2484	7871	758	16000	283	810	871	3866	424	6200
1991	2465	2405	2485	7889	756	16000	278	891	959	4236	466	6800
1992	2498	2382	2507	7855	758	16000	276	945	1024	4477	494	7200
1993	2496	2385	2536	7823	760	16000	295	997	1105	4776	528	7700
1994	2439	2315	2496	8008	742	16000	298	1116	1259	5392	593	8700
1995	2291	2229	2179	8603	698	16000	252	1208	1224	5793	628	9183
1996	2604	2806	2703	7051	836	16000	297	1199	1258	5654	621	9050
1997	2465	2315	2486	7994	741	16000	253	1132	1229	5264	583	8500
1998	2693	2245	2643	7649	770	16000	261	997	1124	4605	520	7500
1999	2481	2404	2711	7633	771	16000	411	752	1003	3951	445	6500
2000	1493	1311	1631	7115	451	12000	241	577	782	3078	323	5000
2001	1581	1877	492	7521	486	11957	0	667	0	2987	276	3930
2002	831	2289	2023	6620	490	12253	151	722	950	2976	364	5163
2003	2776	1007	2457	8026	595	14861	153	743	979	3129	370	5374
2004	2602	920	2231	7810	568	14131	183	738	1020	3282	412	5635
2005	893	2453	2284	8438	573	14641	957	183	1112	3619	402	6273
2006	1604	487	1750	7935	396	12172	107	664	975	3828	254	5828
2007	780	330	1060	9682	463	12315	357	138	789	4542	401	6227
2008	1014	420	1450	9438	521	12843	378	156	808	4595	424	6361
2009	701	281	943	10341	623	12889	164	86	426	4848	459	5983

2010	937	368	1267	9363	444	12379	218	105	524	3924	339	5110
2011	552	322	1183	9347	483	11887	347	125	355	3747	364	4938
2012	534	296	1220	9236	411	11697	374	133	365	3638	337	4847
2013	502	288	1176	8685	279	10930	226	84	300	3666	322	4598
2014	494	294	1152	8322	264	10526	375	126	348	3454	324	4627
2015	548	319	1301	8611	297	11076	368	131	373	3743	322	4937
2016	556	312	1165	9108	382	11523	306	111	271	3925	358	4971
2017	522	304	1191	9334	388	11739	355	125	357	3965	358	5160
2018	766	420	1552	9977	454	13169	533	185	461	4149	398	5726
2019	659	362	1436	10270	434	13161	391	138	364	4307	393	5593
2020	668	371	1418	10280	413	13150	397	142	394	4214	381	5258
2021	552	309	1158	10308	403	12730	454	155	409	4190	427	5635
2022	914	492	1717	10915	427	14465	703	239	555	4572	450	6519
Unit	heads	heads	heads	heads	heads	heads	heads	heads	heads	heads	heads	heads
Source	NSO	NSO	NSO	NSO	NSO	NSO	NSO	NSO	NSO	NSO	NSO	NSO
Uncertainty	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Data collection	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual

Table 17-19 Swine, poultry, rabbit and horse populations for the entire timeseries.

	Swine							Poultry						
Population	Piglets <20kgs	Young pigs 20-50kgs	Fattening pigs>50kgs	Breeding females - sows	Breeding females - gilts	Breeding boars	Totals	Broilers	Laying hens	Other	Totals	Rabbits	Horses	Asses, hinnies & mules
1990	26359	24775	39363	9308	794	601	101200	994144	517555	14993	1526692	51104	944	800
1991	26416	24895	39456	9333	798	602	101500	985490	513194	15028	1513713	56105	944	800

1992	27827	26348	41503	9844	843	635	107000	987061	516568	15275	1518905	61106	935	800
1993	28341	27012	42089	10049	859	649	109000	986628	522057	15412	1524096	66108	926	800
1994	28833	27739	42623	10262	878	665	111000	984331	529605	15352	1529288	71109	917	800
1995	27077	24335	40718	9459	798	613	103000	1012624	507785	14070	1534479	76110	908	800
1996	17915	16682	27184	6283	534	402	69000	1008728	516118	14824	1539671	81111	899	800
1997	18092	17441	27071	6425	562	409	70000	1004548	523995	16319	1544863	86113	889	800
1998	18094	17792	26666	6468	560	420	70000	996358	536928	16768	1550054	91114	880	800
1999	18175	18187	26106	6553	551	429	70000	983754	555252	16240	1555246	96115	871	800
2000	20673	21036	29689	7532	648	496	80074	970145	575309	14984	1560437	101117	862	800
2001	22961	13035	37586	7230	563	466	81841	1184157	375188	6284	1565629	106118	853	800
2002	18901	21356	30252	6788	602	404	78303	957500	552600	19000	1529100	114329	851	800
2003	18351	21534	24996	7035	714	437	73067	852685	505561	23298	1381544	108595	848	800
2004	19881	21807	26660	7376	603	526	76853	713919	487375	15486	1216779	97127	1085	800
2005	19489	21565	23549	7395	519	508	73025	575152	469188	7673	1052013	85660	1322	800
2006	18341	20701	26315	7144	693	489	73683	617684	516501	3956	1138140	80152	1191	800
2007	17510	21353	30368	6974	246	449	76900	660215	563814	238	1224267	74644	1060	800
2008	17591	16828	23681	6413	564	434	65511	662191	476098	1319	1139608	79297	1291	800
2009	16170	18556	23923	6195	655	419	65918	664167	388383	2400	1054950	83951	1523	800
2010	18413	17649	27631	5923	558	409	70583	666143	300667	3481	970291	88604	1754	780
2011	12316	11370	17567	4052	671	311	46287	572537	295007	1175	949261	86622	1339	760
2012	11762	12331	15838	4171	794	313	45209	610815	297015	3196	935714	84639	924	790
2013	13175	12149	18845	4261	704	317	49451	616974	297188	4264	918426	82657	1315	780
2014	11022	12026	19803	3781	564	269	47465	585186	295596	2215	882996	80674	1771	780
2015	10047	10398	18917	3531	513	228	43634	553398	294003	165	847566	78692	2195	777
2016	10001	9489	17240	3282	379	206	40597	438624	337259	2203	778086	76710	3128	779
2017	8303	8371	13667	3046	413	211	34011	438624	337254	1533	777411	76492	3671	777

2018	8585	9077	14779	3116	526	211	36294	473717	360726	616	835059	76492	4189	777
2019	7382	10776	13576	3214	344	185	35477	482211	338219	2244	822674	76492	4658	777
2020	10003	10315	15140	3792	629	211	40090	545396	338516	1109	885021	76492	5117	777
2021	9881	10336	16065	3179	478	110	40049	559876	368566	1077	929519	76492	5751	777
2022	10453	10811	16059	3709	607	194	41832	541380	337337	1283	880000	76492	5410	777
Unit	heads	heads	heads	heads	heads	heads	heads	heads	heads	heads	heads	heads	heads	heads
Source	NSO	NSO	NSO	NSO	NSO	NSO	NSO	NSO	NSO	NSO	NSO	NSO	AHWD	FAOSTAT
Uncertainty	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.5	0.2	0.95
Data collection	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual

Table 17-20 Typical Animal Masses for all livestock categories

Parameter Description	Value	Unit	Uncertainty	Source
Weight - DC	550	kg	0.05	K.Tonna, 2018 (KPH, PersCom)
Weight - NLC	640	kg	0.05	K.Tonna, 2018 (KPH, PersCom)
Weight - Bulls	630	kg	0.05	K.Tonna, 2018 (KPH, PersCom), M. Chiaramonte & R. Montebello, 2018
Weight - Calves	200	kg	0.05	K.Tonna, 2018 (KPH, PersCom)
Weight - Growing Cattle 1-2yrs	480	kg	0.05	K.Tonna, 2018 (KPH, PersCom), M. Chiaramonte & R. Montebello, 2018
Weight - Mature Ewes	50	kg	0.05	K.Tonna, 2018 (KPH, PersCom)
Weight - Mature Sheep >1yr	60	kg	0.05	K.Tonna, 2018 (KPH, PersCom)
Weight - Growing lambs	20	kg	0.05	K.Tonna, 2018 (KPH, PersCom)
Weight - piglets <20kg	10.5	kg	0.05	K.Tonna, 2018 (KPH, PersCom)
Weight - young piglets 20-50kg	35	kg	0.05	Dr. O Frendo, 2021 (KIM, PersCom)
Weight - fattening pigs >51kg	75	kg	0.05	Dr. O Frendo, 2021 (KIM, PersCom)
Weight - breeding sows	175	kg	0.05	Dr. O Frendo, 2021 (KIM, PersCom)
Weight - gilts	120	kg	0.05	Dr. O Frendo, 2021 (KIM, PersCom)

Weight - breeding boars	250	kg	0.05	Dr. O Frendo, 2021 (KIM, PersCom)
Weight - horses	550	kg	0.05	K.Tonna, 2018 (KPH, PersCom)
Weight - goats	35	kg	0.05	K.Tonna, 2018 (KPH, PersCom)
Weight – poultry BOP	1.2	kg	0.05	VPRD
Weight – poultry Layers	1.9	kg	0.05	VPRD
Weight - rabbits	2	kg	0.05	VPRD

Table 17-21 Feed proportions for sheep and cattle used in livestock characterisation.

