MALTA'S NATIONAL INVENTORY OF GREENHOUSE GAS EMISSIONS AND REMOVALS, 2021

APRIL 2021

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

The Malta Resources Authority, on behalf of the Ministry for the Environment, Climate Change and Planning

Title	Malta's National Inventory of Greenhouse Gas Emissions and Removals, 2021
Report pursuant to	Regulation (EU) No 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC (the Monitoring Mechanism), Article 7, in respect of submission to the UNFCCC
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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-1-1 presents annual figures for total national greenhouse gas emissions for the years 1990 to 2019. 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-1-1 Total national greenhouse gas emissions, 1990 – 2019

	Total national emissions with LULUCF (Gg CO2 eq.)	Total national emissions without LULUCF (Gg CO2 eq.)
1990	2602.98	2595.50
1991	2457.44	2450.25
1992	2527.22	2519.74
1993	3114.22	3106.01
1994	2897.83	2889.41
1995	2694.45	2685.61
1996	2818.29	2809.37
1997	2833.62	2824.80
1998	2799.03	2790.41
1999	2886.45	2877.95
2000	2821.02	2813.23
2001	2946.71	2939.15
2002	2997.98	2990.68
2003	3277.80	3271.00
2004	3167.44	3161.12
2005	2990.98	2985.10
2006	3045.76	3040.33
2007	3141.79	3136.83
2008	3081.31	3076.79
2009	2896.21	2892.11
2010	2971.72	2968.46
2011	2975.01	2972.04
2012	3184.16	3181.48
2013	2873.99	2871.60
2014	2907.29	2905.19
2015	2221.90	2220.08
2016	1904.01	1902.48
2017	2062.13	2060.88
2018	2042.13	2041.17
2019	2175.37	2174.72

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-1-2 and Table ES-1-3.

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-1-2 Greenhouse gas emissions by gas.

Note to Table 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.

	CO_2 with LULUCF	CO_2 without LULUCF	CH_4	N_2O	HFC	PFC	SF_6	NF_3	Total with LULUCF	Total without LULUCF
	Gg CO2 eq.									
1990	2414.88	2408.46	5.03	0.21	NO,NE,IE,NA	NA,NO	0.00	NA,NO	2602.98	2595.50
1991	2261.49	2255.39	5.32	0.21	NO,NE,IE,NA	NA,NO	0.00	NA,NO	2457.44	2450.25
1992	2321.30	2314.90	5.62	0.21	NO,NE,IE,NA	NA,NO	0.00	NA,NO	2527.22	2519.74
1993	2898.32	2891.13	5.91	0.22	NO,NE,IE,NA	NA,NO	0.00	NA,NO	3114.22	3106.01
1994	2677.10	2669.72	6.13	0.22	0.00	NA,NO	0.00	NA,NO	2897.83	2889.41
1995	2468.09	2460.27	6.32	0.22	0.00	NA,NO	0.00	NA,NO	2694.45	2685.61
1996	2586.33	2578.45	6.64	0.22	0.00	NA,NO	0.00	NA,NO	2818.29	2809.37
1997	2593.98	2586.19	6.91	0.22	0.00	NA,NO	0.00	NA,NO	2833.62	2824.80
1998	2552.75	2545.13	7.12	0.22	0.01	NA,NO	0.00	NA,NO	2799.03	2790.41
1999	2635.12	2627.59	7.40	0.22	0.01	NA,NO	0.00	NA,NO	2886.45	2877.95
2000	2552.37	2545.52	7.74	0.23	6.70	NA,NO	0.00	NA,NO	2821.02	2813.23
2001	2671.87	2665.17	7.86	0.22	11.26	NA,NO	0.00	NA,NO	2946.71	2939.15
2002	2713.98	2707.48	8.13	0.22	14.99	NA,NO	0.00	NA,NO	2997.98	2990.68
2003	2985.31	2979.28	8.42	0.21	16.60	NA,NO	0.00	NA,NO	3277.80	3271.00
2004	2851.99	2846.41	8.82	0.21	29.90	NA,NO	0.00	NA,NO	3167.44	3161.12
2005	2659.41	2654.26	9.00	0.21	42.21	NA,NO	0.00	NA,NO	2990.98	2985.10
2006	2670.67	2665.94	9.20	0.21	79.73	NA,NO	0.00	NA,NO	3045.76	3040.33
2007	2742.68	2738.40	9.38	0.22	98.68	NA,NO	0.00	NA,NO	3141.79	3136.83
2008	2750.99	2747.13	6.11	0.20	114.97	NA,NO	0.00	NA,NO	3081.31	3076.79
2009	2536.03	2532.57	6.64	0.19	135.93	NA,NO	0.00	NA,NO	2896.21	2892.11
2010	2582.22	2579.52	7.32	0.19	148.48	NA,NO	0.00	NA,NO	2971.72	2968.46
2011	2579.25	2576.84	6.79	0.16	172.35	NA,NO	0.00	NA,NO	2975.01	2972.04
2012	2762.64	2760.50	6.68	0.17	204.83	NA,NO	0.00	NA,NO	3184.16	3181.48
2013	2446.15	2444.30	6.24	0.16	220.45	NA,NO	0.00	NA,NO	2873.99	2871.60
2014	2449.97	2448.40	6.88	0.16	235.56	NA,NO	0.00	NA,NO	2907.29	2905.19
2015	1742.28	1740.99	7.17	0.16	251.27	NA,NO	0.00	NA,NO	2221.90	2220.08

2016	1406.41	1405.39	7.49	0.16	262.73	NO,NA	0.00	NO,NA	1904.01	1902.48
2017	1560.17	1559.43	7.37	0.15	271.64	NO,NA	0.00	NO,NA	2062.13	2060.88
2018	1538.78	1538.32	7.69	0.16	264.45	NO,NA	0.00	NO,NA	2042.13	2041.17
2019	1669.33	1669.15	8.07	0.16	257.29	NO,NA	0.00	NO,NA	2175.37	2174.72

Table ES-1-3 Greenhouse gas emissions by sector.

	Energy	IPPU	Agriculture	LULUCF	Waste	Total with LULUCF	Total without LULUCF
	Gg CO2 eq.						
1990	2417.35	7.78	101.06	7.48	69.32	2602.98	2595.50
1991	2263.65	8.01	102.95	7.18	75.65	2457.44	2450.25
1992	2324.28	9.02	104.76	7.48	81.69	2527.22	2519.74
1993	2903.18	9.04	104.48	8.21	89.32	3114.22	3106.01
1994	2680.87	9.32	101.60	8.42	97.61	2897.83	2889.41
1995	2470.29	9.29	101.49	8.85	104.54	2694.45	2685.61
1996	2589.25	9.09	102.09	8.91	108.95	2818.29	2809.37
1997	2596.82	9.30	103.19	8.81	115.50	2833.62	2824.80
1998	2555.95	8.73	100.23	8.62	125.50	2799.03	2790.41
1999	2639.59	8.15	99.75	8.50	130.46	2886.45	2877.95
2000	2557.30	14.99	100.72	7.80	140.22	2821.02	2813.23
2001	2676.16	19.10	97.03	7.56	146.85	2946.71	2939.15
2002	2718.57	22.97	95.73	7.29	153.42	2997.98	2990.68
2003	2991.50	24.86	92.56	6.80	162.08	3277.80	3271.00
2004	2857.90	37.50	95.31	6.32	170.41	3167.44	3161.12
2005	2665.35	49.88	91.51	5.88	178.35	2990.98	2985.10
2006	2676.40	87.84	90.22	5.43	185.87	3045.76	3040.33
2007	2750.01	106.60	91.10	4.96	189.12	3141.79	3136.83
2008	2759.41	122.70	86.65	4.52	108.02	3081.31	3076.79
2009	2542.43	143.28	83.21	4.10	123.19	2896.21	2892.11
2010	2590.10	155.37	81.56	3.26	141.43	2971.72	2968.46
2011	2586.45	182.61	77.62	2.97	125.36	2975.01	2972.04
2012	2769.72	212.68	79.10	2.68	119.98	3184.16	3181.48
2013	2446.71	235.79	78.14	2.39	110.95	2873.99	2871.60
2014	2451.07	248.06	77.97	2.11	128.09	2907.29	2905.19
2015	1742.96	261.74	78.22	1.82	137.16	2221.90	2220.08
2016	1408.07	272.27	76.69	1.53	145.45	1904.01	1902.48
2017	1563.65	278.27	75.26	1.25	143.70	2062.13	2060.88
2018	1542.61	271.20	76.61	0.96	150.75	2042.13	2041.17
2019	1675.00	263.70	76.34	0.65	159.68	2175.37	2174.72

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[1]. 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 475,701 in 2017, Malta is one of the most densely populated countries in the world, with a population density of 1,505 persons/km^2. Population has seen a growth of just above 31% 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 305% over the period 1990 to 2017. 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.

[1] State of the Environment Report, 2018, Summary Report; Environment & Resources Authority, 2018.

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*'[2].

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. Inventory submissions up to the 2014 (covering the years 1990 to 2012) used 2AR GWP values. This inventory submission uses 4AR GWP values, in accordance with the applicable decisions taken under the UNFCCC.

[2] 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.

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 25 tonnes of CO_2 equivalents; 1 tonne of N_2O can be represented as 298 tonnes CO_2 equivalents, and so on.

Table 1-1 Global Warming Potentials (GWP) of direct greenhouse gases covered by this inventory report pursuant to IPCC Climate Change 2007 – The Physical Science Basis – WGI Contribution to the 4th Assessment Report

Chemical species	Chemical formula	GWP (time horizon: 100 years) based on 4th Assessment Report
Carbon dioxide	CO_2	1
Methane	CH_4	25
Nitrous oxide	N_2O	298
Nitrogen trifluoride	NF_3	17,200
Hydrofluorocarbons:		
HFC-23	CHF_3	14,800
HFC-32	CH_2F_2	675
HFC-125	C_2HF_5	3,500
HFC-134a	$C_2H_2F_4(CH_2FCF_3)$	1,430
HFC-143a	$C_2H_3F_3(CF_3CH_3)$	4,470
HFC-227ea	C_3HF_7	3,220
HFC-245fa	$CHF_2CH_2CF_3$	1,030
HFC-365mfc	$CH_3CF_2CH_2CF_3$	794
Perfluorocarbons:		
Perfluoropropane - PFC-218	C_3F_8	8,830
Sulphur hexafluoride	SF_6	22,800

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[3], 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

[3] 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.

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, Climate Change and Planning (MECP).

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"[4] 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[5].

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)[6]. 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)[7]).

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[4] Establishing a National Greenhouse Gas Inventory System for Malta; Climate Change Unit-Malta Resources Authority; 30th May 2013.

[5] 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).

[6] Climate Action Act, 2015, Chapter 543; 7th July 2015.

[7] "*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*

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[8] 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.

limitation or reduction commitments pursuant to international treaties ad its obligations as a Member State of the European Union […]."

[8] Government Notice No 1036 of 27th October 2015.

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.

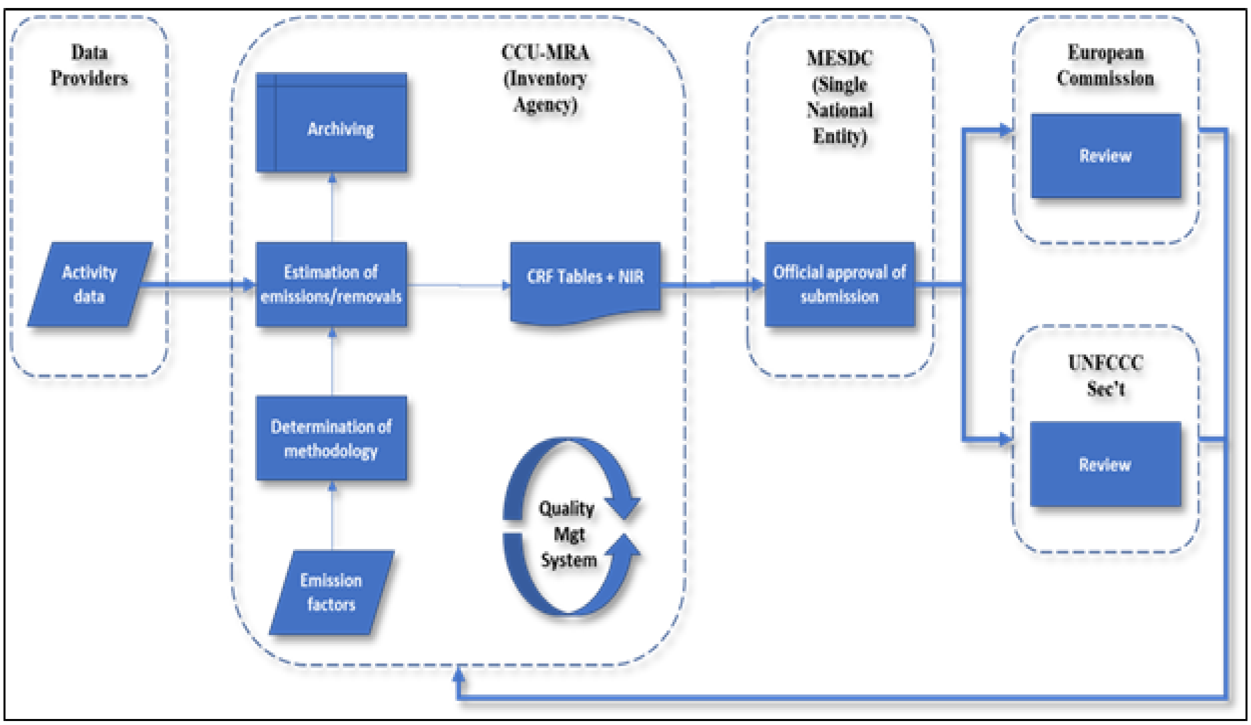

Figure 1-1 Schematic representation of the institutional and procedural arrangements for the preparation and submission of national greenhouse gas inventories of Malta.

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"*[9] 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*"[10].

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;*

[9] Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (GPG2000, IPCC, 2000).

[10] Operations and Quality Manual; Malta Resources Authority; 18th April 2018.

- *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-03Treatment of Non-conformity and Risk	CCU-QOP-03 Methodology, Data collection and Estimation
CCU-QSP-04 Control of Non-Conforming data and service provision requirements	CCU-QOP-04 Completion of Proxy Table and Input of Data into the CRF Reporter
CCU-QSP-05 Training and Competency Management Procedure	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 1-2 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.

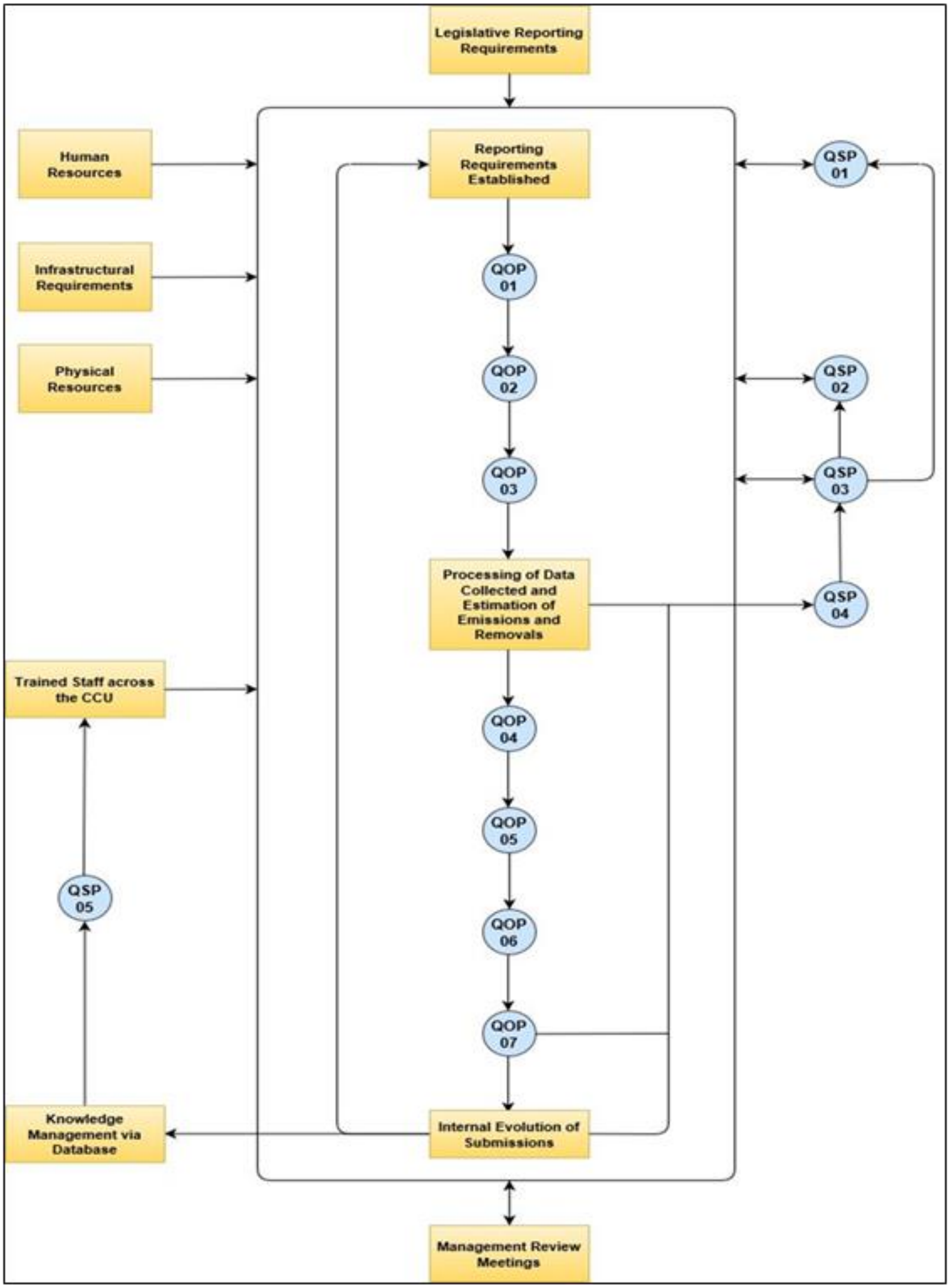

Figure 1-2 QMS process map.

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 – 2021 ongoing
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.

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
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 Changes 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 2020).

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[11] 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.

[11] 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.

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)[12] 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.

[12] Malta Statistics Authority Act, 2000, Chapter 422; 1st March, 2001.

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
1.	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
2.	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
3.	Agriculture	National Statistics Office (NSO) Malta Dairy Products (MDP) Koperattiva Produtturi tal-Halib (KPH) FAOStat
4.	Land Use, Land-use Change and Forestry	Planning Authority (PA) National Statistics Office (NSO)
5.	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, or both.

Malta is here presenting a Tier 1 method for identifying key categories. This approach assesses the influence of different categories of emissions and removals on the level of the national inventory and on the trend of the inventory. This assessment is usually presented as a listing of all those combinations of categories and gases that cumulatively account for up to 95% of the total inventory when summed up in descending order of magnitude. The with-LULUCF key category assessment includes values relating to estimated removals in the LULUCF sector, taking into consideration the quantified values without due account to the sign (removals can be considered as being equivalent to negative emissions). The without-LULUCF assessment excludes estimates of removals from the LULUCF sector.

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 (2019) with and without LULUCF, for Approach 1, refers to the public electricity and heat production category from the Energy sector; liquid fuels CO_2. For Approach 2, for year 2019, the category 'Product Uses as Substitutes for Ozone Depleting Substances – Refrigeration and Air Conditioning' from the IPPU sector is the category with the highest key category.

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 2019 (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 (2019), 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 2019 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 key category for the latest year (2019) with LULUCF, both for Approach 1 and 2, refers to the road transportation from the Energy sector while Approach 1 without LULUCF refers to Public electricity and heat production from Liquid Fuels.

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

The below table refers to the key categories with LULUCF both for year 1990 and 2019 including level and trend assessment both from approach 1 and approach 2.

Table 1-6 KCA including Approach 1 and Approach 2 for base year (1990) and latest year (2019) with LULUCF both Level and Trend Assessment

CRF Code	Category	Classification	GHG	Identification Criteria	
				1990	2019
1A1	Public electricity and heat production	Liquid fuels	CO_2	L1	L1, L2, T1, T2
1A1	Public electricity and heat production	Solid fuels	CO_2	L1	T1
1A1	Public electricity and heat production	Gaseous fuels	CO_2		L1, L2
1A2	Manufacturing industries and construction	Liquid fuels	CO_2	L1	L1, L2
1A3b	Road Transportation	Liquid Fuels	CO_2	L1	L1, T1, T2, L2
1A3d	Domestic Navigation	Liquid fuels	CO_2	L1	L1, L2, T2
1A4a	Commercial/Institutional	Liquid fuels	CO_2	L1	L1, L2, T1, T2
1A4b	Residential	Liquid fuels	CO_2	L1,	L1, L2, T1, T2
1A4c	Agriculture/Forestry/Fishing	Liquid fuels	CO_2		L1, L2, T2
2D1	Non-Energy Products from Fuels and Solvent Use - Lubricant use		CO2		L2
2F1	Product Uses as Substitutes for Ozone Depleting Substances - Refrigeration and Air Conditioning		HFC		L1, L2
2F2	Product Uses as Substitutes for Ozone Depleting Substances – Foam Blowing Agents		HFC		L2
2G3b	Other Product Manufacture and Use - N2O from Product Uses		N2O		T2
3A	Enteric Fermentation	Cattle	CH_4	L1	L1, L2, T2
3A	Enteric Fermentation	Swine	CH4		T2
3B	Manure Management	Cattle	N2O		L2, T2
3D1	Direct N2O Emissions from Managed soils	Inorganic N Fertilizers/Synthetic	N2O		L2

3D1	Direct N2O Emissions from Managed soils	Organic N/Manure	N2O		L2
3D1	Direct N2O Emissions from Managed soils	Organic N/Crop Residue	N2O		L2, T2
3D2	Indirect N2O Emissions from Managed soils	N Leaching/ Runoff	N2O		L2
3B2	Indirect N2O Emissions from Manure Management	Rabbits	N2O		L2. T2
3D2	Indirect N2O Emissions from Managed soils	Atmospheric Deposition	N2O		L2
4C	Grassland		CO2		T2
4C	Grassland		N2O		T2
4E	Settlements		CO2		T2
4E	Settlements		N2O		T2
5A1	Managed Waste Disposal Sites (Anaerobic)		CH_4		L1, L2
5A2	Unmanaged Waste Disposal Sites		CH_4	L1	L1, L2, T2
5D1	Wastewater Treatment and Discharge – Domestic wastewater		CH4	L1	L2, T2
5D1	Wastewater Treatment and Discharge – Domestic wastewater		N_2O		L1, L2, T2

L1 = Level Assessment Approach 1, L2 = Level Assessment Approach 2; T1 = Trend Assessment Approach 1; T2 = Trend Assessment Approach 2

1.5.4 KEY CATEGORIES: WITHOUT LULUCF

The below table refers to the key categories without LULUCF both for year 1990 and 2019 including level and trend assessment both from approach 1 and approach 2.

Table 1-7 KCA including Approach 1 and Approach 2 for base year (1990) and latest year (2019) without LULUCF both Level and Trend Assessment

CRF Code	Category	Classification	GHG	Identification Criteria	
				1990	2019
1A1	Public electricity and heat production	Liquid fuels	CO_2	L1	L1, T1, T2
1A1	Public electricity and heat production	Solid fuels	CO_2	L1	T1
1A1	Public electricity and heat production	Gaseous fuels	CO_2		L1
1A2	Manufacturing industries and construction	Liquid fuels	CO_2	L1	L1
1A3b	Road Transportation	Liquid Fuels	CO_2	L1	L1, T1, T2
1A3d	Domestic Navigation	Liquid fuels	CO_2	L1	L1
1A4a	Commercial/Institutional	Liquid fuels	CO_2	L1	L1, T1,

					T2
1A4b	Residential	Liquid fuels	CO_2	L1	L1, T1, T2
1A4c	Agriculture/Forestry/Fishing	Liquid fuels	CO_2		T2
2F1	Product Uses as Substitutes for Ozone Depleting Substances - Refrigeration and Air Conditioning		HFC		L1
3A	Enteric Fermentation	Cattle	CH_4	L1	L1
4E	Settlements	Total	CO_2		T2
5A1	Managed Waste Disposal Sites (Anaerobic)		CH_4		L1
5A2	Unmanaged Waste Disposal Sites		CH_4	L1	L1, T2
5D1	Wastewater Treatment and Discharge - Domestic wastewater		CH4		T2
5D1	Wastewater Treatment and Discharge - Domestic wastewater		N_2O		L1, L2

L1 = Level Assessment Approach 1, L2 = Level Assessment Approach 2; T1 = Trend Assessment Approach 1; T2 = Trend Assessment Approach 2

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 5.0% and trend uncertainty at 5.62%.

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

The overall profile of total national emissions over the time-series 1990 to 2019 (Figure 2-1Error! Reference source not found.) shows a general increase in total national emissions from 1990 (2602.98 Gg CO_2 eq. with LULUCF; 2595.50 Gg CO_2 eq. without LULUCF) up to year 2012 (3184.16 Gg with LULUCF CO_2 eq.; 3181.48 Gg CO_2 eq. without LULUCF), and a subsequent rapid general decrease until 2016 (1904.01 Gg CO_2 eq. with LULUCF ; 1902.48 Gg CO_2 eq. without LULUCF). Total national emissions increased again between 2017 and 2019 (2175.37 Gg CO_2 eq.; 2174.72 Gg CO_2 eq.).

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

As may be observed from Figure 2-2 and Figure 2-3, the trend profile of total national greenhouse gas emissions follows 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 for most of the time-series; thus, its influence on the total emissions profile. In turn, the Energy sector is strongly influenced by emissions 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 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 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 2-1. The period up until 2012 shows a predominance of year-to-year increases, coinciding with 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 (23.15% reduction between 2014 and 2015 emissions in particular). A significant 13.80% increase is observed between 2016 and 2019.

Annual percentage changes compared to 1990 emission levels are pictorially presented in Figure 2-2. Especially evident for this graph is the peak in total emissions in 2012 (23.45% higher than 1990 levels), and the fact that 2016 emissions were lower than base year emissions (25.27% lower than 1990 levels). Estimated 2019 emissions were 14.95% lower than 1990.

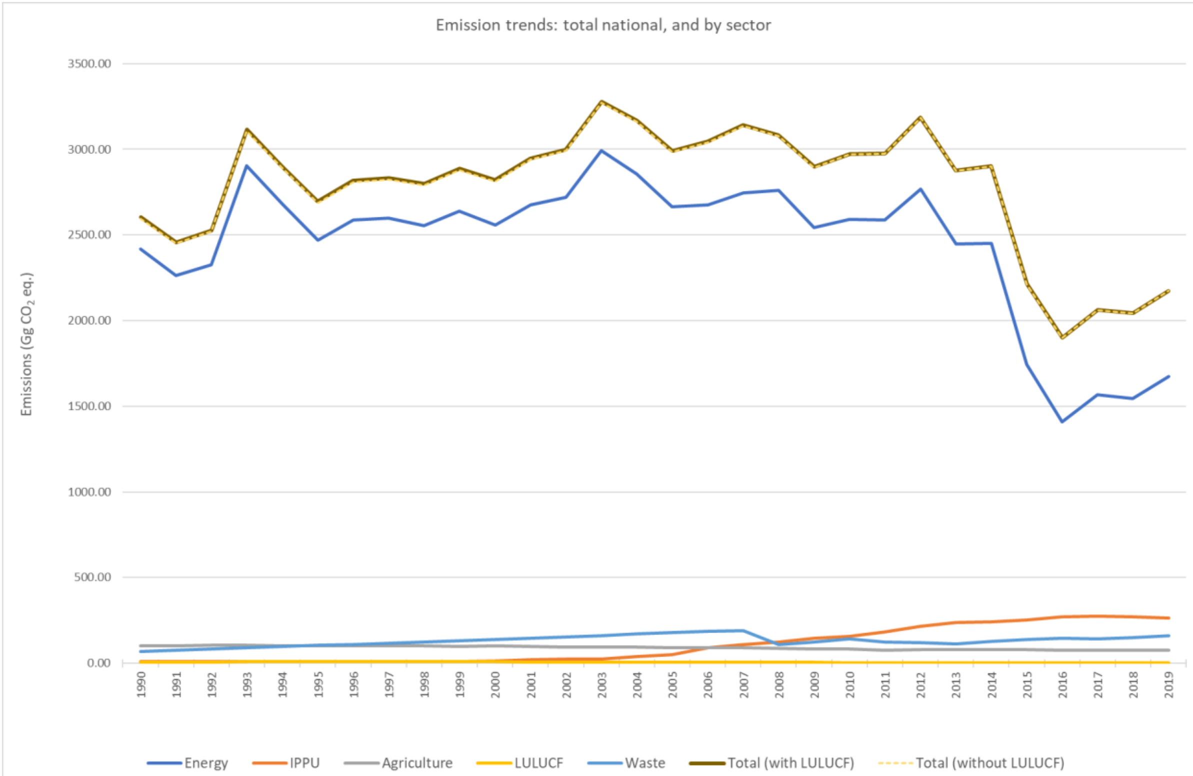

Figure 2-1 National total greenhouse gas emission trends (totals, with/without LULUCF; by sector).

Table 2-1 National net 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	2602.98	2595.50
1995	2694.45	2685.61
2000	2821.02	2813.23
2005	2990.98	2985.10
2010	2971.72	2968.46
2011	2975.01	2972.04
2012	3184.16	3181.48
2013	2873.99	2871.60
2014	2907.29	2905.19
2015	2221.90	2220.08
2016	1904.01	1902.48
2017	2062.13	2060.88
2018	2042.13	2041.17
2019	2175.37	2174.72

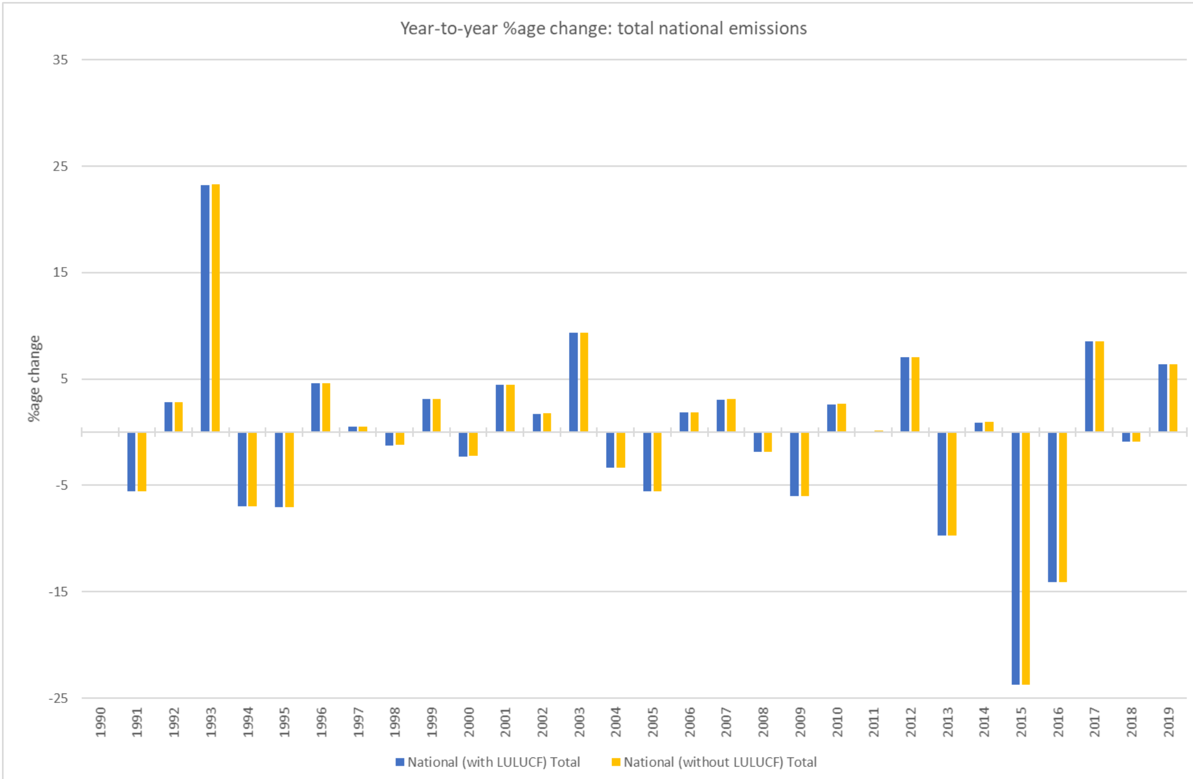

Figure 2-2 Annual year-to-year percentage change in total national emissions.

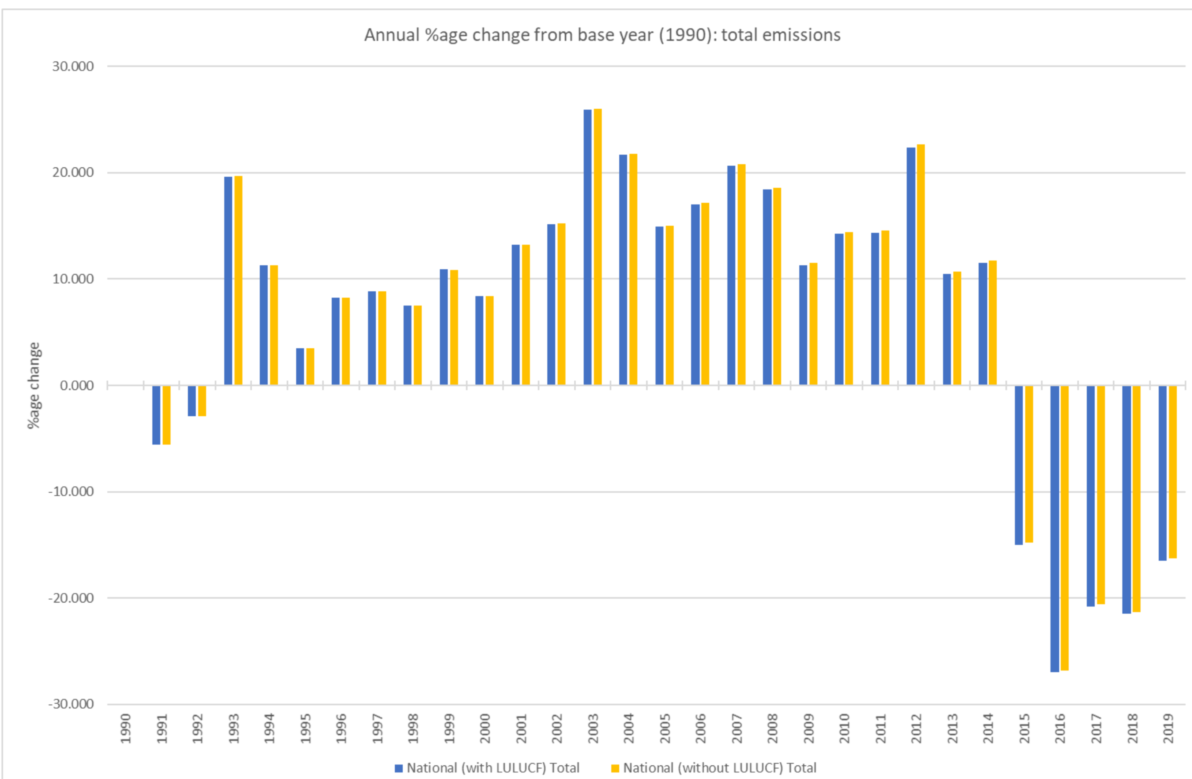

Figure 2-3 Trend in Greenhouse Gas Emissions per Capita

Figure 2-3 describes the correlation between the trend in total national emissions and the population trend of the Maltese Islands, in terms of GHG emissions per capita. Historical data shows that there was a clear correlation between population growth and national total greenhouse gas emissions until 2012, following which a decoupling of these two parameters can be observed.

Population has grown steadily over the years. GHG emissions per capita remain fairly stable for the most part from 1990 until 2012; after this there is a significant drop-off the result of the general decrease in emissions suppled with continued population growth, which itself shows an upsurge in the rate of growth. Emissions per capita in 1990 stood at 7.19 tonnes CO_2 eq. per capita, reaching their highest level in 1993 at 8.35 tonnes CO_2 eq. per capita and a low of 4.13 tonnes CO_2 per capita in 2016, with 4.23 tonnes CO_2 eq. per capita in 2019.

The decoupling between GHG emission trends and population trends for Malta in the latter years implies that population statistics alone cannot directly explain the changes in GHG emissions over the whole period under consideration. Indeed, one could consider that greater demand for major emitting activities in Malta, particularly energy (and therefore, energy generation) and mobility (i.e. road transport) as population grew, could explain the increasing emissions at least until 2012, as these activities have been the major contributors to overall national total emissions in absolute terms.

After 2012, substantial emission reductions due to major technical developments in the electricity generation sector have counteracted any increase that one may have expected would occur due to continued increase in demand as a result of population growth. Targeted measures even in one sector or activity category could have a major impact on overall emissions, despite continued population growth, and presumably, growth in demand, even more so, if that one sector or category has a significant share in total national emissions, as is the case for electricity generation.

The point is not that population is not a factor, it is just that technological improvements have counteracted, to a large extent, the effect on emissions of population growth. The extent to which this trend can continue as emissions are reduced further remains to be seen, but it is true to say that up to this point population increase has not been a limiting factor for emissions reductions.

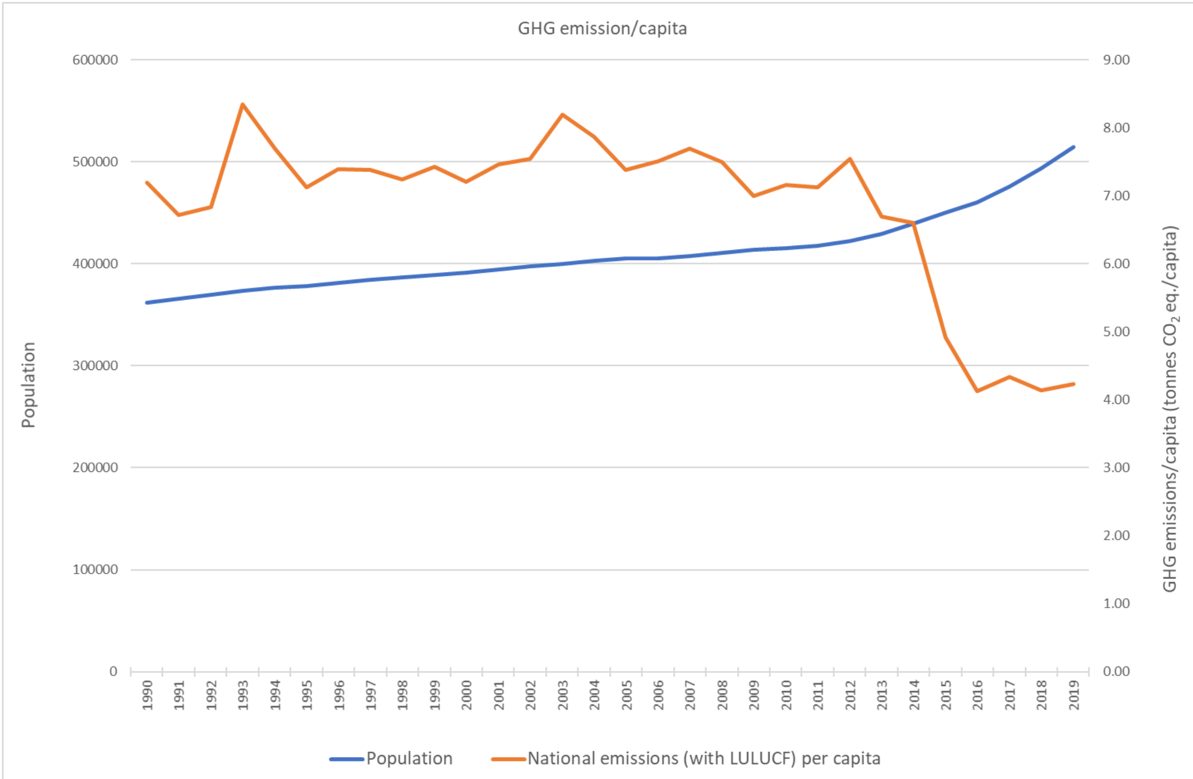

Figure 2-4 Trend in emissions per capita compared to population trend (end-of-year population figures).

2.1.1 *TREND IN GREENHOUSE GAS EMISSIONS COMPARED TO GROSS DOMESTIC PRODUCT*

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

Figure 2-4 shows how GHG emissions per unit million GDP changes over the 1990-2019 time-series. Overall, apart from the years 1990 to 1995, the overall trend is of a continuous decrease in the emissions intensity of Malta's economy: a decoupling of economic growth from greenhouse gas emissions. Between 1990 and 2019, Malta's GDP saw an overall increase of almost 390%, while GHG emissions per unit million GDP in 2019 were 82.8% 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	2019
Emissions/GDP (with LULUCF)	946.70	880.59	679.19	579.83	436.23	221.36	162.41
Emissions/GDP (without LULUCF)	943.98	877.70	677.32	578.69	435.75	221.18	162.36

An important factor related to economic growth is certainly energy demand, translating primarily into electricity generation, the main contributor to total national greenhouse gas emissions. The fact that emissions did not increase at nearly the same rate as GDP over the period 1990-2012, while the sources of energy generation did not change significantly, implies that an economic shift from energy intensive activities to a bigger economic contribution by activities with a relatively lower energy demand (e.g. shift in manufacturing towards high value-added products and shift to services industries) resulted in economic development becoming increasingly efficient emissions-wise during this period.

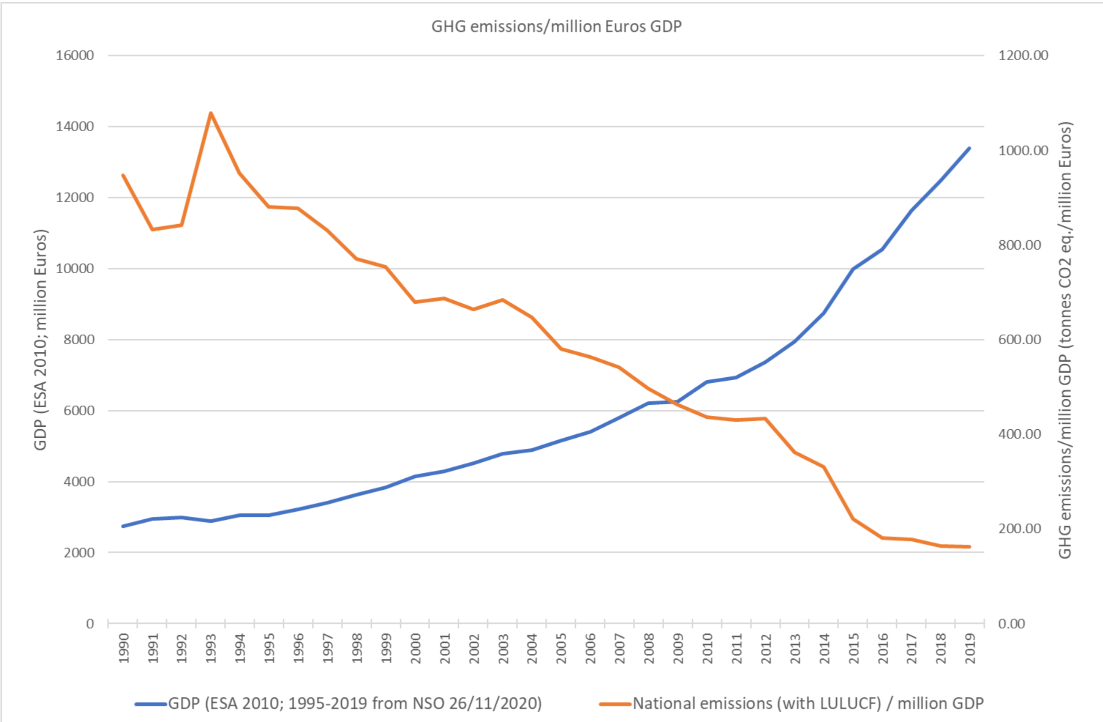

Figure 2-5 Trend in emissions per GDP compared to GDP trend.

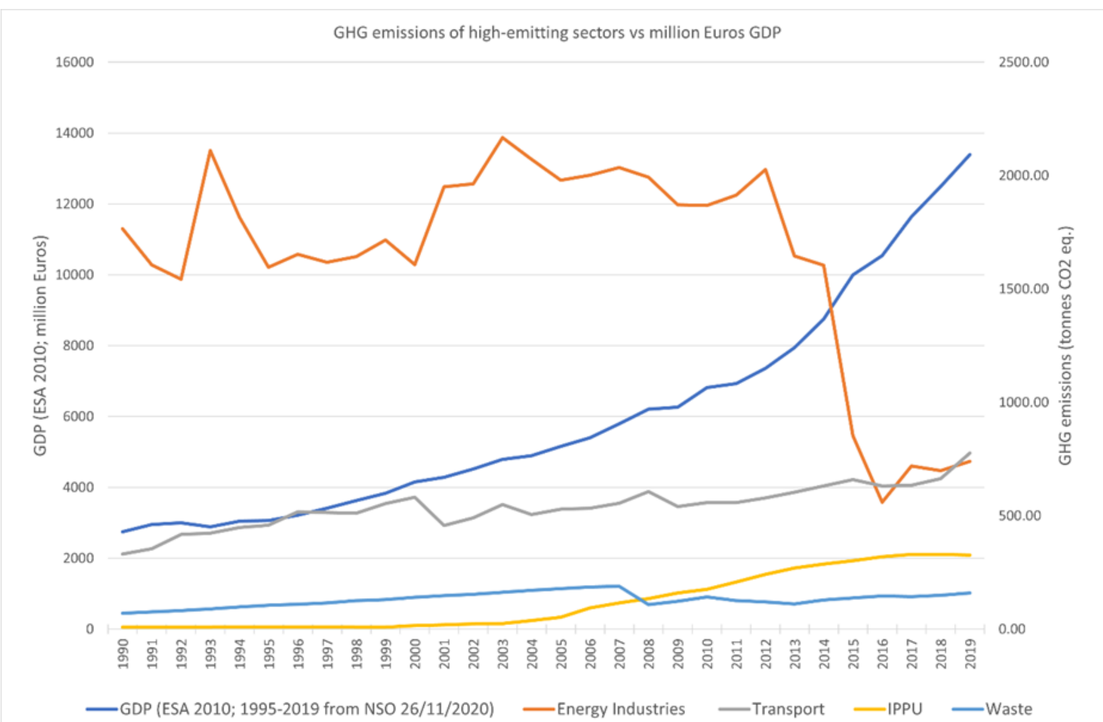

Figure 2-6 Trend in emissions of some high-emitting sectors compared to GDP trend.

Energy generation was then significantly impacted in the following years, and this can to a large extent explain the decoupling of emissions from GDP over a period of high growth. Transport, on the other hand, was never decoupled from growth and has remained highly correlated with GDP (and also with population) over the period looked at. The same goes for IPPU emissions, which show an even higher correlation with GDP. The case for waste is similar to that of energy generation, in that infrastructural advancements have meant that its emissions profile is not strongly linked to the GDP rise. Emissions from Agriculture and LULUCF, which have not been included in Figure […], have fallen steadily over the period looked at despite the GDP rise.

We can therefore say that emissions have essentially been decoupled from GDP over the time period looked at, due to the fall in emissions from some sectors and industries over time making up for the positive contribution of others. The question for the near future therefore becomes, can these sectors continue lead the way, or will the other sectors come into play in terms of emissions reductions in order to meet targets, as will have to happen eventually to achieve carbon-neutrality.

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 2-7; Table 2-3). 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 1990-2019 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).

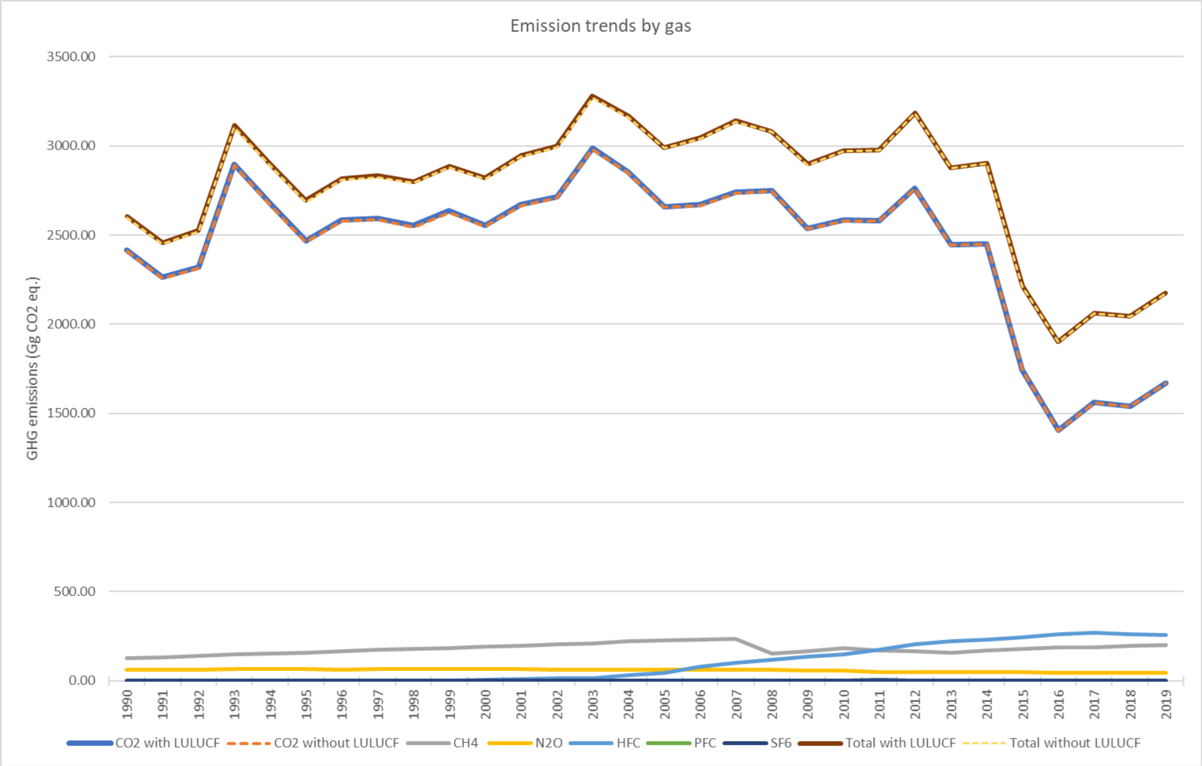

Figure 2-7 Greenhouse gas emission trends by gas.

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

	CO_2 with LULUCF	CO_2 without LULUCF	CH_4	N_2O	HFC	PFC	SF_6	NF_3	Total with LULUCF	Total without LULUCF
	Gg CO2 eq.									
1990	2414.88	2408.46	5.03	0.21	NO,NE,IE,NA	NA,NO	0.00	NA,NO	2602.98	2595.50
1995	2468.09	2460.27	6.32	0.22	0.00	NA,NO	0.00	NA,NO	2694.45	2685.61
2000	2552.37	2545.52	7.74	0.23	6.70	NA,NO	0.00	NA,NO	2821.02	2813.23
2005	2659.41	2654.26	9.00	0.21	42.21	NA,NO	0.00	NA,NO	2990.98	2985.10
2010	2582.22	2579.52	7.32	0.19	148.48	NA,NO	0.00	NA,NO	2971.72	2968.46
2011	2579.25	2576.84	6.79	0.16	172.35	NA,NO	0.00	NA,NO	2975.01	2972.04
2012	2762.64	2760.50	6.68	0.17	204.83	NA,NO	0.00	NA,NO	3184.16	3181.48
2013	2446.15	2444.30	6.24	0.16	220.45	NA,NO	0.00	NA,NO	2873.99	2871.60
2014	2449.97	2448.40	6.88	0.16	235.56	NA,NO	0.00	NA,NO	2907.29	2905.19
2015	1742.28	1740.99	7.17	0.16	251.27	NA,NO	0.00	NA,NO	2221.90	2220.08
2016	1406.41	1405.39	7.49	0.16	262.73	NO,NA	0.00	NO,NA	1904.01	1902.48
2017	1560.17	1559.43	7.37	0.15	271.64	NO,NA	0.00	NO,NA	2062.13	2060.88
2018	1538.78	1538.32	7.69	0.16	264.45	NO,NA	0.00	NO,NA	2042.13	2041.17
2019	1669.33	1669.15	8.07	0.16	257.29	NO,NA	0.00	NO,NA	2175.37	2174.72

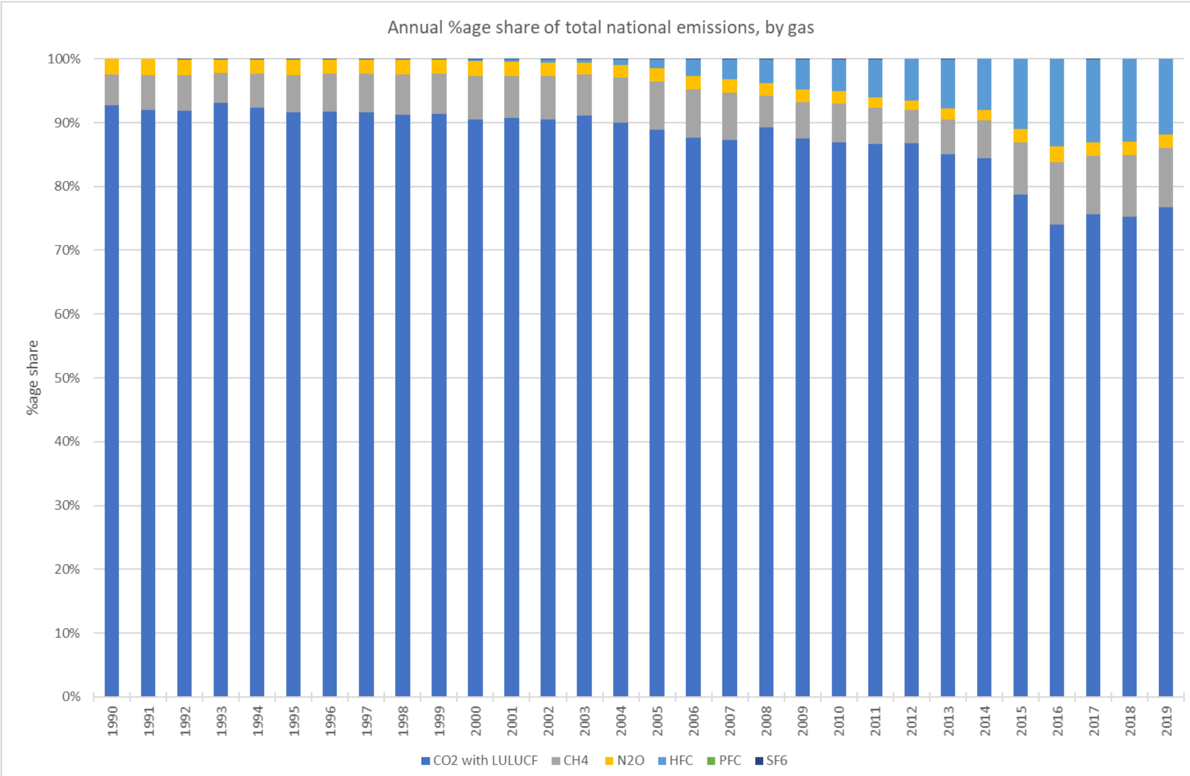

Figure 2-8 Annual percentage share of total national emissions for each GHG.