Parameter Description	Value	Unit	Source	Uncertainty	Data Collection
Protein in feed - Other Mature Sheep	21	%	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Feed (F)	2.5	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Feed of which Forage (Fowf)	1	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Feed of which Concentrate (Fowc)	1.5	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Protein in feed - Mature Ewes	19	%	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Feed (F)	3.8	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Feed of which Forage (Fowf)	2.75	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Feed of which Concentrate (Fowc)	1.05	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Protein in feed - Growing Lambs	16.5	%	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Feed (F)	1.5	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Feed of which Forage (Fowf)	0.8	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Feed of which Concentrate (Fowc)	0.7	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Protein in feed - Dairy cows		%	KPH	0.05	Every 5 years
Feed (F)	15 (1990 – 99) 20 (2000 – 04) 24 (2005 – 14)	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years

	21.5 (2015 – present)				
Feed of which Forage (Fowf)	12 (1990 – 99) 14 (2000 – 04) 13 (2005 – 14) 10 (2015 – present)	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Feed of which Concentrate (Fowc)	3 (1990 – 99) 6 (2000 – 04) 11 (2005 – 14) 11 (2015 – present)	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Protein in feed - Non-lactating cows		%	KPH	0.05	Every 5 years
Feed (F)	15 (1990 – 99) 20 (2000 – 04) 24 (2005 – 14) 21.5 (2015 – present)	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Feed of which Forage (Fowf)	12 (1990 – 99) 14 (2000 – 04) 13 (2005 – 14) 10 (2015 – present)	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Feed of which Concentrate (Fowc)	3 (1990 – 99) 6 (2000 – 04) 11 (2005 – 14) 11 (2015 – present)	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Protein in feed - Bulls	14	%	KPH	0.05	Every 5 years
Feed (F)	13	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Feed of which Forage (Fowf)	7	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Feed of which Concentrate (Fowc)	6	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years

Protein in feed - Calves	18	%	KPH	0.05	Every 5 years
Feed (F)	-	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Feed of which Forage (Fowf)	0.1	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Feed of which Concentrate (Fowc)	0.8	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Protein in feed - Growing Cattle	14	%	KPH	0.05	Every 5 years
Feed (F)	13	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Feed of which Forage (Fowf)	7	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years
Feed of which Concentrate (Fowc)	6	kg day-1	K.Tonna, 2018 (KPH, PersCom)	0.05	Every 5 years

Table 17-22 Milk production and yield activity data for dairy cattle and sheep.

Parameter	Total Cow's Milk	Milk yield - cow	Cow's Milk Fat Content	Total Sheep Milk	Milk yield – sheep
Unit	tonnes	kg/head/day	%	tonnes	kg/head/day
1990	33852.00	10.11	2.50	1667.28	0.44
1991	35544.29	10.13	2.50	1635.08	0.43
1992	37236.59	10.63	2.74	1641.09	0.43
1993	38928.88	11.41	2.60	1634.08	0.43
1994	40621.18	12.85	2.50	1627.69	0.42
1995	42313.47	14.26	2.40	1798.48	0.46
1996	43368.11	12.92	2.47	1474.03	0.41
1997	45988.15	13.76	2.34	1671.17	0.44
1998	46450.62	15.53	2.35	1599.05	0.43
1999	47154.12	15.16	2.47	1595.70	0.42
2000	46471.52	14.47	2.53	1487.41	0.47
2001	46240.91	15.20	2.63	1572.29	0.54
2002	43623.39	14.88	2.67	1465.25	0.46

2003	40844.00	14.71	2.74	1776.95	0.46
2004	41964.00	14.67	2.80	1690.82	0.46
2005	42304.00	14.80	2.90	1801.20	0.46
2006	42074.00	15.38	3.07	1609.92	0.46
2007	41378.00	15.03	3.07	1739.74	0.44
2008	40797.00	15.42	3.18	1783.01	0.45
2009	40219.00	15.90	3.19	1818.55	0.44
2010	42996.00	18.52	3.23	1732.84	0.45
2011	42570.00	18.49	3.32	1712.77	0.45
2012	44283.00	19.20	3.37	1703.16	0.45
2013	41851.00	18.11	3.40	1607.62	0.45
2014	42832.79	18.05	3.31	1545.74	0.45
2015	41637.85	17.90	3.36	1622.04	0.45
2016	43213.09	18.22	3.39	1671.59	0.45
2017	41091.36	18.34	3.40	1712.56	0.45
2018	40412.67	17.82	3.36	1888.80	0.45
2019	41505.03	18.53	3.28	1910.54	0.45
2020	42181.90	19.09	3.31	1908.24	0.45
2021	39535.54	18.44	3.50	1858.27	0.44
2022	38974.47	17.45	3.25	2070.25	0.45
Source	NSO	Total milk*1000/dairy cows/365	MDP	NSO	
Uncertainty	0.05		0.05	0.05	
Data Collection	Annual	Annual	Annual	Annual	Annual

Note on gap filling for milk production:

Values for total cow milk are available for 1990 (33852 t [source: FAO 1992]) and 1995 (42313.47 t [Source: NSO, 2001]), and therefore data gaps occur for 1991-1994. The method to gap fill used was the following:

1991: (33852+(42313.47-33852)/5) = 35544.29 t

1992: (35544.29 +(42313.47-33852)/5) = 37236.59 t

1993: (37236.59 +(42313.47-33852)/5) = 38928.88 t

1994: (38928.88+(42313.47-33852)/5) = 40621.18 t

This method is being used because the value for 1995 is higher than that of 1990, which shows an increasing trend in the milk production. Even though the population of Dairy cattle is higher in 1990 compared to 1995, the milk production is higher since feeds were changed to improve the efficiency of the cows and their milk production capabilities. Therefore, gap filling for milk production using the trend in population as a predictor was not possible in this case.

Table 17-23 Wool production values of sheep used in Enteric Fermentation, Sheep, calculations

Parameter Description	Value	Unit	Source	Data Collection
Wool Produced per year (PrWool) (Mature Ewes)	1.3	kg	Bigi, D & Zanon, A. (2020) Atlante delle razze autoctone (ewes and growing lambs)	Every 5 years
Wool Produced per year (PrWool) (Other Mature Sheep)	2.5	Kg	Bigi, D & Zanon, A. (2020) Atlante delle razze autoctone (rams)	Every 5 years

Table 17-24 Activity data on land areas used in the estimation of N2O emissions from agricultural soils

Parameter	FSN	TAL	UAA	FCL	Area	Area	Area	Area	Area	Area	Area
Parameter Description	Synthetic Nitrogen Fertiliser application	Total Agricultural Land (TAL)	Utilised Agricultural Area (UAA)	Land area Under Fodder (FCL)	Land area under wheat	Land area under barley	Land area under bean	Land area under other fodder	Land area under potato	Land area under carrot	Land area under clover + vetch (sulla)
Unit	kg N/ha	13493	9780	6421	2381	542	259	334	1783	53	1040
1990	60.30	13493	9768	6243	1400	800	268	308	1070	54	983

1991	60.30	13493	9757	6065	1600	796	277	282	1200	55	926
1992	60.30	13493	9746	5887	2000	700	286	257	1265	56	870
1993	60.30	13493	9735	5709	2200	600	295	231	1400	57	813
1994	60.30	11418	9724	5531	2400	550	304	205	1400	58	756
1995	60.30	11418	9712	5353	1100	900	313	180	1250	59	699
1996	60.30	10378	9701	5176	2200	500	322	154	1500	59	642
1997	60.30	9342	9690	4998	2303	519	331	128	1783	65	586
1998	60.30	9342	9679	4820	2183	539	340	102	1783	63	529
1999	60.30	9342	9668	4642	2381	542	349	77	1783	65	472
2000	60.30	10149	9657	4464	3572	426	358	51	1154	63	415
2001	60.30	10378	10223	4831	2000	510	366	54	1152	70	438
2002	60.30	10987	10790	5197	2400	540	401	56	1207	60	461
2003	60.30	10052	10520	4886	2528	577	366	54	1100	58	443
2004	60.30	11071	10250	4574	2618	550	381	52	820	35	426
2005	60.30	9809	10290	4631	2600	500	337	53	820	40	431
2006	60.30	11018	10330	4688	2800	550	383	53	712	50	436
2007	60.30	9798	10703	4984	3000	500	341	57	700	40	464
2008	71.00	9798	11077	5280	2800	520	341	60	700	38	491
2009	80.98	12529	11450	5553	2946	517	425	63	701	51	515

2010	90.31	11128	11260	5653	3006	508	377	64	701	51	525
2011	104.00	11958	11070	5753	3007	507	406	65	701	40	534
2012	118.16	12466	10880	5290	3058	507	434	60	689	53	492
2013	132.82	13275	10980	5202	3100	506	462	59	700	47	484
2014	144.09	14084	11080	5115	3050	498	490	58	700	47	477
2015	155.16	12723	11180	5440	3239	529	430	62	768	47	506
2016	166.03	13199	11929	5647	3239	529	430	62	690	47	506
2017	167.09	13199	11530	5647	3082	503	480	59	690	47	482
2018	173.08	13199	11130	5647	3266	533	421	63	690	47	510
2019	154.98	11403	10731	5252	3182	519	448	61	570	18	497
2020	204.12	11403	10731	5252	3219	525	436	62	570	18	503
2021	191.45	13493	9780	6421	2381	542	259	334	1783	53	1040
Source	Calculation based on UAA and Fertilizer Application (NSO)	NSO/FAO	NSO/FAO/Eurostat	NSO/FAO	NSO/FAO	NSO/FAO	NSO/FAO	NSO/FAO	NSO/FAO	NSO/FAO	NSO
Uncertainty	1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Data Collection	yearly	yearly	yearly	yearly	yearly	yearly	yearly	yearly	yearly	yearly	yearly

Table 17-25 Parameters used in the estimation of N2O emissions from manure management