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 2019.

Table 2-4 The contribution (%) of Malta's total GHG emissions by sector and by gas in 2019.

Sector	GHG emissions (%)			
	CO_2	CH_4	N_2O	F-Gases
Energy	99.67%	2.86%	11.54%	NO
IPPU	0.28%	NO	2.97%	97.56%
Agriculture	NO	22.41%	66.67%	NO
LULUCF	0.01%	NO	1.01%	NO
Waste	0.03%	74.73%	17.81%	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 CO_2 emissions is Energy, being responsible for more than 99% of total carbon dioxide emissions in all years between 1990 and 2019 (1990 share: 99.51%; 2019 share: 99.67%). Very small contributions are given by sectors IPPU (0.28%), LULUCF and Waste (<0.1%).

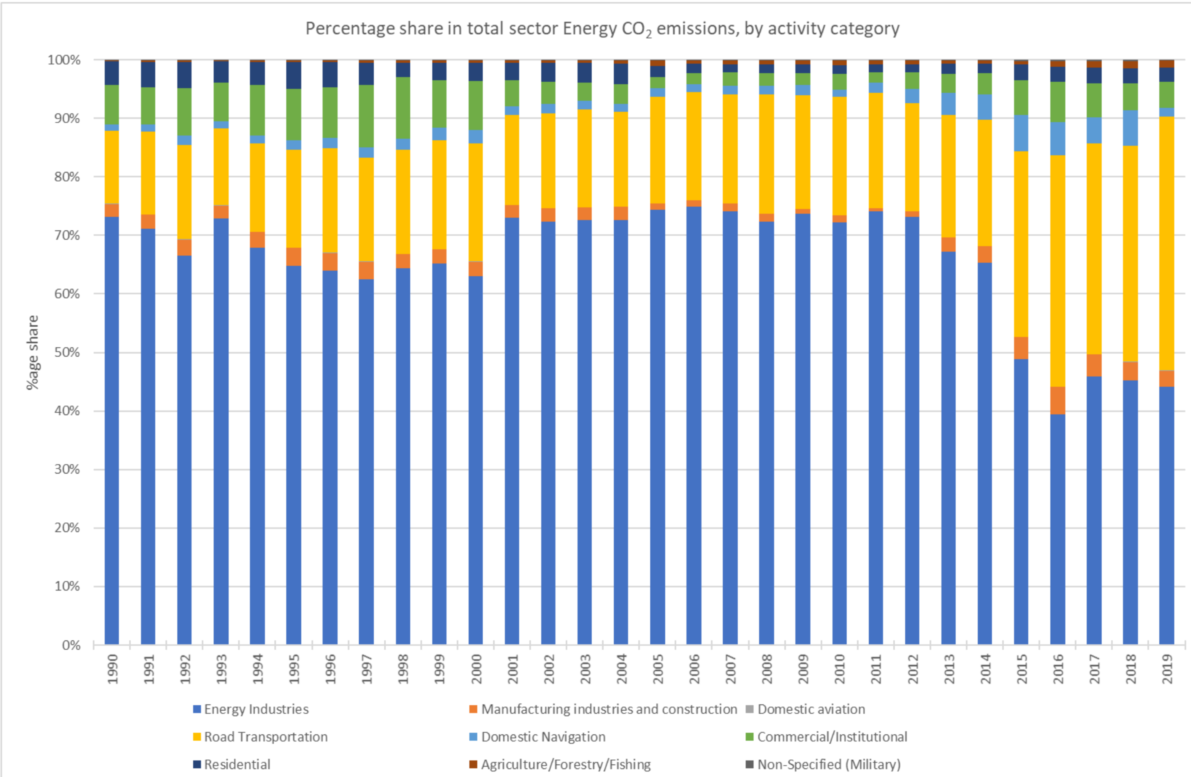

Figure 2-9 Annual percentage share in total carbon dioxide emissions in sector Energy, for activity categories in this sector

2.2.3 *METHANE*

Sectors Waste and Agriculture are the two main contributors towards total national methane emissions (Figure 2-10). In 2019, sector Waste accounted for 74.73% of total national methane emissions, with a 22.41% contribution by sector Agriculture. A much smaller share is provided by the Energy sector (2.86%).

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.

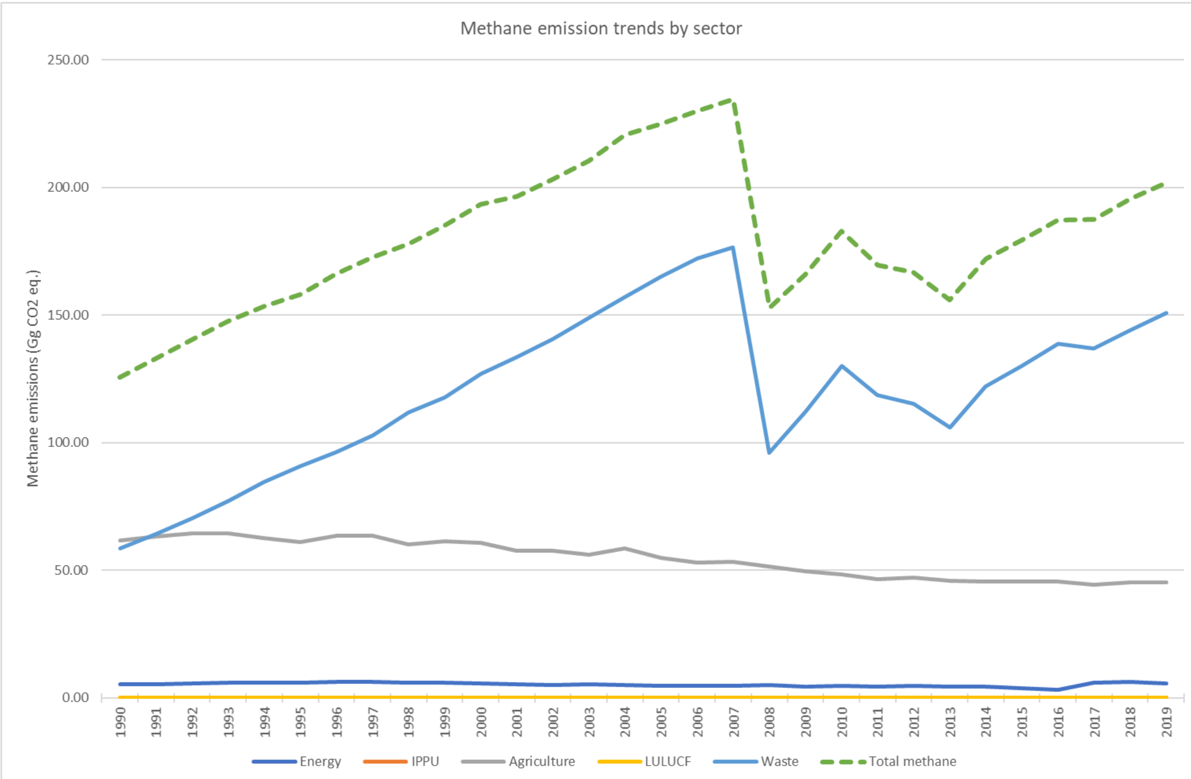

Figure 2-10 Emission trends: methane, total and by sector.

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 2-11).

The relative share of sector Agriculture in total national nitrous oxide emissions in 2019 was 66.67%, not much higher than it was in 1990 (63.26%). The relative share of sector Energy has generally increased, while that of sector Waste has decreased over the time-series.

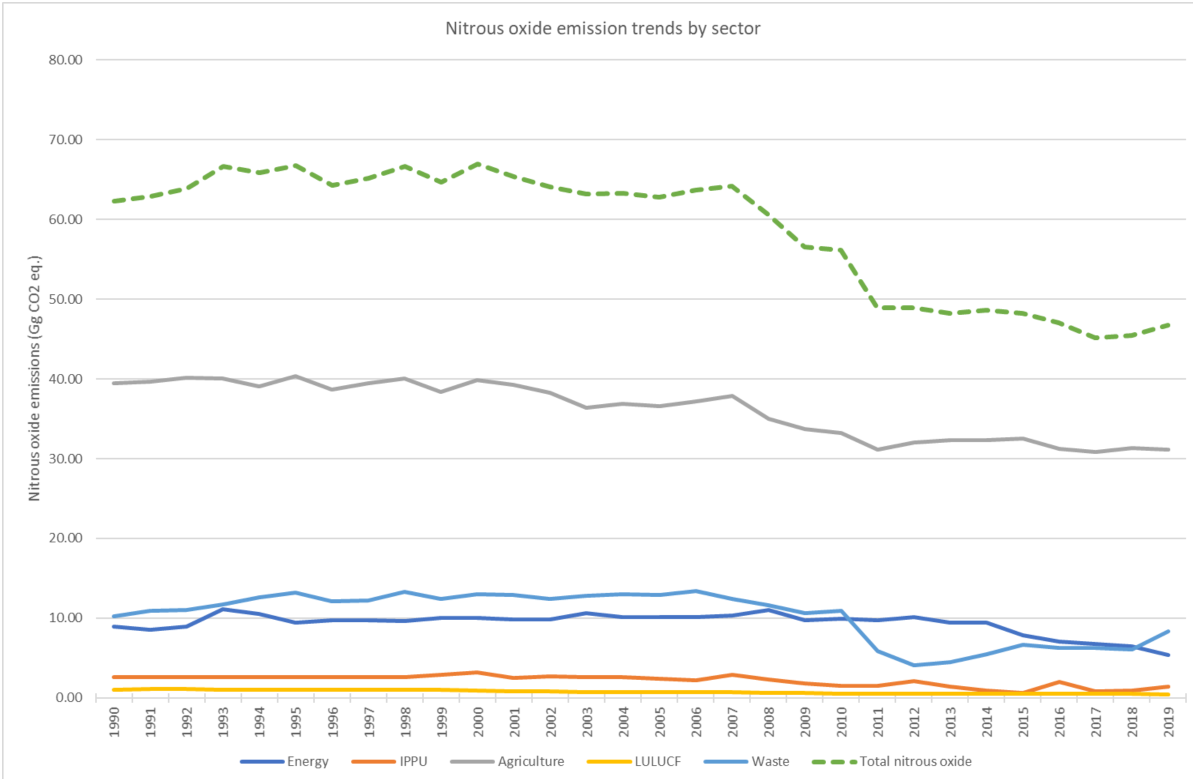

Figure 2-11 Emission trends: nitrous oxide, total and by sector.

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 2-12. Emissions of PFCs are of even more recent occurrence.

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 2019, emissions of HFCs account to 97.56% of total emissions, of all gases, in sector IPPU.

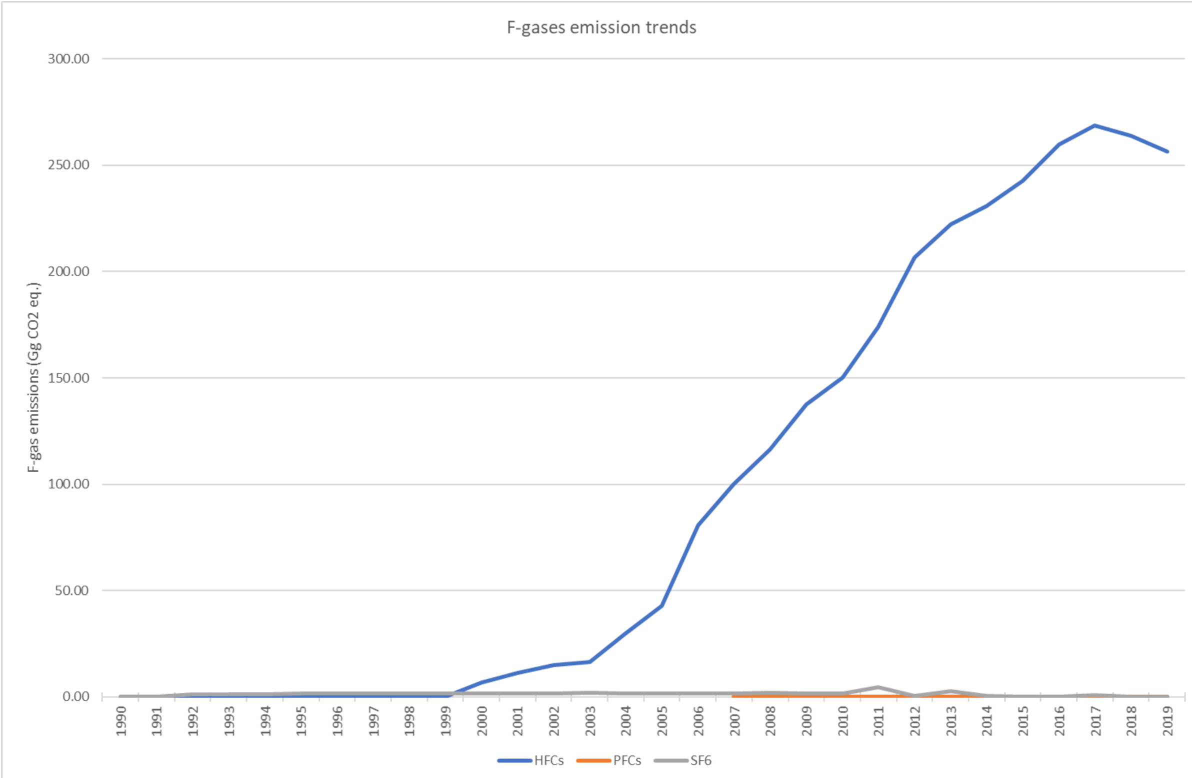

Figure 2-12 Emission trends: fluorinated gases.

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 Figure 2-13.

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	2417.35	7.78	101.06	7.48	69.32	2602.98	2595.50
1995	2470.29	9.29	101.49	8.85	104.54	2694.45	2685.61
2000	2557.30	14.99	100.72	7.80	140.22	2821.02	2813.23
2005	2665.35	49.88	91.51	5.88	178.35	2990.98	2985.10
2010	2590.10	155.37	81.56	3.26	141.43	2971.72	2968.46
2011	2586.45	182.61	77.62	2.97	125.36	2975.01	2972.04
2012	2769.72	212.68	79.10	2.68	119.98	3184.16	3181.48
2013	2446.71	235.79	78.14	2.39	110.95	2873.99	2871.60
2014	2451.07	248.06	77.97	2.11	128.09	2907.29	2905.19
2015	1742.96	261.74	78.22	1.82	137.16	2221.90	2220.08
2016	1408.07	272.27	76.69	1.53	145.45	1904.01	1902.48

2017	1563.65	278.27	75.26	1.25	143.70	2062.13	2060.88
2018	1542.61	271.20	76.61	0.96	150.75	2042.13	2041.17
2019	1675.00	263.70	76.34	0.65	159.68	2175.37	2174.72

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. In fact, the relative share of emissions of IPPU has 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 2019.

Table 2-6 Contribution (%) of Malta's total GHG emissions by sector in 2019.

Sector	% contribution of Malta's total GHG emissions
Energy	77.03%
IPPU	12.09%
Agriculture	3.51%
LULUCF	0.03%
Waste	7.34%

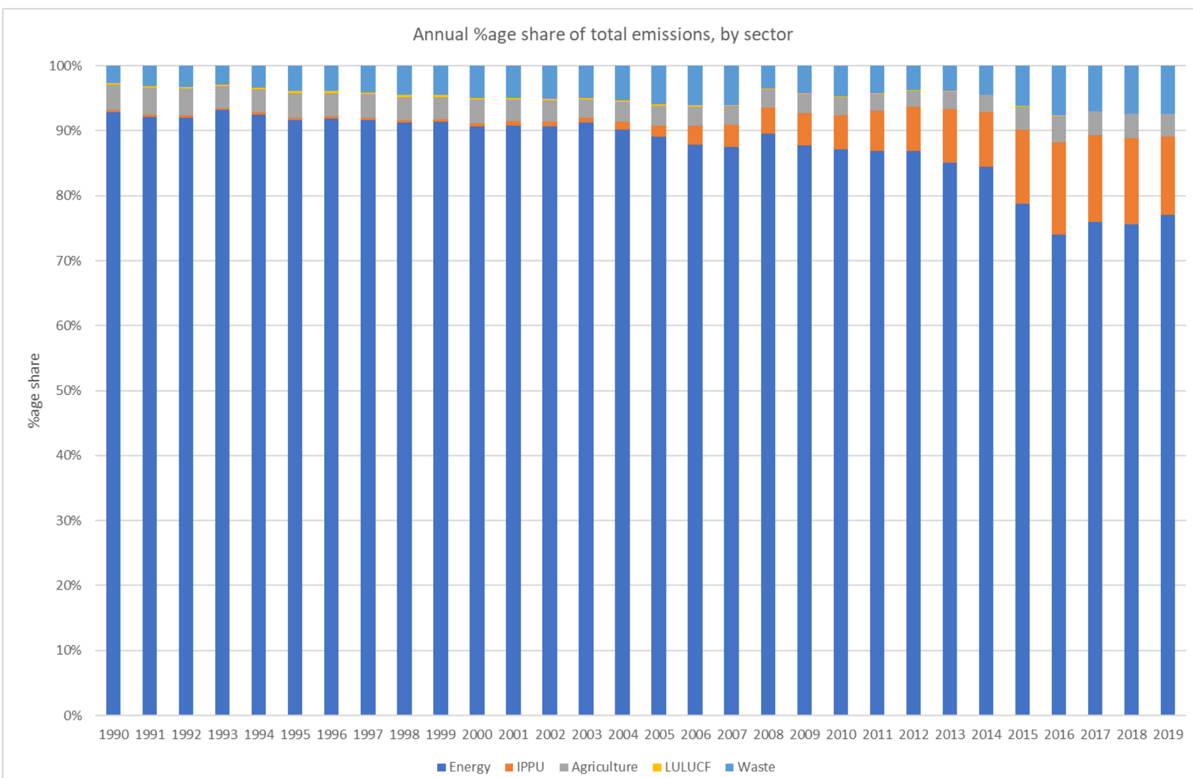

Figure 2-13 Annual percentage share of national emissions for each sector.

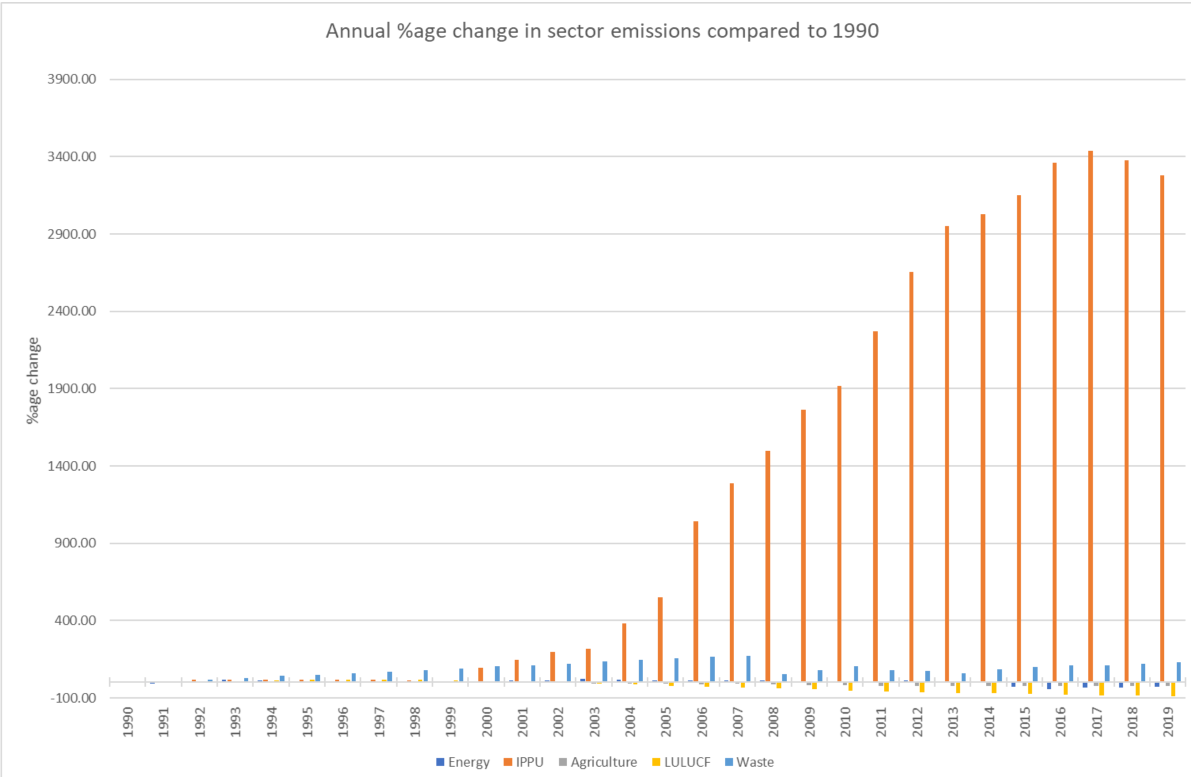

Figure 2-14 Annual percentage change compared to 1990, by sector.

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 2019, the energy sector contributes to 77.03% 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.

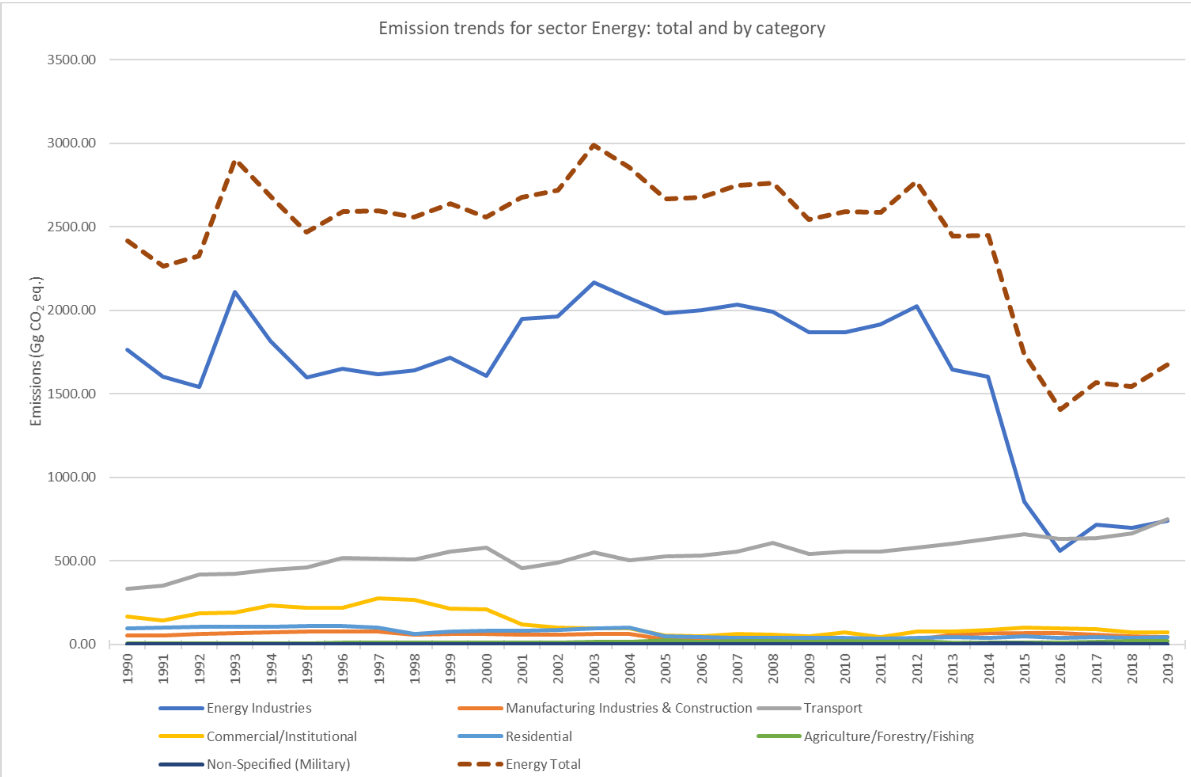

Figure 2-15 Emission trends for sector Energy, by category.

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 and 2019 estimated to actually 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 2019, emissions of methane and nitrous oxide for this sector accounted for 0.34% and 0.32% respectively.

Due to the implementation of the EUROCONTROL model for domestic aviation purposes, a slight discrepancy remains because emissions decrease slightly from 2004 (1.80 $GgCO_2$eq.) to 2005 (0.03 $GgCO_2$eq.) as this marks the switch from Tier 1 to Tier 3 data. From 2005 onwards, the timeseries remains consistent and shows a gradual increase in emissions year after year for both jet kerosene and aviation gasoline. Jet kerosene remains significantly higher than aviation gasoline for the whole timeseries. The implementation of EUROCONTROL data has improved this category but one slight issue with regards a slight decrease in emissions still needs to be explained properly. This issue will be followed up with EUROCONTROL in future in order to understand better why they are modelling low values for Maltese national aviation emissions.

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 397,508 by Q4 of 2019. According to a National Statistics Office News Release entitled 'Motor Vehicles: Q4/2019', a total of 6,154 newly licensed vehicles were added to Maltese roads in 2019 with the majority or 67.7% being passenger cars. This figure was followed by 996 newly licensed motorcycles or 16.2% of all the newly licenced vehicles. It should also be noted that the sub-category Heavy-Duty Vehicles has increased substantially from 2016 (1210.92 TJ) to 2017 (1884.73 TJ) and 2018 (1984.20 TJ). In 2016, they amounted to 14,448 vehicles while in 2017 this value increased to 21,052. This sub-category includes heavy-duty vehicles, buses and coaches. Malta's drastic increase in construction in recent years could be the reason for this rise. An increase in the number of heavy trucks, tractors, fork-lifters and so on; will lead to higher emissions in this category. According to an NSO News Release titled Business Demographics [2018], employment size in the construction industry grew by 279 individuals from 2016 to 2017.

2.3.3 *SECTOR IPPU EMISSIONS*

The trend profile for sector IPPU (Figure 2-16) 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 consistently increased from the early 2000's to the year 2017. This trend changed in the year 2018 with a decrease over the previous year. This decrease continued in the year 2019. The main contributor towards HFC emissions, category Refrigeration and Air-Conditioning, accounted for 97.54% of all direct greenhouse gas emissions estimated for the IPPU sector in 2019. 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 12.09% in 2019.

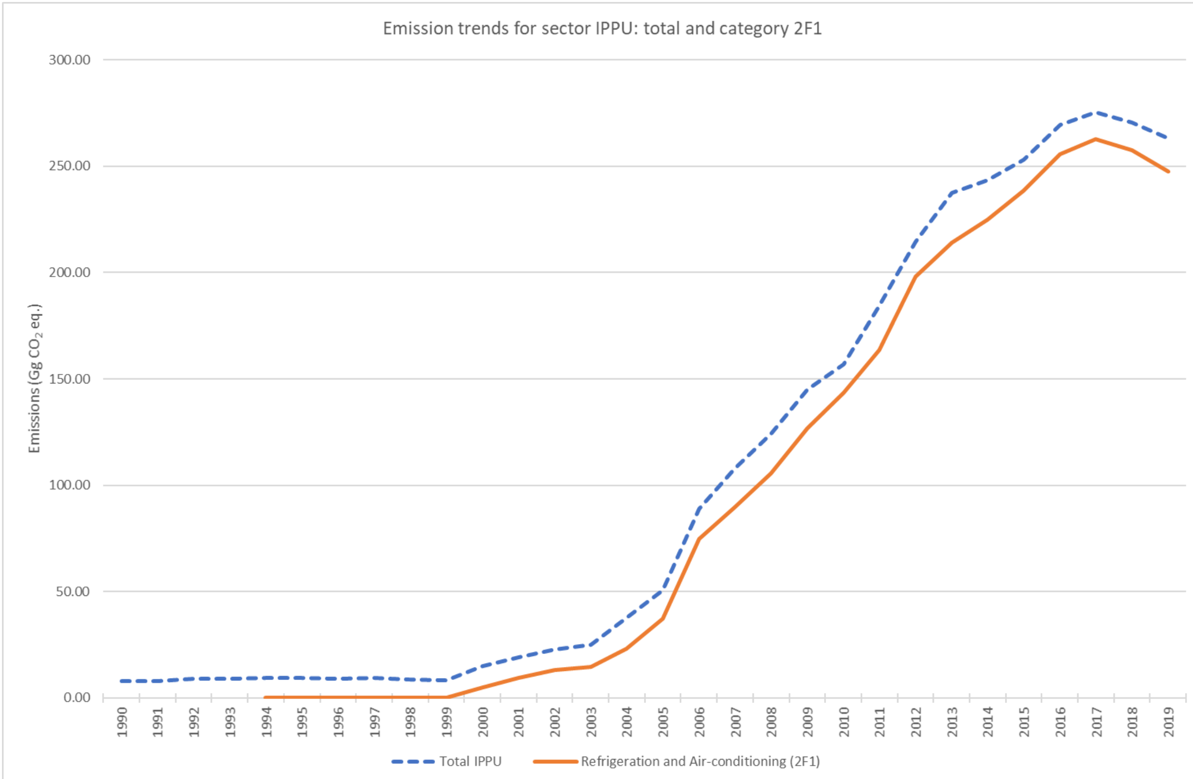

Figure 2-16 Emissions trends for sector IPPU.

2.3.4 *Sector Agriculture Emissions*

In general, sector Agriculture has seen a decrease in emissions of around 24% over the 1990-2019 period and it is certainly not a major contributor towards total national emissions, as has already been discussed above.

Within this sector (**Figure 2-17**), the category Enteric Fermentation (3A) has always had the highest share of total sector emissions, followed by Managed Soils (3D) and Manure Management (3B). In 2019 category Enteric Fermentation accounted for almost half of all sector emissions (45%). No emissions are reported for other activity categories in this sector (**Figure 2-18**).

From the perspective of emitted gases, emissions of methane and nitrous oxide are reported for this sector. All Enteric Fermentation emissions are of methane. Both gases are reported under category Manure Management: more than two thirds of category Manure Management emissions are nitrous oxide. Direct and indirect nitrous oxide emissions are reported under category Managed Soils.

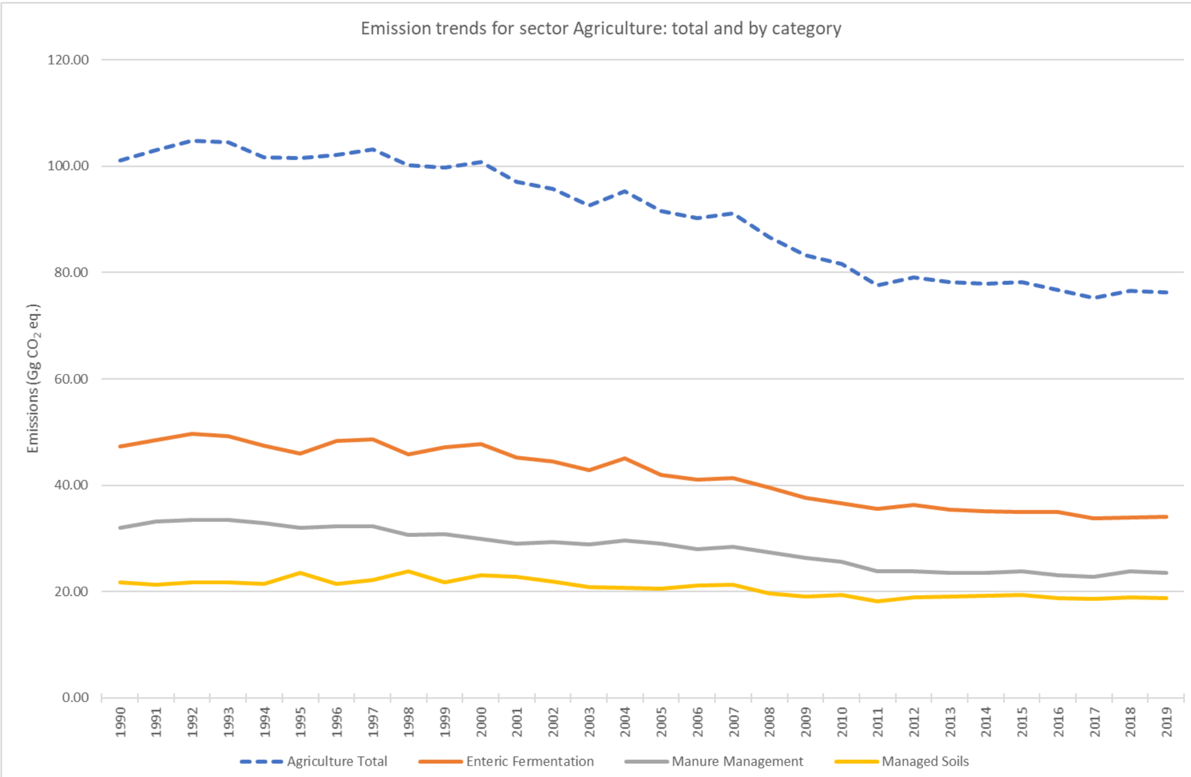

Figure 2-17 Emission trends for sector Agriculture.

Livestock populations have decreased significantly compared to 1990 levels, except for rabbits and horses. These changes could be attributed to the rise in the import of meat and dairy products and the increase in demand for rabbit and horse meat in the catering industry. As a result of these changes in the number of heads, 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 59.23% of total agriculture emissions, while nitrous oxide accounted for 40.77% respectively. Enteric fermentation accounted for 75% of total methane emissions, whereas those coming from the management of manure accounted for 25%. 39% of nitrous oxide emissions resulted from Manure management, while 61% from Agricultural soils.

GHGs from agricultural soils are emitted both directly and indirectly, the latter of which occurs through atmospheric deposition and through leaching and runoff. During 2019, direct emissions accounted for 74%, while atmospheric deposition and leaching/runoff accounted for 9% and 17% of total agricultural soils emissions, respectively. 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 2019 180.85kgN/ha were applied. Inorganic fertilizer is also heavily applied but to a lesser extent than manure. It is estimated that in 2019 585,922 kg N of inorganic fertilizer were applied to agricultural fields.

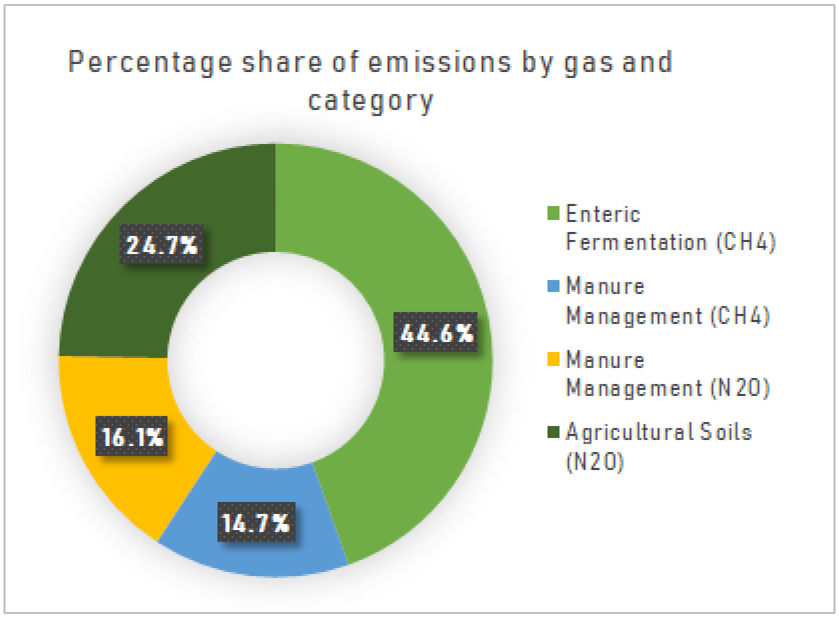

Figure 2-18 Percentage share of agriculture emissions by gas and category.

2.3.5 *SECTOR LULUCF EMISSIONS*

A mean figure of 5.43 Gg CO_2 has been estimated to be emitted by Maltese land use sector during the time series 1990 to 2019. In this inventory, calculations from the categories Cropland (CRF 4.B), Grassland (CRF 4.C), Settlements (CRF 4.D) and Other Land (4.E) were estimated. No estimations were calculated from the categories of Forest Land (CRF 4.A) and Wetlands (CRF 4.D), thus not indicated in the Figure below (more details on the estimations for the categories are given in the corresponding category sections of the LULUCF chapter). Noting that for this submission certain Emission Factors were updated in the LULUCF sector, to represent better the factor parameters in Malta, as a result updates were performed in the estimations of the whole sector.

The LULUCF sector in Malta represents a net emission of 7.48 ktCO_2 eq. in 1990, decreasing to 0.65 ktCO_2 eq. by 2019. The sector accounted for 0.03% of Malta's total GHG emissions in 2019. The main source of emissions in 1990 was represented by the land transitioning to Grassland (10.98 ktCO_2 eq.), followed by the transition to Settlement (6.70 ktCO_2 eq.). In 2019 the source of emissions reduced significantly and mainly became the transition to Other Land and transition to Settlements (1.01 ktCO_2 eq. and 0.83 ktCO_2 eq. respectively). Grassland remaining Grassland represented the most important sink in the year 1990 (-9.80 ktCO_2 eq.), while in 2019 the main sink decreased significantly mainly represented by Cropland (-1.21 ktCO_2 eq.). The shift in decreasing emissions in Settlements came about due to the decreasing 20-year cumulated area conversion periods in conversions to Settlements from 1996 onwards.

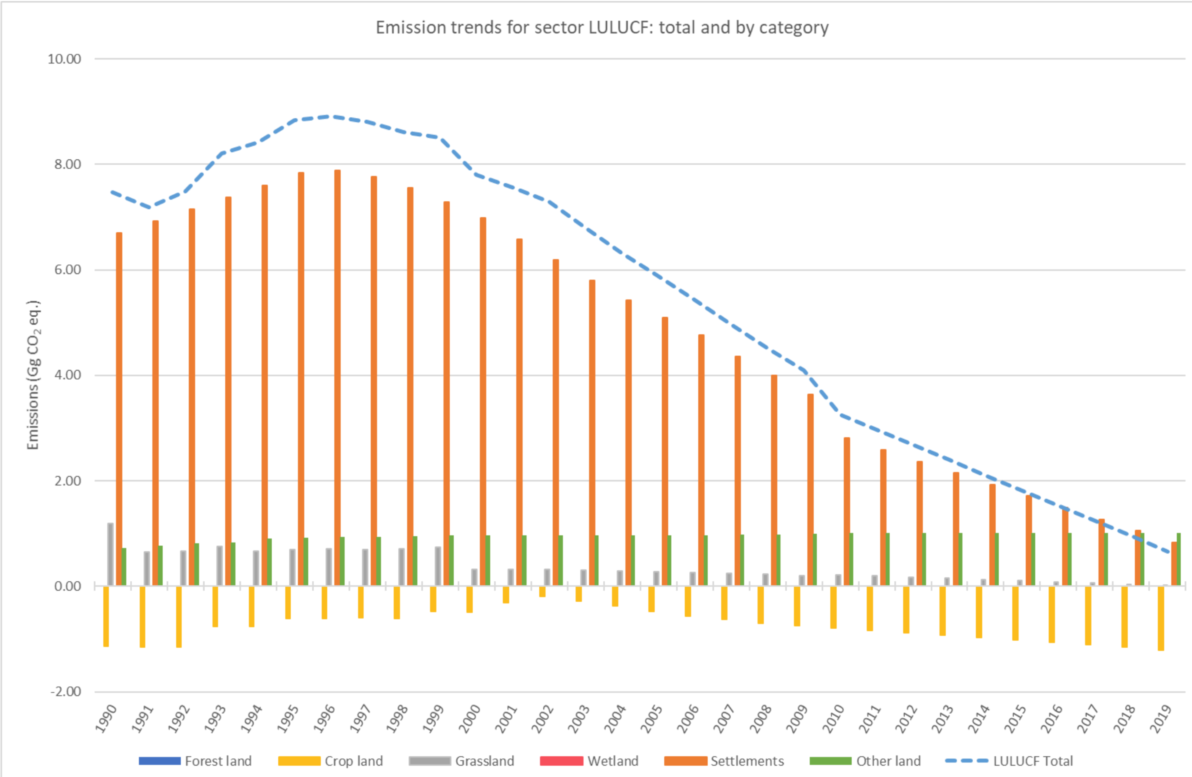

Figure 2-19 Emission trends for sector LULUCF.

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 2019, 88.57% of all sector Waste emissions were generated by the category Solid Waste Disposal (refer to **Figure 2-20** 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 2019, the Waste sector contributes to 7.34% of Malta's total GHG emissions.

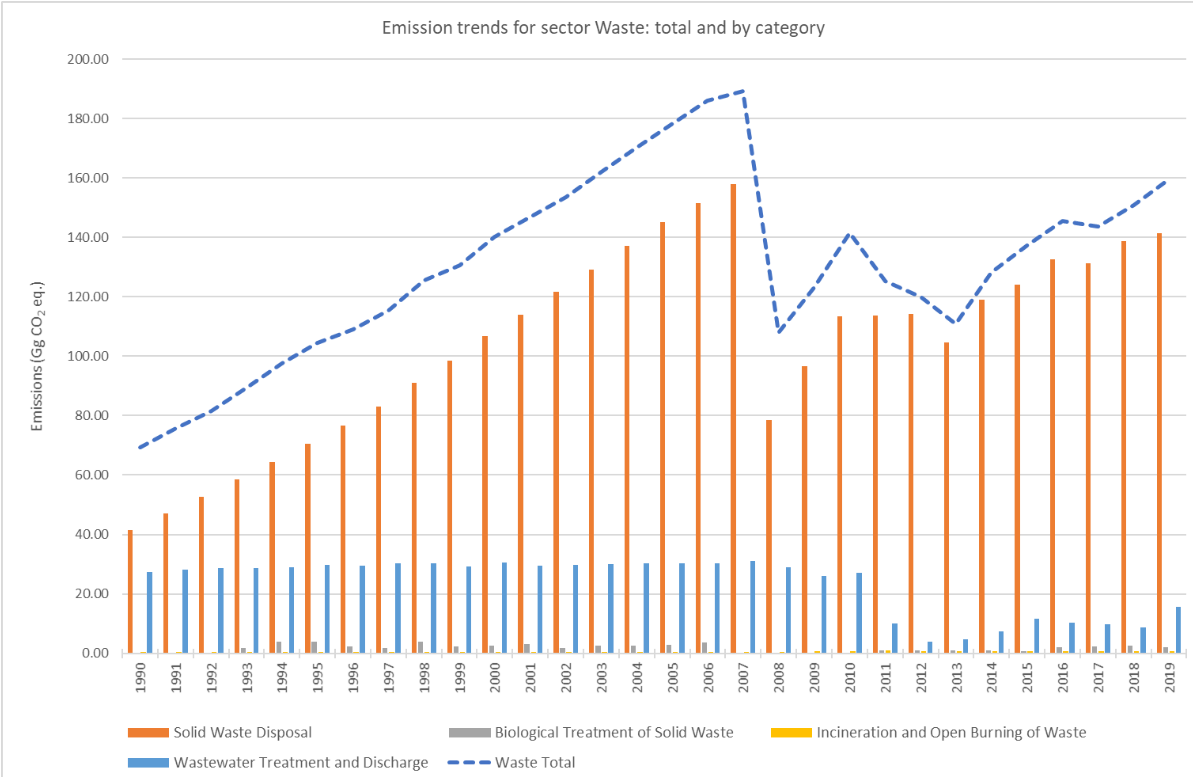

Figure 2-20 Emission trends for sector Waste.

As presented in Figure 2-21 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 rapid change can be summarised as the effect of the entry in operation of specific installations aimed at reducing emissions from these sectors. 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.

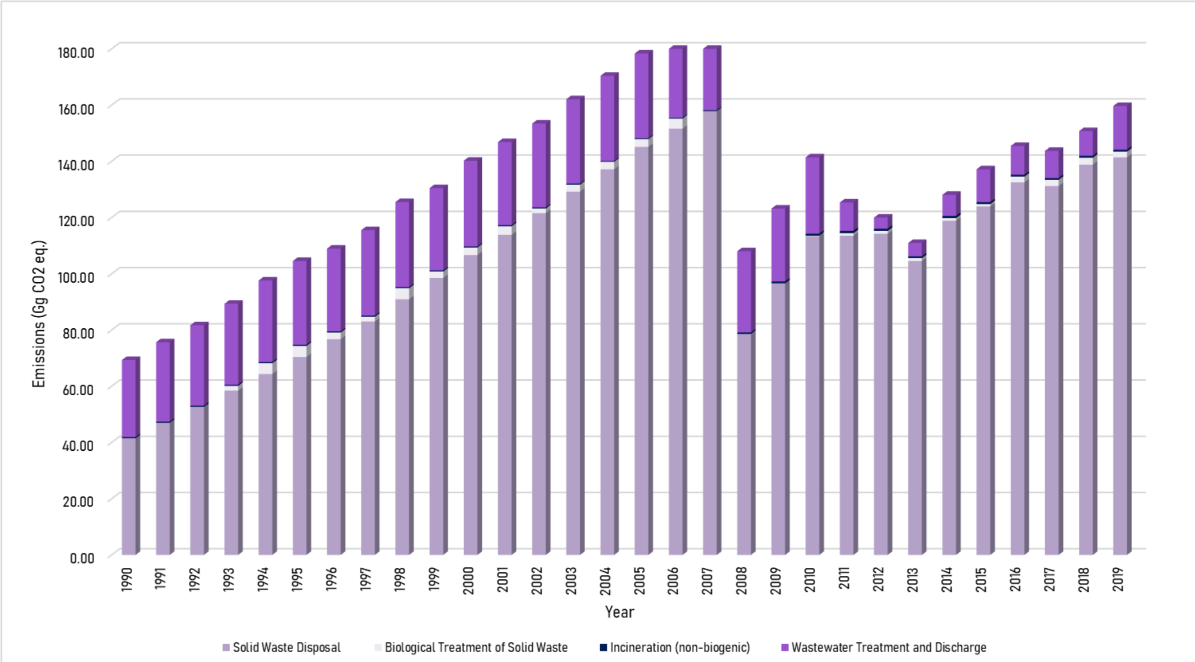

Figure 2-21 Total GHG emissions from waste management overview by activity for sector Waste.

Furthermore, Figure 2-22 below shows the contribution in carbon dioxide equivalents (CO_2 eq.) of carbon dioxide, methane and nitrous oxide emissions in the latest inventory year. As shown, a large proportion of percentage share is from CH_4 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 N_2O from wastewater treatment and discharge category and incineration, and then followed by CO_2 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.

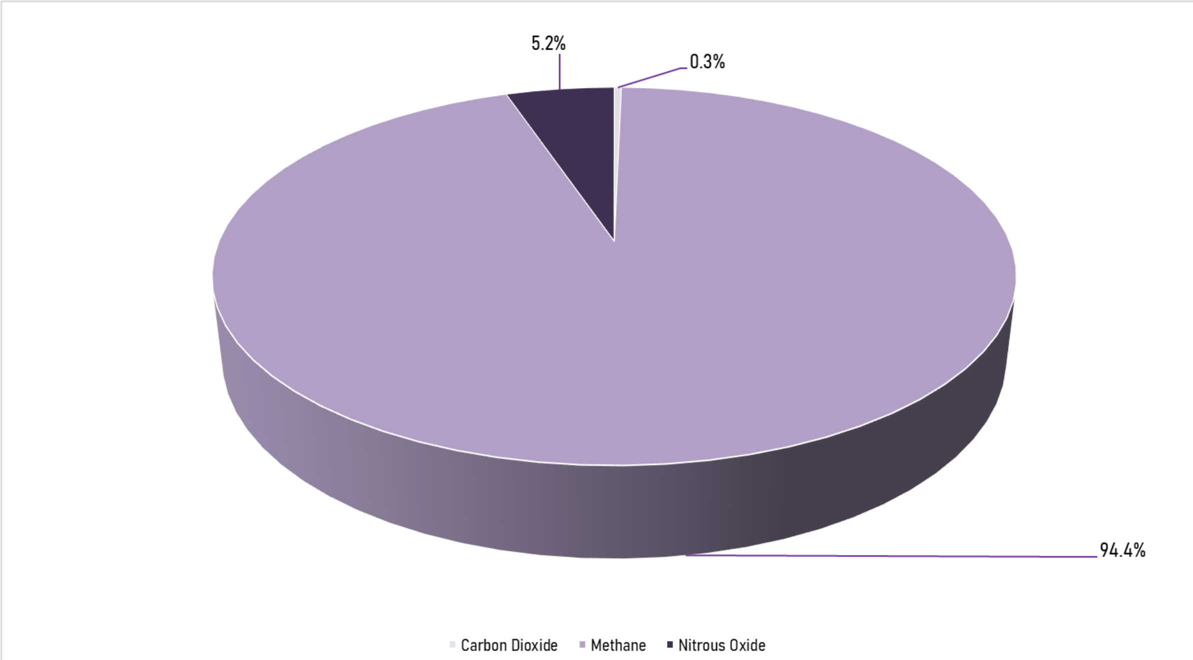

Figure 2-22 Share of emissions, by gas, for sector Waste (% share by gas, based on CO2 equivalents).

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 (2019), according to the GHG emissions and the source category or sub-sector, as applicable.

Table 2-7 GHG emissions from the Waste sector.

		Year									
		1990	1995	2000	2005	2010	2015	2016	2017	2018	2019
		Gg									
GHG	CO_2	0.37	0.37	0.35	0.32	0.52	0.56	0.52	0.51	0.55	0.55
	CH_4	2.35	3.64	5.08	6.61	5.20	5.20	5.55	5.48	5.76	6.03
	N_2O	0.03	0.04	0.04	0.04	0.04	0.02	0.02	0.02	0.02	0.03
	Total	2.75	4.05	5.46	6.97	5.76	5.78	6.09	6.00	6.34	6.61
		Gg CO_2 eq.									
Waste sector category	Solid Waste Disposal	41.50	70.41	106.66	145.12	113.39	123.94	132.51	131.21	138.82	141.42
	Biological Treatment of Solid Waste	0.00	3.92	2.66	2.75	0.15	0.83	2.04	2.19	2.45	2.01
	Incineration and Open Burning of Waste	0.43	0.43	0.40	0.32	0.73	0.72	0.67	0.65	0.69	0.69
	Wastewater Treatment and Discharge	27.39	29.78	30.49	30.16	27.16	11.67	10.23	9.66	8.79	15.56
	Total	69.32	104.54	140.22	178.35	141.43	137.16	146.45	143.70	150.75	159.68

2.4 EMISSION TRENDS FOR INDIRECT GREENHOUSE GASES

The below table (**Table 2-8**) presents emissions of the four indirect greenhouse gases (NO_x, CO, NMVOC and SO_2) included in this submission. Trends for each of these gases are shown in **Figure 2-23**.There are varying trends between the four gases. In 1990, CO and SO_2 were respectively the highest and second highest in terms of absolute emissions, followed by NO_x. By 2019, the highest estimated indirect greenhouse gas emissions were for CO, followed by NO_x and NMVOC respectively.

As illustrated in **Figure 2-24**, **Figure 2-25**, **Figure 2-26** and **Figure 2-27**, the emissions of CO, NO_x and SO_2 have decreased between 1990 and 2019 (70.38%, 31.22% and 97.08% respectively), whereas the emissions of NMVOC have increased by 181.81% since 1990.

Table 2-8 Emissions of indirect greenhouse gases.

	National totals			
	NO_x	CO	NMVOC	SO_2
1990	7.43	20.19	1.54	10.26
1995	9.19	19.95	1.68	11.41
2000	9.50	13.88	1.54	10.03
2005	9.76	10.53	1.83	12.36
2010	8.89	7.96	1.95	8.17
2011	7.80	7.01	1.60	8.11
2012	9.16	6.37	2.48	8.12
2013	8.18	6.76	2.56	5.57
2014	8.61	6.51	2.60	4.91
2015	7.50	6.25	3.12	2.44
2016	6.09	5.80	3.10	2.05
2017	6.34	8.97	3.51	1.04
2018	4.56	5.39	3.81	0.33
2019	4.37	4.80	4.29	0.14

In 2019, the sector that contributed the most to emissions of the NO_x, CO and SO_2 was the sector Energy, category Transport. From the sector Energy, emissions of NMVOC also occurred. However, IPPU was the sector that emitted the most NMVOC, from category Non-energy products from fuels and solvent used. The sector Waste contributed minimally to emissions of all the four indirect gases mentioned above. Moreover, no emissions of indirect gases were reported from the sectors Agriculture and 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 pointed out that no emissions of NF_3 are reported in Malta.

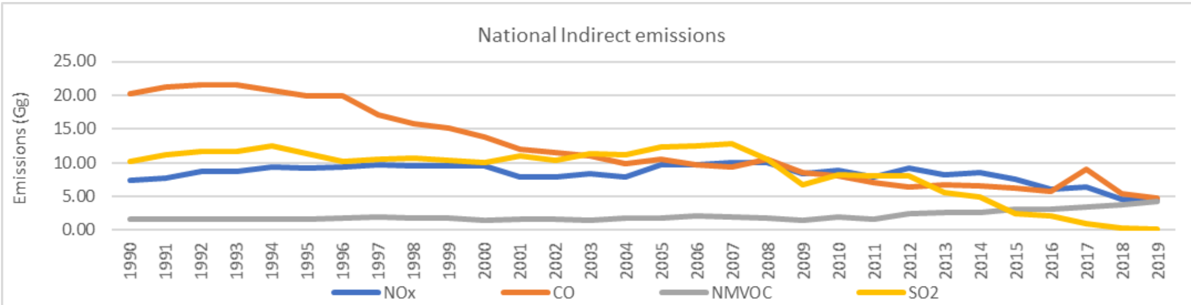

Figure 2-23 Trends in emissions of indirect greenhouse gases.