Livestock category	Nretention_frac(T) (KgN retained/ animal/day)	Uncertainty	TAM	WG (kg/day)	N gain	CP% (Table 10.A1 / CS)	DMI (Kg/animal/day)	N rate Default Table 10.19	EF3 (Table 10.21)	EF4 (Table 11.3)	EF5 (Table 11.3)	Uncertainty	FracLeach	FracGas	Notes
Dairy Cattle	CS	(+/-)50%	550	0	NA	16.1		T2	0.01	0.01	0.011	0 - 0.02	0.02	0.3	
Bulls	CS	(+/-)50%	630	0.4		16.5		T2	0.01	0.01	0.011	0 - 0.02	0.02	0.45	
Replacement/growing	CS	(+/-)50%	550	0		14.7		T2	0.01	0.01	0.011	0 - 0.02	0.02	0.45	
Growing cattle	CS	(+/-)50%	480	0.4		14.7		T2	0.01	0.01	0.011	0 - 0.02	0.02	0.45	
Calves on forage	CS	(+/-)50%	200	0.3		16.5		T2	0.01	0.01	0.011	0 - 0.02	0.02	0.45	
Mature Ewes	0.1	(+/-)50%	50	N/A		5.2		T2	0.01	0.01	0.011	0 - 0.02	0.035	0.4	
Mature Sheep	0.1	(+/-)50%	60	N/A		5.2		T2	0.01	0.01	0.011	0 - 0.02	0.035	0.4	
Growing Lambs	0.1	(+/-)50%	20	N/A		5.2		T2	0.01	0.01	0.011	0 - 0.02	0.035	0.4	
Goats	NA	(+/-)50%	40	N/A		3.66		0.46	0.01	0.01	0.011	0 - 0.02	0.035	0.4	
Fattening 29 to 36 (piglets)	NA	(+/-)50%	7 to 10	N/A	0.028	19	0.4	T2	0.002	0.01	0.011	0 - 0.02	0	0.25	Ckg =1.2kg, WKg=20kg
Fattening 37 to 54 (piglets)	NA	(+/-)50%	11 to 20	N/A	0.022	18	0.8	T2	0.002	0.01	0.011	0 - 0.02	0	0.25	
Fattening 55 to 84 (grower)	NA	(+/-)50%	50 to 65	N/A	0.021	17	1.6	T2	0.002	0.01	0.011	0 - 0.02	0	0.25	
Fattening 85 to 112 (grower)	NA	(+/-)50%	65 to 80	N/A	0.021	16	12.6	T2	0.002	0.01	0.011	0 - 0.02	0	0.25	
Fattening 113 to 180 (grower)	NA	(+/-)50%	80 to 115	N/A	0.019	15.5	3.4	T2	0.002	0.01	0.011	0 - 0.02	0	0.25	
Pre-Farrowing Sows/Gilts	NA	(+/-)50%	120 to 150	N/A	0.018	14	2.5	T2	0.002	0.01	0.011	0 - 0.02	0	0.25	
Lactating Sows	NA	(+/-)50%	180 to 250	N/A	0.019	15.5	5	T2	0.002	0.01	0.011	0 - 0.02	0	0.25	LITSIZE=14 heads, FR=2.4 parturitions per year, Skg=14 kg
Boars	NA	(+/-)50%	110 to 275	N/A	0.016	14	2.5	T2	0.002	0.01	0.011	0 - 0.02	0	0.25	
Horses	NA	(+/-)50%	550	N/A		T1		0.26	0.01	0.01	0.011	0 - 0.02	0.02	0.12	
Hinnies, asses and mules	NA	(+/-)50%	245	N/A		T1		0.26	0.01	0.01	0.011	0 - 0.02	0.02	0.12	
Poultry (BOP)	NA	(+/-)50%	1.2	N/A		T1		0.82	0.001	0.01	0.011	0 - 0.02	0	0.4	
Poultry (Layers)	NA	(+/-)50%	1.9	N/A		T1		0.87	0.001	0.01	0.011	0 - 0.02	0	0.4	
Rabbits	NA	(+/-)50%	2	N/A		T1		8.1	0.001	0.01	0.011	0 - 0.02	0	0.48	

Livestock Populations Data Analysis Report

Annual livestock population data is usually obtained from the National Statistics Office (NSO), who collect livestock statistics through the following six censuses/surveys:

- Census of Agriculture (published every decade);
- Cattle census (published annually);
- Sheep and goats census (published annually);
- Pig census (published annually);
- Farm Structure survey (published every 2 years); and
- Agriculture and Fisheries Census (published annually).

Since NSO data does not always match Eurostat data, a number of consistency issues crop up during the review process (as in FCCC/ARR/2022/MLT A.1 and A.2). For this reason, an analysis of the livestock population data was carried out in 2022.

Livestock population data is available from 4 sources: the National Statistics Office (NSO), the Animal Health and Welfare Department (AHWD), FAOSTAT and Eurostat. The values from none of these sources match, even though the data from NSO should be in line with Eurostat data that is transmitted on a yearly basis in respect to Cattle, Sheep, Goats and Swine, as stipulated in Eurostat Regulation (EU) 1165/2008. The AHWD obtain their values through tagging and registration of livestock.

The AHWD data should be the most accurate, as most livestock are tagged, micro-chipped or registered. Bovines and small ruminants (ovine and caprine). are individually tagged, horses are microchipped, while poultry are registered as batches (not individually identified). Nonetheless, there are several farmers who do not register/tag their livestock, and thus are not captured in the livestock database. The AHWD database started to operate in 2006 for bovines only; other species were added by time. Thus, data before 2006 is unavailable, and data covering the early years of the database might not be very accurate. For bovines, small ruminants and poultry, information is divided between Malta and Gozo, age and sex, while horses are registered under a generic registration and cannot be divided. With regards to water buffalos there are very few registered in Malta and they are all found on one farm.

Values gathered through surveys conducted by the NSO should fill the AHWD data gaps, however there are occasions where farmers lie about the number of livestock on their farm, and thus present another source of uncertainty. FAOSTAT data used to be populated through NSO survey data and calculated data, however their data is revised frequently, in fact the last extraction of data has revealed that their time series is now fully calculated. Hence, neither of the data sources are 100% accurate. Moreover, none of the data providers provide the entire timeseries required for the NIR, i.e. 1990 – year X-2.

An analysis of the livestock population data from the 4 different sources has been carried out. Firstly, a comparison was made. It was evident that sources did not match. The NSO was asked about the mismatch in numbers, and as a result, several revisions were made, as listed below. Some discrepancies remain between NSO and Eurostat; however, these are mostly due to the fact that Eurostat data is rounded.

- Eurostat data: Data related to pigs was not correctly included under the respective years. This has been updated.

- NSO data: Data related to goats for 2020 has been updated as there was a missing number in the data provided last year. Ewes and total sheep data from 2002 to 2015 has been updated as there were some errors in the data provided at that time. The breakdown for 2017 was provided as there was no data.

- FAOSTAT Data: The latest data that NSO have provided to FAO is for 2019. NSO assume that data for 2020 has been compiled directly by FAO.

Most of the data for Cattle, Sheep, Goats and Pigs given by NSO is the same as Eurostat data and FAOSTAT. When it comes to Eurostat data, some differences could still occur due to rounding, since data is transmitted to Eurostat in 1000 heads. According to NSO, the differences between the NSO data and AWHD for Cattle, sheep and goats are due to the time when the data is extracted since AHWD database is updated daily. For cattle, sheep, goats and pigs, NSO suggested to use NSO data for the purposes of the national inventory, as this is the actual data.

With regards to poultry, the data that is provided by NSO is an average of the number of heads present during that year (i.e. average of AHWD).

As for Horses, NSO provide provided the number of horses that are reared on agricultural holdings. For data representative of all the horses reared in Malta, it is suggested to use AWHD data, as that includes all the horses (including those used for races).

As seen in the charts and tables below, data from the 4 sources is quite consistent, with some discrepancy occurring between NSO and Eurostat due to rounding. AHWD is generally also quite close to NSO data, with the exception of the earlier years when the database started to be populated. On the other hand, FAOSTAT data seems vary for some years, and there also seems to be discrepancy between NSO and FAOSTAT in terms of the inputting of data, where data seems to be reported a year later in FAOSTAT.

CATTLE

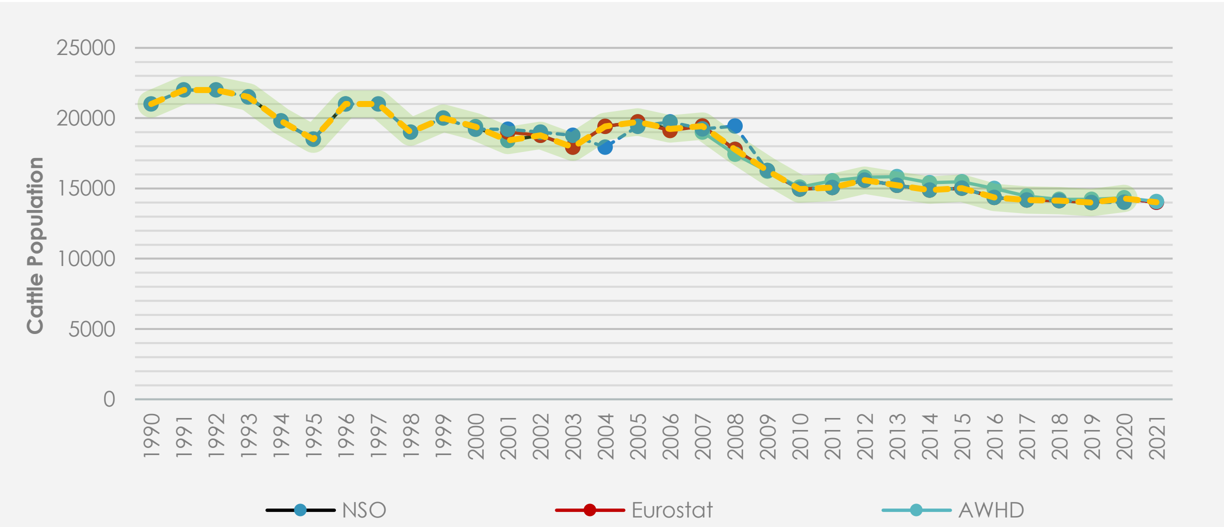


Figure 17-14 Comparison of data from different data sources; Cattle

Table 17-26 Data for cattle population from all 4 data sources and 2022/23 submissions

Cattle						
	NSO	Eurostat	AWHD	FAOSTAT	2022 submission	2023 submission
1990	N/A	N/A	N/A	21000	21000	21000
1991	N/A	N/A	N/A	22000	22000	22000
1992	N/A	N/A	N/A	22000	22000	22000
1993	21500	N/A	N/A	21500	21500	21500
1994	19800	N/A	N/A	19800	19800	19800
1995	18500	N/A	N/A	18500	18500	18500
1996	21000	N/A	N/A	21000	21000	21000
1997	N/A	N/A	N/A	21000	21000	21000
1998	N/A	N/A	N/A	19000	19000	19000
1999	N/A	N/A	N/A	20000	20000	20000
2000	19380	N/A	N/A	19200	19380	19380
2001	18417	19000	N/A	19200	18417	18417
2002	18770	18770	N/A	19003	18770	18770
2003	17940	17940	N/A	18770	17940	17940
2004	19408	19410	N/A	17940	19408	19408
2005	19742	19740	N/A	19408	19742	19742
2006	19233	19120	N/A	19742	19233	19233
2007	19442	19440	19014	19233	19442	19442
2008	17777	17780	17435	19442	17777	17777
2009	16264	16260	16222	16264	16264	16264
2010	14954	14950	15088	14954	14954	14954
2011	15074	15070	15532	15074	15074	15074
2012	15593	15590	15799	15593	15593	15593
2013	15220	15220	15831	15220	15220	15220
2014	14883	14880	15406	14883	14883	14883
2015	15020	15020	15482	15020	15020	15020
2016	14356	14360	14995	14356	14356	14356
2017	14184	14180	14439	14184	14184	14184
2018	14125	14120	14215	14120	14125	14125
2019	13995	14000	14212	14000	13995	13995
2020	14291	14290	14325	14010	14291	14291
2021	14016	14020	14069	N/A	-	14016