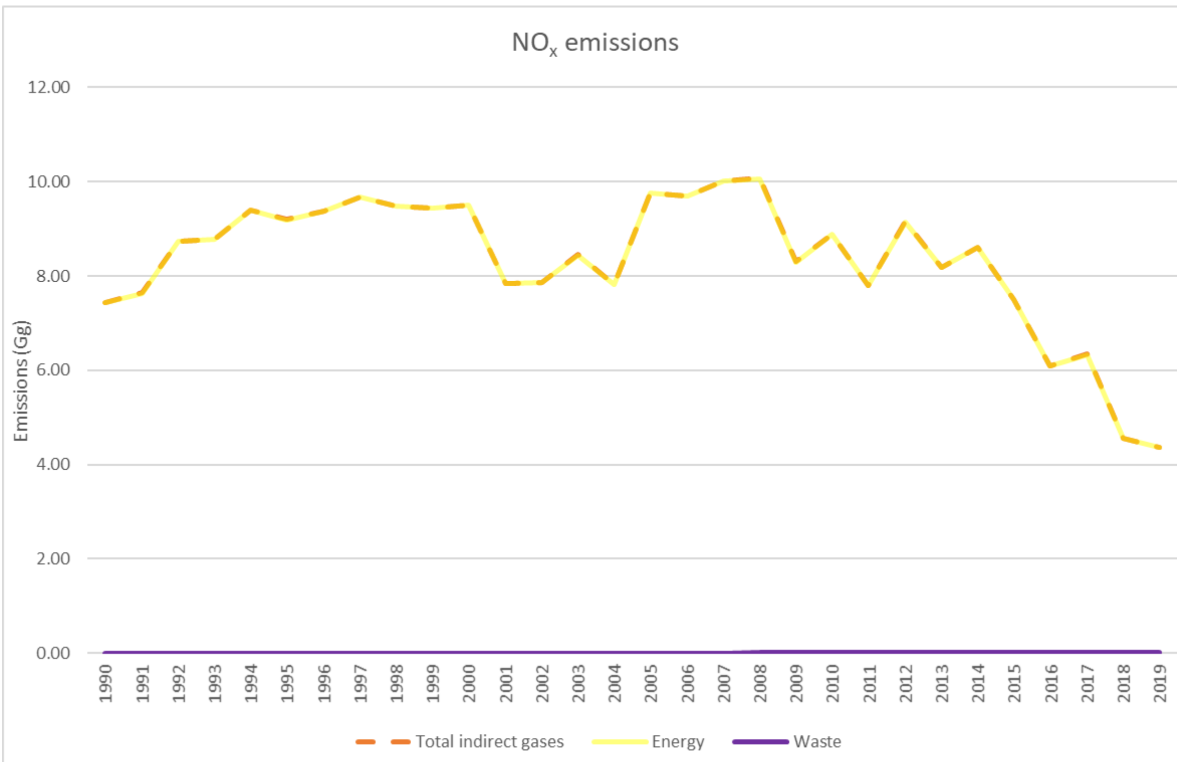

Figure 2-24 NOx emissions by sector.

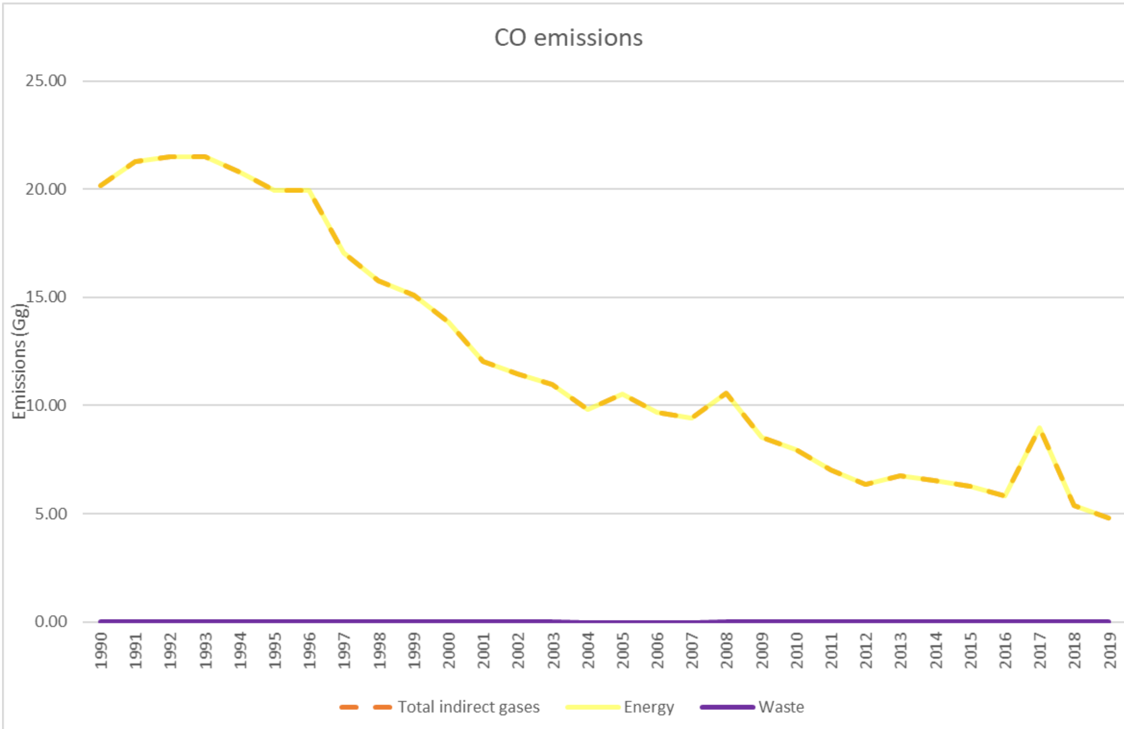

Figure 2-25 CO emissions by sector.

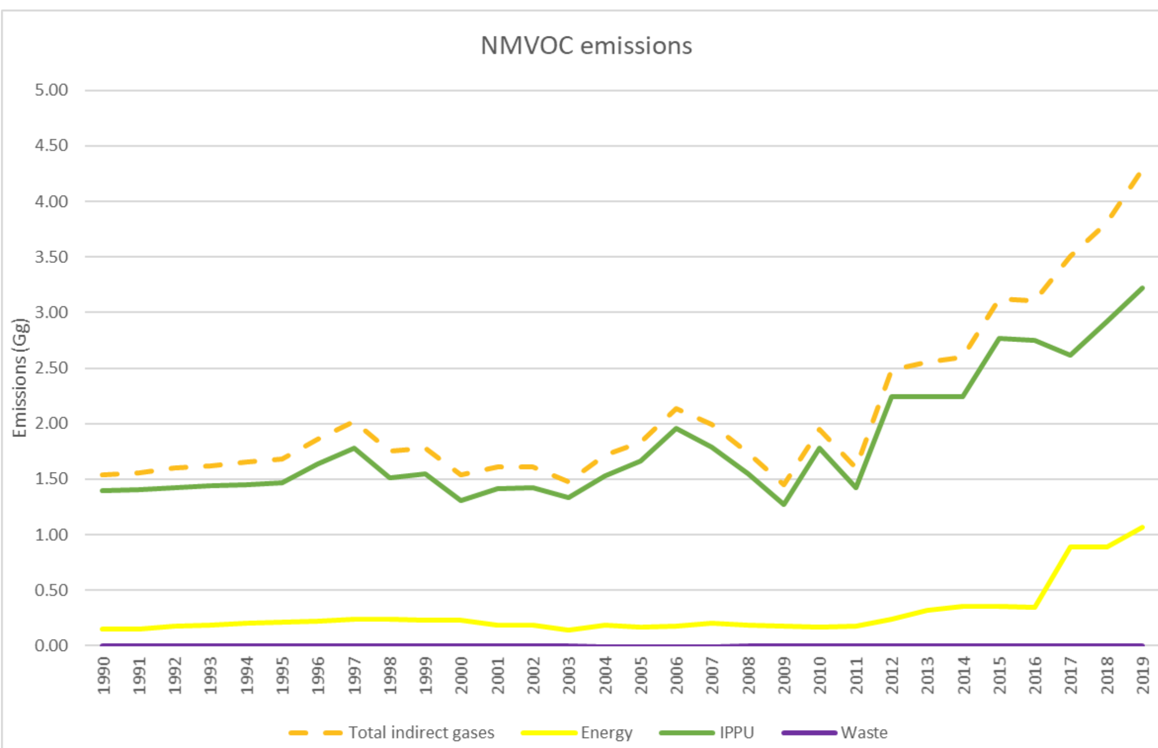

Figure 2-26 NMVOC emissions by sector.

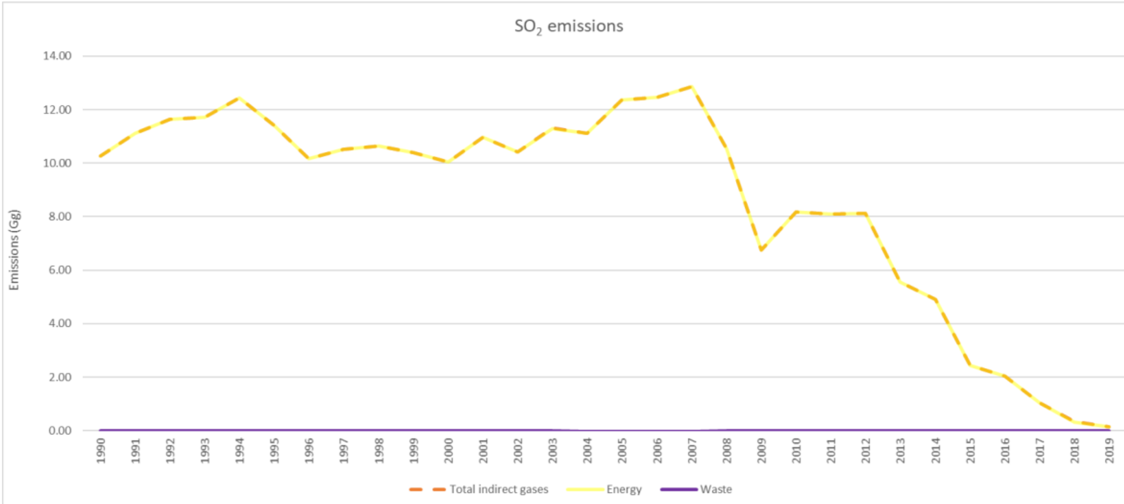

Figure 2-27 SO_2 emissions by sector.

Chapter 3 ENERGY

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 a number of 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 **Sources of Activity Data used in the compilation of the Energy inventory.**

Source	Data
Eurostat	Annual Energy Balance (1990 – 2019)
NSO	Oil Balance Reports covering 2019 Survey Results on Fuels used in the Economic Sectors 2019 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 [°C], max_temperature [°C], humidity [% 2005-2017. 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 – 2005: Enemalta Annual Reports covering 1990-2005 (Enemalta Corporation was the sole operator of power plants in Malta in this period); For years 2006 – 2019: 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 – 2019: 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 2005-2019; Gasoil used in the Power Stations covering 2005-2019; Natural Gas used in the Power Stations covering 2005-2019; Urea used in the Power Stations covering 2005-2019; Bicarbonate used in the Power Stations covering 2005-2019; Net Calorific Value of fuels used in the Power Stations covering 2005-2019; Emission Factors of fuels used in the Power Stations covering 2005-2019; Sulphur content of fuels used in the Power Stations covering 2010-2019.
IPCC Guidelines	Emission Factors of fuels used in the Power Stations covering 1990-2004. Emission Factors of fuels used in Manufacturing Industries 2017-2019; Emission Factors of fuels used in Commercial/Institutional 2017-2019; Emission Factors of fuels used in Residential 2017-2019; Emission Factors of fuels used in Agriculture/Forestry/Fishing 2017-2019; Net Calorific Values of fuels used in all sectors 2017-2019;
EU Commission	Biodiesel reports submitted to fulfil requirements of Article 4 of Directive 2003-30-EC covering 2003-2016.
REWS	Oil Balance Reports 2019; COPERT 5 Input Parameter - s_content [ppm wt] covering 2010-2019; Fuel used for National Navigation & Fishing purposes covering 2015-2019; Fuels used for international aviation purposes covering 2015-2019; Fuels used for international navigation purposes covering 2015-2019; Sulphur content of fuels used in for International Marine Bunkers and International Aviation covering 2010-2019.
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 – reid_vapor_pressure [kPa], 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 2005-2016.
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 2017-2019
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;
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.

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

Source category	CO_2		N_2O		CH4	
	Method	EF	Method	EF	Method	EF
1A1. Energy Industries	T2	CS	T2	CS	T2	CS
1A2. Manufacturing Industries and Construction	T1	D	T1	D	T1	D
1A3. Transport	T1/T3	D/CS	T1/T3	D/CS	T1/T3	D/CS
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/T3	D/CS	T1/T3	D/CS	T1/T3	D/CS

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)		
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)		
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		No
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)		
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)		

3.1.3 Sector-Specific recalculations & 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 (2017) and their status according to this submission.

ID#	Previous recommendation for the issue identified	Number of successive reviews issue not addressed	Status
UNFCCC Review 2018 (FCCC/ARR/2018/MLT)			
E.1	Allocate AD and emissions to the appropriate subcategories in order to improve the comparability of the emission estimates with those of other Annex I Parties.	5 (2012/13/15/16/17)	Addressing.
E.2	Elaborate a QA/QC plan for the energy sector (which accounts for almost 90 per cent of total GHG emissions in the country) as required by the UNFCCC Annex I inventory reporting guidelines	5 (2012/13/15/16/17)	Addressing.

E.3	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, the energy balances and the data reported in the CRF tables.	4 (2013/15/16/17)	Addressed. NIR Chapter 3.2.4.4
E.4	Include copies of the national energy balance for the latest reported year, outlining the final energy consumption by sector.	4 (2013/15/16/17)	Addressed. (Annex IV)
E.5	Estimate CO2 emissions using the reference approach for all years of the time series.	6 (2011/12/13/15/16/17)	Addressing
E.6	Explain differences in CO2 emissions which are above 2.0 per cent	4 (2013/15/16/17)	Addressing
E.7	Correct the discrepancies between CRF table 1.A(c) and the NIR for the differences in energy consumption between the reference and sectoral approaches.	3 (2015/16/17)	Addressing
E8	Estimate the apparent Energy consumption (excluding non-energy use, reductants and feedstocks) for solid, gaseous and other fossil fuels using the reference approach and report the estimates in CRF table 1.A(c).	3 (2015/16/17)	Addressing
E.9	Correct the notation keys for the AD for solid and other fossil fuels in NIR table 3-1 and CRF table 1.A(c).	3 (2015/16/17)	Addressed. NIR table 3-1 and CRF table 1.A(c).
E.10	Increase the transparency in the reporting of feedstocks and non-energy use of fuels, both in the CRF tables and in the NIR, by providing verifiable information that lubricants in transport (including disposal) and bitumen for road paving are not used in the country.	4 (2013/15/16/17)	Addressing.
E.11	For the only two power plants, use the plant-specific EFs as well as the NCVs available from the annual EU ETS reports as far back as possible.	4 (2013/15/16/17)	Addressed. NIR Chapter 3.2.4, table 3-8
E.12	Consider using the averages of NCV factors for the period 1990–2004, while duly considering the fuel mix.	4 (2013/15/16/17)	Addressed NIR Chapter 3.2.4
E.13	Report estimates, including any relevant information such as NCVs, oxidation factors, EFs and AD used for the estimation of emissions, in the NIR.	4 (2013/15/16/17)	Addressed. NIR Chapter 3.2.4, table 3-8
E.14	Allocate the AD and emissions to the appropriate subcategories, in line with the UNFCCC reporting guidelines, in order to improve comparability with other Annex I Parties.	6 (2011/12/13/15/16/17)	Addressing
E.15	Make use of additional sources of information, such as Eurocontrol, which is based on higher-tier methods, as a supplementary QA activity to verify the fuel allocation for domestic and international uses.	4 (2013/15/16/17)	Addressed
E.16	Obtain data on the NCVs and carbon content from the fuel suppliers in order to develop and use a more accurate EF when estimating CO2 emissions from gasoline; if such data are not available, use the default CO2 EF from the 2006 IPCC Guidelines that is applicable to European gasoline passenger cars.	4 (2013/15/16/17)	Addressing
E.17	Ensure the time-series consistency of the CO2, CH4 and N2O emission estimates for liquid fuels in road transportation by using the same methodology (COPERT IV model) for the entire time series, or demonstrate in the NIR that the use of two different methodologies does not introduce inconsistencies in the time series.	3 (2015/16/17)	Addressing The timeseries consistency problem will be addressed in the coming years by generating the whole timeseries from 1990 until 2017 using the COPERT V model.

E.18	Review the CO2 and N2O IEFs for cars for gasoline, diesel oil and LPG and explain any significant inter-annual changes and how the consistency of the time series is ensured.	3 (2015/16/17)	Addressing Emissions from road transportation for the period 2005–2016 were estimated using the COPERT V model using a tier 3 approach, while emissions covering the period 1990–2004 were estimated using a tier 1 approach. An exercise is being carried out to include pre-2005 data in the COPERT V model. An explanation of inter-annual changes has not been included in the NIR.
E.19	Explain in the NIR the methodology, assumptions and sources of AD and EFs used to 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	3 (2015/16/17)	Addressing
E.20	Disaggregate the emissions between stationary and mobile combustion.	3 (2015/16/17)	Addressing
E.21	Report the consumption of and emissions from propane as a liquid fuel (LPG).	1 (2017)	Addressed. NIR Chapter 3.2.1.2
E.22	Justify in the NIR the use of a country-specific EF or use the IPCC default EF (1 kg/TJ) until it develops a country-specific EF.	1 (2017)	Addressing.

Table 3-5 Summary of UNFCC additional provisional findings made during the 2019 review.

ID#	Recommendation for the issue identified	Number of successive reviews issue not addressed	Status
UNFCCC Review 2018 (FCCC/ARR/2018/MLT)			
E.29	The ERT noted that Malta reported "NE" for several fuels in the reference approach in 2017, for instance, other bituminous coal while the party reported "NE" for other gaseous fuel and non-biomass waste. During the view the Party responded that the reference approach figures are sourced from the Eurostat, which in turn, obtains the data from the National Statistics Office. The party highlighted that clarifications are being sought from the National Statistics Office on the reported figures pertaining to bituminous coal, other gaseous fuels and waste.	1 (2017)	Addressing
E.30	The ERT noted that apparent energy consumption (excluding non-energy use, reductants and feedstocks) is larger than the apparent energy consumption in CRF Table 1.A.(c) for solid fuels and other fossil fuels for 2015. Further, for 1990 to 1995, the total apparent consumption diverges between the CRF and the IEA data. The ERT noted that the difference is almost entirely caused by the import of bituminous coal which is reported in the IEA data and not in the CRFs. During the review the party indicated that the issue was being investigated	1 (2017)	Addressing.

E.31	The ERT noted some inconsistences between data in the CRF and that was reported to the IEA. For example, the stock change figure for liquid fuels in the CRF tables are systematically identical but opposed in sign to the IEA figures (from 1990 to 2014, 2015 shows similar figures). Since the IEA figures do not show particularly significant statistical differences, for the purpose of this comparison the figures from the CRF were modified to match those of the IEA. The ERT noted that after this adjustment, the CRF apparent consumption data are very close to those reported to the IEA for most years (often within 1%). The ERT further noted that, some years show large discrepancy (up to 26%), for example 1990 to 1995 (due to missing solid fuel figures in the CRF), 2009, and 2012. In 2015 the total apparent consumption in the CRF was 3.4% higher than what is reported to the IEA. The main cause for the discrepancy was the trade of fuel oil and of gas/diesel oil, as imports and exports. During the review the party highlighted that an exercise was being carried out with the National Statistics Office in order to investigate and identify the reasons for the discrepancies noted between the CRF and IEA, and to reconcile the figures, where applicable.	1 (2017)	Addressing
E.33	In the CRF table 1.A.(d), Malta does not report the quantity or CO2 emissions from bitumen or lubricants reported in the IPPU sector in 2017. The emissions are reported as "IE". During the review the party indicated that according to the National Statistics Office, bitumen and lubricants used locally are for non-energy use and hence, will be reported accordingly in the next Submission.	1 (2017)	Addressed. NIR Chapter 3.2.3
E34	There were large recalculations in CH4 emissions between the 2016 and 2017 submissions for 1990 in energy industries (emissions increased from 0.88 kt CO2 eq to 50.10 kgCO2e, a 5,567.25% increase). During the review the party indicated that the large change after recalculation was due to the inclusion of bituminous coal in the latter Submission	1 (2017)	Addressed. NIR Chapter 3.2.4.5
E.39	The 2017 CH4 IEF for biomass used in commercial sector was low (5kg/TJ) compared to the average of 152.53kg/TJ for the rest of the years in the time series. The details of the type of fuel constituting the biomass was not reported. During the review Malta provided an excel worksheet containing the time series activity data for biomass used in commercial/institution with the 2017 figure being 25.2TJ, but the types of the biomass fuels were not given. The biomass figure reported in the 2017 CRF table for commercial/institution in 2017 is. 49.2TJ, but he types of fuels constituting this figure were not given. The types of biomass fuels were not transparently described in the NIR, either.	1 (2017)	Addressing.
E.40	The ERT noted that Malta estimated CO2 emissions from the use of lubricants as fuel in two stroke engines as explained in the 2019 NIR section 4.5.1, Non-energy products from fuel and solvent use-lubricants-CRF 2D. Although Malta reports, in the NIR section 4.5.1, that CO2 emissions from two stroke engines were reported under Energy, the CO2 emissions from lubricants used in two-stroke engines are not reported under 1A3.b.iv, as required by 2006 IPCC Guidelines Volume 3 Box 3.2.4 . The ERT would appreciate if Malta could explain why CO2 emissions from lubricants used as fuel in two stroke engines were not reported in the CRF table 1A3.b.iv.	1 (2018)	Resolved

Table 3-6 Summary of recommendations from the TERT including rerevised estimates and technical corrections.

ID#	Recommendations for the issues identified	Status
MT-1AB-2018-0001	Include revised estimates in its next submission and explain the revised methodology in the NIR accordingly. The TERT further noted that 2006 IPCC Guidelines for mobile combustion do not provide a default Tier 1 EF for CH4 and N2O but recommends that Malta explore possibilities to improve the current reporting, i.e. use of notation key "NO".	Addressing
MT-1A3b-2019-0004	According to the 2006 IPCC GLs (volume 2, chapter 3, section 'CO2 emissions from biofuels' in page 3.17): "it is important to assess the biofuel origin so as to identify and separate fossil from biogenic feedstocks". In other words, a part of the carbon of biofuels (and the associated CO2 emissions) may have a fossil origin. The IPCC GLs provide some examples about biofuels' fossil part: "biodiesel made from coal methanol with animal feedstocks has a non-zero fossil fuel fraction and is therefore not fully carbon neutral. Ethanol from the fermentation of agricultural products will generally be purely biogenic (carbon neutral), except in some cases,	Addressing. The fossil fuel fraction in biofuel used in Malta will be disaggregated by

	such as fossil-fuel derived methanol. Products which have undergone further chemical transformation may contain substantial amounts of fossil carbon ranging from about 5-10 percent in the fossil methanol used for biodiesel production upwards to 46 percent in ethyl-tertiary-butyl-ether (ETBE) from fossil isobutene (ADEME/DIREM, 2002). Some processes may generate biogenic by-products such as glycol or glycerine, which may then be used elsewhere". It is unclear to the review team if your inventory includes CO2 emissions of biofuels that are of fossil origin. Please check and clarify. If these emissions are included in the inventory, please also explain where they are included (category/fuel).	the 2019 March submission.

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. The Oil Balance Report data was provided at the end of October, and it was used for compiling the reference approach in the absence of the Eurostat's Energy Balance.

Table 3-7 shows the comparison between the Reference Approach and the Sectoral Approach for 2019. The total aggregated difference in energy consumption between both approaches is 2.76%.

Table 3-7 Difference between 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)	13.02	12.50	934.67	13.15	955.69	-4.95	-2.20
Solid fuels (excluding international bunkers)	NO	NO	NO	NO	NO	NO	NO
Gaseous fuels	12.82	14.26	719.21	12.89	708.16	10.63	1.56
Other fossil fuels	NO,NE	NO	NO,NE	NO	NO	NO	NO,NE
Peat	NO	NO	NO	NO	NO	NO	NO
Total	25.84	26.76	1653.88	26.04	1663.84	2.76	-0.60

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.

For this NIR report, provisional data is used for Natural Gas consumption provided by REWS, used in the Reference Approach, as it has not been finalised at the time of compilation of the current NIR submission. Final values will be used for the March submission, provided that the official data is available. Data values have also been approximated for fuel data which is generally taken from the Energy Balance provided by Eurostat, given the unavailability of 2019 data at the time of compilation of the NIR. Upon publication by Eurostat, final values will be used for the March submission.

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 – 2019. 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

A clearer way to compare both approaches (sectoral and reference), would be a Sankey diagram. This was suggested by Aether experts and is included under Annex 4.

3.2.2 International Bunker Fuels

GHG emissions from international aviation and marine bunkers are calculated with the same methodologies as described for internal aviation and navigation. Emissions estimated from International Bunker activities are considered as 'Memo Items' and are not taken into account 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. . It 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. CH4 and N2O emissions on the other hand were added with the national totals in their respective categories.

The fuel used for international aviation includes aviation gasoline and jet kerosene which is also known as jet A1 or aviation turbine fuel. A Tier 3 approach was used for this sub-category with the data taken from the EUROCONTROL model as in 1A3a Civil Aviation from years 2005 to 2019.

The fuel consumption data used for International navigation are taken from the energy balance which is available online by EUROSTAT. These fuels include Gasoil, Diesel Oil and Fuel oil, with the former making up the greater share of the total fuels used for this purpose within this sector. Emissions from international marine bunkering have been estimated using a Tier 1 approach. IPCC 2006 default emission factors (Table 3-8) have been used for estimating CO2, CH4 and N2O emissions and for calorific values. The EMEP/EEA 2013 Guidelines are used for indirect emissions.

Table 3-8 Emission Factors used to calculate emissions from International Marine Navigation

Emission Factors			
Pollutant	Gas/Diesel Oil	Residual Fuel Oil	Source
CO_2	74100 (kg/TJ)	77400 (kg/TJ)	IPCC Guidelines-Volume 2: Energy, Table 3.5.2 p.3.50
CH_4	5(kg/TJ)	5(kg/TJ)	GPG for Water-Borne Navigation, Table 5, p.78
N_2O	0.6(kg/TJ)	0.6(kg/TJ)	GPG for Water-Borne Navigation, Table 5, p.79

3.2.3 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.

3.2.4 Sectoral Approach - Energy Industries (CRF 1A1)

3.2.4.1 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.

3.2.4.2 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[13]. The EU ETS in Malta actually 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 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. As suggested in the UNFCCC review, all relevant data used for estimating emissions are reported in Table 3-9.

Table 3-9 Plant specific information used for Energy Industries.

Power Plant	Activity Data (t)	Emission Factor (tCO_2/t)	NCV (TJ/kt)	Oxidation Factor (%)
Marsa				
Diesel	725.70	74.67	42.84	100.00
Delimara				
HFO	0	0	0	100.00
Diesel	7502.42	73.22	42.96	100.00
D3PG				
Natural Gas	59793.01	55.19	49.92	100.00
Diesel	1470.06	3.15	42.96	100.00
Electrogas (D4)				
Natural Gas	9903.60	53.07	48.00	100.00
Diesel	6.38	74.10	43.00	100.00

3.2.4.3 Uncertainties and time-series consistency

As stated below, time-series consistency was improved due to the use of consistent data sources throughout the period 1990-2019, namely Enemalta plc.

[13] 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.

3.2.4.4 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.

3.2.4.5 Category-specific recalculations

No recalculations were necessary for category 1.A.Energy Industries

3.2.4.6 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.

3.2.5 Sectoral Approach - Manufacturing Industries and Construction (CRF 1A2)

3.2.5.1 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.

3.2.5.2 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 3-10** since these are comparable to data provided by the National Statistics Office.

Table 3-10 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

3.2.5.3 Uncertainties and time-series consistency

The survey results for years 2017- 2019 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.

3.2.5.4 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.

3.2.5.5 Category-specific recalculations

Recalculations were performed for emissions of direct greenhouse gases in this category due to an update of activity data for Fuel Oil and Gas/Diesel Oil for year 2013 till 2018. Recalculations are presented in Table 3-11.

Table 3-11 Table of recalculations for category Manufacturing Industries and Construction.

Year	Emissions as reported in the 2019 inventory report (Gg CO2 eq.)	Emissions as reported in the 2020 inventory report (Gg CO2 eq.)	Percentage Change in reported emissions (%)	Emissions as reported in the 2019 inventory report (Gg CO2 eq.)	Emissions as reported in the 2020 inventory report (Gg CO2 eq.)	Percentage Change in reported emissions (%)	Emissions as reported in the 2019 inventory report (Gg CO2 eq.)	Emissions as reported in the 2020 inventory report (Gg CO2 eq.)	Percentage Change in reported emissions (%)
	CO_2	CO_2		CH_4	CH_4		N_2O	N_2O	
1990	52.67	52.67	0.00%	0.05	0.05	0.00%	0.12	0.12	0.00%
1991	54.61	54.61	0.00%	0.05	0.05	0.00%	0.12	0.12	0.00%
1992	63.49	63.49	0.00%	0.06	0.06	0.00%	0.14	0.14	0.00%
1993	65.16	65.16	0.00%	0.06	0.06	0.00%	0.15	0.15	0.00%
1994	70.49	70.49	0.00%	0.07	0.07	0.00%	0.16	0.16	0.00%
1995	75.31	75.31	0.00%	0.07	0.07	0.00%	0.17	0.17	0.00%
1996	75.96	75.96	0.00%	0.07	0.07	0.00%	0.17	0.17	0.00%
1997	78.30	78.30	0.00%	0.08	0.08	0.00%	0.18	0.18	0.00%
1998	59.72	59.72	0.00%	0.06	0.06	0.00%	0.13	0.13	0.00%
1999	63.46	63.46	0.00%	0.06	0.06	0.00%	0.14	0.14	0.00%
2000	62.44	62.44	0.00%	0.06	0.06	0.00%	0.14	0.14	0.00%
2001	56.46	56.46	0.00%	0.05	0.05	0.00%	0.13	0.13	0.00%
2002	59.59	59.59	0.00%	0.06	0.06	0.00%	0.13	0.13	0.00%
2003	64.04	64.04	0.00%	0.06	0.06	0.00%	0.14	0.14	0.00%
2004	64.18	64.18	0.00%	0.06	0.06	0.00%	0.15	0.15	0.00%
2005	27.76	27.76	0.00%	0.03	0.03	0.00%	0.06	0.06	0.00%
2006	30.66	30.66	0.00%	0.03	0.03	0.00%	0.06	0.06	0.00%
2007	36.86	36.86	0.00%	0.03	0.03	0.00%	0.07	0.07	0.00%
2008	36.86	36.86	0.00%	0.03	0.03	0.00%	0.07	0.07	0.00%
2009	21.47	21.47	0.00%	0.02	0.02	0.00%	0.04	0.04	0.00%
2010	30.75	30.75	0.00%	0.03	0.03	0.00%	0.06	0.06	0.00%
2011	15.30	15.30	0.00%	0.01	0.01	0.00%	0.03	0.03	0.00%
2012	27.78	27.78	0.00%	0.02	0.02	0.00%	0.05	0.05	0.00%
2013	53.46	59.89	12.04%	0.05	0.06	12.95%	0.12	0.13	13.25%
2014	62.65	69.12	10.32%	0.06	0.06	11.34%	0.13	0.15	11.69%
2015	59.74	66.11	10.67%	0.06	0.06	11.42%	0.13	0.15	11.65%
2016	59.51	65.88	10.71%	0.05	0.06	11.81%	0.13	0.14	12.20%
2017	53.50	59.20	10.65%	0.05	0.05	12.00%	0.11	0.12	12.49%
2018	43.21	49.22	13.91%	0.04	0.04	16.36%	0.08	0.10	17.32%

3.2.5.6 Category-specific planned improvements

During a capacity building visit organised in the context of the EU *Effort Sharing Decision Review* capacity building project, in December 2019, the further disaggregation of the Manufacturing Industries and Construction category was discussed in detail. This is deemed not possible considering that there are no energy intensive manufacturing industries operating in Malta. Eurostat's data also shows this in its Energy Balance, where data is not given at a more disaggregated level.

An improvement measure carried out in this category was the change in the notation keys in the CRF, from IE to NO where applicable since the latter represents better the real situation in Malta, ie. that no energy intensive manufacturing industries occur in Malta.

3.2.6 Sectoral Approach - Transport (CRF 1A3)

This category includes all emissions that result from transport activities in the Maltese Islands namely, road transport, domestic water-borne navigation and domestic aviation. International aviation and maritime emissions, also called 'Memo Items', are not included in the national emissions total.

Transport - Civil Aviation (CRF 1A3a)

3.2.6.1 Category Description

This category includes emissions that result from Maltese aviation practices, these include planes that take-off and land in Malta. Aviation turbine fuel or jet kerosene and aviation gasoline are used in Maltese domestic aviation.

3.2.6.2 Methodological Issues

The reporting of domestic aviation emissions has been improved significantly since 2005. GHG emissions from domestic aviation were taken from EUROCONTROL, based on the combination of energy consumption data and air traffic data (Landing and Take off cycles, LTOs) as well as from aircraft fleet composition. EUROCONTROL calculations use Tier 3 approach to assess air pollutants from air traffic. For domestic and International Aviation, fuel burnt are taken directly from Eurocontrol data (Tier 3 method). Road transportation data include emissions from ground activities in airports and thus, all emissions are reported.

3.2.6.3 Uncertainties and time-series consistency

The timeseries has been improved but the switch from Tier 1 to Tier 3 is evident. This issue actually links with the uncertainty that EUROCONTROL are estimating low emissions for the Maltese aviation sector.

3.2.6.4 Category-specific QA/QC and verification

The accuracy of domestic aviation emissions has been improved significantly with the implementation of the EUROCONTROL that has performed detailed, Tier 3, calculations from 2005.

3.2.6.5 Category-specific recalculations

A recalculation of N2O emissions was carried out after the ESD reviews of the January 2021 submission. During the reviews, an error in the calculation of N2O emissions from Domestic Navigation for the year of 2007 was identified. As a result, a revised estimate was submitted in the current submission.

Table 3-12 Table of recalculations for 1.A.3.a Domestic Aviation

Domestic Aviation									
Year	Emissions as reported in the 2019 inventory report (Gg CO2 eq.)	Emissions as reported in the 2020 inventory report (Gg CO2 eq.)	Percentage Change in reported emissions (%)	Emissions as reported in the 2019 inventory report (Gg CO2 eq.)	Emissions as reported in the 2020 inventory report (Gg CO2 eq.)	Percentage Change in reported emissions (%)	Emissions as reported in the 2019 inventory report (Gg CO2 eq.)	Emissions as reported in the 2020 inventory report (Gg CO2 eq.)	Percentage Change in reported emissions (%)
	CO2			CH4			N2O		
1990	1.20	1.20	0.00%	0.001	0.00	0.00%	0.00	0.00	0.00%
1991	1.13	1.13	0.00%	0.001	0.00	0.00%	0.00	0.00	0.00%
1992	1.51	1.51	0.00%	0.002	0.00	0.00%	0.00	0.00	0.00%
1993	1.52	1.52	0.00%	0.002	0.00	0.00%	0.00	0.00	0.00%
1994	1.85	1.85	0.00%	0.002	0.00	0.00%	0.00	0.00	0.00%
1995	2.02	2.02	0.00%	0.002	0.00	0.00%	0.01	0.01	0.00%
1996	2.04	2.04	0.00%	0.002	0.00	0.00%	0.01	0.01	0.00%
1997	2.14	2.14	0.00%	0.002	0.00	0.00%	0.01	0.01	0.00%
1998	2.05	2.05	0.00%	0.002	0.00	0.00%	0.01	0.01	0.00%
1999	2.07	2.07	0.00%	0.002	0.00	0.00%	0.01	0.01	0.00%
2000	2.06	2.06	0.00%	0.002	0.00	0.00%	0.01	0.01	0.00%
2001	1.79	1.79	0.00%	0.002	0.00	0.00%	0.00	0.00	0.00%
2002	1.59	1.59	0.00%	0.002	0.00	0.00%	0.00	0.00	0.00%
2003	1.51	1.51	0.00%	0.002	0.00	0.00%	0.00	0.00	0.00%
2004	1.79	1.79	0.00%	0.002	0.00	0.00%	0.00	0.00	0.00%
2005	0.03	0.03	0.00%	0.000	0.00	0.00%	0.00	0.00	0.00%
2006	0.06	0.06	0.00%	0.000	0.00	0.00%	0.00	0.00	0.00%
2007	0.15	0.15	0.00%	0.000	0.00	0.00%	0.01	0.01	-24.47%
2008	0.22	0.22	0.00%	0.000	0.00	0.00%	0.00	0.00	0.00%
2009	0.30	0.30	0.00%	0.000	0.00	0.00%	0.00	0.00	0.00%
2010	0.49	0.49	0.00%	0.000	0.00	0.00%	0.00	0.00	0.00%
2011	0.33	0.33	0.00%	0.000	0.00	0.00%	0.00	0.00	0.00%
2012	0.37	0.37	0.00%	0.000	0.00	0.00%	0.00	0.00	0.00%
2013	0.47	0.47	0.00%	0.000	0.00	0.00%	0.00	0.00	0.00%
2014	0.57	0.57	0.00%	0.000	0.00	0.00%	0.00	0.00	0.00%
2015	0.53	0.53	0.00%	0.000	0.00	0.00%	0.00	0.00	0.00%
2016	0.78	0.78	0.00%	0.000	0.00	0.00%	0.01	0.01	0.00%
2017	0.43	0.43	0.00%	0.000	0.00	0.00%	0.00	0.00	0.00%
2018	0.72	0.72	0.00%	0.000	0.00	0.00%	0.01	0.01	0.00%

3.2.6.6 Category-specific planned improvements

As mentioned in the 2016 National Inventory Report of the Maltese Islands, the EUROCONTROL model will provide essential activity data in future. It is pertinent to keep in mind though that the EUROCONTROL model altered the timeseries by reducing the national aviation emissions, this obviously needs to be examined further through communication with EUROCONTROL.

Transport – Road Transport (CRF 1A3b)

3.2.6.7 Category Description

This section addresses the estimation of emissions related to category 1.A.3.b Road transportation. Carbon dioxide is the primary greenhouse gas that accounts for the majority of emissions. The fuels used for road transport include Gas/Diesel oil, Motor Gasoline, LPG and biodiesel, with the latter sold pre-blended with diesel following the implementation of EN590 (diesel) and EN228 (petrol) in 2010. The biofuel produced and burned in the Maltese Islands is comprised 93.1% of cooking oil while sugars, oil crops, cereals and other starch-rich crops grown as main crops for energy purposes on agricultural land constitute the rest which amounts to 6.9%. This would mean it is of biogenic origin.

3.2.6.8 Methodological Issues

Activity data for road transport with regards to Environmental Conditions were provided by the National Statistics Office. This data includes the Minimum and Maximum monthly air temperature in [oC] (which is the average of the daily minimum or maximum temperature over the corresponding month) and monthly averaged Humidity [%]. Data with regards to Trip Characteristics and Circulation Data were provided by Transport Malta. In particular, Speed Share and Road Share where calculated based on a model developed by transport Malta. Data referred to Bifuel Share, Blend Share, ETBE content , Fossil fuel in biodiesel (Note that there is no fossil fuel blended in biodiesel in Malta), Reid Vapour Pressure, Sulphur and Lead content were obtained from the Regulator for Energy and Water Services.

The number of vehicles by category (Stock) was estimated based on the timeseries data from the last four years (2014-2018) taking into account the total number of vehicles per category, published by the National Statistics Office (NSO) as data with the required level of aggregation, in order to be used as input in COPERT model, for 2019 were not available during the compilation of the present report. Mean activity and lifetime cumulative activity data were also estimated based on the data referred to the same period (2014-2018).

Total fuels sales with regards to Road transportation were obtained from the energy balance which is available online by EUROSTAT. For any other parameters such as, Fuel Evaporation data, Driving conditions, Axles Number, use of air conditions, Technology Share and remaining Fuel Specifications the default values indicated by COPERT (Emisia S.A.) were used.

All emissions due to Road Transportation were calculated using COPERT (Computer Programme to calculate Emissions from Road Transport). COPERT is a Microsoft Windows software program which is developed as a European tool for the calculation of emissions from the road transport sector. The emissions calculated include regulated (CO, NOx, VOC, PM) and unregulated pollutants (N2O, NH3, SO2, NMVOC speciation …) and energy consumption is also computed. A detailed methodology supports the software application. For more information regarding the methodology, the user should consult the Methodology Report.

A Tier 3 method is used to calculate fuel consumption and emissions from different types vehicles using detailed traffic and fleet information before a final fuel reconciliation is done. Fuel consumption and emissions of CH4 and N2O, as well as the indirect GHGs and air pollutants, NMVOCs, NOx, CO and SO2, from individual vehicle types are calculated as well. The emission factors are from the COPERT 5 (Emisia, 2018) and EMEP/EEA (2016) Emissions Inventory Guidebook source, expressed as equations relating emission factor to average vehicle speed or road type for different vehicle types compliant with different legislative emission standards (Euro standards).

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 Bifuel

• Light Commercial Vehicles (Petrol, Diesel);

• Heavy Duty Trucks (Petrol, Diesel);

• Buses and coaches (Diesel)

• Motorcycles (Petrol)

3.2.6.9 Uncertainties and time-series consistency

Vehicle fleet information is only available from 2005 onwards hence years prior required a back-casting exercise which could have led to some timeseries uncertainties. This can lead to uncertainties in the sub-categories 1A3biii due to the classification of heavy-duty and light-commercial vehicles. It is also important to point out that the category 1A3biii Heavy-Duty trucks includes emissions from heavy duty trucks, buses and coaches.

3.2.6.10 Category-specific QA/QC and verification

The quality of the vehicle fleet data is ensured by the National Statistics Office and the Energy and Water Agency and organised accordingly by the sector compiler.

3.2.6.11 Category-specific recalculations

A recalculation of CH_4 emissions was carried out after the ESD reviews of the March 2020 submission. During the reviews, an error in the calculation of CH_4 emissions from Quad bikes & MTV's derived from COPERT was identified. As a result, a revised estimate was submitted and accepted by the TERT reviewers. In addition, a revised estimate for N2O emissions derived from road transportation [1.A.3.b.i Cars][diesel oil], was also submitted and accepted by the reviewers. In addition, an error in the calculation of CO_2 emissions from category 1.A.3.b.ii, for 2007, was identified after the ESD reviews of January 2021 submission and thus, a revised estimate was submitted.

Table 3-13 Table of recalculations for 1.A.3.b Road Transportation

	Road Transportation								
Year	Emissions as reported in the 2019 inventory report (Gg CO2 eq.)	Emissions as reported in the 2020 inventory report (Gg CO2 eq.)	Percentage Change in reported emissions (%)	Emissions as reported in the 2019 inventory report (Gg CO2 eq.)	Emissions as reported in the 2020 inventory report (Gg CO2 eq.)	Percentage Change in reported emissions (%)	Emissions as reported in the 2019 inventory report (Gg CO2 eq.)	Emissions as reported in the 2020 inventory report (Gg CO2 eq.)	Percentage Change in reported emissions (%)
	CO2			CH4			N2O		
1990	299.59	299.59	0.00%	3.14	3.14	0.00%	2.50	2.50	0.00%
1991	320.42	320.42	0.00%	3.24	3.24	0.00%	2.84	2.84	0.00%
1992	373.72	373.72	0.00%	3.36	3.36	0.00%	3.40	3.40	0.00%
1993	379.48	379.48	0.00%	3.45	3.45	0.00%	3.74	3.74	0.00%
1994	401.16	401.16	0.00%	3.45	3.45	0.00%	4.19	4.19	0.00%
1995	408.82	408.82	0.00%	3.29	3.29	0.00%	4.50	4.50	0.00%
1996	459.88	459.88	0.00%	3.36	3.36	0.00%	4.91	4.91	0.00%
1997	456.02	456.02	0.00%	3.23	3.23	0.00%	4.93	4.93	0.00%
1998	451.06	451.06	0.00%	3.03	3.03	0.00%	4.92	4.92	0.00%
1999	488.42	488.42	0.00%	3.03	3.03	0.00%	5.19	5.19	0.00%
2000	512.21	512.21	0.00%	2.90	2.90	0.00%	5.26	5.26	0.00%
2001	406.48	406.48	0.00%	2.52	2.52	0.00%	4.67	4.67	0.00%
2002	437.38	437.38	0.00%	2.46	2.46	0.00%	4.69	4.69	0.00%
2003	496.46	496.46	0.00%	2.49	2.49	0.00%	4.93	4.93	0.00%
2004	458.11	458.11	0.00%	2.22	2.22	0.00%	4.67	4.67	0.00%
2005	481.95	481.95	0.00%	2.40	2.40	0.00%	5.18	5.18	0.00%
2006	489.29	489.29	0.00%	2.34	2.34	0.00%	5.21	5.21	0.00%
2007	504.07	506.75	0.53%	2.31	2.31	0.00%	5.28	5.28	0.00%
2008	557.58	557.58	0.00%	2.63	2.63	0.00%	6.04	6.04	0.00%
2009	490.05	490.05	0.00%	2.13	2.13	0.00%	5.10	5.10	0.00%
2010	519.12	519.12	0.00%	2.09	2.09	0.00%	5.22	5.22	0.00%
2011	504.96	504.96	0.00%	1.90	1.90	0.00%	5.04	5.04	0.00%
2012	501.50	501.50	0.00%	1.77	1.77	0.00%	4.94	4.94	0.00%
2013	503.38	503.38	0.00%	1.71	1.71	0.00%	4.93	4.93	0.00%
2014	516.25	516.25	0.00%	1.68	1.68	0.00%	4.99	4.99	0.00%
2015	542.26	542.26	0.00%	1.68	1.68	0.00%	5.15	5.15	0.00%
2016	542.64	542.64	0.00%	1.60	1.60	0.00%	5.10	5.10	0.00%
2017	553.60	553.60	0.00%	4.55	1.32	-244.52%	5.11	5.11	0.00%
2018	558.73	558.73	0.00%	5.05	1.50	-237.46%	5.01	6.01	16.67%

3.2.6.12 Category-specific planned improvements

Refinements are required for particular COPERT input data including average mileage, trip duration and trip length. These refinements are currently being discussed with the plan to be updated through consultations between the Malta Resources Authority, Transport Malta and the Environment and Resources Authority. COPERT is a freeware developed by Emisia SA with support from the European Environment Agency. A Maltese working group for transport is currently being worked on to be set up in order to update these values with the most recent data for increased accuracy.

Accurate fuel sold for transport data is proving to be quite problematic to collect but it is essential data that requires a detailed analysis of its accuracy for better results. The National Statistics Office and Regulator for Energy and Water Agency will be consulted regarding the fuel survey and how its accuracy can be improved.

COPERT parameters like environmental information including minimum and maximum temperature and percentage humidity and the stock of licenced vehicles were included so national data / parameters were used when possible. Emissions are calculated using COPERT so no emission factors will be needed as such. The emission factors used can be calculated by dividing the emissions of the greenhouse gas by the fuel consumption (TJ) for each fuel.

Transport – Domestic (Water-Borne) Navigation (CRF 1A3d)

3.2.6.13 Category Description

This category includes emissions that result from national waterborne transport including boats, yachts, pleasure craft, jet skis and fishing vessels that do not leave Malta's exclusive economic zone. Fuels used nationally include Gas/Diesel oil (Diesel EN 590, Gasoil and High-Performance Diesel), Gasoline (Motor Gasoline RON 95 EN 228) and biomass. As in road transport, the CO2 emissions for biofuel were not included in this category but reported under 1D Memo Items. Only CH4 and N2O were added to the national total.

3.2.6.14 Methodological Issues

Carbon dioxide emissions from domestic navigation are calculated according to the IPCC Tier 1 default methodology, which is based on the relative consumption of energy per fuel and default emission factors from the 2006 IPCC Guidelines.

In Malta, the fuel consumption by fuel type for navigation, separated between National and International navigation, for the present submission are obtained from the National Energy Balance , available online by EUROSTAT. Hence, this data is verified and accepted as reliable. The consumption fluctuations are affected by the existing national economic conditions, international circumstances, weather conditions and tourism. Emissions with regards to fuels used by fishing vessels are being reported under 1.A.4.c iii to be inline with energy statistics reporting.

The other GHG emissions are calculated according to the default methodology of CORINAIR, which is based on the relative consumption of energy per fuel and default emission factors. Calculation estimates for emissions from liquid fuels in navigation are based on emission factors from the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories for CO2, CH4 and N2O Emissions from Water-Borne Navigation (**Table 3-14**). It is important to mention that any emissions related to biomass were estimated based on previous years, as data with regards to biomass was not available during the compilation of this submission.

Table 3-14 Emission Factors used to calculate emissions from Domestic Marine Navigation

Emission Factors			
Pollutant	Gas/Diesel Oil	Gasoline	Source
CO_2	74100 (kg/TJ)	69300 (kg/TJ)	IPCC Guidelines-Volume 2: Energy, Table 3.5.2 p.3.50
CH_4	5(kg/TJ)	5(kg/TJ)	GPG for Water-Borne Navigation, Table 5, p.78
N_2O	0.6(kg/TJ)	0.6(kg/TJ)	GPG for Water-Borne Navigation, Table 5, p.79

3.2.6.15 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. There is still some room for improvement by implementing a Tier 3 approach. One small inconsistency in the data is the lack of residual fuel oil sales in 2017 and 2018. Previous years all included sales of residual fuel oil but 2017 and 2018 showed no sales for this fuel. This issue was followed up with the National Statistics Office and the Regulator for Energy and Water Services in 2018 who confirmed that no residual fuel oil was sold nationally for domestic navigation in 2017.

3.2.6.16 Category-specific QA/QC and verification

With the addition of 2019 data, it can be confirmed that the timeseries has remained consistent.

3.2.6.17 Category-specific recalculations

No recalculations were necessary for category 1.A.3.d Domestic Navigation.

3.2.6.18 Category-specific planned improvements

In future, it is planned to shift this sub-category to Tier 3. This can 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. Proper QA/QC also needs to be carried out.

3.2.7 Sectoral Approach - Other sectors (CRF 1A4)

3.2.7.1 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.

3.2.7.2 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 mid-January 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.

3.2.7.3 Uncertainties and time-series consistency

The survey results for years 2017- 2019 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, uncertainties and inconsistences between Eurostat and Fuel Use Survey data is to be verified with the data provider in order to be eliminated.

3.2.7.4 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.

3.2.7.5 Category-specific recalculations

Recalculations were performed for emissions of direct greenhouse gases in this category due to an update of activity data for Fuel Oil, Kerosene and Biogas for year 2013 till 2018. Recalculations are presented in **Table 3-15**.

Table 3-15 Recalculation for category Other Sectors.

Year	Emissions as reported in the 2019 inventory report (Gg CO2 eq.)	Emissions as reported in the 2020 inventory report (Gg CO2 eq.)	Percentage Change in reported emissions (%)	Emissions as reported in the 2019 inventory report (Gg CO2 eq.)	Emissions as reported in the 2020 inventory report (Gg CO2 eq.)	Percentage Change in reported emissions (%)	Emissions as reported in the 2019 inventory report (Gg CO2 eq.)	Emissions as reported in the 2020 inventory report (Gg CO2 eq.)	Percentage Change in reported emissions (%)
	CO_2	CO_2		CH_4	CH_4		N_2O	N_2O	
1990	263.69	263.69	0.00%	0.81	0.81	0.00%	0.53	0.53	0.00%
1991	245.44	245.44	0.00%	0.75	0.75	0.00%	0.48	0.48	0.00%
1992	297.28	297.28	0.00%	0.91	0.91	0.00%	0.59	0.59	0.00%
1993	300.88	300.88	0.00%	0.93	0.93	0.00%	0.60	0.60	0.00%
1994	342.45	342.45	0.00%	1.07	1.07	0.00%	0.70	0.70	0.00%
1995	335.80	335.80	0.00%	1.05	1.05	0.00%	0.68	0.68	0.00%
1996	339.33	339.33	0.00%	1.06	1.06	0.00%	0.70	0.70	0.00%
1997	382.71	382.71	0.00%	1.21	1.21	0.00%	0.81	0.81	0.00%
1998	339.23	339.23	0.00%	1.05	1.05	0.00%	0.69	0.69	0.00%

1999	302.99	302.99	0.00%	0.94	0.94	0.00%	0.61	0.61	0.00%
2000	301.11	301.11	0.00%	0.93	0.93	0.00%	0.61	0.61	0.00%
2001	208.58	208.58	0.00%	0.62	0.62	0.00%	0.39	0.39	0.00%
2002	201.56	201.56	0.00%	0.60	0.60	0.00%	0.37	0.37	0.00%
2003	207.39	207.39	0.00%	0.62	0.62	0.00%	0.38	0.38	0.00%
2004	213.04	213.04	0.00%	0.64	0.64	0.00%	0.40	0.40	0.00%
2005	126.27	126.27	0.00%	0.36	0.36	0.00%	0.21	0.21	0.00%
2006	108.59	108.59	0.00%	0.29	0.29	0.00%	0.16	0.16	0.00%
2007	117.33	117.33	0.00%	0.32	0.32	0.00%	0.18	0.18	0.00%
2008	119.90	119.90	0.00%	0.32	0.32	0.00%	0.18	0.18	0.00%
2009	106.39	106.39	0.00%	0.27	0.27	0.00%	0.14	0.14	0.00%
2010	136.13	133.90	-1.64%	0.60	0.59	-1.30%	0.24	0.24	-2.29%
2011	100.93	101.44	0.51%	0.48	0.48	-0.06%	0.16	0.16	-1.29%
2012	139.76	140.60	0.60%	0.65	0.65	0.01%	0.24	0.24	-1.09%
2013	138.14	139.80	1.21%	0.64	0.64	0.57%	0.25	0.25	0.28%
2014	146.20	147.65	0.99%	0.73	0.74	0.37%	0.29	0.29	-0.05%
2015	165.00	165.99	0.60%	0.81	0.81	0.18%	0.32	0.32	-0.26%
2016	152.55	154.16	1.05%	0.76	0.76	0.41%	0.30	0.30	-0.01%
2017	154.77	157.19	1.56%	0.84	0.84	0.49%	0.30	0.30	0.31%
2018	137.37	138.41	0.75%	0.77	0.77	-0.07%	0.26	0.26	-0.81%

3.2.7.6 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.

3.2.8 Sectoral Approach – Other mobile (CRF 1A5b)

3.2.8.1 Category Description

This section addresses the estimation of emissions related to category 1.A.5.b-mobile, which originate from military aircraft activities. Emissions derived from other military mobile activities are included under their respective category, emissions from military road vehicles are reported under 1.A.3 b Road transportation and emissions derived from marine military purposes are reported under 1.A.3.d Domestic navigation.

3.2.8.2 Methodological Issues

The methodology to estimate military aviation emissions is simpler than the one described for civil aviation since LTO data are not available in this case. As for activity data, total consumption for military aviation is provided by the Armed Forces of Malta and include only jet A1 kerosene. Emission factors for CO_2, CH_4 and N_2O are those provided by the IPCC guidelines. CO, NOx and NMVOC emissions were calculated based on the emission factors on the IPCC Emission Factor Database (EFDB). SO_2 emission factors depend on fuel properties; in order to calculate SO_2 emissions, we assumed that the S content is

0.0005% (IPPC Guidelines) and that 100% of the fuel sulphur is oxidized to SO_2. Therefore, emissions are calculated using a Tier 1 methodology, by multiplying military fuel consumption with the respective emission factor.