***Light orange shading shows calculated data; green shading shows official data; *rounded values.**

SWINE

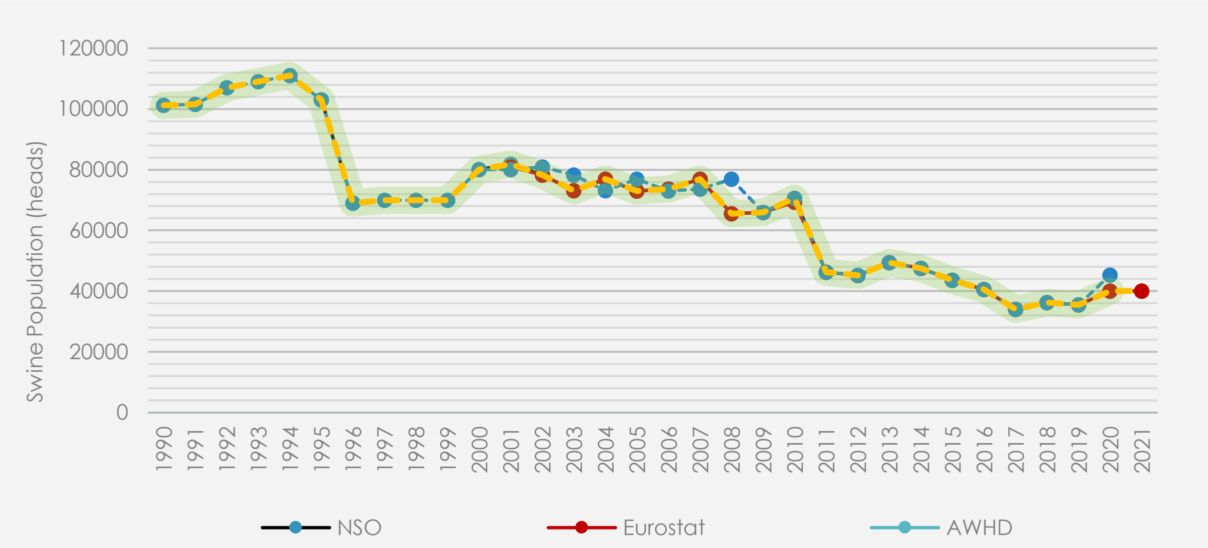


Figure 17-15 Comparison of data from different data sources; Swine

Table 17-27 Data for swine population from all 4 data sources and 2022/23 submissions.

	Swine					
	NSO	Eurostat	AWHD	FAOSTAT	2022 submission	2023 Submission
1990	N/A	N/A	N/A	101200	101200	101200
1991	N/A	N/A	N/A	101500	101500	101500
1992	N/A	N/A	N/A	107000	107000	107000
1993	N/A	N/A	N/A	109000	109000	109000
1994	N/A	N/A	N/A	111000	111000	111000
1995	103000	N/A	N/A	103000	103000	103000
1996	69000	N/A	N/A	69000	69000	69000
1997	N/A	N/A	N/A	70000	70000	70000
1998	N/A	N/A	N/A	70000	70000	70000
1999	N/A	N/A	N/A	70000	70000	70000
2000	80074	N/A	N/A	80074	80074	80074
2001	81841	80900	N/A	80074	81841	81841
2002	78303	78300	N/A	80898	78303	78303
2003	73067	73070	N/A	78303	73067	73067
2004	76853	76850	N/A	73067	76853	76853
2005	73025	73030	N/A	76853	73025	73025
2006	73683	73680	N/A	73025	73683	73683
2007	76900	76900	N/A	73683	76900	76900
2008	65511	65510	N/A	76900	65511	65511
2009	65918	65920	N/A	65918	65918	65918
2010	70583	69280	N/A	70583	70583	70583
2011	46287	46290	N/A	46287	46287	46287
2012	45209	45210	N/A	45209	45209	45209
2013	49451	49450	N/A	49450	49451	49451

2014	47465	47470	N/A	47465	47465	47465
2015	43634	43630	N/A	43634	43634	43634
2016	40597	40600	N/A	40597	40597	40597
2017	34011	34010	N/A	34011	34011	34011
2018	36294	36290	N/A	36290	36294	36294
2019	35477	35480	N/A	35480	35477	35477
2020	40090	40090	N/A	45270	40090	40090
2021	40049	40050	N/A	N/A	-	40049

***Light orange shading shows calculated data; green shading shows official data; dark orange shading shows data that was revised by NSO after our communication.**

SHEEP

As seen in below, for some years, sheep data varies substantially between the 4 sources. For this category, NSO data has been favoured. The consistency between NSO and Eurostat data is high, again with some discrepancies occurring due to rounding of Eurostat data. Although FAOSTAT data should be official (and based on NSO) it seems that the data hasn't been updated. AHWD is close to NSO data, however, varies in the earlier years of use of the database when accuracy was much lower. The dark orange value was provided by NSO to Eurostat (after our communication with them of errors). The discrepancy still exists, however according to NSO, this is due to the rounding of values (even though strictly speaking, the rounding could have been applied at 12100).

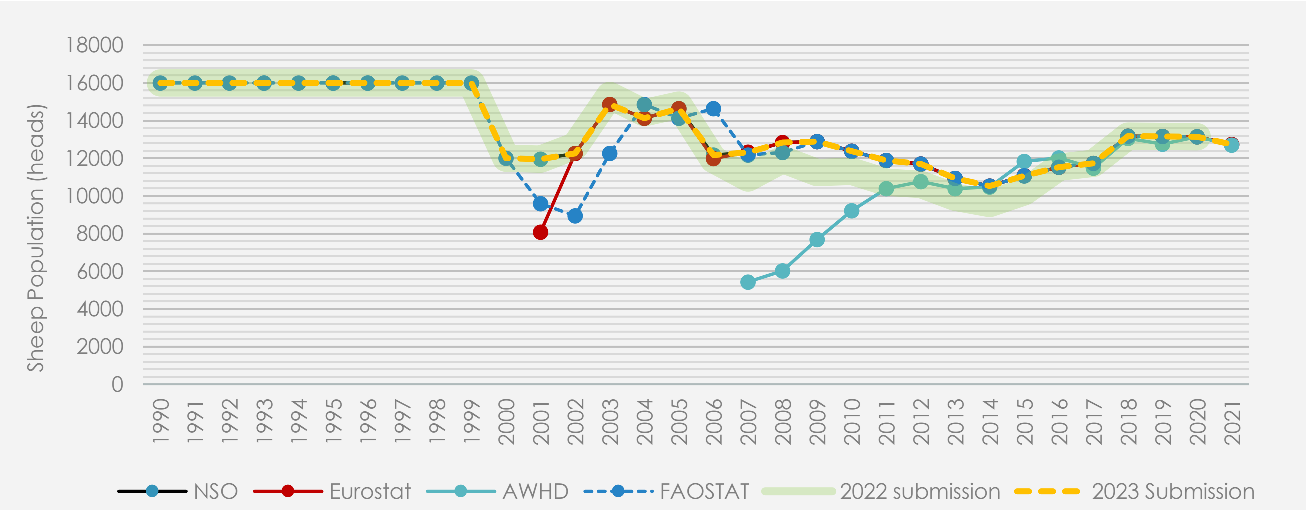


Figure 17-16 Comparison of data from different data sources; Sheep

Table 17-28 Data for sheep population from all 4 data sources

	Sheep					
	NSO	Eurostat	AWHD	FAOSTAT	2022 submission	2023 Submission
1990	N/A	N/A	N/A	16000	16000	16000
1991	N/A	N/A	N/A	16000	16000	16000
1992	N/A	N/A	N/A	16000	16000	16000
1993	16000	N/A	N/A	16000	16000	16000

1994	N/A	N/A	N/A	16000	16000	16000
1995	16000	N/A	N/A	16000	16000	16000
1996	16000	N/A	N/A	16000	16000	16000
1997	N/A	N/A	N/A	16000	16000	16000
1998	N/A	N/A	N/A	16000	16000	16000
1999	N/A	N/A	N/A	16000	16000	16000
2000	N/A	N/A	N/A	12000	12000	12000
2001	11957	8080	N/A	9598	11957.17	11957
2002	12253	12250	N/A	8945	12642	12253
2003	14861	14860	N/A	12253	15335	14861
2004	14131	14130	N/A	14861	14410	14131
2005	14641	14640	N/A	14130	14819	14641
2006	12172	11990	N/A	14642	11938	12172
2007	12315	12320	5435	12172	10955	12315
2008	12843	12840	6029	12315	11934	12843
2009	12889	12890	7681	12889	11247	12889
2010	12379	12380	9213	12379	11305	12379
2011	11887	11890	10395	11887	10733	11887
2012	11697	11700	10756	11697	10608	11697
2013	10930	10930	10384	10930	9935	10930
2014	10526	10530	10476	10526	9598	10526
2015	11076	11080	11838	11076	10224	11076
2016	11523	11520	12022	11523	11523	11523
2017	11739	11740	11479	11739	11739	11739
2018	13169	13170	13057	13170	13169	13169
2019	13161	13160	12757	13160	13161	13161
2020	13150	13150	13140	13150	13150	13150
2021	12730	12730	12701	N/A	-	12730

*** Light orange shading shows calculated data; green shading shows official data; dark orange shading shows data that was revised by NSO after our communication.**