Table 3-16 Emission Factors used to calculate emissions from category 1.A.5.b Other-mobile.

Fuel type: **Jet A1** (Kerosene)			
Pollutant	**Emission Factor**	**Unit**	**Source**
CO2	71500	(kg/TJ)	IPCC Guidelines
CH4	0.5	(kg/TJ)	IPCC Guidelines
N2O	2	(kg/TJ)	IPCC Guidelines
CO	7	(Kg/t of fuel)	IPCC EFDB
NOx	11	(Kg/t of fuel)	IPCC EFDB
NMVOC	0.7	(Kg/t of fuel)	IPCC EFDB
SO2	2.268	(t/TJ)	Calculated

3.2.8.3 Uncertainties and time-series consistency

The Tier 1 calculation implemented for this category leaves few uncertainties and timeseries inconsistencies as it is based on fuel sold data. However, for years prior to 2019 this category also includes emissions derived from military marine purposes and military road vehicles, which are now included under their respective categories (emissions from military road vehicles are reported under 1.A.3 b Road transportation and emissions derived from marine military purposes are reported under 1.A.3.d Domestic navigation)This issue was followed up with the National Statistics Office and the Regulator for Energy and Water Services in 2018 who confirmed that no residual fuel oil was sold nationally for domestic navigation in 2017.

3.2.8.4 Category-specific QA/QC and verification

The quality of the data is ensured by the data provider by performing the necessary quality checks. Please also note that Energy worksheets are currently being redeveloped to include more internal checks of calculations.

3.2.8.5 Category-specific recalculations

No recalculations were necessary for category 1.A.5.b Other-mobile.

3.2.8.6 Category-specific planned improvements

Every effort is being made to recalculate the entire time-series, from 1990 till present for 1.A.5 Category. It is hoped that recalculations will be carried out for next year's submission. Moreover, improvements in the Energy Sector's worksheet are currently underway, to fully automate the worksheets and reduce human error in data entry, conversions, and calculations.

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

3.3.1 OIL AND NATURAL GAS (CRF 1B2A)

3.3.1.1 Category Description

Fuel refining and abstraction processes do not occur in Malta so fugitive emissions are punitive. The only practice worth mentioning is the selling of gasoline which is considered a source of NMVOCs.

3.3.1.2 Methodological Issues

These emissions are dependent on the total volume of gasoline sold throughout the retail network; this data is unfortunately still unavailable. For this reason, a trend analysis spanning from 1990 to 2017 was carried out.

3.3.1.3 Uncertainties and time-series consistency

The trend analysis carried out ensures that no uncertainties are present whilst also preserving the timeseries consistency.

3.3.1.4 Category-specific QA/QC and verification

The estimation of the trend of fugitive indirect emissions is exactly the same as in previous sub-categories, so category specific QA/QC and verification has been carried out.

3.3.1.5 Category-specific recalculations

No category-specific recalculations were carried out for this category.

3.3.1.6 Category-specific planned improvements

With the eventual provision of fuel sold data, these fugitive emissions can be calculated more accurately using a Tier 1 approach. This will be applied immediately once said data becomes available.

3.4 CO2 TRANSPORT AND STORAGE (CRF 1C)

3.4.1.1 Category Description

The transport and storage of CO2 does not occur in Malta. This category encompasses the onshore or offshore storage of CO2 and its transport through either pipeline or maritime transport.

3.4.1.2 Methodological Issues
Not applicable.

3.4.1.3 Uncertainties and time-series consistency
Not applicable.

3.4.1.4 Category-specific QA/QC and verification
Not applicable.

3.4.1.5 Category-specific recalculations
Not applicable.

3.4.1.6 Category-specific planned improvements
Not applicable.

Chapter 4 INDUSTRIAL PROCESSES AND OTHER 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-sectors are considered to be not occurring.

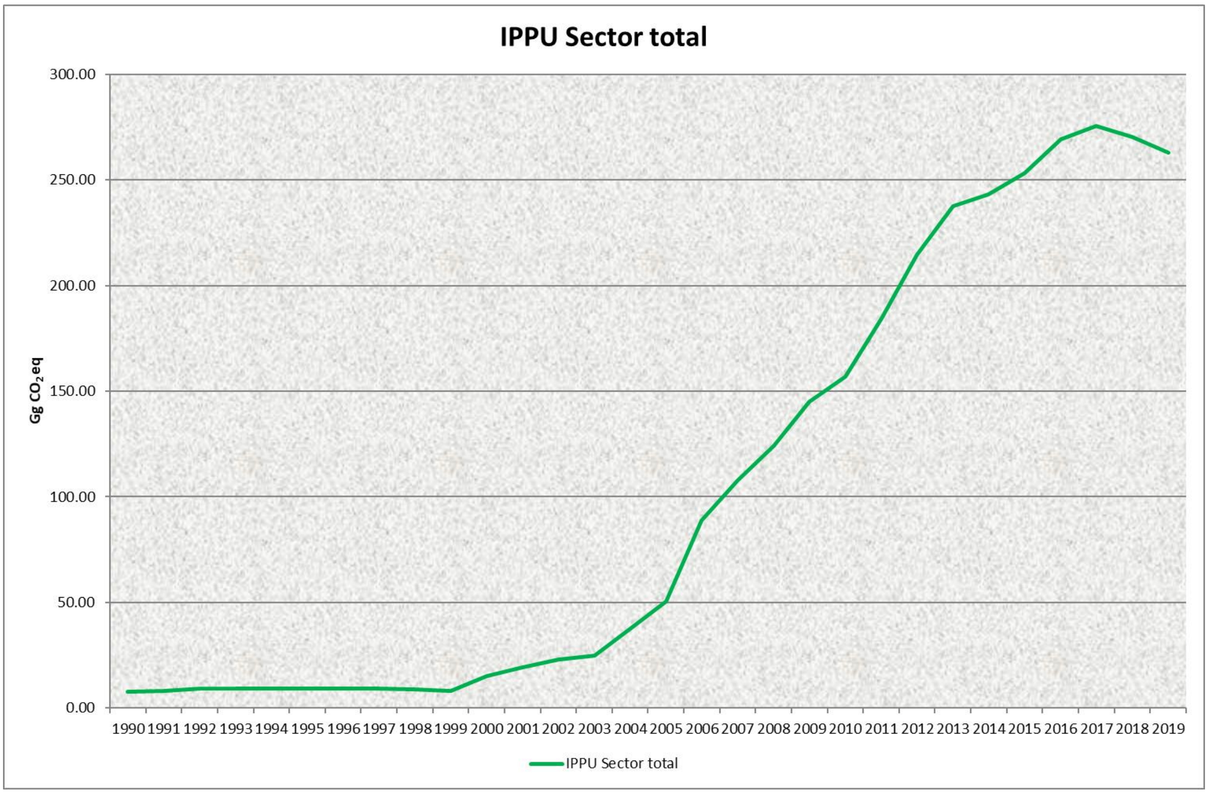

Figure 4-1 Direct GHG emissions for the *Industrial Processes and Product Use* (IPPU) sector.

The direct greenhouses gases estimated for the *IPPU* sector, as presented in the inventory, are illustrated in **Error! Reference source not found.**, by emission sources category or sub-sector, as a pplicable.

Table 4-1 The direct greenhouse gases estimated for the IPPU sector for the year 2019, as presented in the inventory, by emission source category or sub-sector, as applicable.

IPCC Category/Sub-sector	IPPU Category/Sub-sector	CO_2 Gg CO_2 eq	CH_4 Gg CO_2 eq	N_2O Gg CO_2 eq	HFC Gg CO_2 eq	PFC Gg CO_2 eq	SF_6 Gg CO_2 eq
2A1	Cement Production						
2A2	Lime Production						
2A3	Glass production						
2A4	Other processes/uses of Carbonates	0.03					
2A4	Sodium Bicarbonate Use	0.15					
2B10	Chemical Industry	0.03					
2C	Metal Industry						
2D1	Lubricant use	3.18					
2D2	Paraffin Wax use	0.72					
2D3	Solvent use						
2D3	Road Paving with Asphalt	0.01					
2D3	Urea Use	0.63					
2E1	Electronics Industry				0.06		
2F1	Refrigeration and Air Conditioning				247.55		
2F2	Foam Blowing Agents				4.99		
2F3	Fire Protection				3.22		
2F4	Aerosols and Solvents (MDIs)				0.70		
2G1	Electrical Equipment						0.27
2G2	SF_6 and PFC from other Product Uses					0.000001	0.000003
2G3	Use of N_2O for Product uses			1.39			

Figure 4-2 illustrates trends in the indirect greenhouse gas emissions of NMVOC.

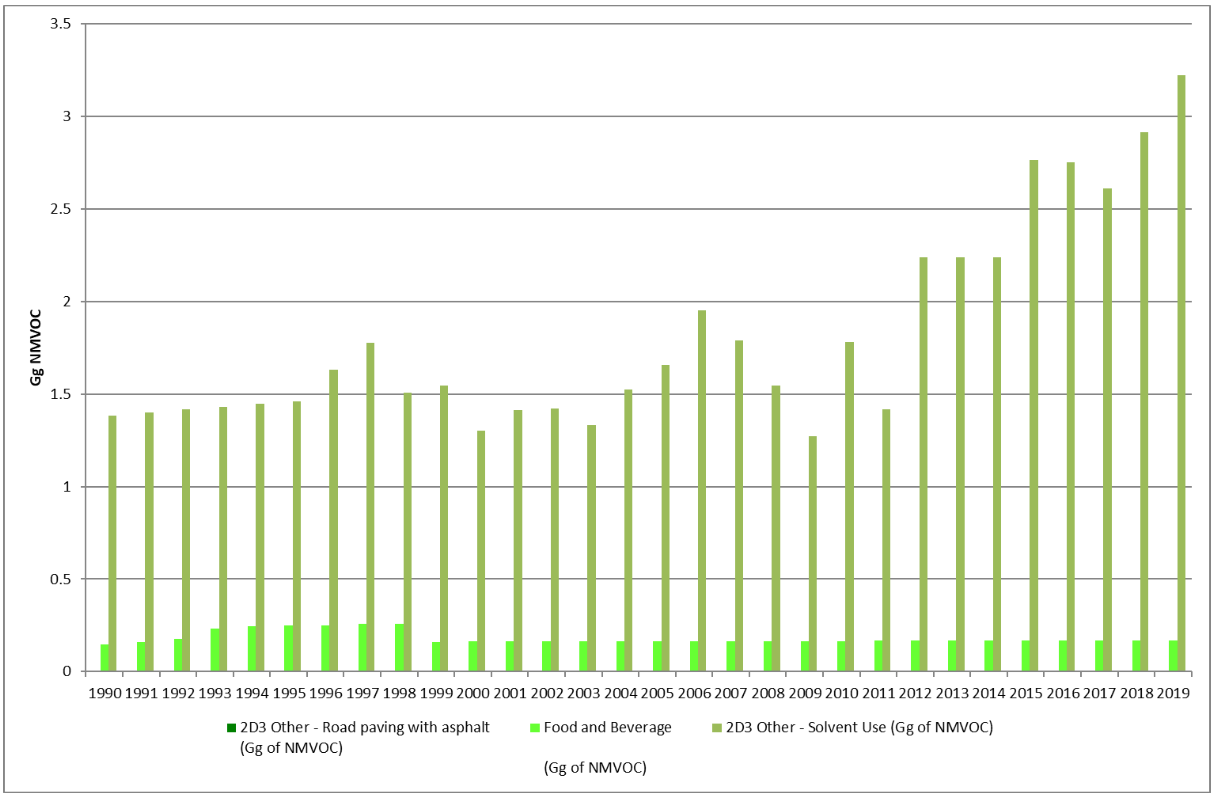

Figure 4-2 Indirect GHG emissions for sector *Industrial Processes and Product Use*.

The data providers for the sector IPPU are primarily private sector industry enterprises, providing data related to their respective activities. Other data are 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.

With regards to the recommendation made by the *Expert Review Team* in the "Report on the individual review of the annual submission of Malta submitted in 2019", FCCC/ARR/2019/MLT, on the issue of development and implementation of QA/QC procedures for this sector, *Finding* ID# I.1, a general comment for the sector IPPU applies. In fact, 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. Moreover, the Inventory Agency is trying to identify alternative sources of data, where possible, to allow more robust QA/QC checks.

Table 4-2 below, is a collection of the recalculations made under the IPPU sector for the 2021 submission of the national inventory.

Table 4-2 Annual percentage change in reported emissions for the whole timeseries.

			1990-2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
CRF 2.F.1.a Commercial (& Industrial) Refrigeration	Recovery	HFC-32																				
		HFC-143a																				
		HFC-125																				
		HFC-134a																				
CRF 2.F.1.a Commercial (& Industrial) Refrigeration	Emissions from stocks	Unspecified mix of HFCs																			-99.71%	
CRF 2.F.1.d Transport Refrigeration (& Mobile Air Conditioning)	Stock	HFC-125					-38.27%	-13.58%	11.11%	11.11%	11.11%	11.11%	11.11%	11.11%	11.11%	11.11%	11.11%	11.11%	11.11%	11.11%	11.11%	
	Stock remaining in products at decommissioning																					
	Emissions from disposal																					
	Stock	HFC-143a					-38.27%	-13.58%	11.11%	11.11%	11.11%	11.11%	11.11%	11.11%	11.11%	11.11%	11.11%	11.11%	11.11%	11.11%	11.11%	
	Stock remaining in products at decommissioning																					
	Emissions from disposal																					
	Stock	HFC-134a		1.77%	2.73%	3.31%	1.13%	0.62%														
	Stock remaining in products at decommissioning																					
	Emissions from disposal																	42.86%	-96.54%	-97.51%	
CRF 2.F.1.f Stationary Air Conditioning	Emissions	HFC-32						-13.17%	-6.26%	1.35%	-5.18%	-9.41%	-10.62%	-12.75%	-9.74%	-14.54%	-18.41%	-17.96%	-19.93%	-22.55%	-25.95%	
	Stock							-58.60%	-55.98%	-49.35%	-54.88%	-60.57%	-63.56%	-65.42%	-63.99%	-67.16%	-69.14%	-68.80%	-68.95%	-69.71%	-69.67%	
	Emissions	HFC-125						-83.25%	-80.85%	-79.34%	-80.62%	-81.67%	-82.14%	-82.66%	-82.34%	-83.15%	-83.86%	-83.96%	-84.37%	-84.86%	-85.45%	
	Stock							-92.02%	-91.00%	-89.34%	-90.47%	-91.76%	-92.41%	-92.85%	-92.75%	-93.30%	-93.70%	-93.75%	-93.84%	-94.02%	-94.08%	
	Emissions	HFC-134a						-59.01%	-51.89%	-48.46%	-50.87%	-53.41%	-54.87%	-56.31%	-56.34%	-57.66%	-59.04%	-59.84%	-60.91%	-61.98%	-63.34%	
	Stock							-80.46%	-77.32%	-73.04%	-75.26%	-78.27%	-80.10%	-81.33%	-81.52%	-82.37%	-83.18%	-83.60%	-83.99%	-84.45%	-84.76%	
	Emissions	HFC-143a						-86.89%	-84.61%	-83.51%	-84.28%	-85.11%	-85.53%	-85.98%	-85.97%	-86.39%	-86.84%	-87.10%	-87.45%	-87.80%	-88.24%	
	Stock							-93.75%	-92.74%	-91.38%	-92.08%	-93.07%	-93.56%	-93.94%	-94.00%	-94.28%	-94.55%	-94.69%	-94.82%	-94.97%	-95.07%	
CRF 2.F.1.f Stationary Air Conditioning	Recovery	HFC-134a																				
		HFC-143a																				
		HFC-125																				

Table 4-3 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 4-3 Implementation of recommendations and adjustments listed in the "Report on the individual review of the annual submission of Malta submitted in 2019", *FCCC/ARR/2019/MLT*, dated 15th May 2020.

ID#	Review recommendation	MS response / status of implementation	Chapter /section in the NIR
I.1	Develop and implement QA/QC procedures for the IPPU sector.	Addressing. As stated in section 4.1 of the 2021 NIR, it should be pointed out that the data or information received from data providers is checked 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. 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 office of statistics. The data obtained from which would be of a provisional status. However, discussions are on-going with this entity to improve the transfer of information between the latter and the Inventory Agency. Nonetheless, the Inventory Agency is trying to identify alternative sources of data, where possible, to allow more robust QA/QC checks.	4

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 2021 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.	4.2.5
I.3	Investigate the time-series inconsistency of the estimates of CO_2 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.4	Collect the necessary data to complete the background information tables for the reporting of F-gases (CRF table 2.II.F) in accordance with the UNFCCC Annex I inventory reporting guidelines.	Resolved.	4.7
I.5	Proceed with the project to develop a better methodology for estimating emissions from refrigeration and air conditioning and report on the status in the NIR.	Addressing. As referred to in section 4.7 of the 2021 NIR, 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 NIR of 2015. Minor continuous improvements will be sustained. The current methodology is in line with the 2006 IPCC Guidelines. As referred to in section 4.7.1.6, 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
I.6	As part of the planned project to develop a better methodology for estimating emissions from refrigeration and air conditioning, consider the import of F-gases in products and report on this in the NIR.	Resolved.	4.7.1
I.7	Ensure consistency between the notation keys used to report AD for "Filled into new manufactured products" and for "Remaining in products and	Addressed.	4.7.1

	decommissioning" ("NE") and the associated emissions (reported as "NO").		
I.8	Review the notation keys reported for disposal emissions in CRF table 2(II).B-H to ensure that the correct notation keys are used.	Addressed.	4.7.1
I.9	Review the AD and 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.	Addressing. An analysis to improve the robustness and consistency of the collection and reporting of activity data for category 2.F.2 is being conducted. In general, for sub-sector 2.F, the Inventory Agency is in the initial stages of a discussion aimed to improve the data available from the local F-gas market. The counterpart to the Inventory Agency in this potential collaboration is 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").	4.7.2
I.10	Explain in the NIR that HFC emissions from foam blowing agents do not occur and ensure that the notation key "NO" is used, where appropriate, in the NIR and in the CRF tables for emissions and AD that are not occurring. Explain in the NIR that HFC emissions from foam blowing agents do not occur and ensure that the notation key "NO" is used, where appropriate, in the NIR and in the CRF tables for emissions and AD that are not occurring.	Resolved.	4.7.2
I.11	Report HFC-227ea emissions from manufacturing, stocks and disposal for the period 1990-2003 as "NO" in CRF table 2(II).B-H and explain in the NIR that non-HFC halons were used prior to 2004.	Resolved.	4.7.3
I.12	Report recovery of HFC-227ea emissions for the period 1990-2003 as "NO" in CRF table 2(II).B-H and explain the use of the notation key "NO" in the NIR.	Resolved.	4.7.3

I.13	Report emissions from mobile air conditioning separately in subcategory 2.F.1.e mobile air conditioning in order to ensure transparency and comparability.	Addressing. An exercise is being carried out to adapt the current methodology to allow separate reporting for sub-categories 2.F.1.d "Transport refrigeration" and 2.F.1.e "Mobile Air Conditioning". As referred to in section 4.7.1.7 of the 2020 NIR and as recommended during the capacity building visit organised by the "Effort Sharing Decision Review Team" in August 2018, 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. Moreover, in general, for sub-sector 2.F, the Inventory Agency is in the initial stages of a discussion aimed to improve the data available from the local F-gas market. The counterpart to the Inventory Agency in this potential collaboration is 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").	4.7.1
I.14	Collect information on incidents that may lead to spikes in emissions and report on them in the NIR.	Resolved.	4.8.1.2
I.15	Include checks (e.g. with the data suppliers) in its QC procedures in case of variations and outliers and report on the outcome of those checks in the NIR.	Resolved.	4.8.1.2
I.16	The ERT recommends that Malta report emissions from the use of urea in road transportation in order to ensure completeness.	Addressing. Section 4.5.3.3.6 of the 2021 NIR refers. During the capacity building visit organised by the *Effort Sharing Decision Review Team* in August 2018, it was pointed out that the emissions from the use of urea in road transportation need to be included in the national inventory report. The methodology needed to estimate these emissions has been determined with the support provided by the *Effort Sharing Decision Review Team* in October 2019. Estimates of these emissions have featured in the 2020 inventory. The amount of urea solution *per se* has not been estimated and, thus, nor reported in the respective CRF table. 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.	4.5.3.3
I.17	The ERT recommends that Malta explain why the average charge factor for buses and coaches is higher than for mobile refrigeration vehicles.	Addressing. The topic referred to by the ERT in the recommendation is being analysed.	4.7.1.3 4.7.1.4

Table 4-4 below, is intended to serve as the sector-specific improvement plan.

Table 4-4 Improvement plan for the IPPU sector.

Action	IPCC Category / Sub-sector	Chapter / section in the NIR
With regards to the recommendation made by the *Expert Review Team* on the issue of development and implementation of QA/QC procedures for this sector, it should be pointed out that 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. (*Finding* ID# I.1 in the "Report on the individual review of the annual submission of Malta submitted in 2019", FCCC/ARR/2019/MLT)	2	4
The Inventory Agency is trying to identify alternative sources of data, where possible, to allow more robust QA/QC checks. (*Finding* ID# I.1 in the "Report on the individual review of the annual submission of Malta submitted in 2019", FCCC/ARR/2019/MLT)	2	4
Implementation of the *2019 IPCC Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*	2	4
It is the intention of the Inventory Agency to determine if the processes carried out in the local glass industry emit greenhouse gases.	2.A.3	4.2.3
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 the "Report on the individual review of the annual submission of Malta submitted in 2019", FCCC/ARR/2019/MLT)	2.A.4	4.2.4
The mass of calcium carbide reported for the year 2018 is being investigated.	2.B.10 Other (Carbide use)	4.3
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.	2.D.1	4.5.1
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).	2.D.1	4.5.1
Paraffin wax use is included in the national energy balance, however, no consumption of paraffin wax is reported. This matter should be looked into.	2.D.2	4.5.2
The time series consistency of the activity data used for "Road Paving with Asphalt" is being analysed. (*Finding* ID# I.3 in the "Report on the individual review of the annual submission of Malta submitted in 2019", FCCC/ARR/2019/MLT)	2.D.3 Other (Road paving with asphalt)	4.5.3.1
The lack of data on the mass of road paving material produced in the year 2018 and 2019 is being looked into.	2.D.3 Other (Road paving with asphalt)	4.5.3.1
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. (*Finding* ID# I.16 in the "Report on the individual review of the annual submission of Malta submitted in 2019", FCCC/ARR/2019/MLT.)	2.D.3 Other Other (Urea for denoxificat ion)	4.5.3
The Inventory Agency is in the initial stages of a discussion with the local competent authority for the purposes of Regulation (EU) No 517/2014 to improve the data available from the local F-gas market.	2.E 2.F 2.G	4.6 4.7 4.8
The Inventory Agency is holding discussions with local market operators to verify the	2.F.1	4.7.1

sources of data for the F-gases imported to Malta for local consumption so as to ensure an adequate coverage of the local market.		
The Inventory Agency is holding discussions with local market operators to identify sources of data for the local collection of F-gases from equipment at end-of-life so as to ensure an adequate coverage of the local market.	2.F.1	4.7.1
The transparency of category 2.F.1 is being improved by including more detailed explanations of the model being used, describing the assumptions and the expert judgements made. This should address better *Finding* ID# I.5 in the "Report on the individual review of the annual submission of Malta submitted in 2019", FCCC/ARR/2019/MLT.	2.F.1	4.7.1
The recommendations made by the *Expert Review Team* in *Finding* ID# I.13 in the "Report on the individual review of the annual submission of Malta submitted in 2019" (FCCC/ARR/2019/MLT). The improvements needed are being coupled with another two initiatives, namely the receipt of the latest vehicle fleet data from the authority for transport in Malta, whilst harmonising this with the transport sector inventory compiler.	2.F.1	4.7.1
The recommendations made by the *Expert Review Team* in *Finding* ID# I.17 in the "Report on the individual review of the annual submission of Malta submitted in 2019" (FCCC/ARR/2019/MLT).	2.F.1	4.7.1
The reporting of R-1234yf from CRF data entry table [2.F.1.a Commercial Refrigeration] [Unspecified mix of HFCs] should be removed.	2.F.1	4.7.1
An analysis to improve the robustness and consistency of the collection and reporting of activity data for category 2.F.2 is being conducted. (*Findings* ID# I.9 and I.10 in the "Report on the individual review of the annual submission of Malta submitted in 2019", FCCC/ARR/2019/MLT.)	2.F.2	4.7.2
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.	2.F.3	4.7.3
The missing information on the import of F-gas in fire protection systems is being investigated.	2.F.3	4.7.3
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.	2.F.4	4.7.4

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 timeseries.

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)[14] 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.

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.

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

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

This section is not applicable.

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

This section is not applicable.

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 amount 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 amount of sodium bicarbonate used for desulphurisation in the waste sector is lower than that reported for the previous year. This decrease was explained by the operator by reporting that, following consultation advice, the feeding rate of sodium bicarbonate was decreased because the mill had been overfeeding the system.

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 by the *Expert Review Team* in *Finding* ID# I.2 in the "Report on the individual review of the annual submission of Malta submitted in 2019", FCCC/ARR/2019/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.

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

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 previous to 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. 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. Data for the year 2019 for gasoline consumption in motorcycles was not received, thus it is assumed that this value was equal to that reported for the year 2018. This data is expected to be duly received.

4.5.1.5 Source Specific Recalculations

No recalculations were required.

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[15]. 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.

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

This section is not applicable.

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.

[15] IntraStat Combined Nomenclature 2013

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 *EMEP/EEA air pollutant emission inventory guidebook 2013* and compared to the latest edition of this guidebook, namely *EMEP/EEA air pollutant emission inventory guidebook 2019*. 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:

$$\text{Emissions (Gg } CO_2) = \text{Emissions (Gg NMVOC)} * 0.85 * (44/12)$$

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 requested mass of road paving material produced in the year 2018 was not received. Thus, it was assumed that this value was equal to the data received for the year 2017. This situation prevails for the data for the year 2019. This data is expected to be duly received.

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 by the Expert Review Team in *Finding* ID# I.3 in in the “Report on the individual review of the annual submission of Malta submitted in 2019”, FCCC/ARR/2019/MLT, the time series consistency of the activity data is being analysed. Furthermore, the lack of data for the year 2018 is being investigated.

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 significant amounts 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 (and, also, the EMEP/EEA air pollutant emission inventory guidebook 2019 which is the latest edition of this guidebook) 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

This section is not applicable.

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 by the *Emissions Review Team* in *Finding* ID# I.16 in the "Report on the individual review of the annual submission of Malta submitted in 2019", FCCC/ARR/2019/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, CO2 is released as a by-product. The amount 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 CO2/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 CO2/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 CO2 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 amount of urea used for denoxification (of gasoil) had decreased. However, a slight increase in the amount of urea used for denoxification in energy generation can be observed in the data for the year 2019 over the year 2018. The explanation given by the local administrator of the EU Emissions Trading System for the increase in the consumption of urea is an increased use of diesel in the diesel engines during the year 2019.

The data for the year 2019 results in a sharp drop in the trend of the amount 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 amount of urea during operation was implemented.

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 data for the year 2019 was not received, thus it is assumed that this value was equal to that reported for the year 2018. This data is expected to be duly received. Also, 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

No recalculations were required.

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. There is only one production plant, which falls within the scope of this sector, in the semi-conductor manufacturing sub-sector. This plant, though, performs only the final stages of semiconductor manufacture. Throughout the whole time-series, it reports the use of HFC-23 and SF_6. The data provider has described that between 2018 and 2019, actions were put in place to align their procedures with relevant European legislation. To this end, leak tests are being performed in the preventive maintenance schedule of the equipment. The data provider has also referred that this action is helping to keep systems under control and consume less F-gases.

4.6.2 Methodological Issues

Due to the very limited use of gases in this sector and the fact that there is only one plant in which such activities occur, activity data is directly obtained from the plant operator. The operator in question (a multinational electronics firm) compiles 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 SF6 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 SF6 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

The data provider for this sector provides ISO 14064 verified inventories for calculation of emissions in this 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. The trend for the use of HFC-23 in this sub-sector seems to be decreasing, overall. This has been explained by the data provider by reporting that this is due to the performance of regular leak tests and to the inclusion of leak tests in the preventive maintenance schedule of the equipment, referred to in section 4.6.1.

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 4-3 presents a pictorial overview of emissions of these gases from various applications over the whole time-series covered by this report.

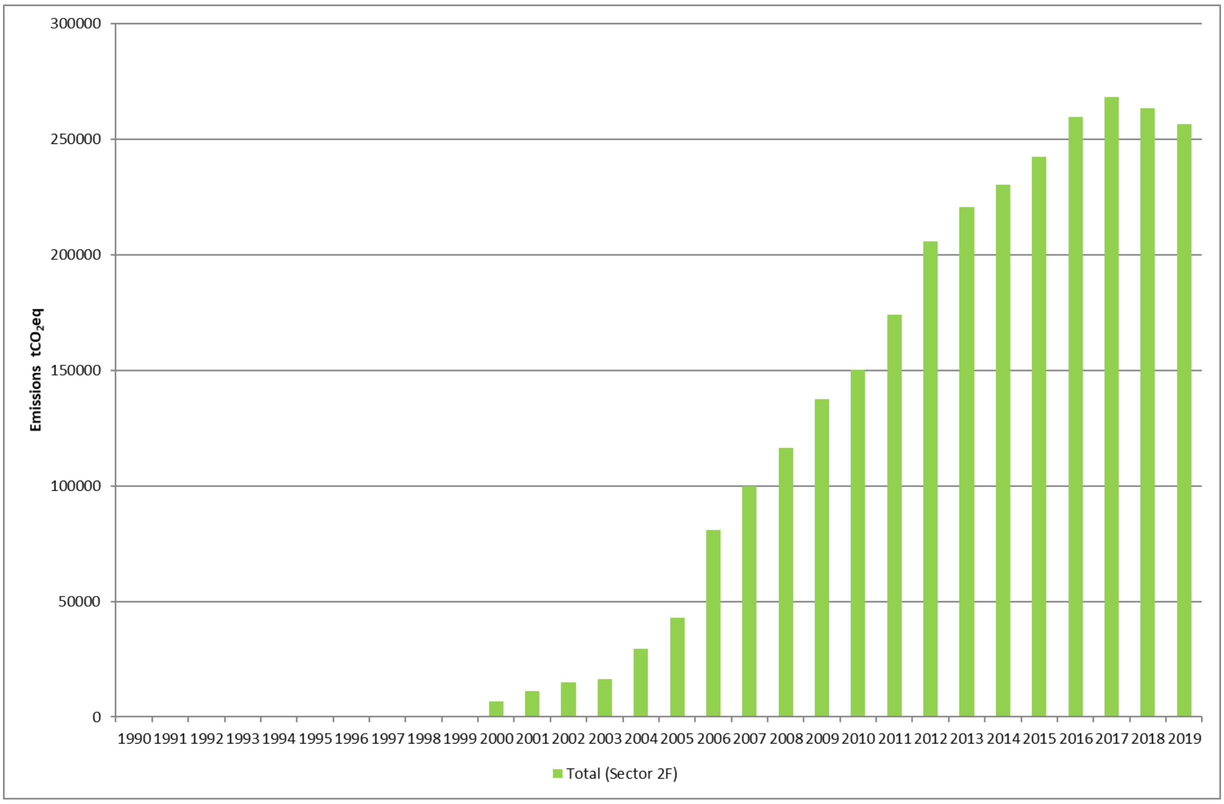

Figure 4-3 Actual emissions from sub-sector 2.F Product Uses as substitutes for ODS.

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 2006 IPCC Guidelines. 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, as well as to identify sources of data for the local collection of F-gases from equipment at end-of-life, so as to ensure an adequate coverage of the local market. Figure 4-4 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.

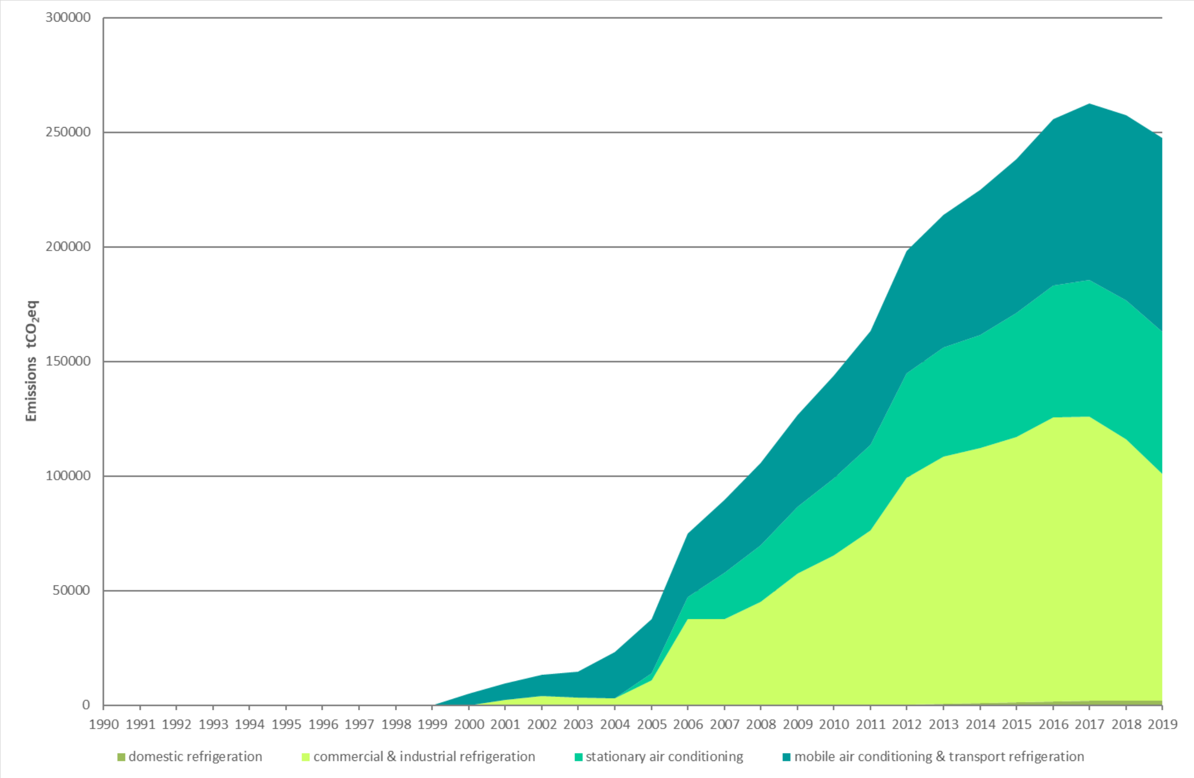

Figure 4-4 Actual emissions from category 2.F.1 Refrigeration and Air Conditioning.

The difference in the emissions from CRF category 2.F.1 over the whole time series in the 2021 GHG inventory when compared to the 2020 GHG inventory is due to the following developments:

- the improvements in the estimation of emissions from mobile air conditioning (CRF 2.F.1.e) and transport refrigeration (CRF 2.F.1.d), both included under CRF 2.F.1.d;
- the improvement in the estimation of the stock accumulated from the charge in pre-charged equipment in stationary air conditioning (CRF 2.F.1.f); and
- the recovery reported in commercial (& industrial) refrigeration (CRF 2.F.1.a & 2.F.1.c) and stationary air conditioning (CRF 2.F.1.f).

The Inventory Agency is holding discussions with local market operators to characterise better the local F-gas market so as to ensure an adequate coverage of the local market in the GHG inventory. To this end, during the year 2020, a source of data for the local collection of F-gases from equipment at end-of-life was identified. As a result of this initiative, in the 2021 GHG inventory, recovery is reported in 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.

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 R134a 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 R134a. 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.

While in other European countries alternative commercial refrigeration technologies relying on natural refrigerants such as CO_2 as a refrigerant and hydrocarbons are gradually being introduced to the market, this development has not started in Malta yet.

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.

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)[16]. 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 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. Refrigerants fully attributed to the commercial refrigeration subcategory (including transport refrigeration and industrial refrigeration) are R404A, R417A, R422A, R422D and R507A.

The situation is different for R134a, which is mainly used in mobile air conditioning equipment but also to some extent in stationary (and transport) 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.

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

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.

The amounts of refrigerants (mainly R134a and some R404A) needed annually for servicing of mobile air conditioning and transport refrigeration are deducted from the total imports of R134a 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.

The remaining refrigerant quantities of R134a, R404A, R417A, R422A, R422D and R507A, are attributed to the commercial refrigeration sub-category (including industrial refrigeration).

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). Moreover, one of the components of one of the refrigerants reported is 2,3,3,3-Tetrafluoropropene (or R1234yf or HFO-1234yf). Since it was not possible to generate a CRF table specifically for this refrigerant, a new table entitled “Unspecified mix of HFCs”, referring solely to R1234yf, was added.

The recovery reported for CRF sub-category 2.F.1.a (& 2.F.1.c) commercial (& industrial) refrigeration was obtained from the market. More specifically, from the waste management site that collected and shipped the F-gas.

The data submitted consisted of the mass of gases collected, categorised by the year in which the gases collected were shipped. 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 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.

Assuming an even distribution among the years of collection for each shipment and an even distribution among the gases collected and removing R22, the total annual mass of ODS substitutes collected was estimated. 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 was 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.

4.7.1.1.3 Source Specific Recalculations

One of the components of one of the refrigerants reported is 2,3,3,3-Tetrafluoropropene (or R1234yf or HFO-1234yf). In the 2020 GHG inventory, a new table entitled “Unspecified mix of HFCs”, referring solely to R1234yf, was added because it was not possible to generate a CRF table specifically for this refrigerant. Moreover, in the 2020 GHG inventory, the GWP of the blend of the refrigerant was erroneously used, instead of the GWP of R1234yf. Hence, in the 2020 GHG inventory, the emissions of R1234yf, have been overestimated. This has, inevitably, led to the following recalculation.

Table 4-5 CRF 2.F.1.a Commercial (& Industrial) Refrigeration - Emissions from stocks - "Unspecified mix of HFCs".

Year	Emissions as reported in the 2020 inventory report Gg CO_2 eq	Emissions as reported in the 2021 inventory report Gg CO_2 eq	Percentage change in reported emissions
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	65.03	0.19	-99.71%
2019	not applicable	0.24	not applicable

The reporting of recovery in CRF sub-category 2.F.1.a (& 2.F.1.c) commercial (& industrial) refrigeration has, inevitably, led to the following recalculations.

Table 4-6 CRF 2.F.1.a (& 2.F.1.c) Refrigeration and Air Conditioning - Commercial (& Industrial) Refrigeration - Recovery - HFC-32

Year	Emissions as reported in the 2020 inventory report	Emissions as reported in the 2021 inventory report	Percentage change in reported emissions
	Gg CO_2 eq	Gg CO_2 eq	
1990	0.00	0.00	not applicable
1991	0.00	0.00	not applicable
1992	0.00	0.00	not applicable
1993	0.00	0.00	not applicable
1994	0.00	0.00	not applicable
1995	0.00	0.00	not applicable
1996	0.00	0.00	not applicable
1997	0.00	0.00	not applicable
1998	0.00	0.00	not applicable
1999	0.00	0.00	not applicable
2000	0.00	0.00	not applicable
2001	0.00	0.00	not applicable
2002	0.00	0.00	not applicable
2003	0.00	0.00	not applicable
2004	0.00	0.00	not applicable
2005	0.00	0.00	not applicable
2006	0.00	0.00	not applicable
2007	0.00	0.00	not applicable
2008	0.00	0.00	not applicable
2009	0.00	0.00	not applicable
2010	0.00	0.00	not applicable
2011	0.00	0.00	not applicable
2012	0.00	0.00	not applicable
2013	0.00	0.00	not applicable
2014	0.00	0.13	not applicable
2015	0.00	0.13	not applicable
2016	0.00	0.05	not applicable
2017	0.00	0.05	not applicable
2018	0.00	0.00	not applicable
2019	not applicable	0.00	not applicable

Table 4-7 CRF 2.F.1.a (& 2.F.1.c) Refrigeration and Air Conditioning - Commercial (& Industrial) Refrigeration - Recovery - HFC-143a

Year	Emissions as reported in the 2020 inventory report	Emissions as reported in the 2021 inventory report	Percentage change in reported emissions
	Gg CO_2 eq	Gg CO_2 eq	
1990	0.00	0.00	not applicable
1991	0.00	0.00	not applicable
1992	0.00	0.00	not applicable
1993	0.00	0.00	not applicable
1994	0.00	0.00	not applicable
1995	0.00	0.00	not applicable
1996	0.00	0.00	not applicable
1997	0.00	0.00	not applicable
1998	0.00	0.00	not applicable
1999	0.00	0.00	not applicable
2000	0.00	0.00	not applicable
2001	0.00	0.00	not applicable
2002	0.00	0.00	not applicable
2003	0.00	0.00	not applicable
2004	0.00	0.00	not applicable
2005	0.00	0.00	not applicable
2006	0.00	0.00	not applicable
2007	0.00	0.00	not applicable
2008	0.00	0.00	not applicable
2009	0.00	0.00	not applicable
2010	0.00	0.00	not applicable
2011	0.00	0.00	not applicable
2012	0.00	0.00	not applicable
2013	0.00	0.00	not applicable
2014	0.00	2.23	not applicable
2015	0.00	2.23	not applicable
2016	0.00	0.91	not applicable
2017	0.00	0.91	not applicable
2018	0.00	0.00	not applicable
2019	not applicable	0.00	not applicable

Table 4-8 CRF 2.F.1.a (& 2.F.1.c) Refrigeration and Air Conditioning - Commercial (& Industrial) Refrigeration - Recovery - HFC-125

Year	Emissions as reported in the 2020 inventory report	Emissions as reported in the 2021 inventory report	Percentage change in reported emissions
	Gg CO_2 eq	Gg CO_2 eq	
1990	0.00	0.00	not applicable
1991	0.00	0.00	not applicable
1992	0.00	0.00	not applicable
1993	0.00	0.00	not applicable
1994	0.00	0.00	not applicable
1995	0.00	0.00	not applicable
1996	0.00	0.00	not applicable
1997	0.00	0.00	not applicable
1998	0.00	0.00	not applicable
1999	0.00	0.00	not applicable
2000	0.00	0.00	not applicable
2001	0.00	0.00	not applicable
2002	0.00	0.00	not applicable
2003	0.00	0.00	not applicable
2004	0.00	0.00	not applicable
2005	0.00	0.00	not applicable
2006	0.00	0.00	not applicable
2007	0.00	0.00	not applicable
2008	0.00	0.00	not applicable
2009	0.00	0.00	not applicable
2010	0.00	0.00	not applicable
2011	0.00	0.00	not applicable
2012	0.00	0.00	not applicable
2013	0.00	0.00	not applicable
2014	0.00	2.83	not applicable
2015	0.00	2.83	not applicable
2016	0.00	1.15	not applicable
2017	0.00	1.15	not applicable
2018	0.00	0.00	not applicable
2019	not applicable	0.00	not applicable

Table 4-9 CRF 2.F.1.a (& 2.F.1.c) Refrigeration and Air Conditioning - Commercial (& Industrial) Refrigeration - Recovery - HFC-134a

Year	Emissions as reported in the 2020 inventory report	Emissions as reported in the 2021 inventory report	Percentage change in reported emissions
	Gg CO_2 eq	Gg CO_2 eq	
1990	0.00	0.00	not applicable
1991	0.00	0.00	not applicable
1992	0.00	0.00	not applicable
1993	0.00	0.00	not applicable
1994	0.00	0.00	not applicable
1995	0.00	0.00	not applicable
1996	0.00	0.00	not applicable
1997	0.00	0.00	not applicable
1998	0.00	0.00	not applicable
1999	0.00	0.00	not applicable
2000	0.00	0.00	not applicable
2001	0.00	0.00	not applicable
2002	0.00	0.00	not applicable
2003	0.00	0.00	not applicable
2004	0.00	0.00	not applicable
2005	0.00	0.00	not applicable
2006	0.00	0.00	not applicable
2007	0.00	0.00	not applicable
2008	0.00	0.00	not applicable
2009	0.00	0.00	not applicable
2010	0.00	0.00	not applicable
2011	0.00	0.00	not applicable
2012	0.00	0.00	not applicable
2013	0.00	0.00	not applicable
2014	0.00	1.98	not applicable
2015	0.00	1.98	not applicable
2016	0.00	0.81	not applicable
2017	0.00	0.81	not applicable
2018	0.00	0.24	not applicable
2019	not applicable	0.24	not applicable

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

4.7.1.2.1 Category Description

The Maltese stationary air conditioning market cannot yet be considered a mature market (CasaInginiera, 2012)[17] 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 emission reporting. 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.

4.7.1.2.2 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 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* has identified a potential problem with this. As a response to this potential problem, the estimate of emissions from this sub-category has been 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

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

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. Up to the 2020 GHG inventory , the data was obtained from the annual data on the estimated national stock of split units of the *EWA Heat-Pumps Model*, rounding up the totals to the nearest integer. However, 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. More specifically, from the waste management site that collected and shipped the F-gas.

The data submitted consisted of the mass of gases collected, categorised by the year in which the gases collected were shipped. 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 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.

Assuming an even distribution among the years of collection for each shipment and an even distribution among the gases collected and removing R22, the total annual mass of ODS substitutes collected was estimated. 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 was 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.

4.7.1.2.3 Source Specific Recalculations

Up to the 2020 GHG inventory, the annual estimated national stock of split units of the *EWA Heat-Pumps Model*, was used. However, 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. The effect of the change described above is a reduction in the emissions from CRF sub-category 2.F.1.f. Moreover, the annual imports of split units in the *EWA Heat-Pumps Model* have been revised for the years 2016 (reduction) and 2018 (increase). These changes have, inevitably, led to the following recalculations.

Table 4-10 CRF 2.F.1.f Refrigeration and Air Conditioning - Stationary Air Conditioning - Emissions - HFC 32

Year	Emissions as reported in the 2020 inventory report Gg CO_2 eq	Emissions as reported in the 2021 inventory report Gg CO_2 eq	Percentage change in reported emissions
1990	0.00	0.00	not applicable
1991	0.00	0.00	not applicable
1992	0.00	0.00	not applicable
1993	0.00	0.00	not applicable
1994	0.00	0.00	not applicable
1995	0.00	0.00	not applicable
1996	0.00	0.00	not applicable
1997	0.00	0.00	not applicable
1998	0.00	0.00	not applicable
1999	0.00	0.00	not applicable
2000	0.00	0.00	not applicable
2001	0.00	0.00	not applicable
2002	0.00	0.00	not applicable
2003	0.00	0.00	not applicable
2004	0.00	0.00	not applicable
2005	0.17	0.15	-13.17%
2006	0.26	0.24	-6.26%
2007	0.39	0.40	1.35%
2008	0.84	0.80	-5.18%
2009	1.14	1.04	-9.41%
2010	1.61	1.44	-10.62%
2011	2.07	1.80	-12.75%
2012	2.80	2.52	-9.74%
2013	3.60	3.08	-14.54%
2014	4.35	3.55	-18.41%
2015	5.54	4.54	-17.96%
2016	6.34	5.08	-19.93%
2017	7.82	6.06	-22.55%
2018	8.99	6.66	-25.95%
2019	not applicable	7.57	not applicable

Table 4-11 CRF 2.F.1.f Refrigeration and Air Conditioning - Stationary Air Conditioning - Stock - HFC 32

Year	Emissions as reported in the 2020 inventory report Gg CO_2 eq	Emissions as reported in the 2021 inventory report Gg CO_2 eq	Percentage change in reported emissions
1990	0.00	0.00	not applicable
1991	0.00	0.00	not applicable
1992	0.00	0.00	not applicable
1993	0.00	0.00	not applicable
1994	0.00	0.00	not applicable
1995	0.00	0.00	not applicable
1996	0.00	0.00	not applicable
1997	0.00	0.00	not applicable
1998	0.00	0.00	not applicable
1999	0.00	0.00	not applicable
2000	0.00	0.00	not applicable
2001	0.00	0.00	not applicable
2002	0.00	0.00	not applicable
2003	0.00	0.00	not applicable
2004	0.00	0.00	not applicable
2005	9.73	4.03	-58.60%
2006	13.50	5.94	-55.98%
2007	18.91	9.58	-49.35%
2008	43.41	19.59	-54.88%
2009	60.56	23.88	-60.57%
2010	84.92	30.94	-63.56%
2011	110.81	38.32	-65.42%
2012	144.37	51.98	-63.99%
2013	195.90	64.34	-67.16%
2014	246.98	76.23	-69.14%
2015	312.93	97.65	-68.80%
2016	368.54	114.41	-68.95%
2017	469.07	142.09	-69.71%
2018	565.64	171.54	-69.67%
2019	not applicable	214.53	not applicable

Table 4-12 CRF 2.F.1.f Refrigeration and Air Conditioning - Stationary Air Conditioning - Emissions - HFC 125

Year	Emissions as reported in the 2020 inventory report Gg CO_2 eq	Emissions as reported in the 2021 inventory report Gg CO_2 eq	Percentage change in reported emissions
1990	0.00	0.00	not applicable
1991	0.00	0.00	not applicable
1992	0.00	0.00	not applicable
1993	0.00	0.00	not applicable
1994	0.00	0.00	not applicable
1995	0.00	0.00	not applicable
1996	0.00	0.00	not applicable
1997	0.00	0.00	not applicable
1998	0.00	0.00	not applicable
1999	0.00	0.00	not applicable
2000	0.00	0.00	not applicable
2001	0.00	0.00	not applicable
2002	0.00	0.00	not applicable
2003	0.00	0.00	not applicable
2004	0.00	0.00	not applicable
2005	1.73	0.29	-83.25%
2006	4.20	0.80	-80.85%
2007	7.79	1.61	-79.34%
2008	11.26	2.18	-80.62%
2009	14.67	2.69	-81.67%
2010	18.43	3.29	-82.14%
2011	21.97	3.81	-82.66%
2012	28.07	4.96	-82.34%
2013	32.73	5.51	-83.15%
2014	36.97	5.97	-83.86%
2015	43.69	7.01	-83.96%
2016	48.62	7.60	-84.37%
2017	54.00	8.18	-84.86%
2018	58.40	8.50	-85.45%
2019	not applicable	8.83	not applicable

Table 4-13 CRF 2.F.1.f Refrigeration and Air Conditioning - Stationary Air Conditioning - Stock - HFC 125

Year	Emissions as reported in the 2020 inventory report	Emissions as reported in the 2021 inventory report	Percentage change in reported emissions
	Gg CO_2 eq	Gg CO_2 eq	
1990	0.00	0.00	not applicable
1991	0.00	0.00	not applicable
1992	0.00	0.00	not applicable
1993	0.00	0.00	not applicable
1994	0.00	0.00	not applicable
1995	0.00	0.00	not applicable
1996	0.00	0.00	not applicable
1997	0.00	0.00	not applicable
1998	0.00	0.00	not applicable
1999	0.00	0.00	not applicable
2000	0.00	0.00	not applicable
2001	0.00	0.00	not applicable
2002	0.00	0.00	not applicable
2003	0.00	0.00	not applicable
2004	0.00	0.00	not applicable
2005	99.32	7.93	-92.02%
2006	202.16	18.19	-91.00%
2007	344.11	36.68	-89.34%
2008	543.22	51.75	-90.47%
2009	738.87	60.85	-91.76%
2010	940.96	71.45	-92.41%
2011	1152.24	82.36	-92.85%
2012	1437.13	104.24	-92.75%
2013	1753.82	117.49	-93.30%
2014	2063.53	130.06	-93.70%
2015	2452.61	153.27	-93.75%
2016	2807.80	173.07	-93.84%
2017	3210.75	192.16	-94.02%
2018	3615.37	214.07	-94.08%
2019	not applicable	237.94	not applicable

Table 4-14 CRF 2.F.1.f Refrigeration and Air Conditioning - Stationary Air Conditioning - Emissions - HFC 134a

Year	Emissions as reported in the 2020 inventory report Gg CO_2 eq	Emissions as reported in the 2021 inventory report Gg CO_2 eq	Percentage change in reported emissions
1990	0.00	0.00	not applicable
1991	0.00	0.00	not applicable
1992	0.00	0.00	not applicable
1993	0.00	0.00	not applicable
1994	0.00	0.00	not applicable
1995	0.00	0.00	not applicable
1996	0.00	0.00	not applicable
1997	0.00	0.00	not applicable
1998	0.00	0.00	not applicable
1999	0.00	0.00	not applicable
2000	0.00	0.00	not applicable
2001	0.00	0.00	not applicable
2002	0.00	0.00	not applicable
2003	0.00	0.00	not applicable
2004	0.00	0.00	not applicable
2005	0.70	0.28	-59.01%
2006	2.34	1.12	-51.89%
2007	4.70	2.42	-48.46%
2008	5.65	2.77	-50.87%
2009	6.80	3.17	-53.41%
2010	8.23	3.72	-54.87%
2011	9.41	4.11	-56.31%
2012	10.71	4.68	-56.34%
2013	10.92	4.62	-57.66%
2014	11.24	4.60	-59.04%
2015	11.56	4.64	-59.84%
2016	12.30	4.81	-60.91%
2017	12.35	4.70	-61.98%
2018	12.82	4.70	-63.34%
2019	not applicable	4.61	not applicable

Table 4-15 CRF 2.F.1.f Refrigeration and Air Conditioning - Stationary Air Conditioning - Stock - HFC 134a

Year	Emissions as reported in the 2020 inventory report	Emissions as reported in the 2021 inventory report	Percentage change in reported emissions
	Gg CO_2 eq	Gg CO_2 eq	
1990	0.00	0.00	not applicable
1991	0.00	0.00	not applicable
1992	0.00	0.00	not applicable
1993	0.00	0.00	not applicable
1994	0.00	0.00	not applicable
1995	0.00	0.00	not applicable
1996	0.00	0.00	not applicable
1997	0.00	0.00	not applicable
1998	0.00	0.00	not applicable
1999	0.00	0.00	not applicable
2000	0.00	0.00	not applicable
2001	0.00	0.00	not applicable
2002	0.00	0.00	not applicable
2003	0.00	0.00	not applicable
2004	0.00	0.00	not applicable
2005	39.93	7.80	-80.46%
2006	107.98	24.49	-77.32%
2007	201.08	54.20	-73.04%
2008	259.97	64.33	-75.26%
2009	329.32	71.57	-78.27%
2010	408.22	81.25	-80.10%
2011	481.48	89.87	-81.33%
2012	547.06	101.12	-81.52%
2013	576.09	101.58	-82.37%
2014	613.31	103.18	-83.18%
2015	643.13	105.46	-83.60%
2016	703.45	112.64	-83.99%
2017	724.97	112.73	-84.45%
2018	779.82	118.82	-84.76%
2019	not applicable	121.77	not applicable

Table 4-16 CRF 2.F.1.f Refrigeration and Air Conditioning - Stationary Air Conditioning - Emissions - HFC 143a

Year	Emissions as reported in the 2020 inventory report Gg CO_2 eq	Emissions as reported in the 2021 inventory report Gg CO_2 eq	Percentage change in reported emissions
1990	0.00	0.00	not applicable
1991	0.00	0.00	not applicable
1992	0.00	0.00	not applicable
1993	0.00	0.00	not applicable
1994	0.00	0.00	not applicable
1995	0.00	0.00	not applicable
1996	0.00	0.00	not applicable
1997	0.00	0.00	not applicable
1998	0.00	0.00	not applicable
1999	0.00	0.00	not applicable
2000	0.00	0.00	not applicable
2001	0.00	0.00	not applicable
2002	0.00	0.00	not applicable
2003	0.00	0.00	not applicable
2004	0.00	0.00	not applicable
2005	2.17	0.28	-86.89%
2006	7.31	1.12	-84.61%
2007	14.69	2.42	-83.51%
2008	17.65	2.77	-84.28%
2009	21.40	3.19	-85.11%
2010	24.46	3.54	-85.53%
2011	27.37	3.84	-85.98%
2012	31.77	4.46	-85.97%
2013	32.36	4.40	-86.39%
2014	33.44	4.40	-86.84%
2015	34.41	4.44	-87.10%
2016	36.88	4.63	-87.45%
2017	37.11	4.53	-87.80%
2018	38.63	4.54	-88.24%
2019	not applicable	4.47	not applicable

Table 4-17 CRF 2.F.1.f Refrigeration and Air Conditioning - Stationary Air Conditioning - Stock - HFC 143a

	Emissions as reported in the 2020 inventory report	Emissions as reported in the 2021 inventory report	
Year	Gg CO_2 eq	Gg CO_2 eq	Percentage change in reported emissions
1990	0.00	0.00	not applicable
1991	0.00	0.00	not applicable
1992	0.00	0.00	not applicable
1993	0.00	0.00	not applicable
1994	0.00	0.00	not applicable
1995	0.00	0.00	not applicable
1996	0.00	0.00	not applicable
1997	0.00	0.00	not applicable
1998	0.00	0.00	not applicable
1999	0.00	0.00	not applicable
2000	0.00	0.00	not applicable
2001	0.00	0.00	not applicable
2002	0.00	0.00	not applicable
2003	0.00	0.00	not applicable
2004	0.00	0.00	not applicable
2005	124.82	7.80	-93.75%
2006	337.52	24.49	-92.74%
2007	628.55	54.20	-91.38%
2008	812.64	64.33	-92.08%
2009	1036.58	71.87	-93.07%
2010	1213.74	78.21	-93.56%
2011	1401.02	84.93	-93.94%
2012	1617.98	97.10	-94.00%
2013	1702.89	97.47	-94.28%
2014	1821.01	99.29	-94.55%
2015	1910.47	101.48	-94.69%
2016	2107.14	109.20	-94.82%
2017	2176.00	109.47	-94.97%
2018	2348.95	115.73	-95.07%
2019	not applicable	118.83	not applicable

The reporting of recovery in CRF sub-category 2.F.1.f stationary air conditioning has, inevitably, led to the following recalculations.

Table 4-18 CRF 2.F.1.f Refrigeration and Air Conditioning - Stationary Air Conditioning - Recovery - HFC-134a

Year	Emissions as reported in the 2020 inventory report Gg CO_2 eq	Emissions as reported in the 2021 inventory report Gg CO_2 eq	Percentage change in reported emissions
1990	0.00	0.00	not applicable
1991	0.00	0.00	not applicable
1992	0.00	0.00	not applicable
1993	0.00	0.00	not applicable
1994	0.00	0.00	not applicable
1995	0.00	0.00	not applicable
1996	0.00	0.00	not applicable
1997	0.00	0.00	not applicable
1998	0.00	0.00	not applicable
1999	0.00	0.00	not applicable
2000	0.00	0.00	not applicable
2001	0.00	0.00	not applicable
2002	0.00	0.00	not applicable
2003	0.00	0.00	not applicable
2004	0.00	0.00	not applicable
2005	0.00	0.00	not applicable
2006	0.00	0.00	not applicable
2007	0.00	0.00	not applicable
2008	0.00	0.00	not applicable
2009	0.00	0.00	not applicable
2010	0.00	0.00	not applicable
2011	0.00	0.00	not applicable
2012	0.00	0.00	not applicable
2013	0.00	0.00	not applicable
2014	0.00	0.00	not applicable
2015	0.00	0.00	not applicable
2016	0.00	0.00	not applicable
2017	0.00	0.00	not applicable
2018	0.00	0.10	not applicable
2019	not applicable	0.10	not applicable

Table 4-19 CRF 2.F.1.f Refrigeration and Air Conditioning - Stationary Air Conditioning - Recovery - HFC-143a

Year	Emissions as reported in the 2020 inventory report	Emissions as reported in the 2021 inventory report	Percentage change in reported emissions
	Gg CO_2 eq	Gg CO_2 eq	
1990	0.00	0.00	not applicable
1991	0.00	0.00	not applicable
1992	0.00	0.00	not applicable
1993	0.00	0.00	not applicable
1994	0.00	0.00	not applicable
1995	0.00	0.00	not applicable
1996	0.00	0.00	not applicable
1997	0.00	0.00	not applicable
1998	0.00	0.00	not applicable
1999	0.00	0.00	not applicable
2000	0.00	0.00	not applicable
2001	0.00	0.00	not applicable
2002	0.00	0.00	not applicable
2003	0.00	0.00	not applicable
2004	0.00	0.00	not applicable
2005	0.00	0.00	not applicable
2006	0.00	0.00	not applicable
2007	0.00	0.00	not applicable
2008	0.00	0.00	not applicable
2009	0.00	0.00	not applicable
2010	0.00	0.00	not applicable
2011	0.00	0.00	not applicable
2012	0.00	0.00	not applicable
2013	0.00	0.00	not applicable
2014	0.00	0.00	not applicable
2015	0.00	0.00	not applicable
2016	0.00	0.00	not applicable
2017	0.00	0.00	not applicable
2018	0.00	0.30	not applicable
2019	not applicable	0.30	not applicable

Table 4-20 CRF 2.F.1.f Refrigeration and Air Conditioning - Stationary Air Conditioning - Recovery - HFC-125

Year	Emissions as reported in the 2020 inventory report	Emissions as reported in the 2021 inventory report	Percentage change in reported emissions
	Gg CO_2 eq	Gg CO_2 eq	
1990	0.00	0.00	not applicable
1991	0.00	0.00	not applicable
1992	0.00	0.00	not applicable
1993	0.00	0.00	not applicable
1994	0.00	0.00	not applicable
1995	0.00	0.00	not applicable
1996	0.00	0.00	not applicable
1997	0.00	0.00	not applicable
1998	0.00	0.00	not applicable
1999	0.00	0.00	not applicable
2000	0.00	0.00	not applicable
2001	0.00	0.00	not applicable
2002	0.00	0.00	not applicable
2003	0.00	0.00	not applicable
2004	0.00	0.00	not applicable
2005	0.00	0.00	not applicable
2006	0.00	0.00	not applicable
2007	0.00	0.00	not applicable
2008	0.00	0.00	not applicable
2009	0.00	0.00	not applicable
2010	0.00	0.00	not applicable
2011	0.00	0.00	not applicable
2012	0.00	0.00	not applicable
2013	0.00	0.00	not applicable
2014	0.00	0.00	not applicable
2015	0.00	0.00	not applicable
2016	0.00	0.00	not applicable
2017	0.00	0.00	not applicable
2018	0.00	0.12	not applicable
2019	not applicable	0.12	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 R-404A and not R-134a.

4.7.1.3.2 Methodological issues

Emission estimates for transport refrigeration are based on an emission factor approach. Data on the number of refrigerated trucks and vans was obtained through the VERA system managed by the authority for transport in Malta and the national statistics agency and the total is used to estimate emissions. 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).

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[18]). However, it is also assumed that R134a was the only refrigerant used in transport refrigeration 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 current number of refrigerated vans, trucks and trailers is not available from vehicle registration data or model reported.

Manufacturing emissions do not occur in Malta since no vehicle production takes place. 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)[19] suggests higher emission rates of up to 25%.

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. It should be pointed out that in the CRF tables, emissions from transport refrigeration (CRF sub-category 2.F.1.d) include also emissions from mobile air conditioning (CRF sub-category 2.F.1.e).

4.7.1.3.3 Source Specific Recalculations

An observation (MT-2F1-2020-0004) related to sub-categories "Transport Refrigeration" (CRF 2.F.1.d) and "Mobile Air Conditioning" (CRF 2.F.1.e) was raised by the *Effort Sharing Decision Review Team* during *step 2* of the review of the 2020 GHG inventory of Malta. As part of the analysis that followed, the changes described below have been made:

- A part of the disposal emissions of HFC-134a were erroneously being reported in tCO_2eq, instead of t.
- The recovery rate has been updated to 0. It was being assumed that a fixed share of refrigerant in vehicles that reach their end-of-life would be recovered, however, there is no data from the local market to confirm that this is happening.
- The amount of gas remaining in products at decommissioning has been estimated.
- 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, were used:
  - cars and minibuses: 50%;
  - buses: 50%;
  - vans and trucks: 50%; and
  - transport refrigeration: 85%.

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

[19] 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.

- The share of the different gases comprising the blends used in transport refrigeration has been corrected.
- The ratios of the different gases used in transport refrigeration were changed to 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 were used:
  - pre-2001: 0:0;
  - 2001-2003: 100:0;
  - 2004: 50:50;
  - 2005: 30:70; and
  - 2006 to date: 10:90.
- The amount of gas remaining in products at decommissioning and the emissions from disposal have been updated to reflect the ratios of the different gases used in transport refrigeration in the year the vehicles were introduced, rather than the ratio from the year of disposal of the vehicles.

Overall, the effect of the changes described above is a reduction in the emissions from sub-categories "Transport Refrigeration" (CRF 2.F.1.d) and "Mobile Air Conditioning" (CRF 2.F.1.e). Thus, it can be concluded that emissions from these sub-categories had been overestimated in previous inventories. This has, inevitably, led to the following recalculations.

Table 4-21 CRF 2.F.1.d Transport Refrigeration - Stock - HFC-125.

Year	Emissions as reported in the 2020 inventory report	Emissions as reported in the 2021 inventory report	Percentage change in reported emissions
	Gg CO_2 eq	Gg CO_2 eq	
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	2.50	1.54	-38.27%
2005	3.13	2.70	-13.58%
2006	3.28	3.64	11.11%
2007	3.67	4.08	11.11%
2008	4.16	4.63	11.11%
2009	4.30	4.78	11.11%

2010	4.59	5.10	11.11%
2011	4.90	5.44	11.11%
2012	4.96	5.51	11.11%
2013	5.79	6.43	11.11%
2014	6.02	6.69	11.11%
2015	6.21	6.90	11.11%
2016	8.33	9.26	11.11%
2017	9.24	10.27	11.11%
2018	9.24	10.27	11.11%
2019	not applicable	10.27	not applicable

Table 4-22 CRF 2.F.1.d Transport Refrigeration - Stock remaining in products at decommissioning - HFC-125.

Year	Emissions as reported in the 2020 inventory report	Emissions as reported in the 2021 inventory report	Percentage change in reported emissions
	Gg CO_2 eq	Gg CO_2 eq	
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	NE	NO	not applicable
2005	NE	NO	not applicable
2006	NE	NO	not applicable
2007	NE	NO	not applicable
2008	NE	NO	not applicable
2009	NE	NO	not applicable
2010	NE	NO	not applicable
2011	NE	NO	not applicable
2012	NE	NO	not applicable
2013	NE	NO	not applicable
2014	NE	NO	not applicable
2015	NE	NO	not applicable
2016	NE	NO	not applicable
2017	NE	NO	not applicable

2018	NE	NO	not applicable
2019	not applicable	NO	not applicable

Table 4-23 CRF 2.F.1.d Transport Refrigeration - Emissions from disposal - HFC-125.

	Emissions as reported in the 2020 inventory report	Emissions as reported in the 2021 inventory report	
Year	Gg CO_2 eq	Gg CO_2 eq	Percentage change in reported emissions
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	NO	not applicable
2019	not applicable	NO	not applicable

Table 4-24 CRF 2.F.1.d Transport Refrigeration - Stock - HFC-143a.

Year	Emissions as reported in the 2020 inventory report	Emissions as reported in the 2021 inventory report	Percentage change in reported emissions
	Gg CO_2 eq	Gg CO_2 eq	
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	3.78	2.33	-38.27%
2005	4.72	4.08	-13.58%
2006	4.95	5.50	11.11%
2007	5.54	6.15	11.11%
2008	6.29	6.98	11.11%
2009	6.49	7.21	11.11%
2010	6.92	7.69	11.11%
2011	7.39	8.22	11.11%
2012	7.49	8.32	11.11%
2013	8.74	9.71	11.11%
2014	9.09	10.10	11.11%
2015	9.37	10.41	11.11%
2016	12.58	13.98	11.11%
2017	13.95	15.50	11.11%
2018	13.95	15.50	11.11%
2019	not applicable	15.50	not applicable

Table 4-25 CRF 2.F.1.d Transport Refrigeration - Stock remaining in products at decommissioning - HFC-143a.

Year	Emissions as reported in the 2020 inventory report	Emissions as reported in the 2021 inventory report	Percentage change in reported emissions
	Gg CO_2 eq	Gg CO_2 eq	
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	NE	NO	not applicable
2005	NE	NO	not applicable
2006	NE	NO	not applicable
2007	NE	NO	not applicable
2008	NE	NO	not applicable
2009	NE	NO	not applicable
2010	NE	NO	not applicable
2011	NE	NO	not applicable
2012	NE	NO	not applicable
2013	NE	NO	not applicable
2014	NE	NO	not applicable
2015	NE	NO	not applicable
2016	NE	NO	not applicable
2017	NE	NO	not applicable
2018	NE	NO	not applicable
2019	not applicable	NO	not applicable

Table 4-26 CRF 2.F.1.d Transport Refrigeration - Emissions from disposal - HFC-143a.

Year	Emissions as reported in the 2020 inventory report	Emissions as reported in the 2021 inventory report	Percentage change in reported emissions
	Gg CO_2 eq	Gg CO_2 eq	
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	NO	not applicable
2019	not applicable	NO	not applicable

Table 4-27 CRF 2.F.1.d Transport Refrigeration - Stock - HFC-134a.

Year	Emissions as reported in the 2020 inventory report	Emissions as reported in the 2021 inventory report	Percentage change in reported emissions
	Gg CO_2 eq	Gg CO_2 eq	
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	25.15	25.15	not applicable
2001	35.00	35.62	1.77%
2002	45.32	46.56	2.73%
2003	56.17	58.03	3.31%
2004	97.75	98.85	1.13%
2005	111.42	112.10	0.62%
2006	129.92	129.92	not applicable
2007	149.78	149.78	not applicable

2008	169.71	169.71	not applicable
2009	190.84	190.84	not applicable
2010	212.71	212.71	not applicable
2011	238.33	238.33	not applicable
2012	257.24	257.24	not applicable
2013	278.63	278.63	not applicable
2014	302.97	302.97	not applicable
2015	323.81	323.81	not applicable
2016	341.44	341.44	not applicable
2017	358.88	358.88	not applicable
2018	373.98	373.98	not applicable
2019	not applicable	389.08	not applicable

Table 4-28 CRF 2.F.1.d Transport Refrigeration - Stock remaining in products at decommissioning - HFC-134a.

Year	Emissions as reported in the 2020 inventory report	Emissions as reported in the 2021 inventory report	Percentage change in reported emissions
	Gg CO_2 eq	Gg CO_2 eq	
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	0.68	not applicable
2017	NO	1.64	not applicable
2018	NO	2.29	not applicable
2019	not applicable	2.86	not applicable

Table 4-29 CRF 2.F.1.d Transport Refrigeration - Emissions from disposal - HFC-134a.

Year	Emissions as reported in the 2020 inventory report	Emissions as reported in the 2021 inventory report	Percentage change in reported emissions
	Gg CO_2 eq	Gg CO_2 eq	
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	0.68	42.86%
2017	47.54	1.64	-96.54%
2018	91.81	2.29	-97.51%
2019	not applicable	2.86	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.

4.7.1.4.2 Methodological Issues

As the refrigerant R134a is the main refrigerant used in mobile air conditioning of road vehicles and vehicle registration data for passenger cars, minibuses, buses and trucks were available, it was decided that emission estimates will follow an emission-factor approach. For emission estimates from mobile air conditioning in ships, the approach chosen relies on data of bulk imports. In the CRF tables, emissions from the mobile air conditioning sub-category (CRF sub-category 2.F.1.e) are included under the transport refrigeration (CRF sub-category 2.F.1.d).

4.7.1.4.2.1 Road vehicles

The method used for emission estimates is based on vehicle registration data for passenger cars, minibuses, buses, coaches and trucks.

Relative to the country's size, 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[20] estimated that the currently used refrigerant R134a, introduced in new cars in 2000[21], 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.

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.

The percentage of air-conditioned vehicles of 54% in 2012 is the same as in a model by Emisia[22] on the vehicle fleet used also for other categories of the Maltese greenhouse gas inventory. The current AC quota of new cars is assumed to be about 90%. There is no data on the number of new cars available therefore it is calculated as the stock divided by the average lifetime plus the increase in stock compared to the year before. It is calculated that the AC quota of new cars in the year 2000 was about 50%, which is rather low compared to other European markets (e.g. Germany: 90% in 2000).

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.

[20] References: Companies "V.Spiteri", "Tecnoplus".

[21] 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 R-12 might have been imported well beyond 2000.

[22] EMISIA SA. Antoni Tritsi 21, GR 57 001, Thessaloniki, Greece.

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 buses and coaches, the average charge is 12 kg and for mobile air conditioning in trucks, a charge of 0.9 kg is assumed.

4.7.1.4.2.2 Ships

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.

During the stakeholder consultation, it was found that 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 of 2F1 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 ship's own refrigerant supply 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 R134a 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 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.

4.7.1.4.3 Source Specific Recalculations

As described earlier, in 4.7.1.3.3, an observation (MT-2F1-2020-0004) related to sub-categories "Transport Refrigeration" (CRF 2.F.1.d) and "Mobile Air Conditioning" (CRF 2.F.1.e) was raised by the *Effort Sharing Decision Review Team* during *step 2* of the review of the 2020 GHG inventory of Malta. As part of the analysis that followed, the changes and the subsequent recalculations explained in 4.7.1.3.3 were made. In the CRF tables, emissions from the mobile air conditioning sub-category (CRF sub-category 2.F.1.e) are included under the transport refrigeration (CRF sub-category 2.F.1.d).

4.7.1.5 Uncertainty and time series consistency

It is implied that due to the nature of this sector, it is expected that efforts are made to reduce uncertainty of estimation to a minimum. The current methodology provides better certainty than the previously used Tier 1 methodology since it disaggregates uses of the diverse gases and provides for sub-sector specific emission factors. The relative completeness of the data collected (for bulk imports) and the characterisation of the market through studies further reduces the uncertainty in this sector.

A key source of uncertainty is still the distribution of the different gases across the sectors, since it is mostly based on a one-time study and not an annual recurrent exercise.

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.

At the time of the compilation of the 2020 NIR, not all the information requested on the amount of F-gas imported in the year 2018 had been received. In such cases, it was assumed that the same amount of the same F-gas imported in the year 2017 was imported during the year 2018 by the respective data provider. However, the missing data for the year 2018 will be duly updated.

The activity data for this category suggests a reduction in the annual imported mass of bulk HFCs when compared to previous years. Feedback from the market has suggested the implementation of the F-gas Regulation (Regulation (EU) No 517/2014[23]) as the reason for this decrease. However, this comment is being investigated.

Some of the data for the year 2019 is assumed to be equal to that reported for the year 2018. This data will be duly updated.

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 more detailed explanations of the model being used, describing the assumptions and the expert judgements made.

The reporting of R-1234yf from CRF data entry table [2.F.1.a Commercial Refrigeration] [Unspecified mix of HFCs] should be removed.

Emissions from mobile air conditioning and transport refrigeration will be reported separately. This improvement is being coupled with another two initiatives, namely the receipt of the latest vehicle fleet data from the authority for transport in Malta, whilst harmonising this with the transport sector inventory compiler.

The recommendations made by the Expert Review Team in *Finding* ID# I.17 in the “Report on the individual review of the annual submission of Malta submitted in 2019” (FCCC/ARR/2019/MLT) on the average charge factor is being investigated.

In general, the Inventory Agency is in the initial stages of a discussion aimed to improve the data available from the local F-gas market. The counterpart to the Inventory Agency in this potential collaboration is 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").

[23] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0517&from=EN

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 being 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-celled 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.

See ESD review of 2020

Open-cell foam: production

Open-cell foam: importation

Closed-cell foam: production … was occurring, now stopped – years: xxxx to 2014

Closed-cell foam: importation … CN codes 39211100 and 39211310 … years

The earliest import of HFCs in Malta dates back to 2000. Moreover, there is no national production. 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 components for local blowing of closed cell foam has been interrupted in 2014 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 February 2021 received from the local competent authority for the purposes of Regulation (EU) No 517/2014, none of the F-gas imports to the Maltese market in the year 2020 were intended to be used for foam blowing.

4.7.2.2 Methodological issues

Estimating emissions for the two different types of foam requires a different methodological approach. 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.

Explain methodology for open-cell foam

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 Gamlen-based model is used for estimating emissions from both blown and imported foam. The method is based on the mass of foam blown in a year and assumes that the blowing agent accounts for 1% of the mass of the foam. The model also assumes that the lifetime of the product is 15 years, that a constant 4.5% emission of blowing agent occurs in each year of the lifetime of the product and that the remaining 32.5% of blowing agent is emitted in the year of destruction.

Imported closed-cell foams under CN codes 39211100 and 39211310 are also accounted for. The method of calculation is identical to the one used for locally blown closed-cell 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.

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.

4.7.2.4 Category-specific QA/QC and verification

This section is not applicable.

4.7.2.5 Source Specific Recalculations

No recalculations were required.

4.7.2.6 Category Specific planned improvements

An analysis to improve the robustness and consistency of the collection and reporting of activity data for category 2.F.2 is being conducted. As part of this analysis, it is the intention of the Inventory Agency to address the use of the notation key 'NE', in the respective CRF tables.

In general, the Inventory Agency is in the initial stages of a discussion aimed to improve the data available from the local F-gas market. The counterpart to the Inventory Agency in this potential collaboration is 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").

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 providers and discussed with the latter. The imported mass of HFC-227ea reported for the year 2019 is high when compared to the trend. This increase was explained by the data provider by clarifying that the reported amount had not been completely consumed within the year of importation, but stored and used from time to time for refills. Moreover, it should be pointed out that not all the information requested on the import of F-gas in fire protection systems has been received.

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.

In general, the Inventory Agency is in the initial stages of a discussion aimed to improve the data available from the local F-gas market. The counterpart to the Inventory Agency in this potential collaboration is 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").

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) **Invalid source specified.**[24] 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.

The data received for the year 2018 showed a reduction in the annual quantity of imported metered dose inhalers containing Norfluorane when compared to previous years. The QA/QC process that followed strengthened the need to ensure a better coverage of the local market. A further reduction in the annual quantity imported is shown by the data for the year 2019.

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.

In general, the Inventory Agency is in the initial stages of a discussion aimed to improve the data available from the local F-gas market. The counterpart to the Inventory Agency in this potential collaboration is 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").

[24] 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.

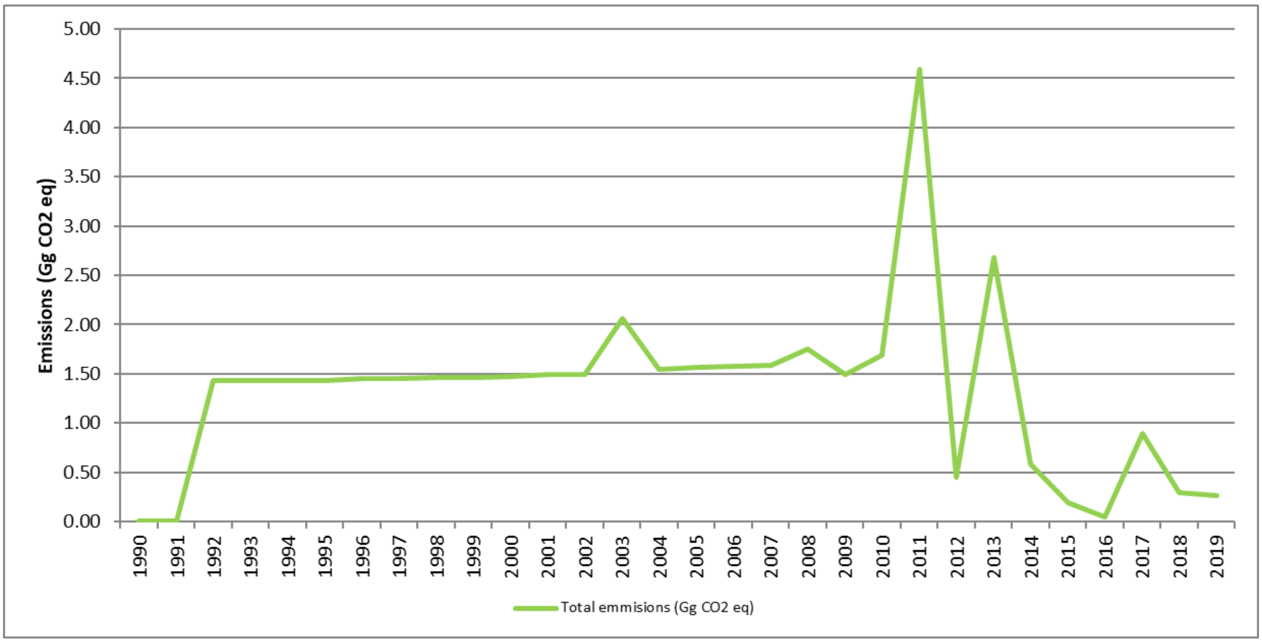

Figure 4-5 Emissions from sub-category 2.G.1 Electrical Equipment.

Figure 4-5 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 timeseries.

During the year 2018, the SF_6 consumed under this category was used for topping up to maintain the correct operational pressures. The quantity reported for the year 2018 is low compared to that reported for previous years. Top ups of SF_6 occurred in substations and distribution centres. SF_6 has also been used to replace the amount of gas lost from a switchgear which was dismantled from one site and transferred and reinstalled at another electricity generation plant. Finally, SF_6 has been used because of a loss attributed to very slight leakages which develop in time in the switchgear mainly where there are rubber seals. The operator of the switchgear has stated that a general maintenance program where all the seals are replaced will be carried out according to the maintenance schedule as recommended by the manufacturer. This final reported use of SF_6 has again occurred in 2019, together with top ups in substations and distribution centres. The quantity of SF_6 reported for the year 2019 is also similar in magnitude, but slightly lower, to that reported for 2018.

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 information requested for the year 2019 has been received. In such cases, it is assumed that the information for the year 2019 is equal to that received for the year 2018 by the respective data provider. However, the missing data for the year 2018 will be duly updated once this is received.

4.8.1.5 Source Specific Recalculations

No recalculations were required.

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

No improvements are planned for this specific category.

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).

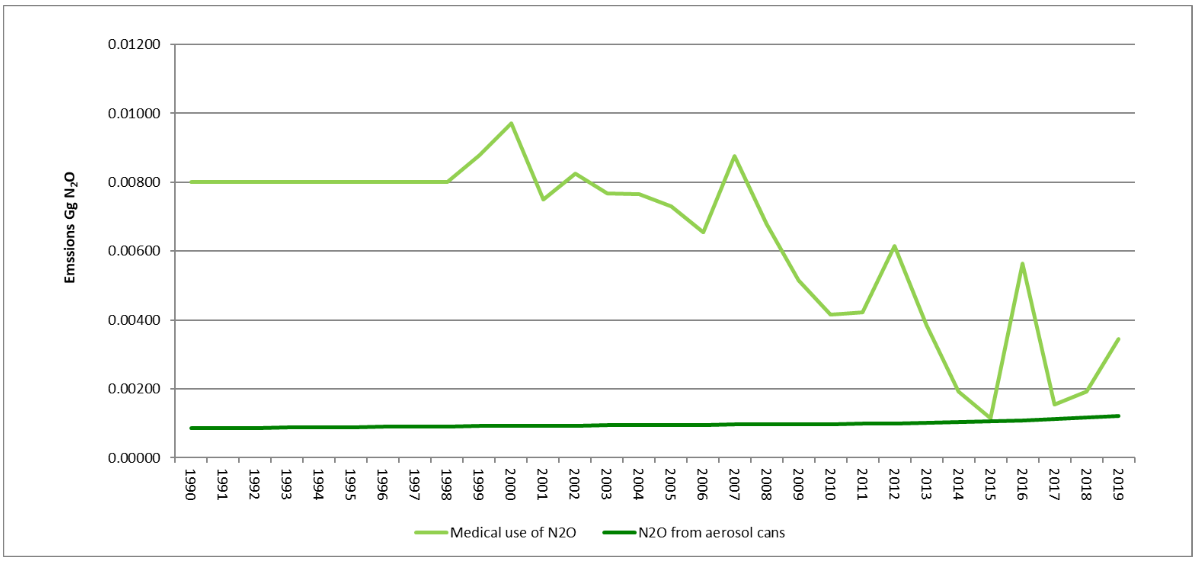

Figure 4-6 Nitrous Oxide emissions from anaesthetic use and aerosol cans.

Figure 4-6 shows the variations in N_2O emissions that result from the consumption of medical grade N_2O during medical applications in Malta and the emissions of N_2O from aerosol cans. 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. A downward trend in the consumption of N_2O for this scope is observed from 2008 onwards. This is linked to a decrease in the use of Antenox in dental and other surgical applications.

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.

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

5.1 OVERVIEW OF SECTOR

5.1.1 Agriculture Sector Description

Accounting for about 2.8% of GDP, Malta's agricultural sector is small yet diverse. It is encompassed of land farming and livestock breeders. The local farmers engage into two main farming practices; namely arable (dry) farming practices and irrigated farmland practices. Arable farming methodologies heavily depend on rain to grow crops; mostly fodder, onions, garlic, broad beans, potatoes, and some permanent trees mainly olive trees, fruit trees and vines. Irrigated farmland utilises mostly irrigation and sprinklers and it is utilised to grow an array of fruits and vegetables. This farming practice can be further subdivided into; farmland in greenhouses, and open fields, where a wide range of vegetables are cultivated. The amount of irrigated farmland proliferated over the last three decades as a result of widespread groundwater tapping.

In 2018, the National Statistics Office citied a total of 13,199ha holdings, of which 98% were ran by sole holders. Predominantly agricultural holdings are relatively small; 65.8% of the total agricultural holdings had a standard output of less than €2,000 and only 5.7% had an output greater than €15,000. During 2015, more than 40,000 tonnes of vegetables and fruit were produced, with a wholesale value close to €23 million. In 2018, the total UAA amounted to 11,929ha, of which 10,618 ha were arable land, 1,311 ha were permanent crop area and 1,217 ha were kitchen gardens. 690 ha of the arable land were being used for growing potatoes, 5,647 ha were used for forage plants and 1,851 ha for growing vegetables.

Most of the crops and foods produced are for domestic consumption. The main crops are potatoes, cauliflower, grapes, wheat, barley, tomatoes, citrus, and green peppers. Generally, farmers engage in mixed farming practices and do not specialise in cash crops, the exception being spring potatoes which is cultivated for export. The spring potatoes are grown exclusively for export to Germany, United Kingdom, Switzerland, and the Netherlands. On the other hand, the less popular winter potato crop is grown solely for the local market.

Contrary to most European counterparts, most local livestock breeders breed their livestock indoors whilst supplementing them with imported feed concentrate and fodder, alongside local fodder. In 2015, 52.7% of farms were registered as sheep farms, followed by goat, cattle and pig. In 2019, livestock in Malta amounted to 976,909 heads, of which 3.63% were pigs, 1.43% cattle, 84.21% poultry, 8.67% rabbits, 1.35% sheep, 0.57% goats and 0.14% horses. In Malta, swine (35,477 heads), poultry (822,674 heads) and rabbit (84,689 heads) are reared mainly for their meat, whereas cattle (13,995 heads), sheep (13,161 heads) and goats (5, 593 heads) are grown for their milk with beef production being considered a by-product of the dairy industry. In 2019, the total cattle and sheep milk produced amounted to 41,505 tonnes and 1,910 tonnes, respectively. Livestock populations decreased significantly compared to 1990 levels, except for rabbits and horses. These changes could be attributed to the rise in the import of meat and dairy products and the increase in demand for rabbit and horse meat in the catering industry. For instance, in the cattle farming industry even though the Holstein Friesian cow is sometimes utilised for both milk and beef production, it cannot compare neither with the growth efficiency nor with the quality of meat of the foreign beef cattle breeds, such as the infamous Angus, Hereford, Simmental and the Charolais breeds (National Agricultural Policy for the Maltese Islands 2018-2028). As a result of these changes in the number of heads, CH_4 emissions from Enteric Fermentation and Manure Management have also dropped. The total agricultural area, UAA and fodder crop land, have also decreased; consequently, so have the nitrogen application rates and the nitrous oxide emissions.

This Chapter describes the estimation methods, equations, activity data, emission factors and parameters 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); and

Emissions from source categories *Rice cultivation* (3C), *Burning of Savannas* (3E), *Field burning of agricultural residues* (3F) and *Liming* (3G) are not included in this report, given that such practices do not occur in Malta. 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.

Table 5-1 Exhaustive disaggregated table of agricultural emissions by gas.

GHG Source Category Emissions										
		1990	1995	2000	2005	2010	2015	2018	2019	% Difference 1990-2019
3. Agriculture Total		101.02	101.45	100.66	91.45	81.52	78.20	76.60	76.33	-24%
3A. Enteric Fermentation		47.30	46.01	47.79	41.92	36.62	35.02	33.95	34.02	-28%
Cattle	CH_4	38.29	36.65	40.61	34.05	29.34	29.13	27.91	27.87	-27%
Sheep	CH_4	3.59	3.51	2.73	3.36	2.81	2.58	2.95	3.08	-14%
Swine	CH_4	3.80	3.86	3.00	2.74	2.65	1.64	1.29	1.31	-66%
Goats	CH_4	0.78	1.15	0.63	0.78	0.64	0.62	0.66	0.67	-13%
Poultry	CH_4	0.36	0.36	0.34	0.26	0.24	0.21	0.20	0.20	-45%
Rabbits	CH_4	0.05	0.08	0.11	0.13	0.16	0.18	0.18	0.17	223%
Horses	CH_4	0.43	0.41	0.39	0.59	0.79	0.66	0.59	0.59	38%
3B. Manure Management		32.00	32.02	29.90	28.98	25.56	23.79	23.77	23.48	-27%
Cattle	CH_4	4.33	4.24	4.82	3.45	3.08	3.00	2.90	2.90	-33%
	N_2O	10.22	9.04	9.81	9.26	7.05	7.13	6.67	6.66	-35%
Swine	CH_4	1.27	1.29	1.00	0.92	0.89	0.55	0.43	0.44	-66%
	N_2O	2.95	2.99	2.30	2.03	2.04	1.32	1.02	1.03	-65%
Poultry	CH_4	1.54	1.51	1.44	1.15	1.03	0.90	0.86	0.87	-43%
	N_2O	2.84	2.79	2.65	2.07	1.90	1.66	1.56	1.58	-44%
Rabbit	CH_4	0.16	0.24	0.32	0.40	0.48	0.56	0.54	0.53	223%
	N_2O	0.59	0.87	1.16	1.44	1.73	2.02	1.93	1.89	223%
Sheep	CH_4	4.26	4.26	3.20	3.95	3.01	2.72	3.19	3.33	-22%
	N_2O	0.57	0.58	0.45	0.56	0.46	0.42	0.49	0.52	-10%
Goat	CH_4	1.81	2.69	1.46	1.83	1.49	1.44	1.54	1.58	-13%
	N_2O	0.24	0.35	0.19	0.24	0.20	0.19	0.20	0.21	-13%
Horse	CH_4	0.94	0.90	0.85	1.31	1.73	1.45	1.30	1.30	38%
	N_2O	0.26	0.25	0.24	0.36	0.48	0.40	0.36	0.36	38%
3D. Agricultural Soils		21.76	23.47	23.05	20.63	19.38	19.42	18.89	18.84	-13%
3.D.1 Direct Emissions	N_2O	16.01	17.29	16.97	15.15	14.30	14.35	13.97	13.95	-11%
3.D.2.1 Indirect emissions due to atmospheric deposition	N_2O	2.15	2.28	2.26	2.06	1.87	1.84	1.78	1.75	-19%
3.D.2.2 Indirect emissions due to leaching/run-off	N_2O	3.60	3.89	3.82	3.41	3.22	3.22	3.14	3.14	-11%

5.1.2 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.

Commencing in 2019, the Ministry for Sustainable Development, Environment, and Climate Change (MSDEC) 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 judgments 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).

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. Tier 1 methodologies, with default emission factors (T1/D), are used for most enteric fermentation calculations except for emissions from rabbits (T1/CS), cattle (T2/CS) and sheep (T2/CS). Methane emissions from cattle, swine, poultry, and rabbits have been estimated using Tier 2 methodologies with some country specific inputs, except for sheep, goats and horses (T1/D). The methodologies and emission factors are summarized in Table 5-2.

Table 5-2 A summary of tier methodologies and emission factors used for Agriculture.

Source Category	CO_2		CH_4		N_2O	
	Method	EF	Method	EF	Method	EF
3.A. Enteric Fermentation	N.A	N.A			N.A	N.A
Cattle	N.A	N.A	T2	CS	N.A	N.A
Sheep	N.A	N.A	T2	CS	N.A	N.A
Goats, Swine, Poultry, Horses	N.A	N.A	T1	D	N.A	N.A
Rabbits	N.A	N.A	T1	CS	N.A	N.A
3.B Manure Management	N.A	N.A			N.A	N.A
Dairy Cattle	N.A	N.A	T2	CS	T2	CS
Other Cattle & Swine	N.A	N.A	T2	CS	T1	D
Sheep, Goats & Horses	N.A	N.A	T1	D	T1	D
Poultry	N.A	N.A	T2	D/CS	T2	CS
Rabbits	N.A	N.A	T2	D/CS	T1	D
3.C. Rice Cultivation	N.A	N.A	N.O.			
3.D. Agricultural Soils	N.A	N.A	N.O.		T1	D
3.E. Prescribed burning of savannahs	N.A	N.A	N.O.		N.O.	
3.F. Field burning of agricultural residues	N.A	N.A	N.O.		N.O.	
3.G. Liming	N.O.					
3.H. Urea application	N.E.					
3.I. Other carbon-containing fertilizer	N.O.					
3.J. Other	N.O.		N.O.		N.O.	

T1, T2: IPCC Guidelines Tier 1 and 2 respectively; D: IPCC default methodology and emission Factor; CS: Country specific.

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.

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).

Other activity data used in the estimation of emissions from livestock and agricultural soils are reported in Table 5-3.

Table 5-3 Sources of Activity Data used in the compilation of the agriculture inventory.

Parameter	Source
Livestock Population (number of heads)	National Statistics Office, FAOSTAT
Females in gestation (%)	K. Tonna (KPH, Expert Communication), 2018.
Weight (kg) (cattle, sheep, swine, horses & goats)	K. Tonna (KPH, Expert Communication), 2018 M. Chiaramonte & R. Montebello, 2018. (Cattle)
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)	K. Tonna (KPH, Expert Communication)
Nitrogen Fertilizer: Rate of N application (Kg N/ha)	NSO, Tapas Action, 2007
Total Agricultural Land, Utilized Agricultural Land, Land Area (under fodder, wheat, barley, bean, other fodder, potato, carrot, clover & vetch) (ha)	NSO & FAOSTAT

FAOSTAT data is used for years where the required data is not readily available through NSO. The remaining data gaps in historical data (1990 – 2000) of both the main livestock category and their respective subcategories, are calculated using a 3-year moving average based on ratios of available years, as suggested through expert advice, whereas data gaps post-2000, are estimated using interpolation and extrapolation techniques.

The GHG emissions for Agricultural soils are estimated utilising the following three categories of Agricultural Land: *Total Agricultural Land*, *Utilised Agricultural Land* (UAA), and *Fodder Crop Land*. Primarily, the data utilised for the purpose of the inventory is attained through the publications issued on a regular basis by the NSO. The data currently available through NSO and FAOSTAT covers parameters such as Total Agricultural Land, Fodder Crop Land, Land Area under Potato, and Total Land Area for Vegetables. Nevertheless, there are instances where such data is not available for the entire time-series. Presently, only six years of data since 2001 are available through NSO for the Total Agricultural Land and Fodder Crop Land, and at two- or three-year intervals through the *"Farm Structure Survey"* undertaken by NSO.

The quantification of land area categories is estimated for the years where data is not readily available, by using the quantified data for those years for which NSO and FAOSTAT data is available, which maintains and ensures completeness and time-series consistency. This is attained by making use of Arable Land Area to estimate Total Agricultural Land and Fodder Crop Land given that Fodder Crop Land is a fraction of Arable land area and a percentage of UAA itself. Crop areas are taken primarily from NSO and FAOSTAT, and any remaining gaps in the data are averaged.

At present no data is readily available describing the rate of Nitrogen fertiliser application to Maltese fields. Subsequently, a new methodology has been drawn up to estimate the fertilizer application rates, which is based on consumption and application data, but dependant on the yearly variation in the UAA. 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 is planned to take place in 2021, and although no exact completion date can be provided at this point, it is assumed that it will be completed by end of 2021. Moreover, there 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

It should also be noted that, although livestock population data is available on a yearly basis, there might still be revisions in the values for the previous years reported, given that the data provider revises the values to the best of their ability and as per their QA/QC procedures. It is pertinent to note that the rabbit population is calculated based on the number of does registered and is not an actual value. Efforts are made on a yearly basis to obtain the actual population of rabbits, however this value is very difficult to obtain given that in Malta, many rabbits are bred as a backyard practice, which might therefore not be registered in censuses or in the abattoir register. Lastly, Total Cow and Sheep Milk values are provided by NSO, however they are validated against values provided by the Malta Dairy Products (MDP).

Table 5-4 below gives the population of all livestock categories for selected years, Table 5-5 gives a basic characterisation of cow and sheep milk and Table 5-6 gives a description of the feed intake for cattle and sheep.

Table 5-4 Livestock population for select years.

	Population							
	1990	1995	2000	2005	2010	2015	2018	2019
Cattle	21000	18500	19380	19742	14954	15020	14125	13995
Sheep	16000	16000	12000	14819	11305	10224	13169	13161
Goats	6200	9183	5000	6273	5110	4937	5726	5593
Swine	101200	103000	80074	73025	70583	43634	36294	35477
Poultry	1451145	1421972	1349013	1052013	970291	847566	835059	822674
Rabbits	26609	39629	52650	65670	78691	91711	90446	84689
Horses	953	908	862	1322	1754	1471	1319	1320

Table 5-5 Cow and sheep milk production, yield and fat content.

2019	Milk Production		
	Total Milk (Tonnes)	Milk yield (kg/Head/Day)	Milk Fat Content (%)
	NSO	2006 IPCC, pp. 10.13	MDP
Cow	41505.03	18.53	3.28
Sheep	1910.54	0.45	/

While no published sources exist documenting the Feed intake and proportions of livestock, data on Feed intake has been provided by K. Tonna (2018) who is an expert in the field within the Kooperattiva Produtturi tal-Halib (KPH). Since Feeds given to the livestock rarely change, this data Is revisited and asked for on a 5-year basis. Therefore, this data will be revisited in 2023.

Table 5-6 Cow and sheep Feed intake

Parameter	Source	DC	NLC	B	C	GC	ME	OMS	GL
		T2/CS	T2/D/CS	T2/D/CS	T2/D/CS	T2/D/CS	T2/D/CS	T2/D/CS	T2/D/CS
Feed	K. Tonna, 2018	15 (1990-99), 20 (2000-2004), 24 (2005-2014), 21.5 (2015-2019)	15 (1990-99), 20 (2000-2004), 24 (2005-2014), 15 (2015-2019)	13	1 to 3L milk replacer (forage offered post weaning)	13	3.8	2.5	1.5
Feed (fodder portion)	K. Tonna, 2018	12 (1990-99), 14 (2000-2004), 13 (2005-2014), 10 (2015-2019)	12 (1990-99), 14 (2000-2004), 13 (2005-2014), 12 (2015-2019)	7	0.1	7	2.75	1	0.8
Fodder (Concentrate)	K. Tonna, 2018	3 (1990-99), 6 (2000-2004), 11 (2005-2014), 11 (2015-2019)	3 (1990-99), 6 (2000-2004), 11 (2005-2014), 13 (2015-2019)	6	0.8	6	1.05	1.5	0.7

5.1.3 Sector specific QA/QC & Verification

The **Table 5-7Error! Reference source not found.** below is a list of all the checks performed in the Agriculture Sector.

Table 5-7 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	Yes

	level	
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.

5.1.4 Sector-Specific Recalculations & Planned Improvements

A number of revisions in data and methodologies were performed following ESD and UNFCCC (Table 5-8) Reviews, internal audits and other QA/QC checks, as well as revisions following the 2019 IPCC Refinements. The revisions in data and methodologies, listed in Table 5-9 gave rise to a number of recalculations throughout the agriculture sector, summarized for select years in Table 5-10. The conversion to IPCC 2019 Refinements was carried out since it was noted that in most cases, the emission factors developed are better suited for Malta's agriculture scenario. Moreover, they provide more options at a disaggregated level making the new EFs more specific. Not all the categories and not all agricultural subsectors were converted to IPCC 2019 refinements; this is because more research has to be conducted by the inventory compiler to assess the applicability of the remaining factors and methods. It is expected that more revisions will be made in the 2022 submission to the EC. The results of the difference between the old calculation methods using 2006 IPCC guidelines and the new 2019 IPCC Refinements are presented in Error! Reference source not found. to Table 5-15. Finally, considering the preliminary questions received by Malta from the EC during February 2021, other minor revisions to the methods/emission factors will take place in the 2022 submission, such as factors used in the DE% calculation for growing cattle and calves.

Table 5-8 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#	Previous recommendation for the issue identified	Number of successive reviews issue not addressed	Status
A1	ForCH4in category 3AEnteric Fermentation and 3B Manure Management, for 2005, 2016, 2017 and 2018 the TERT noted that there were unusual digestibility rates in the calculation of feed intake and Volatile Substance (VS) in manure. In response to a question raised during the review, Malta explained that an error has occurred in the calculation spreadsheet. Malta revised estimates for all years and stated that they will be included in the next submission. The TERT agreed with the revised estimate provided by Malta. The TERT recommends that Malta include the revised estimate in its next submission.	n.a.	The calculations for VS and Digestibility rates (for sheep and cattle) have been revised. Recalculations and the correct methodology are provided in this January submission.
A.2	Provide information on the uncertainty of the agriculture sector.	5	Addressed. Uncertainty is now being provided for every subsector, for all source categories of CH4 and N2O.
A.3	Review the population data for all livestock categories, ensure time-series consistency and report on any recalculations.	5	Addressing. The population data for all livestock categories was reviewed for the current submission. Recalculations were addressed for each sub category. Ongoing efforts are being made to safegurad time-series consistencies throughout all the sub-categories.

A.4	Undertake a detailed review of the AD (animal populations) for the agriculture sector in order to identify the most appropriate data source, including for the base year, and use appropriate techniques as detailed in the 2006 IPCC Guidelines for the development of a consistent time series of AD.	3	Addressing. Animal populations for the agricultural sector are continuously being reviewed to identify the most suitable data source. Appropriate techniques from the 2006 IPCC guidelines are being utilised to aid the development of a consistent timeseries for AD.
A.5	Justify the applicability of the Italian CH_4 EF for rabbits to the national circumstances in Malta.	5	Addressed. Justification of applicability of the emission factor has been discussed in section 5.2.2 of the NIR.
A.13	Compare the country-specific N excretion values for all animal types with the IPCC defaults and explain the differences.	4	Addressed. Country-specific N excretion values were compared to IPCC defaults. Resultantly, a number of revisions were made in which some of the previously country-specific EFs have either been revised to take on a more conservative approach and be more comparable to IPCC defaults, or were altogether revised to an IPCC default.
A.15	Explain in the NIR the tier 2 methodology, assumptions and parameters (including VS and maximum methane-producing potential) used in the estimates of CH_4 emissions from manure management and demonstrate that these estimates are consistent with the estimates for enteric fermentation.	3	Addressed. The tier 2 methodology, assumptions, and parameters utilised in the estimates of CH4 emissions from manure management are explained in Section 5.3. Values used are provided in tables throughout the chapter and are consistent with estimates for Enteric Fermentation.
A.16	Explain in the NIR how N_2O emissions from manure management for dairy cattle, including the N excretion values used, and N_2O emissions from animal manure applied to soils are estimated, and how these estimates are consistent with the tier 2 approach used to estimate CH_4 emissions from enteric fermentation for dairy cattle.	3	Addressing. The methodology for N2O emissions from manure management is explained in section 5.3. N excretion values used are also provided and rationales for their use is provided. The methodology for N2O emissions from animal manure applied to soils can be found under section 5.5 and values provided show consistency with approach used to estimate emissions from enteric fermentation and manure management.
A.17	Provide a rationale in the NIR of future submissions for the use of the default value for N loss due to volatilization of NH_3 and NO_X from manure management for poultry in the estimation of indirect N2O emissions from manure management for rabbits.	3	Addressed. The rationale for the use of the default value for N loss due to the volatilization of NH3 and NOx from manure management for poultry in the estimation of indirect N2O emissions from manure management for rabbits has been provided in the NIR.
A.18	Review the consistency of the time series and explain the trend in the use of synthetic fertilizers in the NIR.	5	Addressing. An assessment of the consistency of the time series has been conducted and the consistency of the time series has been revised for the current and previous submission. The revised methodology permits the estimation of an average application rate per hectare, which when combined with estimates of the utilisable agricultural area allows for a consistent timeseries to be established creating a clear assessment of the trends in fertilizer use.
A.19	Investigate the quality of the statistical data reported on the N content of the imported fertilizers and describe the corrections made to the statistical data in the NIR.	4	Addressed. The quality of the statistical data reported on the N content of the imported fertilizers has been assessed as described in Section 5.5.2.1.1 of the NIR. The Methodological approach has also been revised as per the explanation illustrated in Section 5.5.2.
A.20	Undertake a representative survey of AWMS[b] 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.	3	Addressing. The Ministry for Sustainable Development, Environment and Climate Change has recently commissioned a study aimed at improving the activity data, and

			data collection methodologies adopted for the agricultural sector.
A.21	Explain in the NIR that the net energy to produce wool is excluded from the calculation and how the coefficient for pregnancy was derived.	1	Addressing. The coefficient for pregnancy has been derived as discussed in Section 5.2.2 of the NIR. Any data gaps resulting from the lack of readily available statistical data will be addressed as part of the commissioned study mentioned in A.11. The Net Energy associated with wool production will be included in future NIRs once the necessary data is made available.
A.22	The ERT recommends that Malta update the factors and apply Western European default values to better reflect the circumstances of Malta.	1	Addressed. Parameters, equations and default emission factors used in the calculation of methane emissions from manure management of cattle is discussed in Section 5.3.2.1.1 of NIR and illustrated in the corresponding table.
A.23	Provide in the NIR the justification for the use of the updated Nex values.	1	Addressed. The justification for the utilisation of N excretion values has been provided in section 5.3.2.2 of the NIR.
A.24	The ERT recommends that Malta provide further clarification in the NIR on how the two manure management systems were applied to the different proportions of manure and how the reported value was derived.	1	Addressed. Clarification of how the two manure management systems were applied to the different proportions of the manure was provided in Section 5.3.2.1.2 of the NIR. The method of derivation was also provided.
A.25	The ERT recommends that Malta include the revised AD for crop residues in its annual submission and ensure the time-series consistency of its estimates.	1	Addressed. Activity data was presented and discussed in section 5.5.2.1.1 of the NIR.
A.26	Malta states that the Net Energy associated with wool production is excluded from the estimation of gross energy for sheep and no further rationale is provided in the NIR. Net energy for wool production is required for the estimation of gross energy as stated in equation 10.16 Volume 4, Chapter 10 of the IPCC guidelines. In response to a question raised during the review Malta states that wool is no longer used by local weavers and is nowadays largely discarded and is thus not included in the calculation.	2	Addressed. Net energy for wool is now being calculated using IPCC 2019 Refinements and can be found in this submission under Enteric Fermentation.
A.27	The ERT notes that Malta is one of a small number of parties that report emissions of CH4 from enteric fermentation from poultry. The ERT was unable to find the reference to the emission factor in either the 1996 IPCC guidelines, the 2000 Good Practice guidelines or the 2006 IPCC guidelines and that in each version of the IPCC guidelines that emissions of CH4 from poultry are stated as not estimated.	n.a.	Addressing. Reconsidering whether to continue estimating methane emissions from poultry under Category Enteric Fermentation in future submissions and if so, what emission factor should be used.
A.28	Malta reports the application of animal manures to soil as the only organic N fertilizer application to soils and additionally reports that applications of untreated sewage sludge to soils do not occur in Malta in accordance with the Nitrates Action Plan 91/676/EEC. the ERT is of the view that this does not preclude the application of treated sewage sludge or wastewaters to agricultural land.	n.a.	Addressing. No other sources of organic nitrogen are applied to land in Malta. As part of wider agriculture sector emission estimate improvements, the points raised will be investigated with the national experts.

Table 5-9 Summary of revisions in methodology, corrections and improvements.

Correction or Improvement	Recalculation Category	Years Affected
1. Revisions in methodologies due to IPCC 2019 Refinements	3A., 3B., 3D.	1990 - 2018
2. Revision in the FD Digestibility of Cattle and Sheep, following EC Reviews 2020	3A., 3B., 3D.	1990 - 2018
3. Revision of Sheep calculations (Addition of Ewool)	3A., 3B., 3D.	1990 - 2018
4. Revision of Cow milk quantity (2018) from 40455.79 tonnes to 40412.67 tonnes.	3A., 3B., 3D.	1990 - 2018
5. Revisions of laying hen population (2018) from 320865 to 360726	3A., 3B., 3D.	1990 - 2018
6. Revision of N Mineralized values from LULUCF	3D	1990 - 2018

Table 5-10 A summary of recalculations in the Agriculture sector.