GOATS

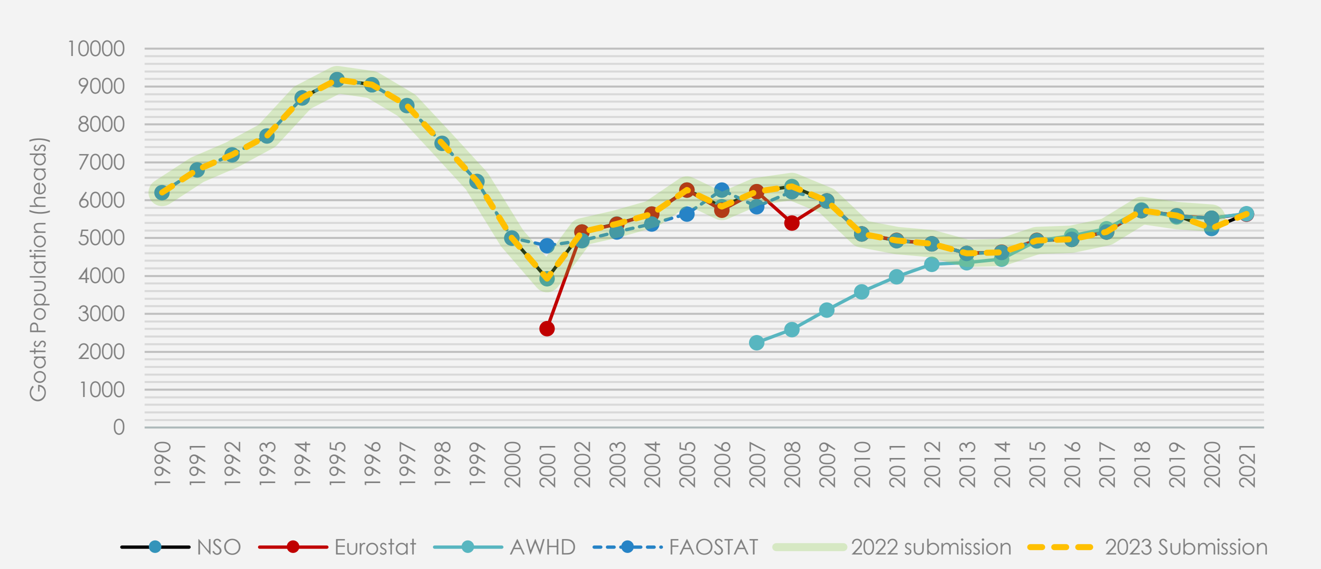


Figure 17-17 Comparison of data from different data sources; Goats

The goat population data give in Table 17-29 below shows that for the most part, data is consistent amongst sources, again except for some years for Eurostat (due to rounding) and AWHD. AWHD is close to NSO data, however, varies in the earlier years of use of the database when accuracy was much lower. The dark orange value was provided by NSO to Eurostat (after our communication with them of errors). The discrepancy still exists, however according to NSO, this is due to the rounding of values (even though strictly speaking, the rounding could have been applied at 5800,6300,5300).

Table 17-29 Data for goat population from all 4 data sources

Goats						
	NSO	Eurostat	AWHD	FAOSTAT	2022 submission	2023 Submission
1990	N/A	N/A	N/A	6200	6200	6200
1991	N/A	N/A	N/A	6800	6800	6800
1992	N/A	N/A	N/A	7200	7200	7200
1993	N/A	N/A	N/A	7700	7700	7700
1994	8700	N/A	N/A	8700	8700	8700
1995	9183	N/A	N/A	9183	9183	9183
1996	9050	N/A	N/A	9050	9050	9050
1997	N/A	N/A	N/A	8500	8500	8500
1998	N/A	N/A	N/A	7500	7500	7500
1999	N/A	N/A	N/A	6500	6500	6500
2000	5000	N/A	N/A	5000	5000	5000
2001	3930	2610	N/A	4800	3930	3930
2002	5163	5160	N/A	4938	5163	5163
2003	5374	5370	N/A	5163	5374	5374
2004	5635	5640	N/A	5374	5635	5635
2005	6273	6270	N/A	5635	6273	6273

2006	5828	5740	N/A	6272	5828	5828
2007	6227	6230	2244	5828	6227	6227
2008	6361	5400	2588	6227	6361	6361
2009	5983	5980	3100	5983	5983	5983
2010	5110	5110	3580	5110	5110	5110
2011	4938	4940	3985	4938	4938	4938
2012	4847	4850	4313	4847	4847	4847
2013	4598	4600	4357	4598	4598	4598
2014	4627	4630	4446	4627	4627	4627
2015	4937	4940	4931	4937	4937	4937
2016	4971	4970	5061	4971	4971	4971
2017	5160	5160	5245	5160	5160	5160
2018	5726	5730	5743	5730	5726	5726
2019	5593	5590	5565	5590	5593	5593
2020	5258	5530	5523	5530	5528	5258
2021	5635	5640	5649	N/A	-	5635

***Orange shading shows calculated data; green shading shows official data.**

POULTRY

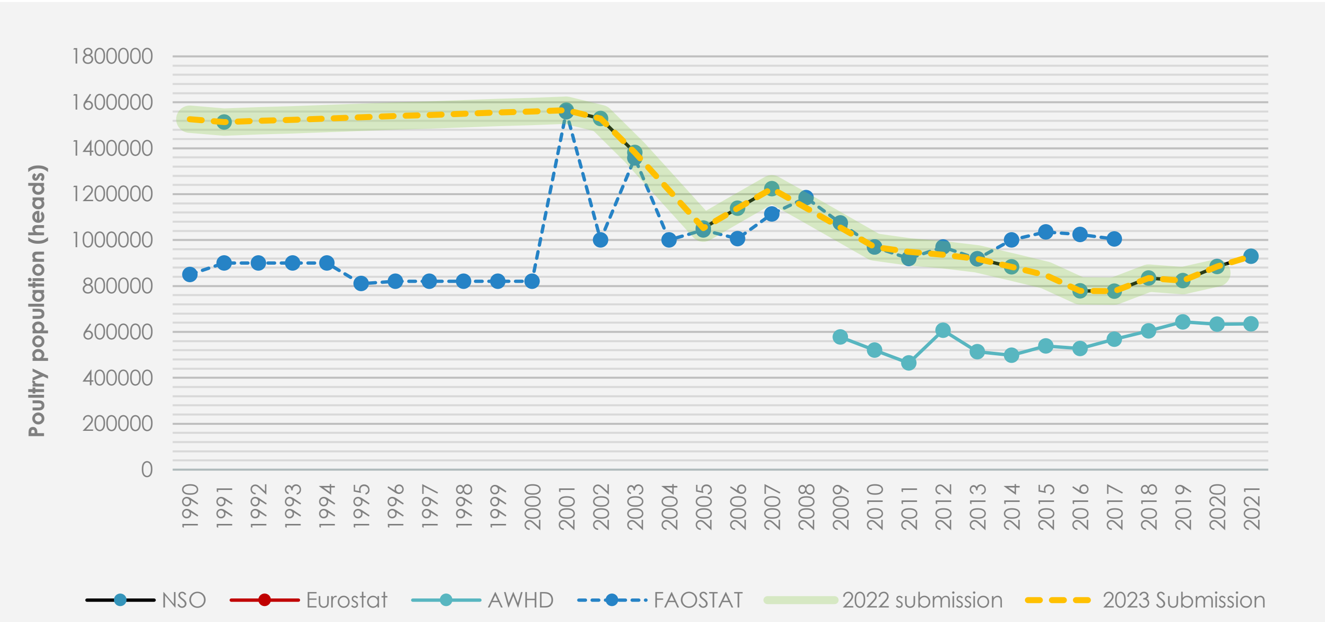


Figure 17-18 Comparison of data from different data sources; Poultry

Consistency in the poultry head data only exists for NSO and Eurostat. The discrepancy between NSO and AHWD exists because there is no clear definition of poultry for the use of the inventory between the two sources. At this current stage, NSO data will be used, since the inventory agency has agreed on a definition for poultry with NSO, and therefore the numbers quoted by NSO should be fine. Nonetheless, work will continue to make sure the definition is made clear between the 3 entities.

Table 17-30 Data for poultry population from all 4 data sources

Poultry						
	NSO	Eurostat	AWHD	FAOSTAT	2022 submission	2023 Submission
1990	N/A	N/A	N/A	850000	1526692	1526692
1991	1513713	N/A	N/A	900000	1513713	1513713
1992	N/A	N/A	N/A	900000	1518905	1518905
1993	N/A	N/A	N/A	900000	1524096	1524096
1994	N/A	N/A	N/A	900000	1529288	1529288
1995	N/A	N/A	N/A	810000	1534479	1534479
1996	N/A	N/A	N/A	820000	1539671	1539671
1997	N/A	N/A	N/A	820000	1544863	1544863
1998	N/A	N/A	N/A	820000	1550054	1550054
1999	N/A	N/A	N/A	820000	1555246	1555246
2000	N/A	N/A	N/A	820000	1560437	1560437
2001	1565629	N/A	N/A	1559000	1565629	1565629
2002	1529100	N/A	N/A	1000000	1529100	1529100
2003	1381544	N/A	N/A	1358000	1381544	1381544
2004	N/A	N/A	N/A	1000000	1216779	1216779
2005	1052013	N/A	N/A	1044000	1052013	1052013
2006	1138140	N/A	N/A	1006000	1138140	1138140
2007	1224267	N/A	N/A	1114000	1224267	1224267
2008	N/A	N/A	N/A	1184000	1139608	1139608
2009	N/A	N/A	577171	1075000	1054950	1054950
2010	970291	N/A	521125	970000	970291	970291
2011	N/A	N/A	464182	920000	949261	949261
2012	N/A	N/A	606827	970000	935714	935714
2013	918426	N/A	513609	918000	918426	918426
2014	882996	N/A	498839	1000000	882996	882996
2015	N/A	N/A	539168	1035000	847566	847566
2016	778086	N/A	526942	1024000	778086	778086
2017	777411	N/A	568603	1004000	777411	777411
2018	835059	N/A	604191	N/A	835059	835059
2019	822674	N/A	643880	N/A	822674	822674
2020	885021	N/A	632927	N/A	856763	885021
2021	929519	N/A	634573	N/A		929519

***FAOSTAT; Orange shading shows calculated data; green shading shows official data; yellow shading shows totals made up of a mix of official and estimate values.**

HORSES

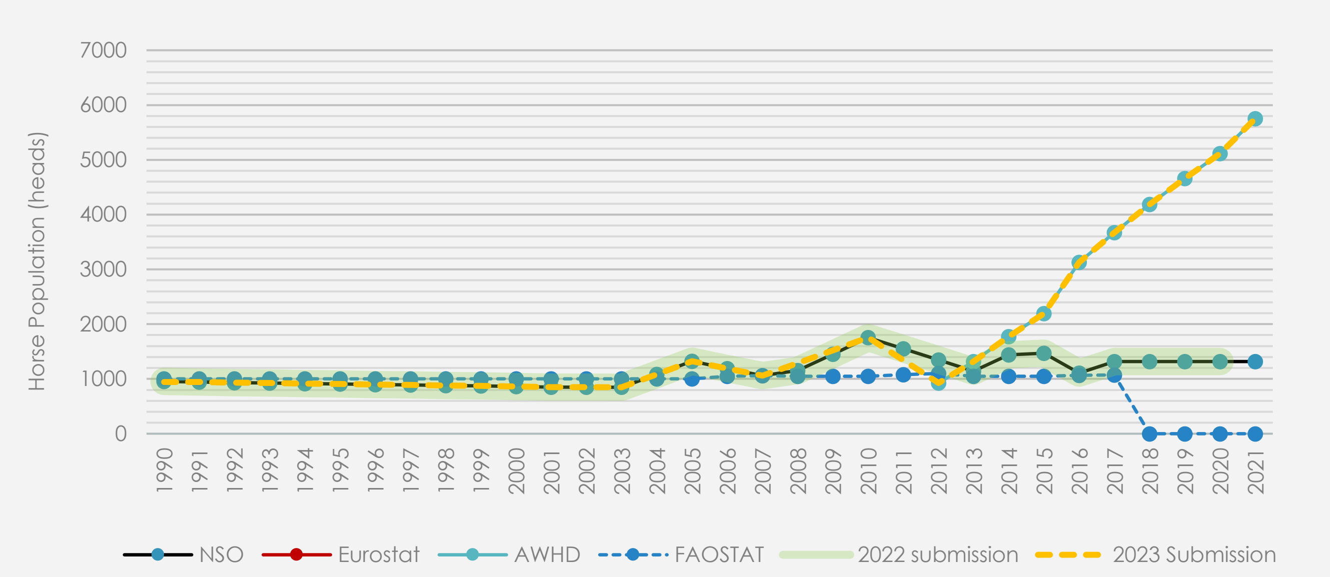


Figure 17-19 Comparison of data from different data sources; horses

Population data for horses is given in Table 17-31**Error! Reference source not found.**. Eurostat does not provide any data, FAOSTAT data is entirely estimated, NSO data is available consistently since 2010, while AHWD data is available from 2012 onwards.

Table 17-31 Data for horse population from all 4 data sources

Horses						
	NSO	Eurostat	AWHD	FAOSTAT	2022 submission	2023 Submission
1990	953	N/A	N/A	1000	953	944
1991	944	N/A	N/A	1000	944	944
1992	935	N/A	N/A	1000	935	935
1993	926	N/A	N/A	1000	926	926
1994	917	N/A	N/A	1000	917	917
1995	908	N/A	N/A	1000	908	908
1996	899	N/A	N/A	1000	899	899
1997	889	N/A	N/A	1000	889	889
1998	880	N/A	N/A	1000	880	880
1999	871	N/A	N/A	1000	871	871
2000	862	N/A	N/A	1000	862	862
2001	853	N/A	N/A	1000	853	853
2002	851	N/A	N/A	1000	851	851
2003	848	N/A	N/A	1000	848	848
2004	1085	N/A	N/A	1000	1085	1085
2005	1322	N/A	N/A	1000	1322	1322
2006	1191	N/A	N/A	1050	1191	1191
2007	1060	N/A	N/A	1060	1060	1060
2008	1153	N/A	N/A	1050	1153	1291
2009	1454	N/A	N/A	1050	1454	1523
2010	1754	N/A	N/A	1050	1754	1754

2011	1550	N/A	N/A	1080	1550	1339
2012	1345	N/A	924	1100	1345	924
2013	1141	N/A	1315	1050	1141	1315
2014	1441	N/A	1771	1050	1441	1771
2015	1471	N/A	2195	1049	1471	2195
2016	1107	N/A	3128	1068	1107	3128
2017	1319	N/A	3671	1070	1319	3671
2018	1319	N/A	4189	0	1319	4189
2019	1319	N/A	4658	0	1320	4658
2020	1319	N/A	5117	0	1320	5117
2021	1319	N/A	5751	0		5751

***Orange shading shows calculated data; green shading shows official data; blue shading shows interpolated values based on NSO.**

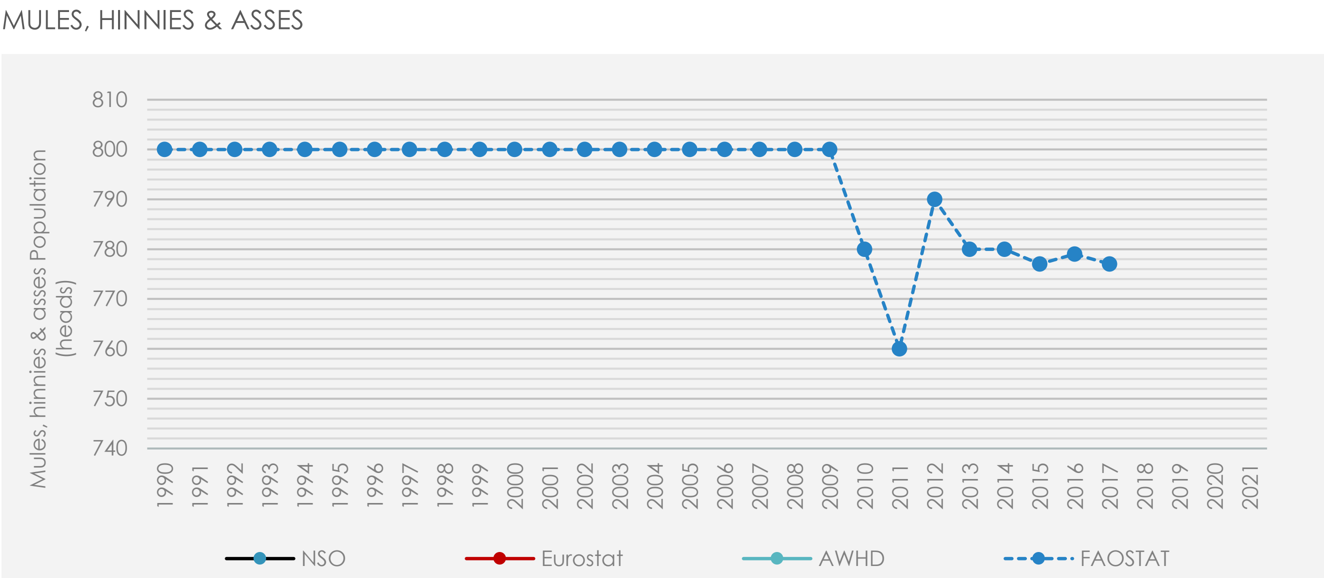


Figure 17-20 Comparison of data from different data sources; Mules, hinnies & asses.

No official data is available for mules, hinnies, and asses. FAOSTAT does however provide an estimate value, which will be used for the purposes of the National GHG inventory.

Table 17-32 Data for mules, hinnies & asses population from all 4 data sources

Mules, Hinnies & Asses				
	NSO	Eurostat	AWHD	FAOSTAT
1990	N/A	N/A	N/A	800
1991	N/A	N/A	N/A	800
1992	N/A	N/A	N/A	800
1993	N/A	N/A	N/A	800
1994	N/A	N/A	N/A	800
1995	N/A	N/A	N/A	800
1996	N/A	N/A	N/A	800
1997	N/A	N/A	N/A	800
1998	N/A	N/A	N/A	800

1999	N/A	N/A	N/A	800
2000	N/A	N/A	N/A	800
2001	N/A	N/A	N/A	800
2002	N/A	N/A	N/A	800
2003	N/A	N/A	N/A	800
2004	N/A	N/A	N/A	800
2005	N/A	N/A	N/A	800
2006	N/A	N/A	N/A	800
2007	N/A	N/A	N/A	800
2008	N/A	N/A	N/A	800
2009	N/A	N/A	N/A	800
2010	N/A	N/A	N/A	780
2011	N/A	N/A	N/A	760
2012	N/A	N/A	N/A	790
2013	N/A	N/A	N/A	780
2014	N/A	N/A	N/A	780
2015	N/A	N/A	N/A	777
2016	N/A	N/A	N/A	779
2017	N/A	N/A	N/A	777
2018	N/A	N/A	N/A	N/A
2019	N/A	N/A	N/A	N/A
2020	N/A	N/A	N/A	N/A
2021	N/A	N/A	N/A	N/A

***Orange shading shows calculated data; green shading shows official data.**

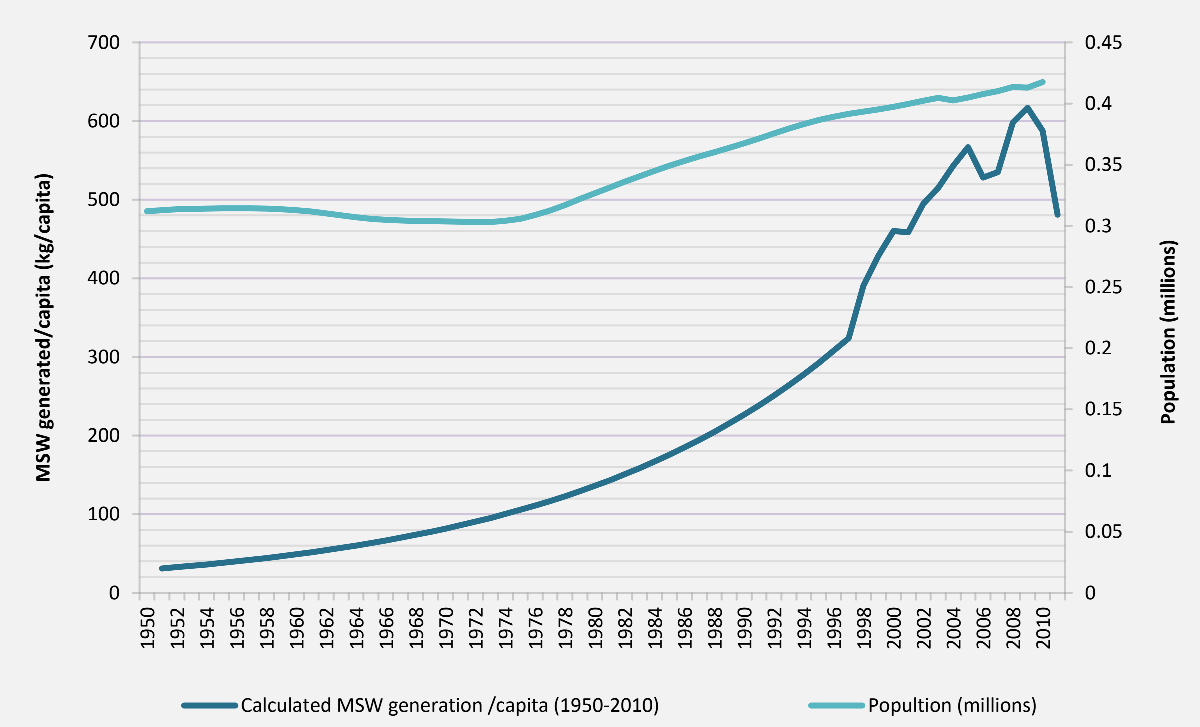
3.5 WASTE (CRF 5)