Summary of Recalculations									
			1990	1995	2000	2005	2010	2015	2018
Current Submission		Gg CO_2 eq.	101.06	101.50	100.74	91.53	81.57	67.57	76.61
Previous Submission		Gg CO_2 eq.	76.52	74.93	76.05	75.07	67.94	65.84	64.86
Percentage Change		%	32.06%	35.47%	32.46%	21.91%	20.06%	2.63%	18.11%
Enteric Fermentation	(CS)	Gg CO_2 eq.	47.30	46.01	47.79	41.92	36.62	35.02	33.95
	(PS)		36.03	34.88	36.68	37.57	32.75	32.88	31.66
		%	31.27%	31.92%	30.29%	11.58%	11.82%	6.52%	7.23%
Manure Management	(CS)	Gg CO_2 eq.	32.00	32.02	29.90	28.98	25.56	23.79	23.77
	(PS)		18.59	18.55	18.16	17.72	15.99	15.36	14.87
		%	72.14%	72.62%	64.65%	63.53%	59.88%	54.86%	59.82%
Agricultural Soils	(CS)	Gg CO_2 eq.	21.76	23.47	23.05	20.63	19.38	19.42	18.89
	(PS)		21.83	23.73	22.83	20.60	19.30	19.33	18.93
		%	-0.33%	-1.11%	0.95%	0.13%	0.43%	0.45%	-0.20%

Table 5-11 The difference between enteric fermentation emissions using 2006 IPCC Guidelines and the 2019 IPCC Refinements.

Enteric Fermentation		1990	1995	2000	2005	2010	2015	2018	2019
Dairy Cows	Gg CO2 eq.	8.72	8.74	8.80	3.04	2.82	0.86	0.84	0.84
Non-Lactating Cows	Gg CO2 eq.	1.22	1.16	1.33	0.05	0.06	0.35	0.36	0.34
Bulls	Gg CO2 eq.	0.03	0.02	0.02	0.06	0.03	0.02	0.01	0.01
Calves	Gg CO2 eq.	0.08	0.03	0.03	0.04	0.03	0.03	0.03	0.03
Growing Cattle	Gg CO2 eq.	0.12	0.11	0.09	0.14	0.09	0.10	0.08	0.09
Total Cattle	Gg CO2 eq.	10.17	10.07	10.28	3.33	3.03	1.36	1.32	1.31
Mature Ewes	Gg CO2 eq.	0.87	0.86	0.70	0.87	0.78	0.74	0.91	0.93
Other Mature Sheep	Gg CO2 eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Growing Lambs	Gg CO2 eq.	0.24	0.22	0.14	0.17	0.06	0.04	0.06	0.05
Total Sheep	Gg CO2 eq.	1.10	1.07	0.83	1.03	0.84	0.78	0.97	0.98
Swine	Gg CO2 eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Goats	Gg CO2 eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry	Gg CO2 eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rabbits	Gg CO2 eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Horses	Gg CO2 eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

**The difference is calculated by subtracting the emissions using 2019 IPCC Refinements from the emissions using 2006 IPCC Guidelines (2019 Refinements – 2006 Guidelines).

Table 5-12 The difference between manure management methane emissions using 2006 IPCC Guidelines and the 2019 IPCC Refinements.

Manure Management - CH4		1990	1995	2000	2005	2010	2015	2018	2019
Dairy Cows	Gg CO2 eq.	2.01	2.02	2.02	0.70	0.65	0.20	0.19	0.19
Non-Lactating Cows	Gg CO2 eq.	0.21	0.20	0.23	0.01	0.01	0.06	0.06	0.06
Bulls	Gg CH4	-0.02	-0.02	-0.02	-0.06	-0.03	-0.02	-0.01	-0.01
Calves	Gg CO2 eq.	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Growing Cattle	Gg CO2 eq.	0.02	0.02	0.01	0.02	0.02	0.02	0.01	0.01
Total Cattle	Gg CO2 eq.	2.26	2.25	2.28	0.76	0.69	0.29	0.28	0.28
Swine	Gg CO2 eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Layers	Gg CO2 eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Broilers & Other Poultry	Gg CO2 eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry Total	Gg CO2 eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rabbits	Gg CO2 eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sheep	Gg CO2 eq.	4.15	4.15	3.11	3.85	2.93	2.65	3.42	3.42
Goats	Gg CO2 eq.	1.78	2.64	1.44	1.80	1.47	1.42	1.65	1.61
Horses	Gg CO2 eq.	0.89	0.84	0.80	1.23	1.63	1.37	1.23	1.23

**The difference is calculated by subtracting the emissions using 2019 IPCC Refinements from the emissions using 2006 IPCC Guidelines (2019 Refinements – 2006 Guidelines).

Table 5-13 The difference between manure management direct N2O emissions using 2006 IPCC Guidelines and the 2019 IPCC Refinements

Manure Management - Direct N2O Emissions		1990	1995	2000	2005	2010	2015	2018	2019
Dairy Cattle	Gg CO2 eq.	2.26	2.00	2.15	1.91	1.56	1.56	1.52	1.50
Calves	Gg CO2 eq.	0.48	0.42	0.40	0.49	0.38	0.36	0.37	0.35
Crowing Cattle	Gg CO2 eq.	0.93	0.81	0.66	1.10	0.70	0.76	0.61	0.65
Non-Lactating Cows	Gg CO2 eq.	0.45	0.43	0.75	0.14	0.17	0.17	0.18	0.17
Bulls	Gg CO2 eq.	0.05	0.05	0.05	0.15	0.07	0.06	0.03	0.04
Total Cattle	Gg CO2 eq.	4.18	3.69	4.01	3.79	2.88	2.91	2.71	2.71
Swine	Gg CO2 eq.	0.33	0.33	0.25	0.21	0.23	0.15	0.12	0.12
Poultry	Gg CO2 eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
sheep	Gg CO2 eq.	-0.56	-0.57	-0.44	-0.54	-0.44	-0.41	-0.53	-0.53
Goats	Gg CO2 eq.	-0.30	-0.45	-0.25	-0.31	-0.25	-0.24	-0.28	-0.27
Horses	Gg CO2 eq.	0.12	0.11	0.11	0.16	0.21	0.18	0.16	0.16
rabbits	Gg CO2 eq.	10.19	9.41	9.42	8.98	7.35	6.94	6.55	6.53

**The difference is calculated by subtracting the emissions using 2019 IPCC Refinements from the emissions using 2006 IPCC Guidelines (2019 Refinements – 2006 Guidelines).

Table 5-14 The difference between manure management indirect N2O emissions using 2006 IPCC Guidelines and the 2019 IPCC Refinements

Manure Management - Indirect N2O Emissions		1990	1995	2000	2005	2010	2015	2018	2019
Cattle	Gg CO2 eq.	0.36	0.32	0.34	0.34	0.25	0.25	0.22	0.23
Swine	Gg CO2 eq.	0.41	0.41	0.31	0.27	0.29	0.19	0.15	0.15
Poultry	Gg CO2 eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
sheep	Gg CO2 eq.	-0.08	-0.08	-0.06	-0.08	-0.06	-0.06	-0.07	-0.07
Goat	Gg CO2 eq.	-0.05	-0.07	-0.04	-0.05	-0.04	-0.04	-0.05	-0.05
Horses	Gg CO2 eq.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rabbits	Gg CO2 eq.	-0.07	-0.11	-0.14	-0.17	-0.21	-0.24	-0.24	-0.22

**The difference is calculated by subtracting the emissions using 2019 IPCC Refinements from the emissions using 2006 IPCC Guidelines (2019 Refinements – 2006 Guidelines).

Table 5-15 The difference between agricultural soils emissions using 2006 IPCC Guidelines and the 2019 IPCC Refinements.

Total N2O emissions from managed soils		1990	1995	2000	2005	2010	2015	2018	2019
Total Direct N2O emissions	KtN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Indirect N2O emissions due to atmospheric deposition	KtN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Indirect N2O emissions due to leaching/run-off	KtN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total N2O emissions from managed soils	KtN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total N2O emissions from managed soils	Gg CO2 eq.	-0.08	-0.27	0.22	0.03	0.08	0.08	-0.18	-0.55

**The difference is calculated by subtracting the emissions using 2019 IPCC Refinements from the emissions using 2006 IPCC Guidelines (2019 Refinements – 2006 Guidelines).

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 (CH_4) emissions from enteric fermentation, pseudo-ruminant and monogastric animals are also included in the emission calculations. The quantity of CH_4 produced and excreted by a single animal is dependent on a number of 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.

In Malta, the two major livestock farmed for meat production are swine and poultry (broilers). Cattle farming for beef occurs as a by-product of the dairy industry.

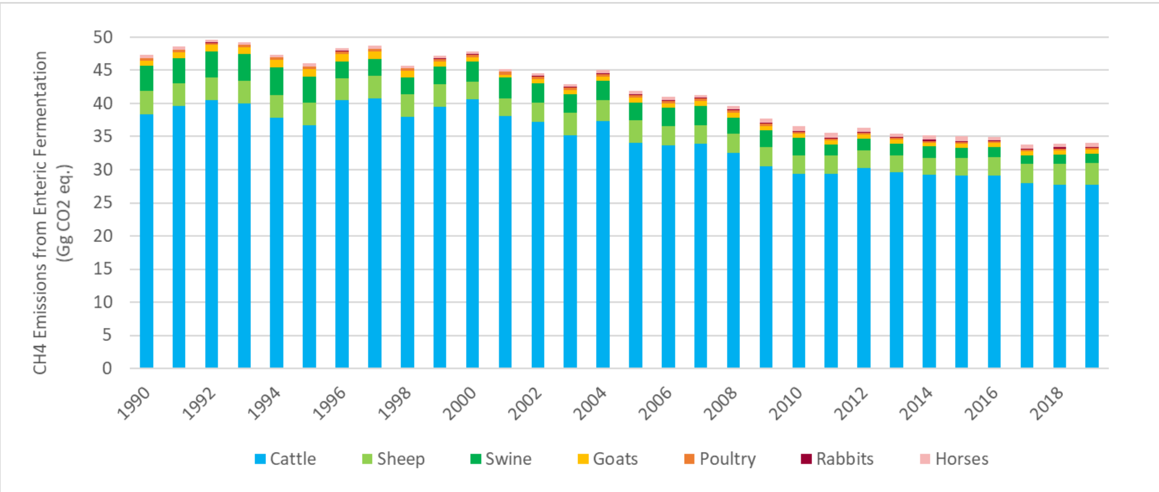

Figure 5-1 Methane emissions from Enteric Fermentation in Gg $CO_{2\ eq}$. by livestock category.

In 2019, the highest contributors towards emissions from Enteric Fermentation were cattle, sheep and swine respectively, as illustrated in **Figure 5-1** above.

5.2.2 METHODOLOGICAL ISSUES

Methane emissions from cattle and sheep enteric fermentation are estimated using a Tier 2 methodology based on a livestock characterisation. The Characterisation data of both livestock categories is highly fragmented and heavy reliance is made on expert judgements made by experts in the field. Emissions from the enteric fermentation of other livestock were made using Tier 1 methodologies, using default emission factors provided in the IPCC 2006 Guidelines and IPCC 2019

Refinements where available, and from scientific literature such as in the case of rabbits and sheep. Table 5-16 to Table 5-19 contain the 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.

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 Activity Data, Emission Factors and equations used in the estimation of emissions from cattle enteric fermentation are tabulated in Table 5-16 and Table 5-17. Cattle are characterised using the values given in Table 5-4, Table 5-5 and Table 5-6 and default values as given in the 2019 IPCC Refinements and 2006 IPCC Guidelines, as tabulated in Table 5-16 and Table 5-17. The default methane conversion factors from Table 10.12 of the 2006 IPCC Guidelines in conjunction with the animal characterisation, are then applied to Equation 10.21 of the 2019 IPCC Refinements to develop an emission factor for each animal category.

The milk yield for both dairy cows and sheep is obtained from the NSO and validated against MDP values, whilst the dairy cow's milk fat content is obtained from the MDP. The milk yield produced per head daily for dairy cows is estimated by multiplying the total cow milk (tonnes) provided by NSO by 1000 and dividing that number by the number of dairy cattle and then by 365. 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 2019 are summarised in Table 5-5.

Subsequently, the milk yield will vary on a yearly basis depending on the population of dairy cows and the milk produced. Two feed digestibility values are being utilised for low quality forage. These two different low-quality forage data utilised reflect the data currently available for Malta. The *feed digestibility low quality forage* (FD%LQF) 2005-2019 represents the data for cattle from the year 2005 till present, whilst the data prior to 2005 is illustrated by the parameter *Feed digestibility low quality forage* (FD%LQF) 1990-2004. The *Feed digestibility of low-quality forage* (FD%LQF) for the period 1990-2004 is being taken as 45% (S. Sammut, 2015 & Table 10.1 2019 IPCC Refinements), whilst 50% (taken from IPCC guidelines table 10.2) is being used for 2005 onwards. 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% has been revised following 2020 ESD Reviews, while the Feed Digestibility Factors have been revised to reflect the 2019 IPCC Refinements.

The below equation is being used to estimate DE%:

$$DE\% = \left(\frac{F_{owf}}{F} * FD\%LQF\right) + \left(\frac{F_{owc}}{F} * FD\% > 85\right)$$

Since this equation also incorporates the *Feed* (F), the result will also be dependent on and fluctuate 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 who work in the field, i.e. Kevin Tonna from Milk Producers Cooperative KPH). 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.

The digestibility of feed (LQF) for dairy cattle used is that of 50% (2005 onwards) (IPCC Guidelines 10.1) and 45% (1990-2004) (National Expert), while the FD%>85% is 78.5% (taken from the 2019 IPCC Refinements). This value will probably be higher compared to other countries' mean, given that we are taking the IPCC 2019 Refinements into consideration. It must also be noted that at present, since there is no information on an EF for FD%LQF for growing cattle and calves, a negative value or a very small value for DE% is returned. Thus, for this submission we have reported that DE% = FD%>85 (IPCC 2019 Refinements). Efforts will be made for the next submission to correct this issue.

Sheep & Goats

Sheep and goats are mainly reared for the production of the traditional Maltese cheeselet, largely marketed by the producers themselves. Only a minimal amount of sheep and goats are slaughtered at the civil abattoir. 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 XX 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)[25]. 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). Equation 5.1 below provides the equation used to calculate the $C_{pregnancy}$ value used.

$Equation\ 5.1$

$$Cpregnancy = (0.126 * 0.785) + (0.77 * 0.187) = 0.113$$

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 5-18.

Sheep are mainly reared for their milk reflecting its use in the production of the traditional Maltese Cheeselets. 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. Nonetheless, since the Energy to produce wool is still being used by the sheep, we calculate the Net Energy associated with wool production in this submission, using 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.

$$NE_{Wool} = \frac{PR_{Wool} * EV_{Wool}}{365}$$

Emissions from enteric fermentation by other species are determined using a Tier 1 method and default emission factors, applying Equation 10.19 and Table 10.10 of the 2019 IPCC Refinements.

[25] The establishment of the Local Sheep Population as a Breed. (Unpublished Diploma dissertation). University of Malta. Valletta, P.P. 2011.

Swine

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. In 2018, the pig population amounted to 36,294 heads, an increase of 6.7% from 2017 values. This increase in population translates into an increasein the methane emissions from enteric fermentation by swine yet the emissions recorded are still lower than those recorded for 2016 or the previous years.

Poultry

The poultry figures include" Broilers*"*, *"Laying hens"*, and *"Other poultry"*, which is mainly comprised of the turkey population. The contribution of broilers to the poultry industry in Malta is around 54%, whereas laying hens contribute around 46%, and other poultry contribute for less than 1%. The methane emissions from enteric fermentation for poultry are estimated using a Tier 1 approach corresponding to 2006 IPCC guidelines. Presently, the data provided by NSO mainly reports the population statistics for the categories "*Layers*", and "*Broilers*". 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. Resultantly the population data used is extrapolated based upon the historic populations of turkey. The IPCC guidelines do not estimate the emission factors associated with Methane emissions for enteric fermentation for poultry. At present, the source of the emission factor utilised is an inherent value from past inventory compilations that was suggested by a local expert. As part of the commissioned SRSS study, Malta will be revaluating whether to continue estimating methane emissions from enteric fermentation form poultry, especially since Malta is one of a small number of parties that report emissions of CH_4.

The EF being used by Malta for CH4 emissions from enteric fermentation for poultry is taken from 1996 IPCC guidelines. In previous submissions, we have tried to provide values being used by other countries with similar conditions to Malta, however the EF was never accepted by both review teams, as in the case of Rabbit EF. As mentioned previously, we are encouraging research to be done on this area to get country specific factors, in the SRSS project, however it is envisaged that this project will take time to yield results. Malta will try to find an EF from those reported by other countries for next year's submission, until a country specific one is developed.

Other livestock

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.

It is vital to note that backyard breeder who do not breed or own rabbits or poultry 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 whole rabbit population was being reported (1990 – 2001).

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[26]. It is assumed that Italy, as a neighbouring country has a similar scenario on rabbits and the Italian CH_4 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.

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.

[26] Methodologies used in Italy for the estimation of air emission inventory in the agriculture sector. Agenzia per la protezione dell'ambiente e per I servizi tecnici (APAT). 2005.

Table 5-16 Parameters used in the calculation of emissions from enteric fermentation, all livestock categories.

Parameter	Source	DC	NLC	B	C	GC	ME	OMS	GL	Swine	Goats	Poultry	Rabbits	Horses
		T2/CS	T2/D/CS	T2/D/CS	T2/D/CS	T2/D/CS	T2/D/CS	T2/D/CS	T2/D/CS	T1/D	T1/D	T1/D	T1/D	T1/D
Ym	Table 10.13 (IPCC 2019 Refinements (sheep), Table 10.12 (IPCC 2006) Cows	6.5	6.5	6.5	6.5	6.5	6.7	6.7	6.7	n.a.				
FD%>85	Table 10.2 (cattle and other ruminants) - 2019 Refinements	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5					
FD%LQF	Table 10.1 S.Sammut, 2015 p.6 (agrees with IPCC 2019 Refinement Table 10.2)	45 (1990-2004), 50 (2005 onwards)	45 (1990-2004), 50 (2005 onwards)	45 (1990-2004), 50 (2005 onwards)	n.a.	n.a.	50	50	50					
W	K. Tonna, 2018	550	640	630	200	400	50	60	20					
WG	K. Tonna, 2018	Assumed 0			0.5	0.4	n.a.	n.a.	n.a.					
C	P. 10.24 (IPCC 2019 Refinements)	0.8	0.8	1.2	1	1	n.a.	n.a.	n.a.					
Cfi	Table 10.4 (IPCC 2019 Refinements)	0.386	0.322	0.37	0.322	0.322	0.217	0.217	0.236					
Ca	(IPCC 2019 Refinements) MJ/day/Kg (goats only)	0	0	0	0	0	0.0096	0.0096	0.0067					
Portion gestating (PG)	K. Tonna, 2018	0.7	n.a.	n.a.	n.a.	n.a.	0.65	n.a.	n.a.					
Cpreg	Table 10.7 (IPCC 2019 Refinements) (Cattle); Sheep (in house calculation)	0.1	n.a.	n.a.	n.a.	n.a.	0.113	n.a.	n.a.					
coefficient a	Table 10.6 (IPCC 2019 Refinements)	n.a.	n.a.	n.a.	n.a.	n.a.	2.1	2.1	2.3					
coeffieicient b	Table 10.6 (IPCC 2019 Refinements)	n.a.	n.a.	n.a.	n.a.	n.a.	0.45	0.45	0.4					
BWi		n.a.	n.a.	n.a.	n.a.	n.a.	11	11	3					
BWf		n.a.	n.a.	n.a.	n.a.	n.a.	18	18	30					

Evmilk	p 10.26 (IPCC 2019 Refinements)	n.a.	n.a.	n.a.	n.a.	n.a.	4.6	n.a.	n.a.					
EF	IPCC 2019 Table 10.10 (IPCC 2019 Refinements); Poultry (2006 IPCC Guidelines)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1.5	5	0.01	0.08	18
Prwool	Bigi, D & Zanon, A. (2020) Atlante delle razze autoctone	n.a.	n.a.	n.a.	n.a.	n.a.	1.3	2.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Evwool	MJ/kg (Eqn. 10.12 IPCC 2019 Refinements)	n.a.	n.a.	n.a.	n.a.	n.a.	24	24	24	n.a.	n.a.	n.a.	n.a.	n.a.

Table 5-17 Equations used in the estimation of emissions from enteric fermentation, cattle.

Parameter	Unit	Source	DC	NLC	B	C	GC
Nem	MJ/day	Eqn. 10.3 (IPCC 2019 Ref.)	$Cfi*W^{0.75}$				
Nea	MJ/day	Eqn. 10.4 (IPCC 2019 Ref.)	Nem*Ca				
Neg	MJ/day	Eqn. 10.6 (IPCC 2019 Ref.)	$22.02(W/(C/W))^{0.75}*WG^{1.097}$			$22.02(W/(C*MW))^{0.75}*WG^{1.097}$	
Nel	MJ/day	Eqn. 10.8 (IPCC 2019 Ref.)	Milk*(1.47+0.4*Fat)	N.A.			
Nep	MJ/day	Eqn 10.13 (IPCC 2019 Ref.)	Cpreg*NEM*PG	N.A.			
DE%	%		((FOWF/F)*FD%LQF)+((FOWC/F)*FD%>85)				
REM	%	Eqn. 10.14 (IPCC 2019 Ref.)	$(1.123-(4.092*10^{-3}*DE\%)+(1.126*10^{-5}*(DE\%)^2))-(25.4/DE\%)$				
REG	%	Eqn. 10.15 (IPCC 2019 Ref.)	((1.164-(5.16*10-3*DE%)+(1.308*10-5*DE%2)-(37.4/DE%))				
GE	MJ/day	Eqn. 10.16 (IPCC 2019 Ref.)	(((Nem+Nea+Nel+Nep)/REM)+((Neg)/REG))/DE%/100)	(((Nem+Nea)/REM)/DE%/100)		(((Nem+Nea)/REM)+((Neg)/REG))/DE%/100)	
EFCH4	KgCH4/head/yr	Eqn. 10.21 (IPCC 2019 Ref.)	GE*(YM/100)*365)/55.65				
Emissions	GgCO2eq.	Eqn. 10.19 (IPCC 2019 Ref.)	((EF*Population)/1000000)*GWP				

Table 5-18 Equations used in the estimation of emissions from enteric fermentation, sheep.

Parameter	Unit	Source	ME	OMS	GL
Nem	MJ/day	Eqn. 10.3 (IPCC 2019 Refinements)	Cfi*W$^{0.75}$		
Nea	MJ/day	Eqn. 10.5 (IPCC 2019 Refinements)	Ca*W		
Neg	MJ/day	Eqn. 10.7 (IPCC 2019 Refinements)	WG(a+0.5b(Bwi+BWf))/365		
Nel	MJ/day	Eqn. 10.9 (IPCC 2019 Refinements)	MY*Evmilk	n.a.	n.a.
NeWool	MJ/day	Eqn. 10.12 (IPCC 2019 Refinements)	Evwool*PrWool/365	Evwool*PrWool/365	
Nep	MJ/day	Eqn 10.13 (IPCC 2019 Refinements) - Coefficient for pregnancy was provided by an external consultant (S. Sammut) using CS values derived from a study by Valletta, P.P. (2011). The values in the study were averaged for single and twin pregnancies, getting values of 0.1873 and 0.7853. These were then multiplied by the respective Cpreg values provided in the guidelines (0.077 and 0.126). Therefore, Cpreg=(0.126*0.785)+(0.077*0.187)=0.113	Cpreg*Nem*(PG/100)	n.a.	n.a.
DE%	%		((FOWF/F)*FD%LQF)+((FOWC/F)*FD%>85)		
REM	%	Eqn. 10.14 (IPCC 2019 Refinements)	(1.123-(4.092*10^{-3}*DE%)+(1.126*10-5*(DE%)^{2}))-(25.4/DE%)		
REG	%	Eqn. 10.15 (IPCC 2019 Refinements)	((1.164-(5.16*10^{-3}*DE%)+(1.308*10-5*DE%)^{2}-(37.4/DE%))		
GE	MJ/day	Eqn. 10.16 (IPCC 2019 Refinements)	(((Nem+Nea+Nel+Nep)/REM)+((Neg+NEwool)/REG))/DE%/100)		((NEa+NEm/REM)+(Neg+NeWookl/REG))/(DE%/100)
EFCH4 EF	KgCH4/head/yr	Eqn. 10.21 (IPCC 2019 Refinements)	(GE(Ym/100)*365)/55.65		
Emissions	GgCO2eq.	Eqn. 10.19 (IPCC 2019 Refinements)	((POP*EF)/1000000)*GWP		

Table 5-19 Equations used in the estimation of emissions from enteric fermentation, other livestock categories

Parameter	Unit	Source	Swine	Goats	Poultry	Rabbits	Horses
Emissions	GgCO2eq.	Eqn. 10.19	((POP*EF)/1000000)*GWP				

5.2.3 Uncertainties and time-series consistency

Time-series consistency has been improved by using only two sources for animal numbers, i.e. FAOSTAT statistics and NSO statistics. Any remaining gaps in cattle, swine, goats, sheep and poultry data, prior to 2000, have been filled using a 5-year moving average or interpolation.

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 illustrated 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. **Table 5-20** below illustrates the uncertainty values for all activity data and emission factors utilised for the estimation of emissions from enteric fermentation. The overall uncertainty is calculated based on methodologies described in the 2006 IPCC guidelines Volume 1.

Table 5-20 Uncertainty of activity data and emission factors used in the estimation of emissions from Enteric Fermentation.

IPCC Category	Gas	AD Uncertainty	EF Uncertainty	Combined Uncertainty
	(CO2, CH4, N2O)	*% Using Equation 3.2*	*% Using Equation 3.2*	*% =sqrt(E^2+F^2)*
3A1a Cattle (Enteric Fermentation)	CH4	15%	9%	17%
3A1c Sheep (Enteric Fermentation)	CH4	12%	15%	19%
3A1d Goats (Enteric Fermentation)	CH4	20%	40%	45%
3A1f Horses (Enteric Fermentation)	CH4	20%	10%	22%
3A1h Swine (Enteric Fermentation)	CH4	20%	40%	45%
3A1i Poultry (Enteric Fermentation)	CH4	20%	40%	45%
3A1j Rabbits (Enteric Fermentation)	CH4	20%	10%	22%

Category-specific QA/QC and verification

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.

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.

Data that is received from data providers is logged into an activity data log sheet to allow traceability and transparency on 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 were numerous parameters were fed into the construction of the emission factor that are based on expert judgment and thus reflect the present local scenario. Wherever possible, data was verified with other sources, such as National statistics office data with FAOSTAT data.

5.2.5 Category-specific recalculations

In this submission, Malta has revised the methodologies to reflect the 2019 IPCC Refinements. Following the 2020 ESD Reviews, the **Feed Digestibility** for **Cattle** and **Sheep** were also updated, since an incorrect equation was being used. Moreover, the **Net Energy for wool** of **Sheep** is now being calculated. The **cow milk quantity** for 2018 was revised down to 40412.67 tonnes from 40455.79 tonnes. The 2018 **laying hen population** was also revised from 320,865 heads to 360,726 heads on provision of new data.

Table 5-21 A table of recalculations for Enteric Fermentation.

Year	Enteric Fermentation (Gg CO2 eq.) as reported in the previous inventory report	Enteric Fermentation (Gg CO2 eq.) as reported in this inventory report	Percentage change in reported emissions (%)	*Change in Gg CO2 eq.*
1990	36.03	47.30	31.29%	11.27
1991	36.89	48.56	31.64%	11.67
1992	37.70	49.63	31.66%	11.94
1993	37.48	49.29	31.51%	11.81
1994	36.11	47.38	31.21%	11.27
1995	34.88	46.01	31.93%	11.14
1996	36.25	48.31	33.27%	12.06
1997	36.59	48.68	33.03%	12.09
1998	34.44	45.74	32.81%	11.30
1999	35.56	47.17	32.65%	11.61
2000	36.68	47.79	30.30%	11.11
2001	35.05	45.24	29.07%	10.19
2002	34.98	44.53	27.31%	9.55
2003	33.69	42.90	27.33%	9.21
2004	35.51	45.00	26.72%	9.49
2005	37.57	41.92	11.60%	4.36
2006	36.83	40.99	11.29%	4.16
2007	37.17	41.31	11.14%	4.14
2008	35.50	39.61	11.57%	4.11
2009	33.76	37.70	11.69%	3.95

2010	32.75	36.62	11.83%	3.87
2011	31.71	35.54	12.07%	3.83
2012	32.38	36.28	12.05%	3.90
2013	31.68	35.47	11.96%	3.79
2014	31.36	35.15	12.08%	3.79
2015	32.88	35.02	6.51%	2.14
2016	32.72	34.94	6.77%	2.22
2017	31.56	33.75	6.95%	2.19
2018	31.66	33.95	7.23%	2.29

5.2.6 Category-specific planned improvements

The possibility of improving methodologies to Tier 2 is being explored for other livestock. A characterisation of said livestock will be carried out and upon finalisation, they will be reported in the NIR. Commencing in 2019, the Ministry for Sustainable Development, Environment, and Climate Change (MSDEC) commissioned a study entitled "*Technical support on the Emission Framework for the Agricultural Sector in Malta*", under the European Commission's SRSS Programme, as to elaborate methodologies for the collection of data of parameters that are currently excluded from the data collection processes.

Moreover, the rabbit population is currently being looked at in more depth, in order to achieve the most realistic population based on doe and buck population and yearly reproductive rate.

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 Judgments 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).

5.3 MANURE MANAGEMENT (CRF 3B)

5.3.1 CATEGORY DESCRIPTION

This category reports emissions of methane and nitrous oxide from animal manure as well as emissions arising during the storage of said manure. The management of domestic livestock manure leads to the emission of CH4 and N2O. The decomposition of manure by methanogenic bacteria, under anaerobic condition releases methane, while the nitrification and denitrification of manure nitrogen, produces nitrous oxide. N2O 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. Emissions from manure management account for 23% of the total agriculture emissions, of which 31% are methane and 69% are nitrous oxide emissions.

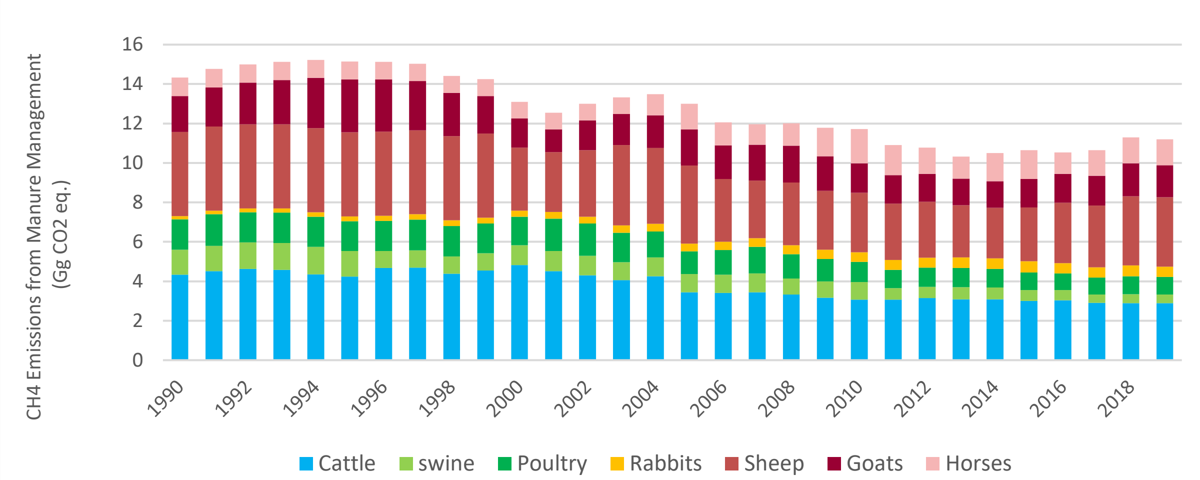

Figure 5-2 Methane emissions from manure management by livestock category.

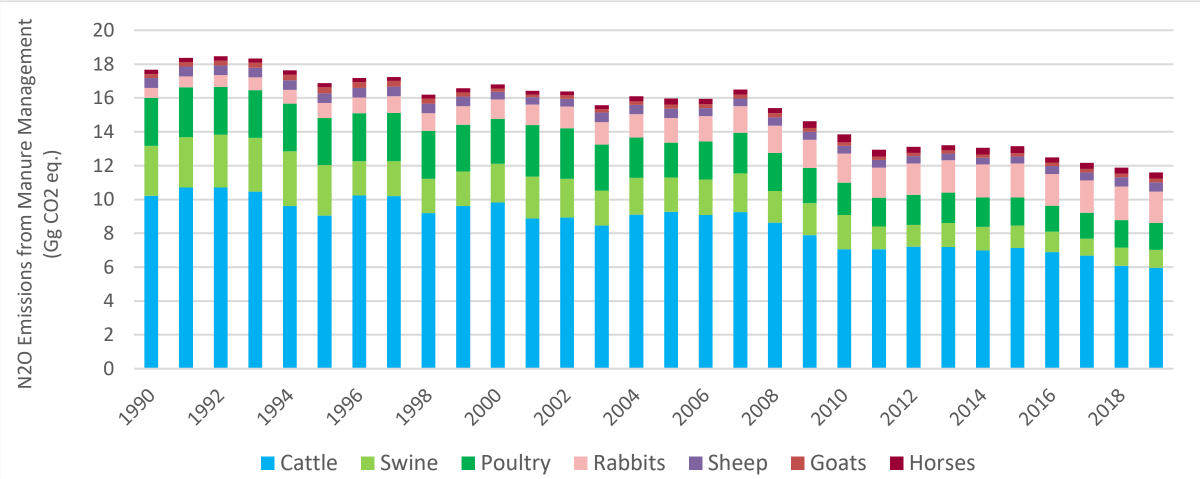

Figure 5-3 Nitrous oxide emissions form manure management by livestock category.

5.3.2.1 Methane emissions

Methane emissions from cattle, swine, poultry and rabbits have been estimated using Tier 2 methodology with country specific inputs. A Tier 1 methodology and default emission factors for other livestock are applied.

5.3.2.1.1 Cattle

The Estimation of methane emissions from Cattle are based on the livestock characterisation developed for the estimation of enteric fermentation emissions. Gross Energy and Digestible Energy are used as inputs to derive a methane emission factor. Equation 10.24 of the 2019 IPCC Refinements is applied to estimate the volatile solid excretion rate (VS). *Maximum methane producing capacity* (B_0) and *Methane Conversion Factor* (MCF) are default values taken from Tables 10.16 of the 2019 IPCC Refinements and Table 10A4 and 10A5 of the 2006 IPCC Guidelines respectively, using values for solid storage in temperate regions (19°C) and Western Europe (given the climatic conditions of the Maltese islands). Equation 10.23 of the 2019 IPCC Refinements is applied to develop a methane emission factor. The values used are shown in **Table 5-23**.

The average IEF of CH4 emissions for category 3.B.1.1.1. from 1990-2019 is 1.017 while only in 2005 the value decreased to 0.78. Moreover, the IEF of CH4 emissions for category 3.B.1.1.2 for years 2000 and 2001. The average IEF from 1990-2019 is 1.007 while in 2000 the value increased to 1.256 and then decreased to 0.78. It should be noted that the drop in 2005 is due to a decrease in the Volatile solids, which is affected by the Gross Energy and which is calculated in Enteric Fermentation. It is evident that the GE in Enteric Fermentation also experiences a drop in 2005, which albeit small is affecting the VS. This change in GE is due to another change in the REM and REG, whose change is solely due to an increase in the DE% which goes up to 60.35 in 2005 from 55.05 (1990-2004). The change between 2000 and 2001 can be very simply attributed to the change in population, where the population of NLC in 1999 was 1154, in 2000 it went up to 2695 and in 2001 it dropped again to 1286 heads.

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.

In order to estimate the amount of dry matter excreted, the average excretion of wet slurry (16.05 kg animal^{-1} day^{-1}) 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 VS day^{-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 some cases, the farm is directly linked to the sewer system, but 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 about 10% of slurry is applied to soils. This is revised downwards to 5% after the adoption of the "Nitrates *Action Plan"* 2013.

In order 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 and the fraction that is directed to the sewer system. This results in separate emission factors for each fraction of the slurry as shown in **Table 5-24** applying equation 10.23 of the 2019 IPCC Refinements. The final value for emissions of methane from swine is calculated as shown in Equation 5.2.

Equation 5.2

$$CH4\ Emissions = \left[\frac{\left(Population * EF_{SRS} * (1 - MMS)\right) + \left(Population * EF_{SATS} * (MMS)\right)}{1000000}\right] * 25$$

Where, EF_{SRS} if the Emission factor calculated for the fraction of slurry directed to the sewers, EF_{SATS} is the EF for the fraction of slurry applied to soils and MMS is the fraction of slurry that is applied to soils (0.10 and 0.05).

Additionally, the total sum of Emission Factors is now being taken in consideration when calculating the methane emissions for manure management. This decision was taken following a capacity building exercise with the Commission where it was determined that the emissions were being underestimated.

5.3.2.1.3 Poultry and Rabbits

As for poultry, some information is available in order to enable a Tier 2 estimation of methane emissions from manure management of poultry. 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 VS day^{-1} for layers and 0.030 kg VS day^{-1} for broilers.

A default methane conversion factor is applied for poultry and rabbits from Table 10.17 of the IPCC Refinements (poultry) and Table 10A-9 of the 2006 IPCC guidelines (rabbits) representing solid storage in temperate regions, resulting in separate emission factors for each category as shown in **Table 5-25** using Equation 10.23 of the 2019 IPCC Refinements.

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 5-25**.

5.3.2.1.4 Other Livestock

Methane emissions from sheep, goats and horses are estimated using Tier 1 methodology. Emission factors used are tabulated in **Table 5-26**.

The emissions for category 3.B.1.2 are calculated using IPCC methods and defaults, as shown in the below equation. It must be kept in mind, that a comparison of Malta's 2021 submission values for 3.B.1.2. will show higher values than those for the 2020 submission given that the 2019 IPCC Refinements method is being used. The 2006 IPCC Guidelines did not take into account the VS, thus with the IPCC 2019 Refinements, a higher value will result.

EF = 1.3 (IPCC guidelines 10.15)

VS = 8.2 (IPCC 2019 Refinements)

Emissions = ((EF * VS * Population) /1000000) * 25

For 2019 GL = 1.3 * 8.2 * 1021 /1000000 = 0.01088 * 25 = 0.27 ktCO2eq

OMS = 1.3 * 8.2 * 11706/100000 = 0.1248 = 3.11 ktCO2eq

ME = 1.3 * 8.2 * 434/100000 = 0.12 ktCO2eq.

5.3.2.2 Direct Nitrous oxide emissions

Nitrous oxide emissions are dependent on the storage and treatment of manure before it is applied to agricultural land. Direct N_2O emissions occur via combined nitrification and denitrification of nitrogen contained in the manure.

Emissions from dairy cattle and poultry have been estimated using Tier 2 methodology with country specific nitrogen excretion rates. Tier 1 methodology with default emission factors for other livestock is applied. Some parameters used in the livestock characterisation have been used to develop a nitrogen excretion rate and emission factor for dairy cattle.

5.3.2.2.1 Cattle

The default Nitrogen excretion rates for other cattle categories are taken from table 10.19 and table 10.20 of the 2019 IPCC refinements. $Nex_{(T)}$ is calculated using equation 10.30 of the 2019 IPCC Refinements. $Nex_{(T)}$ is then multiplied by the livestock population and by the Emission factor for direct N_2O emissions (solid storage). **Table 5-27** gives a list of parameters, emission factors and equations used in the calculation of nitrous oxide emissions from the management of cattle manure.

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.

5.3.2.2.2 Swine

In the case of swine, equation 10.30 of the 2006 IPCC guidelines is used, where the live weight is multiplied by the Nitrogen excretion rate, by 365 and the livestock population. Two different N rates were taken from Table 10.19 of the 2019 IPCC refinements, 0.76 kg N/1000kg/day for market pigs and 0.38 kg N/1000kg/day for breeding pigs (see **Table 5-27**).

5.3.2.2.3 Poultry

The country-specific nitrogen excretion rates used for poultry are presented in **Table 5-29** below. The "*Agricultural Waste Management Plan for the Maltese Islands"* Report (Sustech) has been consulted in order to derive the Country-Specific Nitrogen Excretion Rates. For Broiler, the Agricultural Waste Management Plan quotes the range 0.35kgN/place to 0.82kgN/place.

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, as the default value within the 2006 IPCC Guidelines is quoted to be 1.10kgN/1000kg/day, which is beyond the higher end of the range quoted above, it was decided that the highest values of 0.82kgN/place is to be utilised for both broiler and other poultry. The nitrogen excretion is then multiplied by the default emission factor from Table 10.21 of the 2019 IPCC Refinements for poultry manure, i.e. 0.001 kg N_2O-N (kg nitrogen excreted)$^{-1}$.

Data that is currently provided by NSO mainly report the population statistics for the categories "*Layers*", and "*Broilers*". Every 3 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. Resultantly the population data used is extrapolated based upon the historic populations of turkey.

5.3.2.2.4 Sheep

Default nitrogen excretion rates from Table 10.19 (values for Western Europe) and emission factors for direct N_2O emissions from manure management from Table 10.21 of the 2019 IPCC Refinements were used for the determination of direct nitrous oxide emissions for sheep, rabbits, goats and horses. The excretion rates, emission factors and management systems used are presented in **Table 5-28**.

5.3.2.3 Indirect Nitrous oxide Emissions

A significant proportion of the total nitrogen excreted by the animals in managed systems is lost prior to final application of the manure to the soils. In order to estimate the amount of animal manure nitrogen that is directly applied to the soils, it is necessary to reduce the total amount of nitrogen excreted by the animals that is lost as volatilisation. Equation 10.26 of the 2019 IPCC Refinements was used to calculate the nitrogen lost due to volatilisation from manure management.

Default values for nitrogen loss due to volatilisation of NH_3 and NO_x from manure management, from Table 10.22 of the 2019 IPCC Refinements are applied to the quantities of kg N excreted annually by livestock categories.

The value for all poultry categories is taken as 40% i.e. poultry with litter, whereas that for rabbits is being taken as 48%, since rabbit MMS category falls under poultry without litter and no default values is given specifically for rabbits in the 2019 IPCC Refinements (and/or 2006 Guidelines). These are presented in **Table 5-30** below. The fraction of nitrogen thus volatilised is multiplied with the default emission factor to estimate indirect N_2O-N emissions from manure management (0.01 kg N_2O-N kg N^{-1}), as presented in Table 11.3 of the 2019 IPCC Refinements.

It could be assumed that that higher productivity also leads to high N excretion per animal head. However, the while milk yield increases by more than 70% in the period 1990-2019, while nitrogen excretion rate remained almost constant. Nitrogen excretion is very important for the calculation of N2O emissions from manure management system, but also for N2O emissions from cultivated soils. It should thus be noted that the milk yield had increased from 10.02 kg/head/day in 1990 to 17.83 kg/head/day in 2018. So did the NEl and GE. The milk yield is used in the calculation of NEl in Enteric Fermentation, which in turn is used in the calculation of GE. NEl was 24.74 MJ/day in 1990 and increased to 50.22 MJ/day in 2018. Same goes for GE which increased from 183.00 MJ/day to 305.73 MJ/day in 2018. The calculation of VS in Manure management utilizes the same GE which was calculated in Enteric Fermentation, and as the GE increased over time, so did the VS, which went up from 2.83 kg VS/day to 6.28 kg VS/day. Therefore, the nitrogen excretion rates being reported are indeed consistent with the trend in milk yield and GE.

It should be noted that the value describing Other poultry in Malta is not disaggregated by poultry categories by our data providers, and therefore an exact number of turkeys is not available. Moreover, the method being used to calculate emissions for other poultry is being taken from the IPCC guidelines and Country Specific EFs are being used, since they are available.

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. However, emissions are estimated for all livestock categories and all systems of manure management as far as possible.

Table 5-22 Uncertainty of activity data and emission factors used in the estimation of emissions from manure management.

IPCC Category	Gas	AD Uncertainty	EF Uncertainty	Combined Uncertainty
Manure Management - Cattle	CH4	15%	9%	17%
Manure Management - Sheep	CH4	12%	15%	19%
Manure Management - Swine	CH4	20%	20%	28%
Manure Management - Goats	CH4	20%	20%	28%
Manure Management - Poultry	CH4	20%	20%	28%
Manure Management - Rabbits	CH4	20%	10%	22%
Manure Management - Horses	CH4	20%	10%	22%
Manure Management - Cattle	N2O	15%	26%	30%
Manure Management - Sheep	N2O	12%	50%	51%
Manure Management - Swine	N2O	20%	26%	33%
Manure Management - Goats	N2O	20%	50%	54%
Manure Management - Poultry	N2O	20%	38%	43%
Manure Management - Rabbits	N2O	20%	50%	54%
Manure Management - Horses	N2O	20%	50%	54%
Indirect N2O Emissions from Manure Management - Cattle	N2O	15%	41%	44%
Indirect N2O Emissions from Manure Management - Sheep	N2O	12%	65%	66%
Indirect N2O Emissions from Manure Management - Swine	N2O	20%	41%	46%
Indirect N2O Emissions from Manure Management - Goats	N2O	20%	65%	68%
Indirect N2O Emissions from Manure Management - Poultry	N2O	20%	53%	57%
Indirect N2O Emissions from Manure Management - Rabbits	N2O	20%	65%	68%
Indirect N2O Emissions from Manure Management - Horses	N2O	20%	65%	68%

Table 5-23 Parameters, equations and default emission factors used in the calculation of methane emissions from manure management, cattle.

3.B MANURE MANAGEMENT (CH_4)							
Parameter	Unit	Source	DC T2/D	NLC T2/D	B T2/D	C T2/D	GC T2/D
UE		P10.42	0.04	0.04	0.04	0.04	0.04
ASH		P10.43	0.08	0.08	0.08	0.08	0.08
BO		Table 10.16 IPCC refinements	0.24	0.18	0.18	0.18	0.18
MCF	%	Table 10A4 (DC) Table 10A5 (OC)	4	4	4	4	4
DE%	%		taken from Enteric Fermentation				
GE	MJ/day	Eqn. 10.16	taken from Enteric Fermentation				
VS		Eqn. 10.24 IPCC Refinements	GE(1-DE%/100)+(UE*GE))*((1-ASH)/18.45)				
MMCH4 EF	Kg CH_4/head/yr	Eqn 10.23	(VS*365)*(BO*0.67*(MCF/100))				
Emissions	Gg CO_2 eq.	Eqn. 10.19	((EF*Population)/1000000)*GWP				

Table 5-24 Parameters, equations and default emission factors used in the calculation of methane emissions from manure management, swine.

Parameter	Unit	Source	Swine T2/CS
ML (Manure Solid + Urine)	kg/animal/day	Sustech 2008 Table 4	16.05
DS%	%	Sustech 2008 Table 4	1.55
VS%	%	Sustech 2008 Table 7	61.1
BO	$m^3 CH_4$/Kg VS	Table 10.16 IPCC refinements	0.45
SATS	%	Directive (revised from 0.1 to 0.05 after adoption of directive) in 2013	0.05
MCF (storage >1 month)		Table 10.17	3
MCF (storage <1 month)		Table 10.17	39
MDM			ML*(DS%100)
VS			VS%*(MDM/100)
MCF (@19 degC)		%	(3*(1-0.05))+39*0.05
EF sewer		Eqn 10.23	(VS*365)*(BO*0.67)*(MCF/100*(1-SATS)
EF soil		Eqn 10.23	(VS*365)*(BO*0.67)*(MCF/100*SATS)
EF Total		Eqn 10.23	EF Sewer + EF Soil
Emissions	Gg CO_2 eq.	Eqn. 10.19	(EF Total * Population/1000000)*GWP

Table 5-25 Parameters, equations and default emission factors used in the calculation of methane emissions from manure management, poultry and rabbits.

Parameter	Unit	Source	Layers	Broilers	Other Poultry	Rabbits
			T2/CS	T2/CS	T2/CS	T2/CS
ML (Manure Solid + Urine)	L/animal/day	Sustech 2008 Table 4	0.167	0.149	0.149	1.97
Density	Kg/m3		944	503	503	717
DS%	%	Sustech 2008 Table 4	29.44	46.15	46.15	26.28
VS%	%	Sustech 2005, pg 59	74.06	85.97	85.97	84.4
BO	$m^3 CH_4$/Kg VS	Table 10.16 chicken/Table 10.15 rabbits IPCC refinements	0.39	0.36	0.36	0.32
MCF		Table 10.17 poultry / Table 10A-9	1.5	1.5	1.5	1
Mkg			(ML*density)/100			
MDM			(DS%*Mkg)/100			

VS			VS%*(MDM/100)
EF sewer		Eqn. 10.23 IPCC 2019 Refinements	(VS*365)*(EO*0.67)*(MCF/100)*AWMS)
Emissions	Gg CO_2 eq.	Eqn. 10.19	((EF*population)/1000000)*GWP

Table 5-26 Parameters, equations and default emission factors used in the calculation of methane emissions from manure management, sheep, horses and goats.

Parameter	Unit	Source	Sheep T1/D	Horses T1/D	Goats T1/D	
EF	G CH_4 KG VS-1	Table 10.14 IPCC refinements 2019	1.3	7	1.3	*Sheep and goats: low productivity, dry lot; horses: low productivity, solid storage.
VS	kg VS (1000kg animal mass)-1 day-1	Table 10.13a IPCC refinements 2019	8.2	5.65	9	
AWMS	fraction of total annual VS for each livestock species/category		1	1	1	
Emissions	Gg CO_2 eq.	Eqn. 10.22 IPCC 2019 Refinement		(((VS*AWMS*EF*population)/1000))/1000000)*GWP		

Table 5-27 Parameters, equations and default emission factors used in the calculation of direct nitrous oxide emissions from manure management, cattle and swine.

3.B. MANURE MANAGEMENT (N2O) - DIRECT			Cattle					Swine					
Parameter	Unit	Source	DC	NLC	B	C	GC	piglets <20kg	young piglets 20-50kg	fattening pigs >51kg	breeding sows	gilts	breeding boars
			T1/D	T2/D	T2/D	T2/D	T2/D	T1/D	T1/D	T1/D	T1/D	T1/D	T1/D
MMS					Solid Storage					Pit storage below animal confinement			
Weight	K Tonna (2018)		550	640	630	200	400	10.5	35	75	175	120	250
Nrate(T)		Table 10.19 (DC, Sheep) /Table 10.20 (OC)	0.5	0.42	0.42	0.42	0.42	0.76	0.76	0.76	0.38	0.38	0.38
EF3 for direct N2O Emissions	KgN2O-N/yr	Table 10.21 Refinements	0.01	0.01	0.01	0.01	0.01	0.002	0.002	0.002	0.002	0.002	0.002
NexT		Eqn. 10.30 (IPCC Refinements)			0					(LW*Nrate(T)*365)/1000			
Nitrogen Excretion					Population*NexT					Population*NexT			
Nloss		Part of Eqn. 10.25			EF*Nitrogen Excretion					EF*Nitrogen Excretion			
N_2O_D (MM)					((Nloss*44/28)/1000000)*GWP					((Nloss*44/28)/1000000)*GWP			

Table 5-28 Parameters, equations and default emission factors used in the calculation of direct nitrous oxide emissions from manure management, sheep, goats and horses.

3.B. MANURE MANAGEMENT (N2O) - DIRECT			Sheep			Goats	Horses
Parameter	Unit	Source	ME	OMS	GL		
			T1/D	T1/D	T1/D	T1/D	T1/D
MMS				Deep Bedding		Deep Bedding	Solid Storage
Weight			50	60	20	35	550
Nrate(T)		Table 10.19 (DC, Sheep) /Table 10.20 (OC)		0.36		0.46	0.26
EF3 for direct N2O Emissions	KgN2O-N/yr	Table 10.21 Refinements	0.01	0.01	0.01	0.01	0.01
NexT		Eqn. 10.30 (IPCC Refinements)		(LW*Nrate(T)*365)/1000		(LW*Nrate(T)*365)/1000	(LW*Nrate(T)*365)/1001
Nitrogen Excretion				Population*NexT		Population*NexT	Population*NexT
Nloss		Part of Eqn. 10.25		EF*Nitrogen Excretion		EF*Nitrogen Excretion	EF*Nitrogen Excretion
N_2O_D (MM)				((Nloss*44/28)/1000000)*GWP		((Nloss*44/28)/1000000)*GWP	((Nloss*44/28)/1000000)*GWP

Table 5-29 Parameters, equations and default emission factors used in the calculation of direct nitrous oxide emissions from manure management, poultry and rabbits.

3.B. MANURE MANAGEMENT (N2O) Parameter	Unit	Source	Poultry Layers T2/CS	Poultry Broilers T2/CS	Poultry Other Poultry T2/CS	Rabbits T1/D
MMS				Poultry manure with litter		Poultry manure without litter
Weight	Kg		n.a.	n.a.	n.a.	n.a.
Nrate(T)		Sustech /IPCC refinements (Rabbits) table 10.19	0.87	0.82	0.82	8.1
EF3 for direct N2O Emissions	KgN2O-N/yr	Table 10.21 Refinements	0.001	0.001	0.001	0.001
NexT		Eqn. 10.30 (IPCC Refinements)	n.a.	n.a.	n.a.	n.a.
Nitrogen Excretion				Nrate(T)*Population		Nrate(T)*Population
Nloss		Part of Eqn. 10.25		EF*Nitrogen Excretion		EF*Nitrogen Excretion
N_2O_D (MM)				((Nloss*44/28)/1000000)*GWP		((Nloss*44/28)/1000000)*GWP

Table 5-30 Parameters, equations and default emission factors used in the calculation of indirect nitrous oxide emissions from manure management, all livestock categories.

3.B. MANURE MANAGEMENT (N2O) - INDIRECT Parameter	Unit	Source	Cattle Dairy cattle	Cattle Other cattle	Swine	Poultry Layers	Poultry Broilers and other Poultry	Sheep	Goats	Horses	Rabbits
FracGasMS	%	Table 10.22	30	45	25	40	40	40	40	12	48
EF4	KgN2O-N	Table 11.3	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Nvol							Nex * FracGasMS				
$N2O_{Indirect}$ (MM)		eqn 10.28					((Nvol*EF4*(44/28))/1000000)*GWP				

*DC: Dairy Cattle; OC: Other Cattle; SW: Swine; L: Layers; BOP: Broilers & Other Poultry; SH: Sheep; G: Goats; H: Horses; R: Rabbits

5.3.4 Category-specific QA/QC and verification

Wherever possible, data was verified with other sources, such as National statistics office data with FAOSTAT data. Commencing in 2019, the Ministry for Sustainable Development, Environment, and Climate Change (MSDEC) commissioned a study entitled "*Technical support on the Emission Framework for the Agricultural Sector in Malta*", under the European Commission's SRSS Programme, as 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).

5.3.5 Category-specific recalculations

Revisions listed under Enteric Fermentation Recalculations have had an impact on the emissions from manure management.

Table 5-31 A table of recalculations for Manure Management.

Year	Manure Management (Gg CO2 eq.) as reported in the previous inventory report	Manure Management (Gg CO2 eq.) as reported in this inventory report	Percentage change in reported emissions (%)	*Change in Gg CO2 eq.*
1990	18.59	32.00	72.11%	*13.41*
1991	19.29	33.14	71.82%	*13.85*
1992	19.42	33.45	72.27%	*14.03*
1993	19.46	33.46	71.99%	*14.01*
1994	19.10	32.85	72.00%	*13.75*
1995	18.55	32.02	72.63%	*13.47*
1996	18.35	32.30	76.09%	*13.96*
1997	18.47	32.27	74.69%	*13.80*
1998	17.69	30.62	73.16%	*12.94*
1999	17.88	30.83	72.47%	*12.95*
2000	18.16	29.90	64.62%	*11.74*
2001	18.15	28.96	59.58%	*10.81*
2002	18.18	29.39	61.63%	*11.21*
2003	17.47	28.90	65.40%	*11.43*
2004	17.66	29.58	67.55%	*11.93*
2005	17.72	28.98	63.52%	*11.26*
2006	17.71	28.02	58.24%	*10.31*
2007	18.28	28.46	55.68%	*10.18*
2008	17.34	27.42	58.15%	*10.08*

2009	16.62	26.40	58.86%	*9.78*
2010	15.99	25.56	59.89%	*9.58*
2011	14.86	23.85	60.55%	*9.00*
2012	15.10	23.89	58.24%	*8.79*
2013	15.15	23.54	55.39%	*8.39*
2014	15.01	23.55	56.91%	*8.54*
2015	15.36	23.79	54.82%	*8.42*
2016	14.83	23.02	55.22%	*8.19*
2017	14.47	22.82	57.66%	*8.34*
2018	14.87	*23.77*	59.83%	*8.90*

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 2019, nitrous oxide emissions from agricultural soils accounted for 24.7% of the total agricultural emissions.

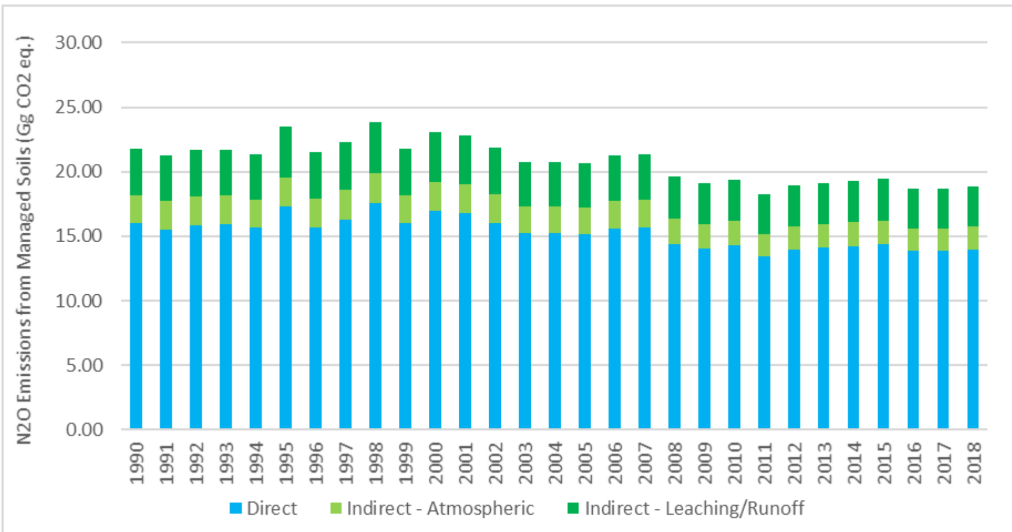

Figure 5-4 A representation of the direct and indirect N_2O emissions from Agricultural Soils.

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}).

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

There are two possible sources to establish the input of nitrogen from synthetic fertilisers on managed soils for the estimation of both direct and indirect N_2O emissions. One is using data on the consumption of fertilisers on a national level, derived from importation/trade data, and the other is using nitrogen application rates on the basis of fertiliser use data for different crops, aggregated on a national level. In fact, the source for the latter rates is the NSO study on the gross nitrogen balance for Malta conducted in 2007 and published in 2008[27].

At present, no information is readily available on the usage of synthetic nitrogen fertiliser. Efforts are still being made to obtain the actual and real value of the N fertiliser applied. Several meetings were held in conjunction with the Ministry for the Environment, Sustainable development & Climate Change and with the department of Agriculture in the hopes for this data to be collected and continuous efforts to be maintained until this data is obtained.

Moreover, a revision in methodology has allowed for the estimation of average nitrogen rate per hectare, which is being derived based on the consumption and application data, as well as the historic distribution of the UAA. This shows the trend in average N application based on 2 strands of data; one based on the gross nitrogen balance and another on the Fertilizer consumption data and UAA.

As seen in the figure, the trend of fertilizer application to soils has increased from 1990 levels, however decreased along the years.

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 not available for the entire time-series: 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 is used for filling of gaps in the 1991 - 2000 period. Additionally, for those years for which actual 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 data is available.

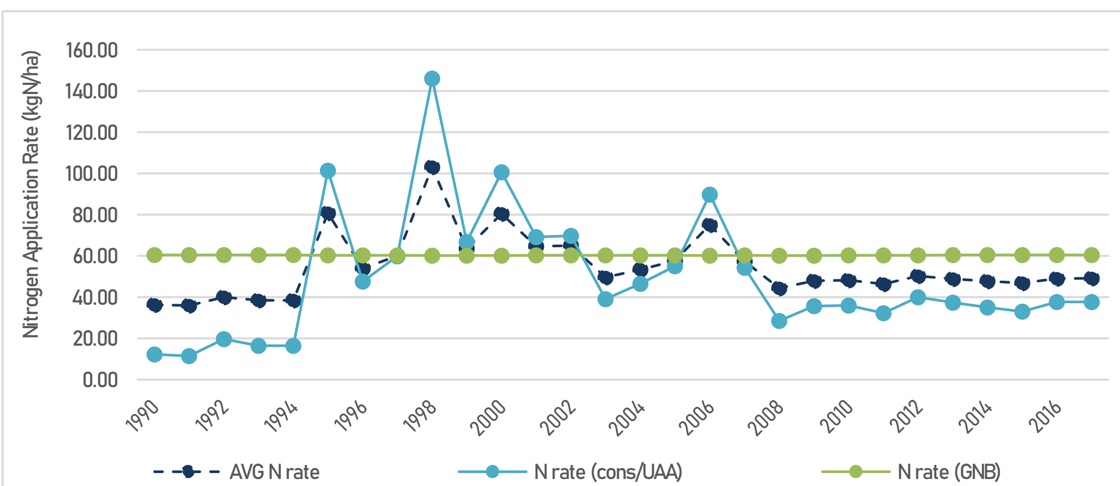

Figure 5-5 Average Nitrogen Application Rate derivation based on the Gross Nitrogen Balance value and on consumption data and UAA.

[27] Gross Nitrogen Balance for Malta, 2007. NSO. 2008.

5.5.2.1.2 Animal Manure Nitrogen Applied 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. Therefore, the sum of N lost as direct N_2O, total N volatilised and swine manure N going to sewers is subtracted from the total N excreted. In the case of 2019, 1571467.11 kgN were available for application to soils (see equation 5.3 below).

Equation 5.3

$$2{,}602{,}733.60 - 13{,}629.99 - 10{,}36288.9 + 18652.28 = 1{,}571{,}467.11\text{kgN}$$

For the estimation of emissions due to pig slurry, the assumption that only a small fraction of pig slurry is applied to soils, is made. Since it is customary for almost all pig slurry to be flushed into the sewerage system, in effect any emissions from the slurry are considered at the sewage treatment plant. Therefore, in order to avoid double counting of emissions – as applied on land and as treated in the sewage treatment plant – the same assumptions made for calculating methane emissions from manure management of pig slurry are made when transferring nitrogen from pig slurry to agricultural soils.

The amount of nitrogen transferred to the sewage system is passed on to the Waste sector for accounting under that sector. As for the estimations from cattle, sheep, goat, poultry, rabbit and horse manure applied to soil, equation 10.34 of the 2019 IPCC refinements is used.

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. For example, 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*".

It was communicated to Malta's agricultural inventory compiler, during an Agriculture stakeholder meeting towards the end of 2020, that the organic fertilizer application in Malta comprises of livestock manure. Hence, the application of organic fertilizer in our calculations is being taken from manure management only.

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. These crops constitute a significant share of the total utilised agricultural area, standing at 55% in 2013.

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].

Table 5-32 Land and crop areas in ha.

Parameter	Unit	1990	1995	2000	2005	2010	2015	2017	2018	2019
Total agricultural land (managed soils)	ha	13493	11418	9342	11071	12529	14084	13199	13199	13199
Total UAA	ha	12839	10864	8889	10254	11453	13206	11929	11929	11929
Total land area under fodder	ha	6421	5531	4642	4574	5553	5115	5647	5647	5647
Wheat	ha	2381	2400	2381	2618	2946	3050	3239	3082	3266
Barley	ha	542	550	542	550	517	498	529	503	533
Bean	ha	259	304.3	349.3	380.5	425.0	490.0	429.7	480	421
Other Fodder (including green beans and chickpeas)	ha	334	205.2	76.6	52.2	63.2	58.4	62.0	59.0	63
Potato	ha	1783	1400	1783	820	701	700.0	690.0	690	690
Carrot	ha	53	57.7	65	35	51	47	47	47	47
Clover (sulla) & Vetch	ha	1040	756	472	426	515	477	506	482	510

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. These are tabulated in Table 5-33.

Table 5-33 Emission factors used in the calculation of N_2O emissions from agricultural soils.

Parameter	Description	Source	Unit	EF
EF1	Default EF for direct N2O emissions from managed soils - fertilisers	IPCC 2019 Table 11.1	kg N2O-N/kgN	0.01
EF4	Default EF for indirect N2O emissions from volatilisation	IPCC 2006 Table 11.3	kg N2O-N/kgN	0.01
EF5	Default EF for indirect N2O emissions from leaching	IPCC 2006 Table 11.3	kg N2O-N/kgN	0.0075
FracGasF	Default EF for nitrogen loss due to volatilisation - fertiliser (kg NH3-N + NOx-N)	IPCC 2006 Table 11.3	kg N applied/deposited	0.1
FracGasM	Fraction of livestock N excretion that volatilises as NH3 and NOx	IPCC 2006 Table 11.3	kg N2O-N/kg N excreted	0.2
FracLeach	Default EF for Nitrogen loss due to leaching	IPCC 2006 Table 11.3	kg N	0.3

For the estimation of direct emissions, the total nitrogen applied to soils is multiplied by the respective emission factor (EF_1). In the case of the annual amount of N in crop residue retuned to soil, equation 11.6 of the 2019 IPCC refinements was used. Table 5-34 to Table 5-38 give the activity data, parameters and equations used in the calculation of N applied/ returned to soils.

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).

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 5-34 Nitrogen applied/returned to soils.

Parameter	Unit	1990	1995	2000	2005	2010	2015	2017	2018	2019
N application Rate	kg N/ha	36.31	80.82	80.43	57.63	48.19	46.78	49.08	49.10	49.12
Annual amount of synthetic fertilizer N applied to soils	kg N yr-1	466143	780228	714983	590892	551925	617749	585487	585705	585922
Annual amount of animal manure N applied to soils	kg N yr-1	2064175	1999193	2039093	1909301	1719448	1654880	1552079	1604871	1571467
Annual amount of N in crop residue returned to soils	kg N yr-1	878182	803181	813758	722806	773171	787398	816872	791289	821135
Annual amount of N mineralization associated with loss of soil	kg N yr-1	9405.00	12375	15390	12825	8550	4275	2565	1710	855

Table 5-35 Equations used for the estimation of nitrogen availability for soils.

Nitrogen Available to Soils	
Total N excreted	∑(direct Nitrogen Excretion (Nex))
Nloss as direct N2O	∑(Direct Nloss)
Total N volatislised	∑(Indirect Nvol)
Fraction of slurry applied to soils	0.10KgN (1990-2012), 0.05KgN (2013 onwards)
Swine slurry applied to soils	(Nex-Nloss-Nvol)*Fraction of slurry applied to soils
Total N available for application to soils (goes to Agricultural Soils 3.D.1.2.a)	(Nex cattle+Nex poultry+Nex sheep+Nex goats+Nex horses+Nex rabbits) – (Nloss cattle+Nloss poultyr+Nloss sheep+Nloss goats+Nloss horses+Nloss rabbits)-(Nvol cattle+Nvol poultyr+Nvol sheep+Nvol goats+Nvol horses+Nvol rabbits) + (Swine slurry applied to soils)
Swine manure N going to sewers (goes to waste sector)	N excretions swine – Nloss swine – Nvol swine)*(1-Fraction of slurry applied to soils)

Table 5-36 Equations used for the estimation of nitrogen fertilizer application to soils and nitrogen in crop residues.

3.D. Agricultural Soils Parameter	Unit	Source	Crop Residues
Areas		NSO/FAOSTAT	Time series data (1990-X-2)
Avergae N rate	KgN/ha	Worked out based on application and cnsumption data and calculated on change in UAA	Time series data (1990-X-2)
Averae FSN	KgN/ha		Average N rate*UAA
CropT (wheat, barley, sulla)		DMY (Vella, 1997)	(DMY*10000)/100
CropT (potato)		Yield (Vella, 2001), DMC (IPCC)	Yield *DMC
CropT (carrot)		Yied (manuale di concimazione in NSO 20017), DMC (IPCC)	Yield *DMC
CropT (bean)		DMC (IPCC)	Assumed in accordance to low yield levels reported from other countries; no data for MT.
AGDM		Table 11.2	((CropT/100)*slope)+Intercept
RAG(T)			AGDM*1000
AGDM			(RAG(T)+CropT)//CropT
FCR (Annual amount of N in crop residues)	KgN/yr		CropT*CropArea*((RAGT*NAG)+(RBG*NBG)
FCR (Annual amount of N in crop residues)	KtN/yr		FCR/1000000

Table 5-37 Parameters used in the estimation of nitrogen from crop residues.

	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

Table 5-38 Equations used for the estimation of nitrous oxide emissions from agricultural soils.

3.D.1. Direct N2O Emissions	
FSN	Taken from Fertilizer data
FON	Taken from N available to Soils
FCR	Taken from Crop Residue returned to soils
FSOM	N mineralized from LULUCF
Total N applied to soils	∑(FSN+FON+FCR+FSOM)
Annual Direct N2O-N Emissions	
3.D.1.1. Synthetic Fertilizer Emissions	((FSN*EF1)*44/28)/1000000
3.D.1.2.a Animal Manure N Emisisons	((FON*EF1)*44/28)/1000000
3.D.1.4. Crop Residue Emissions	((FCR*EF1)*44/28)/1000000
3.D.1.5 N mineralized Emissions	((FSOM*EF1)*44/28)/1000000
N1ODirect-N	∑(FSN Em+FON Em+FCR Em+FSOM Em)*298
Annual N addition (from manure + synthetic fertilizer addition)	(FSN+FON)/UAA

Annual amount of Volatilized N2O emissions from atmospheric depostion	(FSN*FracGasF)+(FON*FracGasM)
3.D.2.1. N2O Emissions	(((N2O Volatilised*EF4)*44/28)/1000000)*298
N from fertilizers and other agricultural inputs that is lost through leaching and run-off	Total N applied to soils * FracLeach
3.D.2.1. N2O Emissions	(((Nleach*EF5)*44/28)/1000000)*298
Total N emissions from managed soils	N2O Direct + N2O Indirect + N2O Leached

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 is planned to take place in 2021, and although no exact completion date can be provided at this point, it is assumed that it will be completed by end of 2021. 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 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.

The inconsistencies in *Utilisable Agricultural Land Area* (UAA), *Fodder Crop Land* (FCL) and *Total Agricultural Land* (TAL) 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.

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. Table 5-39 below gives the uncertainty of activity data and emissions factors in the estimation of emissions from managed soils.

Table 5-39 Uncertainty of activity data and emission factors used in estimation of emissions from managed soils.

IPCC Category	Gas	AD Uncertainty	EF Uncertainty	Combined Uncertainty
Direct N2O Emissions from Managed soils – Synthetic Fertilizer	N2O	100%	20%	102%
Direct N2O Emissions from Managed soils – Animal Manure	N2O	18%	36%	40%
Direct N2O Emissions from Managed soils – Crop Residue	N2O	10%	30%	32%
Direct N2O Emissions from Managed soils - Mineralization	N2O	5%	30%	30%
Indirect N2O Emissions from Managed soils – Atmospheric Deposition	N2O	45%	35%	57%
Indirect N2O Emissions from Managed soils – Runoff and Leaching	N2O	33%	20%	39%

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. Sector-specific revisions followed the outcomes of the ESD Review 2020 as well as recommendations made during the UNFCCC review of 2018.

5.5.5 Category-specific recalculations

Revisions in the $N_{rate(T)}$ as well as livestock weights resulted also in recalculations for the sector Agricultural Soils. Additionally, revisions in the methodologies adopted within the LULUCF sector for the estimation of direct and indirect N_2O emissions associated with the SOC losses in Mineralised soils have given raise to recalculations within the Agricultural Sector. Subsequently, a decrease in the N2O and total emissions in the Agricultural sector can be observed as illustrated in Table 5-40 and the CRF Category 3.D.1.5 entitled *"N in mineral soils that is mineralized in association with loss of soil C."*

Table 5-40 A table of recalculations for the Agricultural Soils sector.

Year	Agricultural Soils (Gg CO2 eq.) as reported in the previous inventory report	Agricultural Soils (Gg CO2 eq.) as reported in this inventory report	Percentage change in reported emissions (%)	*Change in Gg CO2 eq.*
1990	21.83	21.76	-0.35%	*-0.08*
1991	21.33	21.26	-0.34%	*-0.07*
1992	21.75	21.68	-0.31%	*-0.07*
1993	21.83	21.73	-0.44%	*-0.10*
1994	21.57	21.38	-0.87%	*-0.19*
1995	23.73	23.47	-1.13%	*-0.27*
1996	21.69	21.48	-0.96%	*-0.21*
1997	22.43	22.25	-0.79%	*-0.18*
1998	24.04	23.88	-0.68%	*-0.16*
1999	21.82	21.77	-0.26%	*-0.06*
2000	22.83	23.05	0.95%	*0.22*
2001	22.58	22.85	1.18%	*0.27*
2002	21.67	21.83	0.73%	*0.16*
2003	20.80	20.78	-0.07%	*-0.01*
2004	20.66	20.74	0.38%	*0.08*
2005	20.60	20.63	0.13%	*0.03*
2006	21.05	21.22	0.82%	*0.17*
2007	21.13	21.34	0.98%	*0.21*
2008	19.55	19.63	0.41%	*0.08*
2009	19.05	19.11	0.34%	*0.06*
2010	19.30	19.38	0.41%	*0.08*
2011	18.20	18.23	0.16%	*0.03*
2012	18.87	18.93	0.31%	*0.06*
2013	19.02	19.14	0.61%	*0.12*
2014	19.17	19.27	0.54%	*0.10*

2015	19.33	19.42	0.43%	*0.08*
2016	18.78	18.73	-0.27%	*-0.05*
2017	18.77	18.69	-0.45%	*-0.08*
	18.93	*18.89*	-0.21%	*-0.04*

5.5.6 Category-specific planned improvements

Efforts are being made to obtain data on evapotranspiration and precipitation. Moreover, it is planned that a re-evaluation of the information that is currently available, with reference to animal waste management systems and leaching of nutrients arising from non-conforming farms, is carried out.

At present, no information is readily available on the usage of synthetic nitrogen fertiliser. Efforts are still being made to obtain the actual and real value of the N fertiliser applied. Several meetings were held in conjunction with the Ministry for the Environment, Sustainable development & Climate Change and with the department of Agriculture in the hopes for this data to be collected and efforts would keep being made until this data is obtained. Commencing in 2019, the Ministry for Sustainable Development, Environment, and Climate Change (MSDEC) commissioned a study entitled "*Technical support on the Emission Framework for the Agricultural Sector in Malta*", under the European Commission's SRSS Programme, as 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 Judgments 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).

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 to 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.[28]

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.

[28] Estimation of greenhouse gas emissions from agricultural activities for Malta's inventory. Final Report. October 2015. Sammut and Associates.

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]. 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. It is known that most likely the bulk of urea imports goes towards utilisation by the energy generation sector. 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. Therefore, this category is reported as not estimated.

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. 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. However, we will keep investigating those sources for a possible indication. 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.

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 LAND USE, LAND-USE CHANGE AND FORESTRY

6.1 OVERVIEW OF SECTOR

In this chapter emissions and removals of greenhouse gases from the Land Use, Land-Use Change and Forestry sector are presented, and methodologies used to estimate emissions/removals by each source/sink category are described. The calculations for this sector were formulated using the '2006 IPCC Guidelines for National Greenhouse Gas Inventories' and the '2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories' following 'Volume 4: Agriculture, Forestry and Other Land Use', which were applied for all 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, were, assistance was 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 CO_2 and other greenhouse gases are based on the following 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 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 for the production of specific, more accurate and reliable data about land use change at national level. This 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 this 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 in order to adapt the process to the Maltese geography and land use singularity. These are the key aspects:

- 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 concerns 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 is 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 needed. 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 welltrained 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 colours (RGB). 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', 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 National Forestry Accounting Plan (NFAP) & Forest Reference Level (FRL) for 2021-2025 (Task 1) pursuant to Article 8(3) of Regulation (EU) 2018/841[29], and of GHG inventories of emissions and removals needed for accounting under the same Regulation (Task 2). The support under Task 1 was held in October 2018, whereas for Task 2 was held in September 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 is 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 National Forestry Accounting Plan (NFAP) and the Forest Reference Level (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

[29] 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

methodology and modelling necessary to create the NFAP and FRL establishment, 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 Joint Research Centre (JRC) under the above-mentioned project. The visit served to assist Malta to prioritise and identify the main issues which were highlighted to be of significant importance for the improvements 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 FL based on new data sources

The following describes the issues in-depth and these shall be addressed through the recommendations proposed by the project experts, as concluded in the final capacity building plan report. It is important to note that, these issues are highly extensive and require a significant degree of arrangements and resources to be set up and performed, incurring several years of work to accomplish such a system and to be fully functional. The LULUCF Inventory compiler is currently working on his sole capacity to address the issues stated above and perform the improvements in the LULUCF sector, due that the resources and knowledge are highly limited, and hence noting the extensive amount of time incurred to perform the improvements by a single compiler. As a result, work is currently ongoing on the implementation of this system, however concrete timeframes of when certain issues (especially issues 1 & 2) will be addressed collectively and fully in future submissions are unknown at this stage.

Issue 1

Malta is currently using Approach 2 for land use (LU) representation; the current source of information for the LU matrix are Corine Land Cover layers contained in a geodatabase managed by the Planning Authority (PA) and complemented by the National Statistics (NS) retrieved from the National Statistics Office (NSO) of Malta. Statistics regarding the various CLCs layers (1990, 2000, 2006, 2012) are received and compared to the national statistics. There are several inconsistencies between the two sources of statistical information (NS and CLC), therefore, the NIR is not based on spatially explicit information but only on statistical information. The current representation of LU is not in line with the requirement of the EU Reg. 2018/1999[30] (Annex V, part 3), which requires a geographically-explicit LU representation and a yearly update of the land use matrix (LUM).

Moving towards Approach 3 would improve the accuracy of estimates in terms of carbon emissions and removals in Malta, based on the explicit tracking of land use in each parcel of land. This approach would

[30] Regulatiom (EU) 2018/1999 of the European Parliament and of the council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council

allow the tracking of the location of land use changes, instead of providing only aggregate information of land use change between two years, thus it would also allow the consideration of the sequence of changes in each area and its implication in terms of carbon dynamics. The project experts recommended to implement all the various datasets available from national sources and from European sources, which were analysed and discussed during the visit, and as a result need to be harmonized and combined to provide a full coverage of all the different LULUCF categories on a yearly basis. The project experts further elaborated that this can be possible by combining different spatially explicit datasets from both historically and latest data available. The experts further recommended the country team to set up a geographical mapping system to integrate existing maps and other spatial explicit datasets for observing and tracking LUs over time. Once a base layer of polygons is set up for the entire country, it can host the land use information derived from national data together with other layers for all other LUs. Taking into account this national data, the land coverage would need to be extended by using also the other available spatial datasets and creating a 'reference land use grid' with a full coverage of all the different LU categories. Once created, the grid would need to be fully populated with current LU, updated with future land use changes, as well as filled with the past land uses in each grid-cell.

Issue 2

The CLC maps from 1990 to 2012 are used in combination with national statistics as an Approach 2 for the reconstruction of the LU matrix in Malta, the rest of the historical time series is reconstructed by backwards extrapolations from the CLC layers. There are inconsistencies between the definitions in national statistics and CLC for the different LU categories. The past land use matrix was based only on statistics (Approach 2) which need to be improved to track explicitly the location of LU changes over time. Until now, the main limitation for the CLC product was the minimum mapping unit (25 ha for status and 5 ha for changes), which make it unsuitable for tracking of forest land in Malta according to Malta national forest definition (the minimum forest area to be mapped is 1 ha). The very fragmented land use in Malta makes the CLC application difficult for other land use categories and the CLCs have not been statistically verified in Malta. The CLC layers would need to be verified and other spatial explicit information would need to be acquired for making the past land use consistent to the present and to create spatially explicit land use matrices in the future. There are inconsistencies between the different sources of data, and there is a current inability to track land uses changes backwards for 20 years (LU reported in 1990 would need to have a history of land from 1970) in a spatially-explicit way. The lack of historical information creates the inability to ascertain the level of confidence for the results of the GHG inventories produced for the past and affects also the current estimates. An improvement of the historical LU matrix is essential for the correct reporting under the IPCC and the LULUCF Regulation, especially for land categories which experienced significant changes in the past.

The project experts recommended that the approach for reconstructing the past land uses would need to start from a current grid with a mapping of the present land use in the recent years (i.e. 2010-2015). The reconstruction would start from the polygons that are being set up according to the methodology described in the solution for issue 1. These polygons would be filled with information collected in the past. Efforts would be needed for finding historic spatially explicit data, if available at all on a national scale, since at times this can be difficult to obtain. it was recommended to consider a consistent way of integrating the historical information into the national grid being constructed for present and future tracking of land uses.

Issue 3

Malta is currently retrieving information on the Cropland management from the National Statistics Office. One issue with this information is that it does not provide data for every single year and therefore some form of statistical interpolation and extrapolation for the past is needed. A more accurate spatial explicit and continuous estimation of the Cropland and Grassland could be possible by making use of the LPIS/IACS dataset. Malta has already included a CL sub-categorization by splitting perennial and annual crops in the NIR, and the respective surfaces are based on the NSO. There is also a sub-categorization of GL into “maquis Grassland” and “other Grassland”. In the NIR, parameters for the most frequent categories of perennials (vineyards) from other similar countries (Greece) are currently being used. Also, olive trees are present in Malta but to a minor extent compared to vineyards; therefore, they are currently not accounted for as a separate category but instead included in the calculations for vineyards (as perennials). The estimation of the CL assigned to annual/perennials could be improved upon with spatially explicit mapping of the different land use categories. Most of GL is currently unmanaged and unproductive; therefore, for GL the improvement in the categorization of management practices is not considered a priority by the country team. However, the project experts recommended that given the close interaction (in term of land use changes) between CL and GL, both land use categories would benefit from a spatially explicit revision of their LU matrix. The current assumption of conversion to CL only from GL is based on the trends observed in the CLC maps however, as discussed during the visit, that needs to be further verified by use of LPIS/IACS and the Nitrate Directive Registry information.

The project experts encouraged that the accuracy of carbon stock and emission factors sourced from Greece and IPCC 2006 for above ground biomass in CL and GL can be improved by means of updated common Mediterranean factors (ex: factors from the MediNet project under the LIFE). It has been noted that some of the reported values seem to need a revision (i.e. the conversion between tonne dry matter and tonne C). Based on the information on agricultural land contained in the IACS, it could be possible to also revise the selection of appropriate emission factors from the IPCC 2006, especially by making use of information on typical management practices in cropland (i.e. typical tillage and level of input) and applying updated factors from similar Mediterranean countries.

The experts emphasised that it is important to accurately represent the land use transitions between CL and GL, given the legacy effects in the soil carbon, as well as the transitions between the specified sub-categories. For the same reason, it is also relevant to consider the most appropriate values for the SOC stocks under different managements, as well as biomass accumulation rates and losses for each of the land use categories/sub-categories identified.

Issue 4

During the development of the FRL for Malta, the country team collected new data concerning the historical afforestation level in Malta (2018 submission of the NFAP). The afforestation was made in the past century (60s’). However, in the NFAP mostly “expert judgement” has been used for assessing the age of the forests on the afforested land, as well as the previous land uses. The experts recommended that the country team will need to update the FL category stratification in the NIR, by differentiating forests which have reached a maturity state (i.e. neutral balance between removals and emissions), forest still growing and removing carbon from the atmosphere (i.e. less than 100 years old) and forests which were planted less than 20 years ago (afforestation with associated land use conversion). Accordingly, the LUM for forests needs to reflect the proposed stratification and the dynamic transitions between the different classes and categories (i.e. FL, L-FL).

A harmonization of the NIR inventory to the new data collected during the development of the FRL is required for future accounting of emissions/removals reported, to be consistently compared to the submitted FRL. The experts further suggested the historical LUM should be updated with the new data sources regarding the afforestation. Currently, the historical LUMs used for the NIR and FRL are inconsistent. Some LU change to forest was observed in historical orthophotos but not yet incorporated into the LUM. The issue has been found during the previous capacity building assistance (2018) in preparation of the FRL. Possible sources of documentation were investigated together with the forest managing authorities. The country team is currently retrieving more information on the origin of land converted to FL which would allow to improve the LUM in a spatial explicit way and create the category of L-FL.

In summary, the key outcomes of the capacity building support visit and recommendations provided by the project experts were the following:

- 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.
- 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.
- 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.
- 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.

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 2019.

It is to note that currently Malta is undergoing efforts together with national entities, 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, the Land Parcel Identification System (LPIS) polygon maps, imagery of the Maltese Islands, Corine Land Cover map layers, Copernicus datasets and agriculture statistics.

The next step will require expert support for the integration and harmonisation of the different imagery and numerical datasets to form a single representative land use map. This would provide an accurate land use matrix and land use representation of the different categories of the LULUCF sector. The timeframes for this task will depend on the ability to source the appropriate expertise which will possibly also involve outsourcing the work to experts from outside Malta.

Efforts are and will be ongoing for continued development and improvement in the LULUCF sector, working with national stakeholders and entities, thus to try to increase the transparency and accuracy of the LULUCF chapter as possible, as well as incorporating the recommendations and improvements from the capacity building support exercises Task 1 and 2 along the way. Nonetheless, the issue of documentation of data and information present on a national level, more importantly country-specific data, still persists, and at times access to data primarily historical data can be quite difficult to obtain. The issue of lack of documentation can pose certain issues since it restricts the type of activity data and parameters that can be utilised to develop the calculations within the LULUCF categories in an accurate and complete way.

6.1.1 Emission and Removal trends

The Land Use, Land-Use Change and Forestry (LULUCF) sector can contribute to both emissions (from sources) and removals of CO_2 (through sinks). Overall, the sector accounted for 0.65 Gg of CO_2 equivalent emissions in 2019.

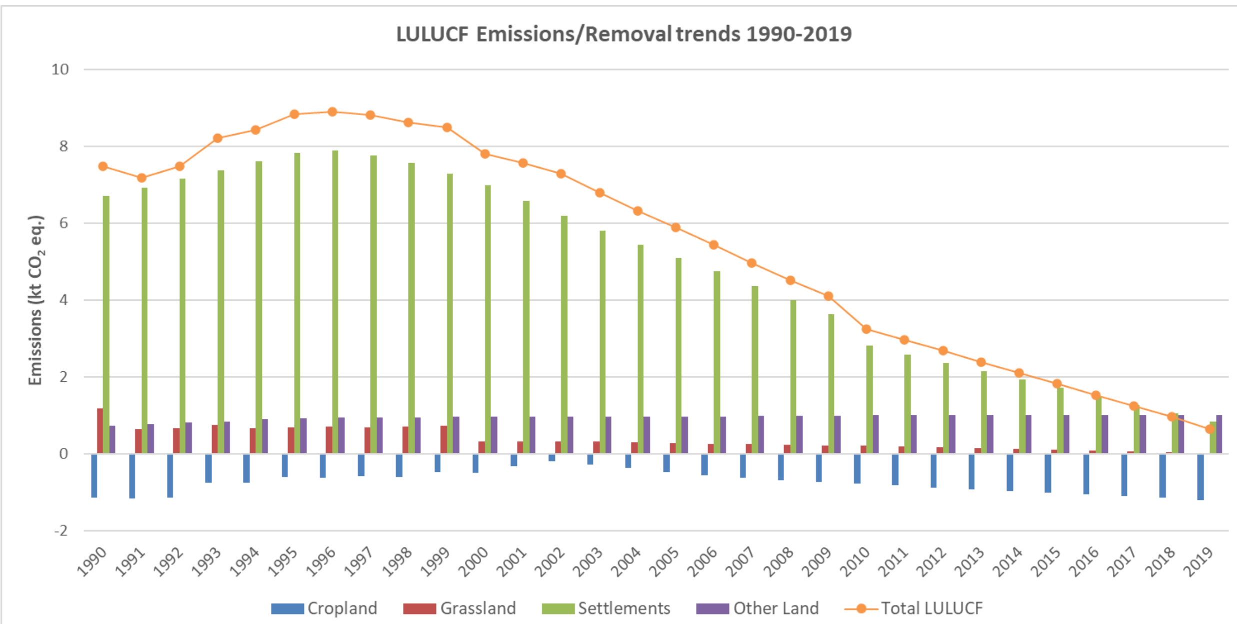

Figure 6-1 Total CO2 eq. removals and emissions for the LULUCF sector

CO_2 is the main greenhouse gas emission source and sink from the various categories. N_2O emissions also occur in the sector. Emissions from non-CO_2 greenhouse gases, such as CH_4 are not estimated since no data is available nationally on burning. 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.

For this year's submission, the LULUCF sector has undergone updates with regards to the Emission Factors utilised, to better represent the estimations in the sector. This was performed also in view of addressing the findings and recommendations in Issue 3 of Task 2 of the capacity building support mentioned in Section 6.1, as the project experts encouraged that the accuracy of carbon stock and emission factors can be improved by means of updated common Mediterranean factors. As a result, some of the factors were revised accordingly to better represent the different land use categories of Malta, especially in the context that the Maltese Islands for part of the Mediterranean region. Furthermore, this exercise was also performed to reduce the range of uncertainty within the Emission Factors used, and as a result decrease the potential uncertainties in the LULUCF sector. The relevant revisions as per the categories in the LULUCF sector are indicated in the following sections.

Table 6-1 below includes the total GHG emission/removal estimates for each category for the LULUCF sector for the period 1990-2019. **Table 6-2** shows the total GHG emission/removal estimates share by gas.

Table 6-1 GHG emissions/removals (kt CO2) by category from the LULUCF sector for the period 1990-2019.

Net CO_2 emissions/removals by category (kt CO_2)															
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
A. Forest Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Cropland	-1.13	-1.16	-1.15	-0.76	-0.76	-0.60	-0.62	-0.59	-0.61	-0.48	-0.49	-0.31	-0.19	-0.28	-0.38
C. Grassland	1.18	0.65	0.67	0.76	0.67	0.69	0.71	0.69	0.72	0.74	0.32	0.32	0.32	0.31	0.30
D. Wetlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Settlements	6.70	6.93	7.16	7.38	7.61	7.83	7.89	7.76	7.56	7.28	6.99	6.59	6.19	5.80	5.43
F. Other Land	0.72	0.77	0.81	0.83	0.90	0.93	0.93	0.94	0.95	0.96	0.97	0.97	0.97	0.97	0.97
G. HWPs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total LULUCF	**7.48**	**7.18**	**7.48**	**8.21**	**8.42**	**8.85**	**8.91**	**8.81**	**8.62**	**8.50**	**7.80**	**7.56**	**7.29**	**6.80**	**6.32**
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
A. Forest Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Cropland	-0.47	-0.56	-0.62	-0.69	-0.74	-0.78	-0.83	-0.87	-0.92	-0.97	-1.01	-1.06	-1.10	-1.15	-1.21
C. Grassland	0.28	0.26	0.25	0.23	0.21	0.22	0.20	0.17	0.15	0.13	0.11	0.08	0.06	0.04	0.02
D. Wetlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
E. Settlements	5.10	4.76	4.36	4.00	3.64	2.81	2.59	2.37	2.15	1.93	1.71	1.49	1.27	1.05	0.83
F. Other Land	0.97	0.97	0.98	0.99	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
G. HWPs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total LULUCF	**5.88**	**5.43**	**4.96**	**4.52**	**4.10**	**3.26**	**2.97**	**2.68**	**2.39**	**2.11**	**1.82**	**1.53**	**1.25**	**0.96**	**0.65**

Table 6-2 GHG emissions/removals (kt CO2 equivalent) by gas from the LULUCF sector for the period 1990-2019.

Net CO_2 emissions/removals by gas (kt CO_2 eq)															
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
CO_2	6.42	6.10	6.40	7.20	7.38	7.82	7.88	7.80	7.62	7.52	6.85	6.70	6.50	6.03	5.58
N_2O	1.06	1.09	1.08	1.01	1.04	1.02	1.03	1.01	1.00	0.98	0.95	0.87	0.79	0.77	0.74
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**

CO_2	5.16	3.78	4.28	3.86	3.47	2.69	2.42	2.14	1.86	1.58	1.30	1.02	0.74	0.46	0.18
N_2O	0.73	0.71	0.68	0.66	0.64	0.56	0.55	0.55	0.54	0.53	0.52	0.51	0.51	0.50	0.47

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 the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4 Agriculture, Forestry and Other Land Use, as well as the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume Agriculture, Forestry and Other Land Use. Moreover, specific estimates were derived also from assistance by the Joint Research Centre (JRC), and from Technical Expert Reviewers and consultants.

The data and information utilised to compile the LULUCF sector was derived from National Statistics Office (NSO) of Malta, and the Corine Land Cover (CLC) 1990, 2000, 2006 and 2012 land use maps, which are released by the Mapping Unit within the Malta Planning Authority (former Malta Environment and Planning Authority).

Since national information on emissions factors is not available, default information from the IPCC Guidelines were utilised, as well as data on Mediterranean countries acquired from the LIFE Project MediNet[31] which have closer land conditions to the Maltese conditions. For this year's submission some Emission Factors were revised to reflect better the land representation parameters of Malta, as well as, considering parameters and factors from countries which have similar conditions to the Maltese Islands. Further detail and information on the specific methodologies, as well as the choice of emission/removal factors are described in the relevant sections of this chapter. Table 6-3 below presents the data providers list for the data necessary to compile the LULUCF chapter.

Table 6-3 Data providers list

Description	Provider	Source
Area – Land Use Cover	Planning authority	Corine Land Cover
Area – Cropland	National Statistics Office	Farm Structure survey and Agriculture Census

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. Moreover, category Settlements is key in the Trend Assessment Approach 2 in the latest year, i.e., 1990. The shift in decreasing emissions in Settlements came about due to the decreasing 20-year cumulated area conversion periods in conversions to Settlements from 1996 onwards. 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.

[31] https://www.lifemedinet.com/

6.1.2.2 Uncertainty

The uncertainty in the LULUCF sector was established following recommendations from the ERT during previous reviews, as well as to improve the completeness in this sector. The uncertainty analysis was undertaken on the estimations of emissions from previous submissions to the present one, on the emission factors utilised for the calculations as well as on the activity data used.

The uncertainty analysis on the emission in this sector was analysed by comparing the emissions from past inventories to the latest inventory. Emissions from the period of 1990 to the latest submission period of 2019 were selected starting from the inventory submission of 2017 to the current inventory submission of 2021. The uncertainty in the emissions was calculated by applying a maximum and a minimum value of emission of the time-series. The average, standard deviation and count of the emissions in the time-series were computed, to then calculate the uncertainty levels of the emissions. The uncertainty in emission was calculated by dividing standard deviation calculation 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.

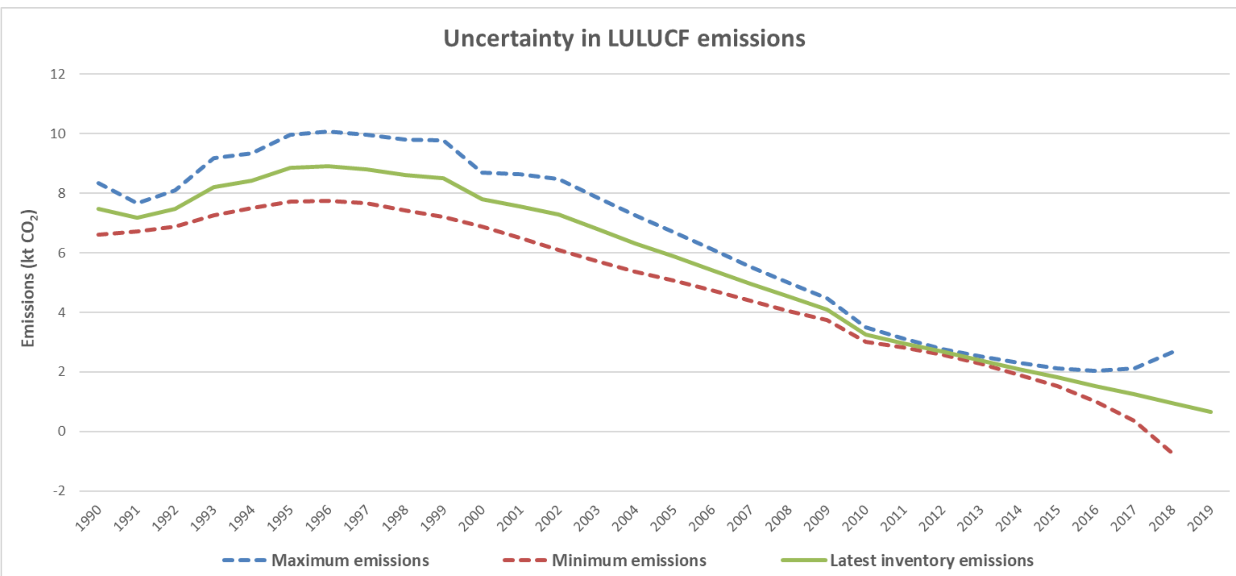

Figure 6-2 Uncertainty graph for the emissions in the LULUCF sector.

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 the National Statistics Office and the Corine Land Cover (CLC). 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 also, where this uncertainty 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 %)"*[32]. No national data on uncertainty level is available currently on the CLC.

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 6-4 below indicates the completeness of the LULUCF sector by Method and Emission Factor details per category and sub-categories for each gas (referred also in the CRF tables).

Table 6-4 Summary of methodologies used in the LULUCF GHGI, by land use.

IPCC category	CO_2		N_2O		CH_4	
	Method	**EF**	**Method**	**EF**	**Method**	**EF**
A. Forest Land	NA	NA	NA	NA	NA	NA
1. FL remaining FL	NA	NA	NA	NA	NA	NA
2. Land converted to FL	NA	NA	NA	NA	NA	NA
B. Cropland	T1	D, OTH	T1	D	NA	NA
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	T1	D, OTH	NA	NA	NA	NA
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	NA	NA	NA	NA	NA	NA
1. WL remaining WL	NA	NA	NA	NA	NA	NA
2. Land converted to WL	NA	NA	NA	NA	NA	NA
E. Settlements	T1	D, OTH	T1	D	NA	NA
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	T1	D, OTH	T1	D	NA	NA
1. OL remaining OL						
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

[32] Source: http://land.copernicus.eu/pan-european/corine-land-cover/clc-2012)

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 and 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 as well as the Malta National Statistics Office.
- 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.

Moreover, the national GHG inventory of Malta has undergone several reviews 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 FRL, and the GHG Inventory. The most important issues that require significant action in the LULUCF sector are:

- More efforts need to be done to acquire a national land use map of Malta and the annual changes in land, thus presenting more accurate maps, and minimize or limit assumptions within the national land use matrix. This is based on the recommendations for the improvement exercise that was carried out during the Tasks of the capacity building support visit, which will be reflected in future submissions noting the extent of the update to take place.
- A revision of the Land Use Matrix to reflect better the historic and present land use situations of Malta, and thus try to eliminate the need for assumptions, and make efforts to limit the extrapolations within the time-series.
- The need for the collection of national data, mainly through field studies, related to the information on the parameters relevant to the specific sectors of the LULUCF sector, thus, to acquire country-specific data.

Table 6-5 QA/QC Checks performed for the LULUCF 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	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 emission factors	At times Yes, for other EFs

Country-specific emission factors		
Comparisons		
9	Are country-specific factors compared with IPCC default factors	No, country-specific factors not currently present
10	Is comparison between countries, including historical trends, min and max value, base and most recent year value, IEF performed	No
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
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:

- Better reconstruction of the land use areas and land use changes/conversions to acquire an accurate representation of the land use matrix for the years starting 1970 to the present year minus 2, following the experts' recommendation during the in-country capacity building support visits.
- Improved estimations in the categories and sub-categories of the LULUCF sector.
- Update in the Forest Land category, following the provision of new information and data related to Malta's woodland reserves.
- Correction of notation keys in the CRF tables.
- Use of various emission factors from other countries having similar land conditions to Malta, with the assistance of the external experts and reviewers.
- Uncertainty is being reported, and QA/QC checks being performed, following the recommendations from the ERT.
- More detailed information on the reporting of estimates and information on the national land use categories to improve the NIR.

Recalculations from this submission to the previous submission were reported in the LULUCF sector and recorded in the relevant sections for each LULUCF category.

A number of issues and recommendations identified in the LULUCF and KP-LULUCF sectors were addressed, while a few are currently being addressed or else planned to be addressed in future submissions, as part of the ongoing improvement in both sectors. The issues and recommendations were issued following the ERT's provisional views on the issues raised in the previous review report of the UNFCCC individual review of the annual submission of Malta submitted in 2017 'FCCC/ARR/2017/MLT'[33], which are depicted in **Table 6-6**. These are also based on Table 1 of the centralised review report of the 2019 annual submission of Malta. Moreover, **Table 6-7** contains additional provisional findings made during the 2019 centralised review of the annual submission of Malta, which are based on Table 2 of said report. The report containing the draft provisional main findings made during the 2019 review, was published on 14 September 2019.

Table 6-6 Status of implementation of issues and/or problems raised in the review reports of Malta (FCCC/ARR/2017/MLT) & based on Table 1 of the centralised review report of the 2019 annual submission of Malta

ID#	Issue and/or problem classification	Previous recommendation for the issue identified	Status
L3	4. General (LULUCF) (L.8, 2016) (L.8, 2015) (77, 2013) (80, 2012) Adherence to the UNFCCC Annex I inventory reporting guidelines	Report the sources of the uncertainty values.	Addressed. The uncertainty is being reported, and QA/QC checks being performed,
L9	Land representation (L.15, 2016) (L.15, 2015) Transparency	Report all information, including assumptions, on the method applied to construct a consistent land representation while using two different data sets (national statistics for cropland and forest land and CORINE land cover data for all other land uses).	Addressing. Work is ongoing to construct and develop the land representation and land use matrix to be more consistent.
L10	Land representation (L.16, 2016) (L.16, 2015) Transparency	Report a confusion matrix between the CORINE land cover/land-use categories and the IPCC land-use categories, including the two grassland subdivisions: woody grassland and non-woody grassland.	Addressing. Work is ongoing to construct and develop the land representation and land use matrix to be more consistent, thus to allow the development of the confusion matrix
L13	4.A.1 Forest land remaining forest land – CO_2 (L.19, 2016) (L.19, 2015) Transparency	Report any information collected from the surveillance system on any disturbance that has occurred on forest land and report the associated GHG emissions and subsequent removals.	Partially addressed. The relevant information is presented in the Forest Land chapter, however this will be further updated in future submission to reflect the changes in the sector.
L14	4.B Cropland – CO_2 (L.20, 2016) (L.20, 2015) Accuracy	Report information in the NIR to justify the selected age of maturity (26 years) for perennial crops.	Addressed. The relevant information is presented in the Cropland chapter.
L17	4 (III) Direct N_2O emissions from N mineralization/ immobilization and 4 (IV) Indirect N_2O emissions from managed soils – N_2O (L.22, 2016) (L.22, 2015) Completeness	Estimate direct and indirect N_2O emissions associated with SOC losses in mineral soils and report under the LULUCF sector the N_2O emissions originating from land categories that do not need to be reported under the agriculture sector (category 3.D (managed soils)) to avoid the double counting of N_2O emissions.	Addressed. The estimations were reported accordingly as indicated in the recommendation.
L18	4. General (LULUCF) – CO_2	The ERT recommends that Malta maintain consistency of the total areas for each land-use category between the land transition matrix in CRF table 4.1 and CRF tables 4B,	Addressed. The areas in CRF categories 4.A-4.F were updated accordingly to be consistent with

[33] FCCC/ARR/2017/MLT Report on the individual review of the annual submission of Malta submitted in 2017

		4C, 4E and 4F by including the land areas under conversion in the land-use change matrices.	CRF table 4.1
L.19	4.E.2.3 Grassland converted to settlements – N2O	The ERT recommends that Malta report in CRF table 9 the information required in relation to the use of the notation key "IE" for grassland converted to settlements.	Addressed. The information related to this issue will be entered manually in CRF Table 9
L.20	4 (IV).1 Atmospheric deposition – N2O	The ERT recommends that Malta report in CRF table 9 that the N2O emissions were included under the agriculture sector.	Addressed. The information related to this issue will be entered manually in CRF Table 9
KL.1	General (KP-LULUCF) (KL.1, 2016) (KL.1, 2015) Transparency	Report for each KP-LULUCF activity the following information in the NIR: (1) a description of how the definition of the activity has been implemented and applied consistently over time; (2) the methods used to calculate the carbon stock changes and GHG emission and removal estimates for each activity; (3) information on whether indirect and natural GHG emissions and removals have been factored out of the calculations; and (4) information that demonstrates that the activity has occurred since 1 January 1990 and is human-induced.	Addressing. Efforts are still ongoing to address and complete this information in the KP-LULUCF chapter to also reflect the updates in the Forest Land category
KL.2	General (KP-LULUCF) (KL.1, 2016) (KL.1, 2015) Transparency	Report information in the NIR on conversion of natural forest to planted forest.	Addressed. The relevant information is reported in the KP LULUCF chapter
KL.3	Deforestation (KL.3, 2016) (KL.3, 2015) Transparency	Justify in the NIR the absence of deforestation since 1990.	Addressed. This information was reported in the KP-LULUCF chapter
KL.5	Forest management (KL.5, 2016) (KL.5, 2015) Accuracy	Identify the areas that meet the forest definition and that are not reported under any KP-LULUCF activity and report on the impact of such exclusion on the accounting.	Addressed. The relevant information is reported in the KP LULUCF chapter
KL.7	Forest management (KL.7, 2016) (KL.7, 2015) Transparency	Report in the NIR information on the entities involved in the implementation of the forest management plan, including surveillance, and information on the entities involved in the monitoring of forest land, so that anthropogenic sources and sinks are identified and the associated emissions and removals are reported when they actually occur.	Partially addressed. Information on the management plans is provided in this submission. However, more information will be presented in future submissions to reflect the estimations in this category
KL.8	Forest management – CO2	The ERT recommends that Malta report AD for forest management in CRF table 4(KP-I) B.1.	Partially addressed. The information related to this issue was entered accordingly in the CRF, however this will be updated in future submissions to reflect the estimations in this category.

Table 6-7 Additional findings made during the centralised review of the 2019 annual submission of Malta

ID#	Finding classification	Description of the finding with recommendation or encouragement	Status
L.10	4. General (LULUCF) – CO2, N2O	The ERT noted that Malta reported in the NIR, chapter 6.1, that the results of the UNFCCC in-country review and the in-country capacity building support on the Forest Reference Level are going to be used for the updating Forest Land category reporting in the next submission. During the review process Malta informed ERT that through the capacity building support with regards to the establishment of the National Forestry Accounting Plan new information has been acquired to report and update the Forest Land and Forest Management categories in the next submission. Also, as part of the implementation of the LULUCF	Addressing. The improvement plan of the issues and recommendations is described in this submission. These issues are highly extensive and require a significant degree of arrangements and

		Regulation support through the European Commission was also being received by Malta for the improvement of the LULUCF sector of the GHG Inventory. As it was communicated by Malta during review process the results of the support received are going to be used also for the land use matrix development and the fulfilment of some recommendations from ARR 2017, such as L.9, L.13 etc. However, Malta did not report in the NIR the improvement plan in order increase transparency of the planned improvements for the next submission.	resources to be set up and performed, incurring several months to years of work to accomplish such system and to be fully functional. As a result, concrete timeframes are not known at this stage since the planning stages to implement this system are currently ongoing.
L.11	4.B.1 Cropland remaining cropland CO2	The ERT noted that Malta applied emission factors used by Greece in the calculation of carbon stock changes in biomass, such as the value of 12 tonnes d.m. ha-1 for vine crops and the maturity age of 26 years (NIR, chapter 6.5.2.1). During the review Malta informed the ERT that maturity age was not actually used for activity data preparation for the calculation.	Addressed. The emission factors were updated for this year's submission, using factors from Mediterranean countries to reflect better the climatic and land conditions similar to that of Malta's
L.12	4.F.2 Land converted to other land – CO2	The ERT noted that Malta did not report in the NIR, chapter 6.9.2 what tier of methodology from 2006 IPCC Guidelines have been applied for the calculation of biomass losses from the land converted to other land. However, Malta reported in the NIR (p. 228) the equations 2.15 and 2.16 of the 2006 IPCC Guidelines that belong to the tier 2 or tier 3. The results of the carbon stock changes in living biomass in land converted to other land calculation for entire time series have been reported in the NIR, table 6-27 in Gg CO2. The ERT noted that these results are much smaller and correspond to the Mt CO2 instead of kt CO2. During the review week Malta provided the calculation sheet for the ERT with the assessment of carbon stock changes in biomass from grassland converted to other land. However, the ERT mentioned that in the provided calculation sheet the area unit has not been indicated in order to check the calculation.	Addressed. An explanation together with the related calculation sheet was provided to the ERT. Furthermore, the relevant units have been indicated and are shown in the Other Land chapter of this submission.
L.13	4(III) Direct N2O emissions from N mineralization/immobilization – N2O	The ERT noted that Malta reported in the CRF table (III) 2.67 kha of land converted to cropland that is not equal to the area reported for the land converted to the cropland in the CRF table 4.B (2.61 kha). Also, Malta reported IE for the direct N2O emissions from mineralization/immobilization in land converted to cropland with the description that emissions are reported in the agriculture sector. In response to the question raised by the ERT during the review week Malta informed that the area under land converted to cropland (2.67 kha) in the CRF table 4(III) also includes the conversion within cropland land remaining cropland land itself, namely annual cropland to perennial cropland, that is equal 0.06 kha according to the CRF table 4.B. According to the 2006 IPCC Guidelines direct N2O emissions from N mineralization/immobilization associated with loss of soil organic matter resulting from change of land use or management of mineral soils should be reported in the CRF table (III), however, N2O emissions from cropland remaining cropland should be included in the agriculture sector..	Addressed. The estimations were reported accordingly as indicated in the recommendation.
KL.7	General (KP-LULUCF) – NA	The ERT noted that Malta reported the notation keys IE, NO and NR in the CRF table NIR-1 for activities not selected under Article 3.4, such as Cropland management, Grazing management,	Addressed. In view of this recommendation, the CRF table NIR-1 was

		Revegetation and Wetland drainage and rewetting instead of NA.	updated with the correct Notation Key.
KL.8	Deforestation – CO2	The ERT noted that Malta reported the definition of deforestation in the NIR, chapter 11.1.3, that is not in line with the definition provided in the decision 16/CMP.1 "Deforestation is the direct human-induced conversion of forested land to non-forested land". However, Malta reported in the NIR that no deforestation occurs in the country. During the review week Malta confirmed the non-occurrence of deforestation based on the Trees and Woodland Protection Regulations (Legal Notice 12 of 2001) that address the conservation of trees and woodland sites strictly. Also, this information is presented in the National Forestry Accounting Plan of Malta.	Addressed. Relevant Information pertaining to deforestation is being presented in the Forest Land chapter of this submission.