Back extrapolation of activity in Solid Waste Disposal sites

As highlighted in the main text, weighbridges for the accurate measurement of waste entering waste disposal sites on land became operational only in 1997. Data prior to this date is both scant and only indicative. Therefore, in order to ensure completeness and time series consistency, the values for deposited amounts were back extrapolated using reliable and validated available data. Due to the type of model being used for the estimation of emissions from such sites, the back extrapolation was required for the period 1950-1997. The extrapolation is based on UN data on population and GDP as referred to in section 3.2.2 of the 2006 IPCC Guidelines Volume 5.

Data for population was obtained from the United Nations POPIN Database (http://www.un.org/popin/data.html). Waste generation trends were calculated extrapolating the waste generation rates (/capita) in recent years to previous periods. The waste generation rates calculated, and the actual rates are summarised in the figure below.

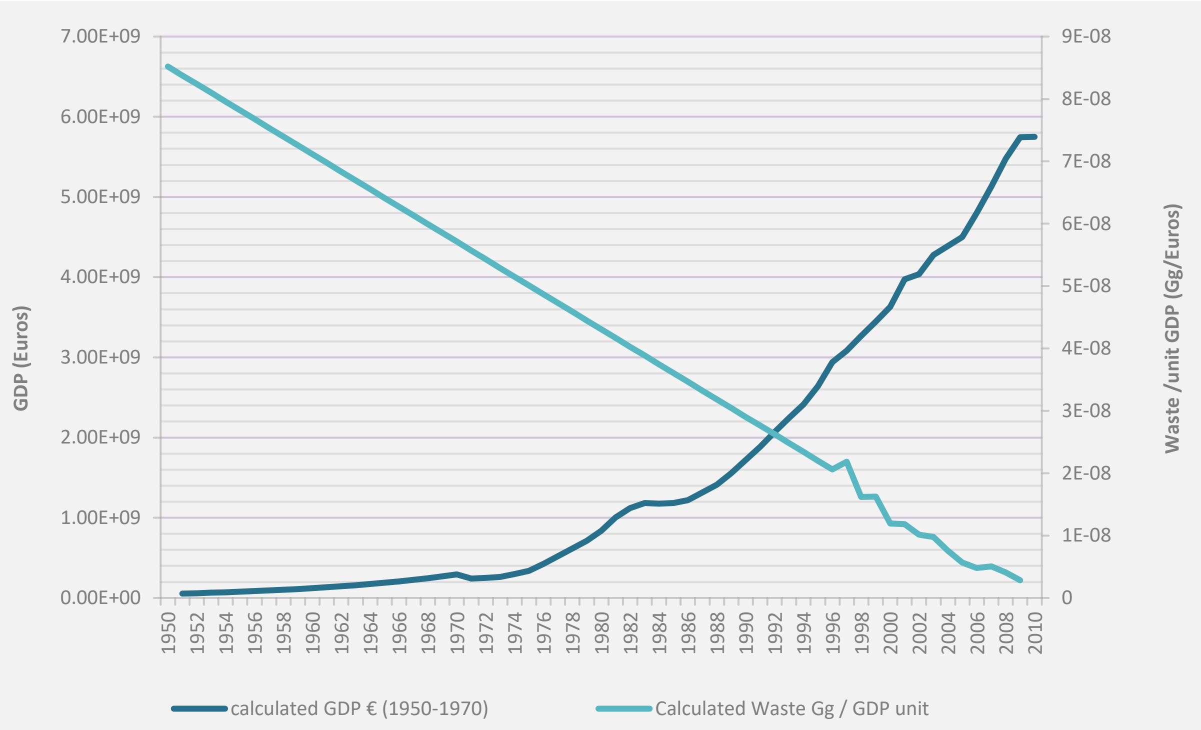
Figure 17-21 Trend of municipal solid waste generation/capita



Multiplying the population estimate by the generation rate, the actual estimate for MSW generation is obtained.

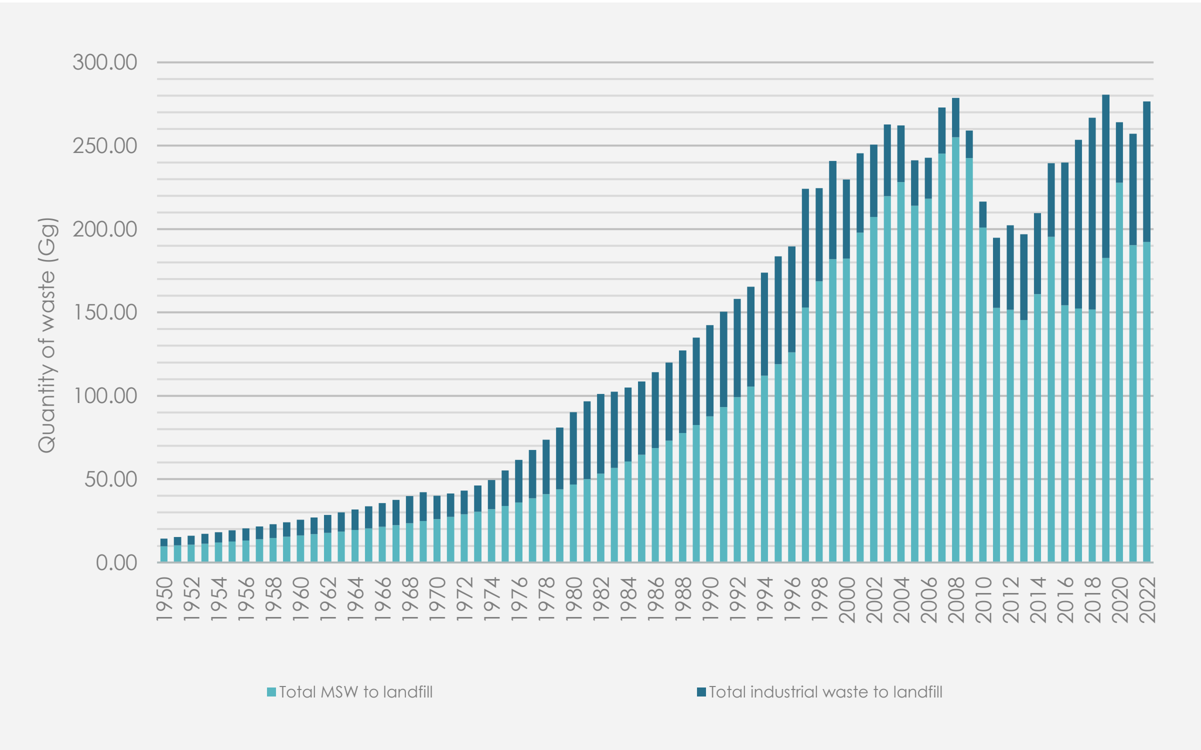
For industrial waste, GDP is more indicative of activity than population, thus GDP was used instead of population. Similar to the above the trends in Waste generation/GDP were calculated and back extrapolated with GDP estimates used to calculate the industrial waste activity over the period 1950-1997 (later data was available from weighbridges).

Figure 17-22 Trend of industrial waste/unit GDP for 1950-2010 compared to GDP



Following the combination of the two above mentioned calculations, the below figure depicts the final activity amounts used in the FOD model.

Figure 17-23 Waste deposited in landfills for 1950-2022



Incineration emission factors

- Municipal Waste

Table 17-33 Example calculation for CO_2 emissions of municipal waste from incineration

For 1990:

		Value
A	Total amount of municipal waste incineration (wet weight): Biogenic: Fossil (non-biogenic):	0.25Gg 0.2125 Gg 0.0375 Gg
B	Dry Matter Content (fraction)	0.40
C	Fraction of Carbon in Dry Matter (fraction)	0.38
D	Fraction of fossil carbon in total carbon (fraction)	1
E	Oxidation factor (fraction)	1
F	Conversion factor	44/12
G	Emission Factor (Gg CO_2/Gg waste) *(B*C*D*E*F)*	0.56
	Emissions of CO_2 (Gg) non-biogenic *(A*G)*	0.02
	Emissions of CO_2 (Gg) biogenic (*A*G*)	0.12

The following emission factors have been used to calculate CH_4 emissions:

- 6500g CH_4/tonne waste between years 1990 and 2003 and
- 0.2g CH_4/tonne waste from 2007 till present.

The following emission factors have been used to calculate N_2O emissions:

- 221g N_2O/tonne waste between years 1990 and 2003 and
- 60 g N_2O/t waste from 2007 till present.

The following emission factors between 1990 and 2003 have been used to calculate:

- NO_x emissions (1.80 kg NO_x/Mg waste),
- CO emissions (0.70 kg CO/Mg waste),
- NMVOC emissions (0.02 kg NMVOC/Mg waste) and
- SO_2 emissions (1.70 kg SO_2/Mg waste, as available in EMEP/EEA.

The gap between years 2004 and 2006 is due to the unavailability of waste treatment facilities, thus this type of incineration was not operational, as discussed in the NIR under section 7.4.1.1.

From 2008 onwards, emission factors for CO, NO_x and SO_2 were taken from plant specific data reported in the E-PRTR of the plant submitted to the Malta Environment and Planning Authority at the end of each year, and EF for NMVOC was extrapolated from the IPPC permit specific TOC emission limit (correcting for the CH4 emissions), this assuming the plant operated to the limit for the whole number of hours of operation as reported in the E-PRTR report.

The below table illustrates the emission factors used from year 2008 onwards.

Table 17-34 Emission factors for indirect GHGs in incineration

Year	NOx	CO	NMVOC	SO2
2008	1.43	0.21	0.17	0.06
2009	1.02	0.41	0.13	0.21
2010	1.67	0.46	0.12	0.05
2011	1.14	0.5	0.14	0.1
2012	1.40	0.22	0.12	0.12
2013	1.53	0.36	0.11	0.1
2014	1.24	0.09	0.11	0.07
2015	1.24	0.09	0.11	0.07
2016	1.24	0.09	0.11	0.07
2017	1.24	0.09	0.11	0.07
2018	1.24	0.09	0.11	0.07
2019	1.24	0.09	0.11	0.07
2020	1.24	0.09	0.11	0.07
2021	1.24	0.09	0.11	0.07

- Clinical Waste

Table 17-35 Example of calculation for CO2 emissions of clinical waste from incineration

Year	A: Total Amount of clinical waste incinerated (wet weight) (Gg)	B: Dry Matter Content (fraction)	C: Fraction of Carbon in Dry Matter (fraction)	D: Fraction of fossil carbon in total carbon (fraction)	E: Oxidation Factor (fraction)	F: Conversion Factor	G: Emission Factor (Gg CO2/ Gg waste) (C*D*E*F)	H: Emissions of CO2 (Gg) (A*G)
1990	0.3957	NA	0.6	0.4	1	3.67	0.88	0.35

The following emission factors have been used to calculate CH4 emissions:

- 60kg CH4/Gg waste between years 1990 and 2007 and
- 0.2kg CH4/Gg waste from 2008 till present.

The following emission factors have been used to calculate N2O emissions:

- 100g N2O/tonne waste throughout the timeseries.

The following emission factors between 1990 and 2007 have been used to calculate:

- NOx emissions (2.3kg NOx/Mg waste),
- CO emissions (0.19 kg CO/Mg waste),
- NMVOC emissions (0.7kg NMVOC/Mg waste) and
- SO2 emissions (0.54kg SO2/Mg waste), as available in EMEP/EEA.

As from year 2008, the emissions factors listed in Table 17-34 were used.

- Industrial Waste

Table 17-36 Example of calculation for CO2 emissions of Industrial waste from incineration

Year	A: Total amount of waste incinerated (Gg waste)	B: Dry Matter Content (fraction)	C: Fraction of Carbon in Dry Matter (fraction)	D: Fraction of Fossil Carbon in Total Carbon (fraction)	E: Oxidation Factor (fraction)	F: Conversion Factor	G: Emission Factor for CO2 emissions (Gg CO2 / Gg Waste) (B*C*D*E*F)	H: Emissions (Gg CO2) (A*G)
1990	0.07	0.9	0.46	0.01	1	3.67	1.52	0.00

The following emission factors have been used to calculate CH4 emissions:

- 60kg CH4/Gg waste between years 1990 and 2007 and
- 0.2kg CH4/Gg waste from 2008 till present.

The following emission factors have been used to calculate N2O emissions:

- 10g N2O/tonne waste between years 1990 and 2007 and
- 100g N2O/tonne waste from 2008 till present, as reported in the IPCC Guidelines in Table 5.6.

The following emission factors between 1990 and 2007 have been used to calculate:

- NOx emissions (2.5kg NOx/Mg waste),
- CO emissions (0.13 kg CO/Mg waste),
- NMVOC emissions (7.4kg NMVOC/Mg waste) and
- SO2 emissions (0.07kg SO2/ Mg waste for), as available in EMEP/EEA.

As from year 2008, the emission factors listed in Table 17-34 were used.

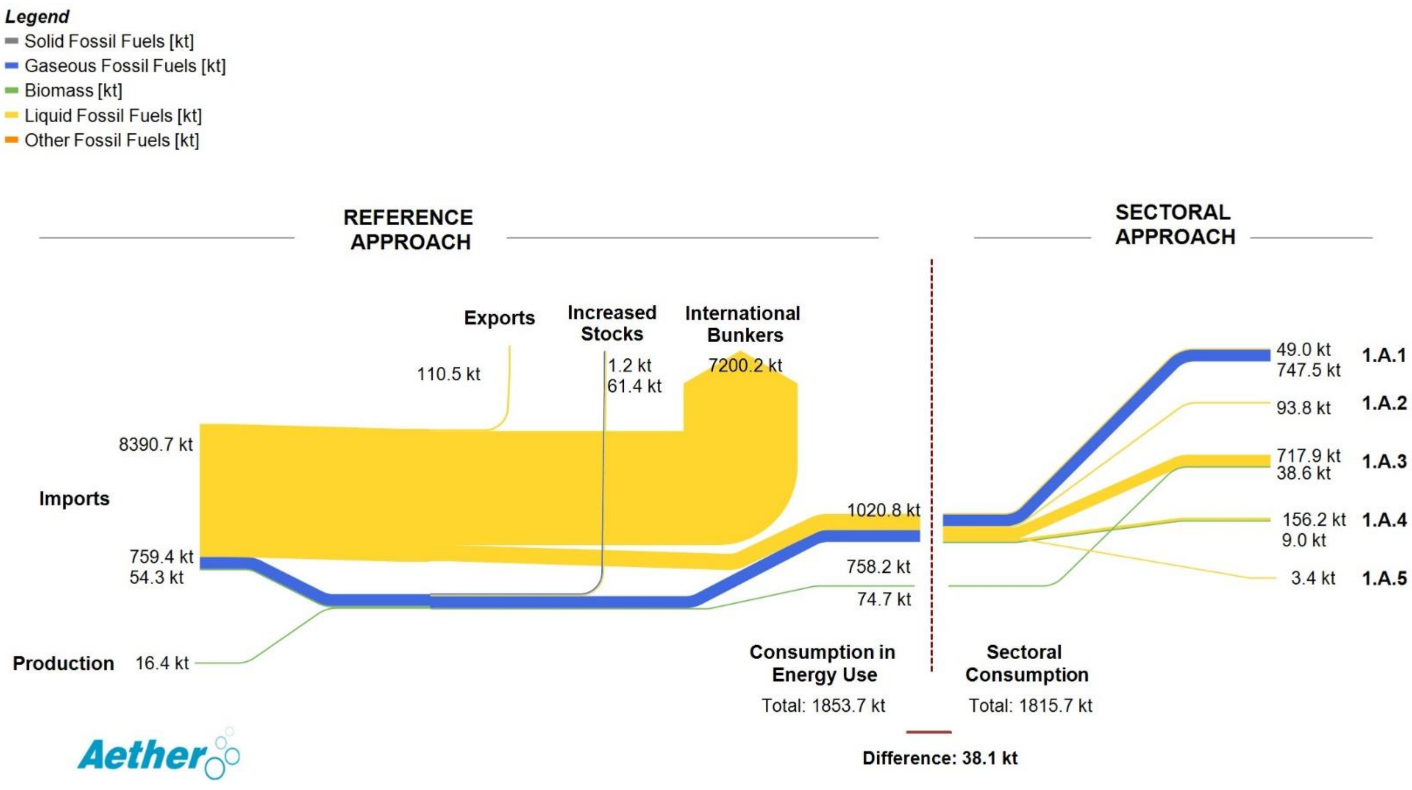
4. NATIONAL ENERGY BALANCE

Annual Energy Balance 2024

Eurostat Energy Balance		O4630	O4652XR5210B	O4651	O4661XR5230B	O4669	O4671XR5220B	O4680	O4692	O4695	G3000	R5110-5150_W6000RI	R5300	
ktoe		Liquefied petroleum gases	Motor gasoline (excluding biofuel portion)	Aviation gasoline	Kerosene-type jet fuel (excluding biofuel portion)	Other kerosene	Gas oil and diesel oil (excluding biofuel portion)	Fuel oil	Lubricants	Bitumen	Natural gas	Primary solid biofuels	Biogases	Bioenergy
+	Primary production	z	z	z	z	z	z	z	z	z	z	z	1.955	1.955
+	Recovered & recycled products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
+	Imports	27.085	93.248	0.064	128.212	0.431	684.223	1,710.828	7.162	3.728	323.298	1.136	0.000	13.050
-	Exports	0.000	0.000	0.000	0.000	0.000	28.285	7.040	0.000	0.000	0.000	0.000	0.000	0.002
+	Change in stock	0.808	-7.813	-0.006	-1.579	0.043	-8.386	-2.459	0.000	0.000	-0.506	0.000	0.000	1.362
=	**Gross available energy**	27.892	85.435	0.058	126.634	0.474	647.552	1,701.329	7.162	3.728	322.792	1.136	1.955	16.365
-	International maritime bunkers	0.000	0.000	0.000	0.000	0.000	431.051	1,693.787	0.000	0.000	0.000	0.000	0.000	0.000
=	**Gross inland consumption**	27.892	85.435	0.058	126.634	0.474	216.502	7.542	7.162	3.728	322.792	1.136	1.955	16.365
-	International aviation	0.000	0.000	0.026	125.950	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
=	**Total energy supply**	27.892	85.435	0.032	0.684	0.474	216.502	7.542	7.162	3.728	322.792	1.136	1.955	16.365

Reference Approach – Sankey Diagram

In order to verify the energy sector estimates, GHG emissions have also been estimated using the reference approach. The data is based on the national energy balance. The Sankey diagram below has been designed to compare the carbon release in 2022 due to apparent energy consumption (left hand side) with bottom-up sectoral consumption (right-hand side). The graphic highlights that the energy sector in Malta is almost entirely oil (liquid fossil) based. Most fuel in Malta is imported, with a small amount of export and stock change. Much of the imported fuel is consumed in international bunkers (international shipping and aviation). The remainder is designated as being consumed for national energy use. A very small quantity of natural gas is imported, and biomass is both imported and produced in small quantities. The sectoral approach indicates that most liquid fossil fuels are consumed for power generation and in road transport. Some biofuel is used in the road transport sector. The imbalance between liquid fuel consumption is 38.1 kt, with the sectoral estimate being the greater in terms of emissions.



5. OTHER INFORMATION

Malta has no other information to report.