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 where vegetation falls below the thresholds used for forestry land categories. 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, oils seeds, vegetables, root crops and forages. Perennial crops can include trees and shrubs, in combination with herbaceous crops (e.g. agroforestry) or as orchards, vineyards and plantations, except where these lands meet the criteria for categorisation as forest land. Arable land which is normally used for cultivation of annual crops but which is temporarily used for forage crops or grazing as part of an annual crop-pasture rotation is included under cropland.

- Grassland is defined as areas with highly biodiverse grassland:
    - habitats as listed in Annex I of Council Directive 92/43/EEC[34];
    - habitats of significant importance for animal and plant species of Union interest listed in Annex II and IV of Directive 92/43/EEC;
    - habitats of significant importance for wild bird species listed in Annex I of Directive 2009/147/EC. Highly biodiverse grassland in the European Union is not limited to the geographic ranges referred to under Article 3 of Directive 92/43/EEC. Other grassland might fulfill the criteria for highly biodiverse grassland set out in Article 1 of the same Directive. "
- Wetland is defined the same as for the RAMSAR Convention, Article 1.1 and Article 2.1[35]:
    - Article 1.1 states:

[34] Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora
[35] Convention on Wetlands of International Importance especially as Waterfowl Habitat, Paris, 1994

"For the purpose of this Convention wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres."

- Article 2.1 provides that wetlands:

"[…] *may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands"*.

- **Settlement** includes all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories.
- **Other Land** includes bare soil, rock, ice, and all unmanaged land areas that do not fall into any of the other five 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, where it essentially provides 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 CLC (1990, 2000, 2006 and 2012), with additional data relating to Cropland from the National Statistics Office such as the Agriculture Censuses and Farm Structure surveys, the latter providing more recent data for the Cropland category. CLC data was obtained from the local competent authority Planning Authority (PA) responsible for the CLC, rather than the EEA directly. The latest CLC report available for the purpose of this submission was the 2012 CLC.

The table below demonstrates a comparison exercise for the different land use categories involved in the LULUCF sectors. The comparison exercise was performed to categorise the land use categories from the CLC with the categories of the IPCC guidelines.

Table 6-8 Land use categories in CLC2012 vs land use categories in the IPCC Guidelines.

IPCC Guidelines Land-Use Categories	Corine Land Cover (CLC) 2012
Cropland	Agriculture with significant area of natural vegetation
Cropland	Complex cultivation patterns
Cropland	Non-irrigated arable land
Cropland	Vineyards
Forest Land	Mixed forest
Forest Land	Coniferous forest
Grassland	Sclerophyllous vegetation
Grassland	Sparsely vegetated areas
Other Land	Mineral extraction sites

Settlements	Airports
Settlements	Continuous urban fabric
Settlements	Discontinuous urban fabric
Settlements	Dump sites
Settlements	Green urban areas
Settlements	Industrial or commercial units
Settlements	Port areas
Settlements	Sport and leisure facilities
Wetland	Salines

6.3.1 THE LAND USE TRANSITION MATRIX

The land use matrix was created to represent, in a consistent quantified manner, land-use conversions. The matrices allow 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 with expert judgement of land-use changes in Malta, with support from the LULUCF Expert Review Team (ERT) during reviews. Land-use change matrices for each year of the period 1970-2018 have been drawn up, based on national land use statistics for categories Forest land, Cropland (which is divided into sub-categories: Annual Cropland, and Perennial Cropland), Grassland (divided into sub-categories: maquis Grassland, and other Grassland), Wetland, Settlement and Other Land.

Areas of land use and land-use change are compiled from a number of sources. Areas of Forest Land, Grassland, Wetland, Settlement and Other Land are derived from the CLC 1990, 2000, 2006 and 2012. Land areas related to Cropland were sourced from the National Statistics Office. The values for the land use transition matrix being presented in the present submission were adjusted by the LULUCF ERT during the in-country review 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-use matrix was constructed by firstly arranging the areas which are available from the national statistics and the CLC for the years which are readily available in the statistical reports. The areas were thus used to construct a 2-phase calculation for the annual areas remaining in the same category and for the annual conversions and taking in consideration assumptions. 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 from the CLC and national statistics, a gap filling exercise using linear extrapolation was carried out, to be consistent with the trendline of the whole time-series.

For the land use changes, it was assumed that conversion to category Other land comes from the categories Other Grassland, maquis Grassland and Settlements. For land use transitions to category Settlements, changes are assumed to come from categories annual Cropland, other Grassland, maquis Grassland and Perennial Cropland. For land converted to other Grassland, changes are assumed from categories annual Cropland and maquis Grassland. For land converted to maquis Grassland, changes are assumed from categories Other Grassland, perennial Cropland and Settlements (conversions from category Settlements are assumed to refer to abandoned gardens). For land use converted to annual Cropland, changes are assumed from categories Other Grassland, perennial Cropland and maquis

Grassland. Lastly, land use converted to perennial Cropland is assumed to be from categories annual Cropland, Other Grassland and maquis Grassland.

It is to note that three types of conversions, namely those from Other Grassland to Perennial Cropland, Perennial Cropland to Settlements, and, Other Grassland to Other Land, were not considered since no such conversions have occurred, thus no carbon stock changes will have accumulated within these changes.

The land-use matrix of the annual matrices from 1989-2019, is presented in Table 6-9 below. It is to note that for the categories Forest Land and Wetland, no land-use transition to, or from, have occurred. The areas in the Annual Matrix were utilised to fill CRF table 4.1.

The Land Use Matrix will eventually be revised in future submissions as a result of the capacity building support tasks to reflect better the historic and present land use situations of Malta, and thus try to eliminate the need for assumptions, and make efforts to limit the extrapolations within the time-series.

[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 discrepancies of .01 in the areas reported in CRF table 4.1 due to the decimal places rounding between the CRF and the sector excel worksheets.]

Table 6-9 Annual land-use change matrices for the years 1989-2019 (areas in kilo hectares)

Annual Matrix 1989-1990		1990						Total 1989
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1989	Forest Land	0.07						0.07
	Cropland		10.69	0.00		0.12		10.80
	Grassland			11.85			0.00	11.85
	Wetland				0.03			0.03
	Settlement					8.49		8.49
	Other Land						0.30	0.30
Total 1990		0.07	10.69	11.85	0.03	8.60	0.30	31.54
Land converted to		-	-	-	-	0.12	0.00	

Annual Matrix 1990-1991		1991						Total 1990
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1990	Forest Land	0.07						0.07
	Cropland		10.57	0.09		0.03		10.69
	Grassland			11.84			0.01	11.85
	Wetland				0.03			0.03
	Settlement					8.60		8.60
	Other Land						0.30	0.30
Total 1991		0.07	10.57	11.93	0.03	8.63	0.31	31.54
Land converted to		-	-	-	-	0.03	0.01	

Annual Matrix 1991-1992		1992						Total 1991
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1991	Forest Land	0.07						0.07
	Cropland		10.45	0.09		0.03		10.57
	Grassland			11.92			0.01	11.93
	Wetland				0.03			0.03
	Settlement					8.63		8.63
	Other Land						0.31	0.31
Total 1992		0.07	10.45	12.01	0.03	8.66	0.31	31.54
Land converted to		-	-	-	-	0.03	0.01	

Annual Matrix 1992-1993		1993						Total 1992
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1992	Forest Land	0.07						0.07
	Cropland		10.33	0.09		0.03		10.45
	Grassland			12.00			0.01	12.01
	Wetland				0.03			0.03
	Settlement					8.66		8.66
	Other Land						0.31	0.31
Total 1993		0.07	10.33	12.09	0.03	8.70	0.32	31.54
Land converted to		-	-	-	-	0.03	0.01	

Annual Matrix 1993-1994		1994						Total 1993
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1993	Forest Land	0.07						0.07
	Cropland		10.22	0.09		0.03		10.33
	Grassland			12.08			0.01	12.09
	Wetland				0.03			0.03
	Settlement					8.70		8.70
	Other Land						0.32	0.32
Total 1994		0.07	10.22	12.17	0.03	8.73	0.32	31.54
Land converted to		-	-	-	-	0.03	0.01	

Annual Matrix 1994-1995		1995						Total 1994
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1994	Forest Land	0.07						0.07
	Cropland		10.10	0.09		0.03		10.22
	Grassland			12.17			0.01	12.17
	Wetland				0.03			0.03
	Settlement					8.73		8.73
	Other Land						0.32	0.32
Total 1995		0.07	10.10	12.25	0.03	8.76	0.33	31.54
Land converted to		-	-	-	-	0.03	0.01	

Annual Matrix 1995-1996		1996						Total 1995
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1995	Forest Land	0.07						0.07
	Cropland		9.98	0.09		0.03		10.10
	Grassland			12.25			0.01	12.25
	Wetland				0.03			0.03
	Settlement					8.76		8.76
	Other Land						0.33	0.33
Total 1996		0.07	9.98	12.33	0.03	8.79	0.34	31.54
Land converted to		-	-	-	-	0.03	0.01	

Annual Matrix 1996-1997		1997						Total 1996
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1996	Forest Land	0.07						0.07
	Cropland		9.86	0.09		0.03		9.98
	Grassland			12.33			0.01	12.33
	Wetland				0.03			0.03
	Settlement					8.79		8.79
	Other Land						0.33	0.33
Total 1997		0.07	9.86	12.41	0.03	8.82	0.34	31.54
Land converted to		-	-	-	-	0.03	0.01	

Annual Matrix 1997-1998		1998						Total 1997
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1997	Forest Land	0.07						0.07
	Cropland		9.75	0.09		0.03		9.86
	Grassland			12.41			0.01	12.41
	Wetland				0.03			0.03
	Settlement					8.82		8.82
	Other Land						0.34	0.34
Total 1998		0.07	9.75	12.49	0.03	8.85	0.35	31.54
Land converted to		-	-	-	-	0.03	0.01	

Annual Matrix 1998-1999		1999						Total 1998
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1998	Forest Land	0.07						0.07
	Cropland		9.63	0.09		0.03		9.75
	Grassland			12.49			0.01	12.49
	Wetland				0.03			0.03
	Settlement					8.85		8.85
	Other Land						0.35	0.35
Total 1999		0.07	9.63	12.58	0.03	8.88	0.35	31.54
Land converted to		-	-	-	-	0.03	0.01	

Annual Matrix 1999-2000		2000						Total 1999
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1999	Forest Land	0.07						0.07
	Cropland		9.51	0.09		0.03		9.63
	Grassland			12.57			0.01	12.58
	Wetland				0.03			0.03
	Settlement					8.88		8.88
	Other Land						0.35	0.35
Total 2000		0.07	9.51	12.66	0.03	8.91	0.36	31.54
Land converted to		-	-	-	-	0.03	0.01	

Annual Matrix 2000-2001		2001						Total 2000
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2000	Forest Land	0.07						0.07
	Cropland		9.51					9.51
	Grassland		0.10	12.54		0.01	0.01	12.66
	Wetland				0.03			0.03
	Settlement					8.91		8.91
	Other Land						0.36	0.36
Total 2001		0.07	9.61	12.54	0.03	8.92	0.36	31.54
Land converted to		-	0.10	-	-	0.01	0.01	

Annual Matrix 2001-2002		2002						Total 2001
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2001	Forest Land	0.07						0.07
	Cropland		9.61					9.61
	Grassland		0.10	12.43		0.01	0.01	12.54
	Wetland				0.03			0.03
	Settlement					8.92		8.92
	Other Land						0.36	0.36
Total 2002		0.07	9.71	12.43	0.03	8.94	0.37	31.54
Land converted to		-	0.10	-	-	0.01	0.01	

Annual Matrix 2002-2003		2003						Total 2002
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2002	Forest Land	0.07						0.07
	Cropland		9.71					9.71
	Grassland		0.19	12.22		0.01	0.01	12.43
	Wetland				0.03			0.03
	Settlement					8.94		8.94
	Other Land						0.37	0.37
Total 2003		0.07	9.90	12.22	0.03	8.95	0.37	31.54
Land converted to		-	0.19	-	-	0.01	0.01	

Annual Matrix 2003-2004		2004						Total 2003
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
	Forest Land	0.07						0.07
	Cropland		9.90					9.90
	Grassland		0.19	12.01		0.01	0.01	12.22
	Wetland				0.03			0.03
	Settlement					8.95		8.95
	Other Land						0.37	0.37
Total 1990		0.07	10.09	12.01	0.03	8.96	0.38	31.54
Land converted to		-	0.19	-	-	0.01	0.01	

Annual Matrix 2004-2005		2005						Total 2004
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
2004	Forest Land	0.07						0.07
	Cropland		10.09					10.09
	Grassland		0.19	11.80		0.01	0.01	12.01
	Wetland				0.03			0.03
	Settlement					8.96		8.96
	Other Land						0.38	0.38
Total 2005		0.07	10.29	11.80	0.03	8.97	0.38	31.54
Land converted to		-	0.19	-	-	0.01	0.01	

Annual Matrix 2005-2006		2006						Total 2005
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
2005	*Forest Land*	**0.07**						*0.07*
	Cropland		**10.29**					*10.29*
	Grassland		0.19	**11.59**		0.01	0.01	*11.80*
	Wetland				**0.03**			*0.03*
	Settlement					**8.97**		*8.97*
	Other Land						**0.38**	*0.38*
Total 2006		*0.07*	*10.48*	*11.59*	*0.03*	*8.98*	*0.39*	***31.54***
Land converted to		-	**0.19**	-	-	**0.01**	**0.01**	

Annual Matrix 2006-2007		2007						Total 2006
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
2006	*Forest Land*	**0.07**						*0.07*
	Cropland		**10.48**					*10.48*
	Grassland		0.19	**11.39**		0.00	0.01	*11.59*
	Wetland				**0.03**			*0.03*
	Settlement					**8.98**		*8.98*
	Other Land						**0.39**	*0.39*
Total 2007		*0.07*	*10.68*	*11.39*	*0.03*	*8.98*	*0.39*	***31.54***
Land converted to		-	**0.19**	-	-	**0.00**	**0.01**	

Annual Matrix 2007-2008		2008						Total 2007
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
2007	*Forest Land*	**0.07**						*0.07*
	Cropland		**10.68**					*10.68*
	Grassland		0.15	**11.23**		0.00	0.01	*11.39*
	Wetland				**0.03**			*0.03*
	Settlement					**8.98**		*8.98*
	Other Land						**0.39**	*0.39*
Total 2008		*0.07*	*10.82*	*11.23*	*0.03*	*8.99*	*0.40*	***31.54***
Land converted to		-	**0.15**	-	-	**0.00**	**0.01**	

Annual Matrix 2008-2009		2009						Total 2008
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
2008	*Forest Land*	**0.07**						*0.07*
	Cropland		**10.82**					*10.82*
	Grassland		0.15	**11.08**		0.00	0.01	*11.24*
	Wetland				**0.03**			*0.03*
	Settlement					**8.99**		*8.99*
	Other Land						**0.40**	*0.40*
Total 2009		*0.07*	*10.97*	*11.08*	*0.03*	*8.99*	*0.40*	***31.54***
Land converted to		-	**0.15**	-	-	**0.00**	**0.01**	

Annual Matrix 2009-2010		2010						Total 2009
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
2009	*Forest Land*	**0.07**						*0.07*
	Cropland		**10.97**					*10.97*
	Grassland		0.15	**10.93**		0.00	0.01	*11.08*
	Wetland				**0.03**			*0.03*
	Settlement					**8.99**		*8.99*
	Other Land						**0.40**	*0.40*
Total 2010		*0.07*	*11.11*	*10.93*	*0.03*	*8.99*	*0.41*	***31.54***
Land converted to		-	**0.15**	-	-	**0.00**	**0.01**	

Annual Matrix 2010-2011		2011						Total 2010
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
2010	*Forest Land*	**0.07**						*0.07*
	Cropland		**11.11**					*11.11*
	Grassland		0.15	**10.78**		0.00	0.01	*10.93*
	Wetland				**0.03**			*0.03*
	Settlement					**8.99**		*8.99*
	Other Land						**0.41**	*0.41*
Total 2011		*0.07*	*11.25*	*10.78*	*0.03*	*8.99*	*0.41*	***31.54***
Land converted to		-	**0.15**	-	-	**0.00**	**0.01**	

Annual Matrix 2011-2012		2012						Total 2011
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
2011	*Forest Land*	**0.07**						*0.07*
	Cropland		**11.25**					*11.25*
	Grassland		0.15	**10.63**		0.00	0.01	*10.78*
	Wetland				**0.03**			*0.03*
	Settlement					**8.99**		*8.99*
	Other Land						**0.41**	*0.41*
Total 2012		*0.07*	*11.40*	*10.63*	*0.03*	*8.99*	*0.42*	***31.54***
Land converted to		-	**0.15**	-	-	**0.00**	**0.01**	

Annual Matrix 2012-2013		2013						Total 2012
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
2012	*Forest Land*	**0.07**						*0.07*
	Cropland		**11.40**					*11.40*
	Grassland		0.15	**10.48**		0.00	0.01	*10.63*
	Wetland				**0.03**			*0.03*
	Settlement					**8.99**		*8.99*
	Other Land						**0.42**	*0.42*
Total 2013		*0.07*	*11.54*	*10.48*	*0.03*	*8.99*	*0.43*	***31.54***
Land converted to		-	**0.15**	-	-	**0.00**	**0.01**	

Annual Matrix 2013-2014		2014						Total 2013
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
2013	*Forest Land*	**0.07**						*0.07*
	Cropland		**11.55**					*11.55*
	Grassland		0.14	**10.33**		0.00	0.01	*10.48*
	Wetland				**0.03**			*0.03*
	Settlement					**8.99**		*8.99*
	Other Land						**0.43**	*0.43*
Total 2014		*0.07*	*11.69*	*10.33*	*0.03*	*8.99*	*0.43*	***31.54***
Land converted to		-	**0.14**	-	-	**0.00**	**0.01**	

Annual Matrix 2014-2015		2015						Total 2014
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
2014	*Forest Land*	**0.07**						*0.07*
	Cropland		**11.69**					*11.69*
	Grassland		0.14	**10.18**		0.00	0.01	*10.33*
	Wetland				**0.03**			*0.03*
	Settlement					**8.99**		*8.99*
	Other Land						**0.43**	*0.43*
Total 2015		*0.07*	*11.83*	*10.18*	*0.03*	*8.99*	*0.44*	***31.54***
Land converted to		-	**0.14**	-	-	**0.00**	**0.01**	

Annual Matrix 2015-2016		2016						Total 2015
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
2015	*Forest Land*	**0.07**						*0.07*
	Cropland		**11.83**					*11.83*
	Grassland		0.14	**10.03**		0.00	0.01	*10.18*
	Wetland				**0.03**			*0.03*
	Settlement					**8.99**		*8.99*
	Other Land						**0.44**	*0.44*
Total 2016		*0.07*	*11.98*	*10.03*	*0.03*	*8.99*	*0.44*	***31.54***
Land converted to		-	**0.14**	-	-	**0.00**	**0.01**	

Annual Matrix 2016-2017		2017						Total 2016
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
2016	*Forest Land*	**0.07**						*0.07*
	Cropland		**11.98**					*11.98*
	Grassland		0.14	**9.88**		0.00	0.01	*10.03*
	Wetland				**0.03**			*0.03*
	Settlement					**8.99**		*8.99*
	Other Land						**0.44**	*0.44*
Total 1990		*0.07*	*12.12*	*9.88*	*0.03*	*8.99*	*0.45*	***31.54***
Land converted to		-	**0.14**	-	-	**0.00**	**0.01**	

Annual Matrix 2017-2018		2018						Total 2017
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
2017	*Forest Land*	**0.07**						*0.07*
	Cropland		**12.12**					*12.12*
	Grassland		0.14	**9.73**		0.00	0.01	*9.88*
	Wetland				**0.03**			*0.03*
	Settlement					**8.99**		*8.99*
	Other Land						**0.45**	*0.45*
Total 2018		*0.07*	*12.27*	*9.73*	*0.03*	*8.99*	*0.45*	***31.54***
Land converted to		-	**0.14**	-	-	**0.00**	**0.01**	

Annual Matrix 2018-2019		2019						Total 2018
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
2018	*Forest Land*	**0.07**						*0.07*
	Cropland		**12.27**					*12.27*
	Grassland		0.14	**9.57**		0.00	0.01	*9.73*
	Wetland				**0.03**			*0.03*
	Settlement					**8.99**		*8.99*
	Other Land						**0.45**	*0.45*
Total 2019		*0.07*	*12.41*	*9.57*	*0.03*	*8.99*	*0.46*	***31.54***
Land converted to		-	**0.14**	-	-	**0.00**	**0.01**	

To perform the estimations for the carbon stock changes in living biomass and soils, the 20-year land use change matrices for the years 1970-2019 were utilised. Table 6-10 below indicates the 20-year land use change matrices, where these areas were utilised in CRF tables 4.A to 4.F.

[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 discrepancies of .01 in the areas of certain categories reported in 4.A to 4.F due to the decimal places rounding between the CRF and the sector excel worksheets.]

Table 6-10 20 year land-use change matrices for the years 1970-2019 (areas in kilo hectares)

20 Years Matrix 1971-1990		1990						Total 1971
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1971	Forest Land	**0.07**						*0.07*
	Cropland		**8.31**	2.99		0.67		*11.98*
	Grassland		2.38	**8.69**		0.25	0.08	*11.40*
	Wetland				**0.03**			*0.03*
	Settlement			0.16		**7.67**	0.02	*7.86*
	Other Land						**0.20**	*0.20*
Total 1990		*0.07*	*10.69*	*11.85*	*0.03*	*8.60*	*0.30*	***31.54***
Land converted to:		**-**	**2.38**	**3.16**	**-**	**0.93**	**0.10**	

20 Years Matrix 1972-1991		1991						Total 1972
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1972	Forest Land	**0.07**						*0.07*
	Cropland		**8.19**	1.92		0.71		*10.82*
	Grassland		2.38	**9.90**		0.25	0.08	*12.61*
	Wetland				**0.03**			*0.03*
	Settlement			0.11		**7.67**	0.02	*7.80*
	Other Land						**0.21**	*0.21*
Total 1991		*0.07*	*10.57*	*11.93*	*0.03*	*8.63*	*0.31*	***31.54***
Land converted to:		**-**	**2.38**	**2.03**	**-**	**0.96**	**0.10**	

20 Years Matrix 1973-1992		1992						Total 1973
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1973	Forest Land	**0.07**						*0.07*
	Cropland		**8.37**	2.01		0.74		*11.11*
	Grassland		2.09	**9.94**		0.25	0.09	*12.37*
	Wetland				**0.03**			*0.03*
	Settlement			0.06		**7.67**	0.01	*7.75*
	Other Land						**0.21**	*0.21*
Total 1992		*0.07*	*10.45*	*12.01*	*0.03*	*8.66*	*0.31*	***31.54***
Land converted to:		**-**	**2.09**	**2.07**	**-**	**0.99**	**0.10**	

20 Years Matrix 1974-1993		1993						Total 1974
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1974	Forest Land	**0.07**						*0.07*
	Cropland		**9.01**	2.10		0.77		*11.87*
	Grassland		1.33	**9.98**		0.25	0.10	*11.65*
	Wetland				**0.03**			*0.03*
	Settlement			0.02		**7.67**	0.01	*7.70*
	Other Land						**0.22**	*0.22*
Total 1993		*0.07*	*10.33*	*12.09*	*0.03*	*8.70*	*0.32*	***31.54***
Land converted to:		**-**	**1.33**	**2.12**	**-**	**1.02**	**0.10**	

20 Years Matrix 1975-1994		1994						Total 1975
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1975	Forest Land	**0.07**						*0.07*
	Cropland		**8.89**	1.94		0.80		*11.63*
	Grassland		1.33	**10.23**		0.25	0.10	*11.91*
	Wetland				**0.03**			*0.03*
	Settlement					**7.67**	0.00	*7.68*
	Other Land						**0.22**	*0.22*
Total 1994		*0.07*	*10.22*	*12.17*	*0.03*	*8.73*	*0.32*	***31.54***
Land converted to:		**-**	**1.33**	**1.94**	**-**	**1.05**	**0.10**	

20 Years Matrix 1976-1995		1995						Total 1976
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1976	Forest Land	**0.07**						*0.07*
	Cropland		**9.16**	2.03		0.83		*12.01*
	Grassland		0.94	**10.22**		0.25	0.10	*11.52*
	Wetland				**0.03**			*0.03*
	Settlement					**7.67**		*7.67*
	Other Land						**0.23**	*0.23*
Total 1995		*0.07*	*10.10*	*12.25*	*0.03*	*8.76*	*0.33*	***31.54***
Land converted to:		**-**	**0.94**	**2.03**	**-**	**1.08**	**0.10**	

20 Years Matrix 1977-1996		1996						Total 1977
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1977	Forest Land	**0.07**						*0.07*
	Cropland		**9.04**	2.08		0.84		*11.96*
	Grassland		0.94	**10.25**		0.25	0.11	*11.55*
	Wetland				**0.03**			*0.03*
	Settlement					**7.70**		*7.70*
	Other Land						**0.23**	*0.23*
Total 1996		*0.07*	*9.98*	*12.33*	*0.03*	*8.79*	*0.34*	***31.54***
Land converted to:		-	**0.94**	**2.08**	-	**1.09**	**0.11**	

20 Years Matrix 1978-1997		1997						Total 1978
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1978	Forest Land	**0.07**						*0.07*
	Cropland		**8.92**	2.07		0.82		*11.81*
	Grassland		0.94	**10.35**		0.25	0.11	*11.65*
	Wetland				**0.03**			*0.03*
	Settlement					**7.75**		*7.75*
	Other Land						**0.23**	*0.23*
Total 1997		*0.07*	*9.86*	*12.41*	*0.03*	*8.82*	*0.34*	***31.54***
Land converted to:		-	**0.94**	**2.07**	-	**1.07**	**0.11**	

20 Years Matrix 1979-1998		1998						Total 1979
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1979	Forest Land	**0.07**						*0.07*
	Cropland		**8.80**	2.15		0.83		*11.79*
	Grassland		0.94	**10.34**		0.21	0.11	*11.60*
	Wetland				**0.03**			*0.03*
	Settlement					**7.81**		*7.81*
	Other Land						**0.24**	*0.24*
Total 1998		*0.07*	*9.75*	*12.49*	*0.03*	*8.85*	*0.35*	***31.54***
Land converted to:		-	**0.94**	**2.15**	-	**1.04**	**0.11**	

20 Years Matrix 1980-1999		1999						Total 1980
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1980	Forest Land	**0.07**						*0.07*
	Cropland		**8.77**	2.24		0.86		*11.87*
	Grassland		0.86	**10.34**		0.14	0.11	*11.44*
	Wetland				**0.03**			*0.03*
	Settlement					**7.88**		*7.88*
	Other Land						**0.24**	*0.24*
Total 1999		*0.07*	*9.63*	*12.58*	*0.03*	*8.88*	*0.35*	***31.54***
Land converted to:		-	**0.86**	**2.24**	-	**1.00**	**0.11**	

20 Years Matrix 1981-2000		2000						Total 1981
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1981	Forest Land	**0.07**						*0.07*
	Cropland		**8.65**	1.30		0.82		*10.77*
	Grassland		0.86	**11.36**		0.14	0.11	*12.47*
	Wetland				**0.03**			*0.03*
	Settlement					**7.95**		*7.95*
	Other Land						**0.25**	*0.25*
Total 2000		*0.07*	*9.51*	*12.66*	*0.03*	*8.91*	*0.36*	***31.54***
Land converted to:		-	**0.86**	**1.30**	-	**0.96**	**0.11**	

20 Years Matrix 1982-2001		2001						Total 1982
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1982	Forest Land	**0.07**						*0.07*
	Cropland		**9.11**	1.30		0.82		*11.23*
	Grassland		0.49	**11.25**		0.08	0.11	*11.93*
	Wetland				**0.03**			*0.03*
	Settlement					**8.02**		*8.02*
	Other Land						**0.25**	*0.25*
Total 2001		*0.07*	*9.61*	*12.54*	*0.03*	*8.92*	*0.36*	***31.54***
Land converted to:		-	**0.49**	**1.30**	-	**0.90**	**0.11**	

20 Years Matrix 1983-2002		2002						Total 1983
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1983	Forest Land	**0.07**						*0.07*
	Cropland		**9.51**	1.30		0.82		*11.63*
	Grassland		0.20	**11.13**		0.02	0.11	*11.46*
	Wetland				**0.03**			*0.03*
	Settlement					**8.09**		*8.09*
	Other Land						**0.26**	*0.26*
Total 2002		*0.07*	*9.71*	*12.43*	*0.03*	*8.94*	*0.37*	***31.54***
Land converted to:		-	**0.20**	**1.30**	-	**0.85**	**0.11**	

20 Years Matrix 1984-2003		2003						Total 1984
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1984	Forest Land	**0.07**						*0.07*
	Cropland		**9.51**	1.24		0.76		*11.51*
	Grassland		0.39	**10.97**		0.04	0.11	*11.51*
	Wetland				**0.03**			*0.03*
	Settlement					**8.15**		*8.15*
	Other Land						**0.26**	*0.26*
Total 2003		*0.07*	*9.90*	*12.22*	*0.03*	*8.95*	*0.37*	***31.54***
Land converted to:		-	**0.39**	**1.24**	-	**0.79**	**0.11**	

20 Years Matrix 1985-2004		2004						Total 1985
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1985	Forest Land	**0.07**						*0.07*
	Cropland		**9.51**	1.19		0.70		*11.39*
	Grassland		0.58	**10.82**		0.05	0.11	*11.56*
	Wetland				**0.03**			*0.03*
	Settlement					**8.22**		*8.22*
	Other Land						**0.27**	*0.27*
Total 2004		*0.07*	*10.09*	*12.01*	*0.03*	*8.96*	*0.38*	***31.54***
Land converted to:		-	**0.58**	**1.19**	-	**0.74**	**0.11**	

20 Years Matrix 1986-2005		2005						Total 1986
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1986	Forest Land	**0.07**						*0.07*
	Cropland		**9.51**	1.13		0.64		*11.28*
	Grassland		0.78	**10.67**		0.06	0.11	*11.62*
	Wetland				**0.03**			*0.03*
	Settlement					**8.27**		*8.27*
	Other Land						**0.27**	*0.27*
Total 2005		*0.07*	*10.29*	*11.80*	*0.03*	*8.97*	*0.38*	***31.54***
Land converted to:		-	**0.78**	**1.13**	-	**0.70**	**0.11**	

20 Years Matrix 1987-2006		2006						Total 1987
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1987	Forest Land	**0.07**						*0.07*
	Cropland		**9.51**	1.07		0.58		*11.16*
	Grassland		0.97	**10.52**		0.07	0.11	*11.67*
	Wetland				**0.03**			*0.03*
	Settlement					**8.33**		*8.33*
	Other Land						**0.28**	*0.28*
Total 2006		*0.07*	*10.48*	*11.59*	*0.03*	*8.98*	*0.39*	***31.54***
Land converted to:		-	**0.97**	**1.07**	-	**0.65**	**0.11**	

20 Years Matrix 1988-2007		2007						Total 1988
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1988	Forest Land	**0.07**						*0.07*
	Cropland		**9.51**	1.00		0.53		*11.04*
	Grassland		1.17	**10.38**		0.07	0.11	*11.73*
	Wetland				**0.03**			*0.03*
	Settlement					**8.39**		*8.39*
	Other Land						**0.28**	*0.28*
Total 2007		*0.07*	*10.68*	*11.39*	*0.03*	*8.98*	*0.39*	***31.54***
Land converted to:		-	**1.17**	**1.00**	-	**0.60**	**0.11**	

20 Years Matrix 1989-2008		2008						Total 1989
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1989	Forest Land	**0.07**						*0.07*
	Cropland		**9.51**	0.94		0.48		*10.92*
	Grassland		1.31	**10.30**		0.07	0.11	*11.79*
	Wetland				**0.03**			*0.03*
	Settlement					**8.44**		*8.44*
	Other Land						**0.29**	*0.29*
Total 2008		*0.07*	*10.82*	*11.23*	*0.03*	*8.99*	*0.40*	***31.54***
Land converted to:		-	**1.31**	**0.94**	-	**0.55**	**0.11**	

20 Years Matrix 1990-2009		2009						Total 1990
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1990	Forest Land	**0.07**						*0.07*
	Cropland		**9.51**	0.87		0.43		*10.80*
	Grassland		1.46	**10.21**		0.08	0.11	*11.86*
	Wetland				**0.03**			*0.03*
	Settlement					**8.49**		*8.49*
	Other Land						**0.29**	*0.29*
Total 2009		*0.07*	*10.97*	*11.08*	*0.03*	*8.99*	*0.40*	***31.54***
Land converted to:		-	**1.46**	**0.87**	-	**0.50**	**0.11**	

20 Years Matrix 1991-2010		2010						Total 1991
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1991	Forest Land	**0.07**						*0.07*
	Cropland		**9.51**	0.87		0.31		*10.69*
	Grassland		1.60	**10.07**		0.08	0.11	*11.86*
	Wetland				**0.03**			*0.03*
	Settlement					**8.60**		*8.60*
	Other Land						**0.29**	*0.29*
Total 2010		*0.07*	*11.11*	*10.93*	*0.03*	*8.99*	*0.41*	***31.54***
Land converted to:		-	**1.60**	**0.87**	-	**0.39**	**0.11**	

20 Years Matrix 1992-2011		2011						Total 1992
		Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	
1992	Forest Land	**0.07**						*0.07*
	Cropland		**9.51**	0.78		0.28		*10.57*
	Grassland		1.75	**10.00**		0.08	0.11	*11.94*
	Wetland				**0.03**			*0.03*
	Settlement					**8.63**		*8.63*
	Other Land						**0.30**	*0.30*
Total 2011		*0.07*	*11.25*	*10.78*	*0.03*	*8.99*	*0.41*	***31.54***
Land converted to:		-	**1.75**	**0.78**	-	**0.36**	**0.11**	

20 Years Matrix 1993-2012		2012						Total 1993
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
1993	***Forest Land***	**0.07**						*0.07*
	Cropland		**9.51**	0.70		0.25		*10.45*
	Grassland		1.89	**9.94**		0.08	0.11	*12.02*
	Wetland				**0.03**			*0.03*
	Settlement					**8.66**		*8.66*
	Other Land						**0.31**	*0.31*
Total 2012		*0.07*	*11.40*	*10.63*	*0.03*	*8.99*	*0.42*	***31.54***
Land converted to:		-	**1.89**	**0.70**	-	**0.33**	**0.11**	

20 Years Matrix 1994-2013		2013						Total 1994
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
1994	***Forest Land***	**0.07**						*0.07*
	Cropland		**9.51**	0.61		0.22		*10.33*
	Grassland		2.04	**9.87**		0.08	0.11	*12.10*
	Wetland				**0.03**			*0.03*
	Settlement					**8.69**		*8.69*
	Other Land						**0.31**	*0.31*
Total 2013		*0.07*	*11.54*	*10.48*	*0.03*	*8.99*	*0.43*	***31.54***
Land converted to:		-	**2.04**	**0.61**	-	**0.30**	**0.11**	

20 Years Matrix 1995-2014		2014						Total 1995
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
1995	***Forest Land***	**0.07**						*0.07*
	Cropland		**9.51**	0.52		0.19		*10.22*
	Grassland		2.18	**9.81**		0.08	0.11	*12.18*
	Wetland				**0.03**			*0.03*
	Settlement					**8.72**		*8.72*
	Other Land						**0.32**	*0.32*
Total 2014		*0.07*	*11.69*	*10.33*	*0.03*	*8.99*	*0.43*	***31.54***
Land converted to:		-	**2.18**	**0.52**	-	**0.27**	**0.11**	

20 Years Matrix 1996-2015		2015						Total 1996
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
1996	***Forest Land***	**0.07**						*0.07*
	Cropland		**9.51**	0.43		0.16		*10.10*
	Grassland		2.32	**9.74**		0.08	0.11	*12.26*
	Wetland				**0.03**			*0.03*
	Settlement					**8.75**		*8.75*
	Other Land						**0.32**	*0.32*
Total 2015		*0.07*	*11.83*	*10.18*	*0.03*	*8.99*	*0.44*	***31.54***
Land converted to:		-	**2.32**	**0.43**	-	**0.24**	**0.11**	

20 Years Matrix 1997-2016		2016						Total 1997
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
1997	***Forest Land***	**0.07**						*0.07*
	Cropland		**9.51**	0.35		0.12		*9.98*
	Grassland		2.47	**9.68**		0.08	0.11	*12.34*
	Wetland				**0.03**			*0.03*
	Settlement					**8.78**		*8.78*
	Other Land						**0.33**	*0.33*
Total 2016		*0.07*	*11.98*	*10.03*	*0.03*	*8.99*	*0.44*	***31.54***
Land converted to:		-	**2.47**	**0.35**	-	**0.21**	**0.11**	

20 Years Matrix 1998-2017		2017						Total 1998
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
1998	***Forest Land***	**0.07**						*0.07*
	Cropland		**9.51**	0.26		0.09		*9.86*
	Grassland		2.61	**9.62**		0.08	0.11	*12.42*
	Wetland				**0.03**			*0.03*
	Settlement					**8.82**		*8.82*
	Other Land						**0.33**	*0.33*
Total 2017		*0.07*	*12.12*	*9.88*	*0.03*	*8.99*	*0.45*	***31.54***
Land converted to:		-	**2.61**	**0.26**	-	**0.18**	**0.11**	

20 Years Matrix 1999-2018		2018						Total 1999
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
1999	***Forest Land***	**0.07**						*0.07*
	Cropland		**9.51**	0.17		0.06		*9.75*
	Grassland		2.76	**9.55**		0.08	0.11	*12.51*
	Wetland				**0.03**			*0.03*
	Settlement					**8.85**		*8.85*
	Other Land						**0.34**	*0.34*
Total 2018		*0.07*	*12.27*	*9.73*	*0.03*	*8.99*	*0.45*	***31.54***
Land converted to:		-	**2.76**	**0.17**	-	**0.15**	**0.11**	

20 Years Matrix 2000-2019		2019						Total 2000
		Forest Land	*Cropland*	*Grassland*	*Wetland*	*Settlement*	*Other Land*	
2000	***Forest Land***	**0.07**						*0.07*
	Cropland		**9.51**	0.09		0.03		*9.63*
	Grassland		2.90	**9.49**		0.09	0.11	*12.59*
	Wetland				**0.03**			*0.03*
	Settlement					**8.88**		*8.88*
	Other Land						**0.35**	*0.35*
Total 2019		*0.07*	*12.41*	*9.57*	*0.03*	*8.99*	*0.46*	***31.54***
Land converted to:		-	**2.90**	**0.09**	-	**0.12**	**0.11**	

6.4 FOREST LAND (CRF CATEGORY 4A)

6.4.1 Forest Land - Forest land remaining forest land (4.A.1)

During 2018, 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 3-day 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 below sections provide a description of the Forest Land category information, as well as the methodological description of the estimates.

As already indicated, noting that the extent of the recommendations and revisions from the two tasks of the capacity building support visits have deemed to require more time to be implemented than previously envisaged in the inventory, the updates in the area land use matrix and calculation of estimations in Forest Land will not be indicated in this submission. Nevertheless, an explanation of the Forest Land areas that will be considered for the future updates will be explained in this section, reflecting the information present in the national forestry accounting plan and for consistency with the two reporting systems. More details and further discussion on the status and the planning of these updates are mentioned in previous sections of this submission, based on the conclusions from the Capacity Building Plan report.

6.4.1.1 Category Description

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 (Cassar & Conrad, 2014).

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)[36]. Additionally, FAOSTAT information sourced from the Forestry Production and Trade indicate that the production quantity has never been produced in Malta[37].

As indicated in Section 6.2 above, the definition established and used for this reporting the category of Forest Land is the following: **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. The forest/woodland areas which are considered for Forest Land category, in line with the definition, are the 'Buskett', 'Mizieb' and 'Wardija' areas. Moreover, for the afforestation criteria the area pertaining to the 'Foresta 2000' reserve and 'Buskett' are taken into consideration, since afforestation occurred within these two locations. Below accounts for the detailed description of the woodland areas.

Il-Buskett

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 and is located within Ir-Rabat, Ħad-Dingli and Is-Siġġiewi locality boundaries. The area includes both a Special Area of Conservation (SAC) and a Special Protection Area (SPA). L-Inħawi tal-Buskett SAC is one of the largest SACs in the Maltese Islands. It consists of three valley systems, Wied l-Isqof, Wied il-Luq and Wied il-Girgenti, each of which has a permanent watercourse running through it, 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. Buskett is also a popular site with both Maltese and foreigners, recording a high footfall, particularly in winter. Buskett, and the area around it, is also important as a concentration point for birds of prey, many of which are of international importance. This has allowed the area to receive designation both as a Special Area of Conservation (SAC) and a Special Protection Area (SPA).

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. Certain parts of the woodland are under direct management of the ELC consortium through a Private-Public Partnership agreement with the Government of Malta while the former Directorate for Parks, Afforestation and Countryside Restoration (PARKS) (now called 'Ambjent

[36] ENVIRONMENT PROTECTION ACT (CAP. 348) Trees and Woodlands (Protection) Regulations, 2001, LEGAL NOTICE 12 of 2001
[37] Source: http://www.fao.org/faostat/en/#data/FO

Malta' agency) within the Ministry for Sustainable Development, the Environment and Climate Change is responsible for the woodland.

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)

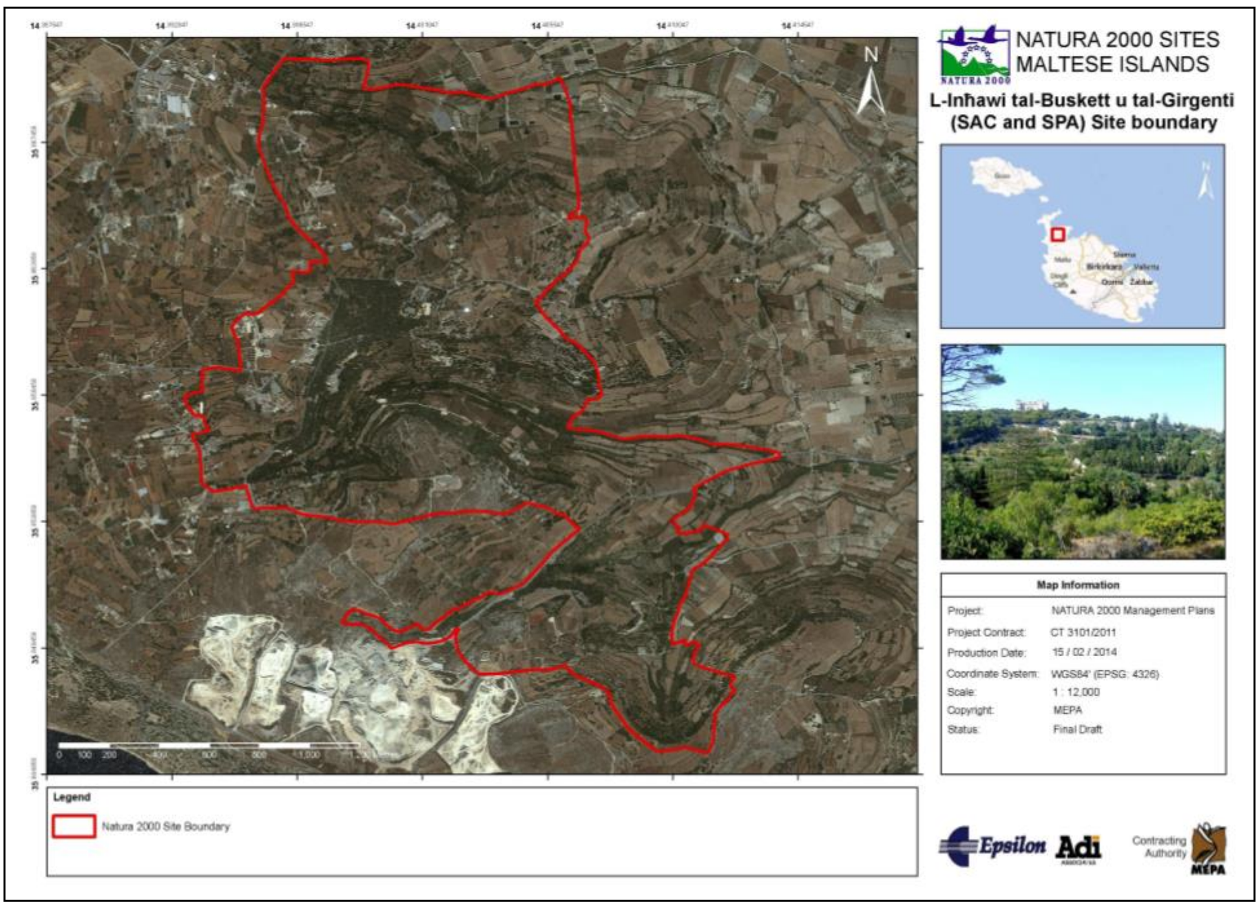

Figure 6-3 L-inhawi tal-Buskett u tal-Girgenti (SAC & SPA) Site boundary

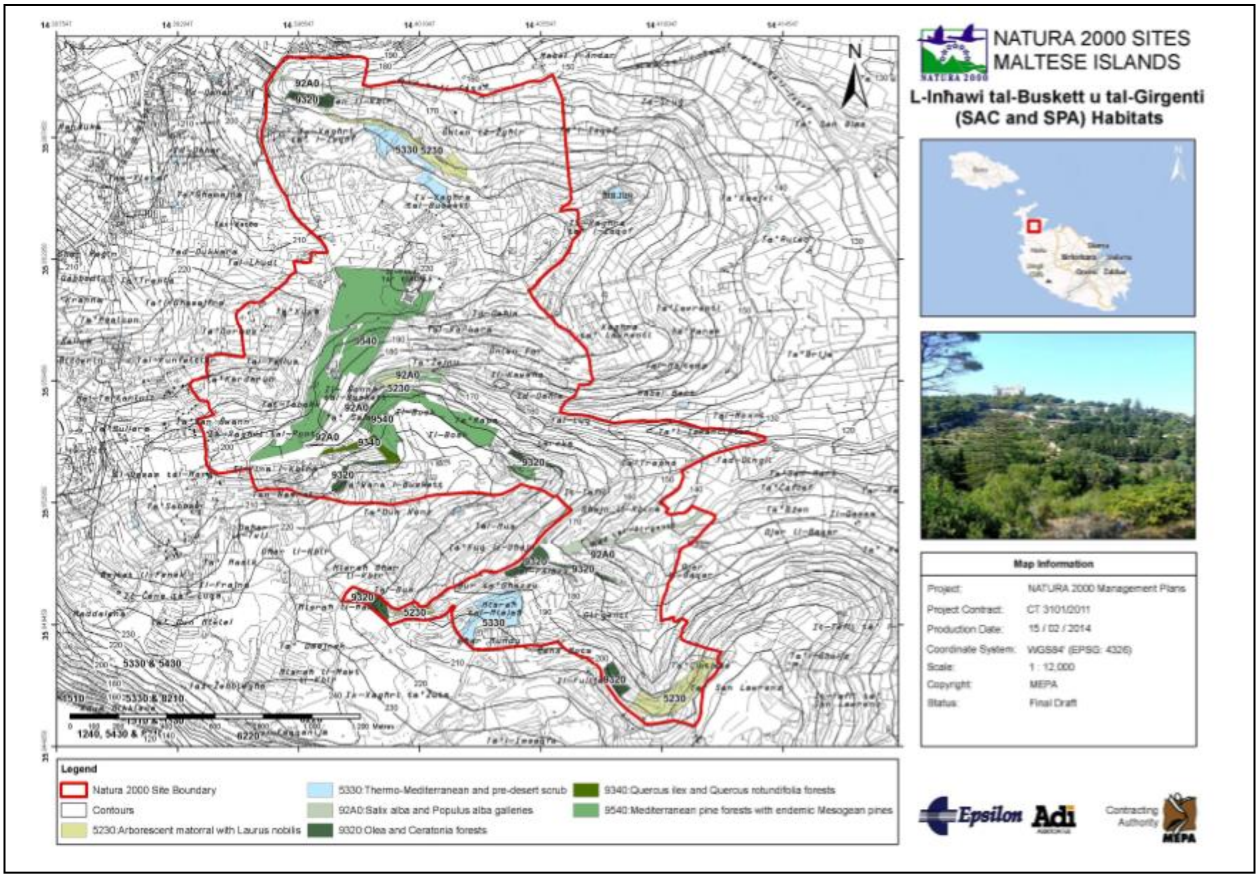

Figure 6-4 L-inhawi tal-Buskett u tal-Girgenti (SAC & SPA) Habitats

Il-Wardija

Il-Ballut tal-Wardija Special Area of Conservation (SAC) is found in the north-east coast of Malta. The site is found in an area between Wardija and St. Paul's Bay. To the north of the site there is St. Paul's Bay and there are views of Xemxija Bay whilst to the west there are views of the Pwales Valley. The Wardija settlement is found to the east of the SAC. To the south west there is the San Martin Valley. Il-Ballut tal-Wardija SAC 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

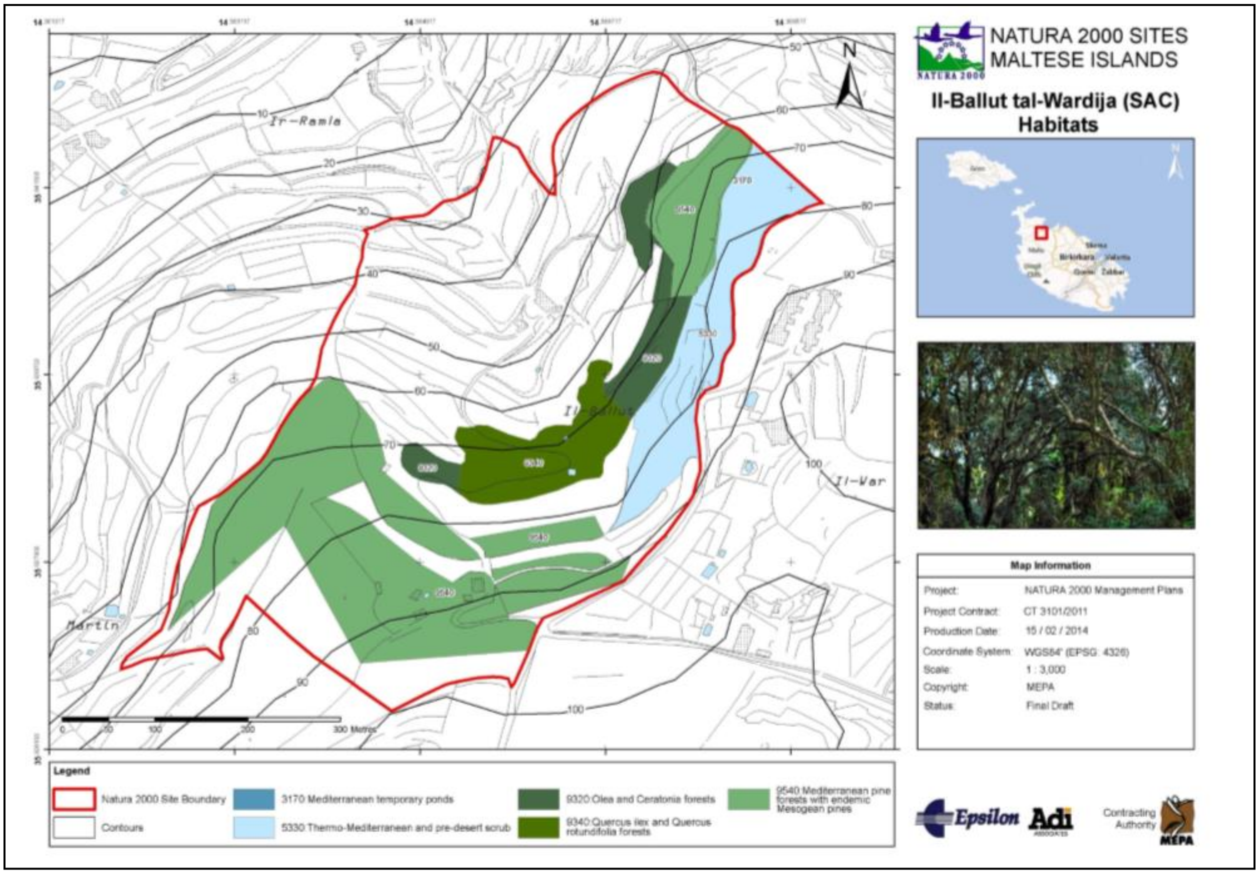

Figure 6-6 Il-Ballut tal-Wardija (SAC) Habitats

Il-Mizieb

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.

Information on the Mizieb site was still not provided to the LULUCF inventory compilers from FKNK's side, for the preparation and submission of the GHG Inventory as well as the NFAP, thus this forest reserve will be considered and updated in the LULUCF sector reporting accordingly for future submissions, based on the information that may eventually be received.

Foresta 2000

The northern flank of the SAC, at is-Sdieri, below the ridge is under the joint management of a Non-Governmental Organisation, entitled Birdlife Malta and the Government, being the focus of an afforestation project: Foresta 2000. 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 that would become an attraction for both Maltese and foreigners wanting to explore and enjoy nature. The Foresta 2000 initiative is being run by BirdLife Malta, in collaboration with Din l-Art Helwa and the former PARKS which was the afforestation department of the Ministry for Sustainable Development, Environment and Climate Change (now 'Ambjent Malta' Agency), and involves the environmental improvement of a site of approximately 104 ha located on the west slope of Marfa Ridge, 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, as was confirmed by the Ambjent Malta agency during task 1 of the capacity building support visits, which up until now amounts to a total of 44 hectares of afforested land.

The project has drawn on the participation of several individuals, schools and corporations, and on the work of volunteers. It has also 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).

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 in **Table 6-7** below.

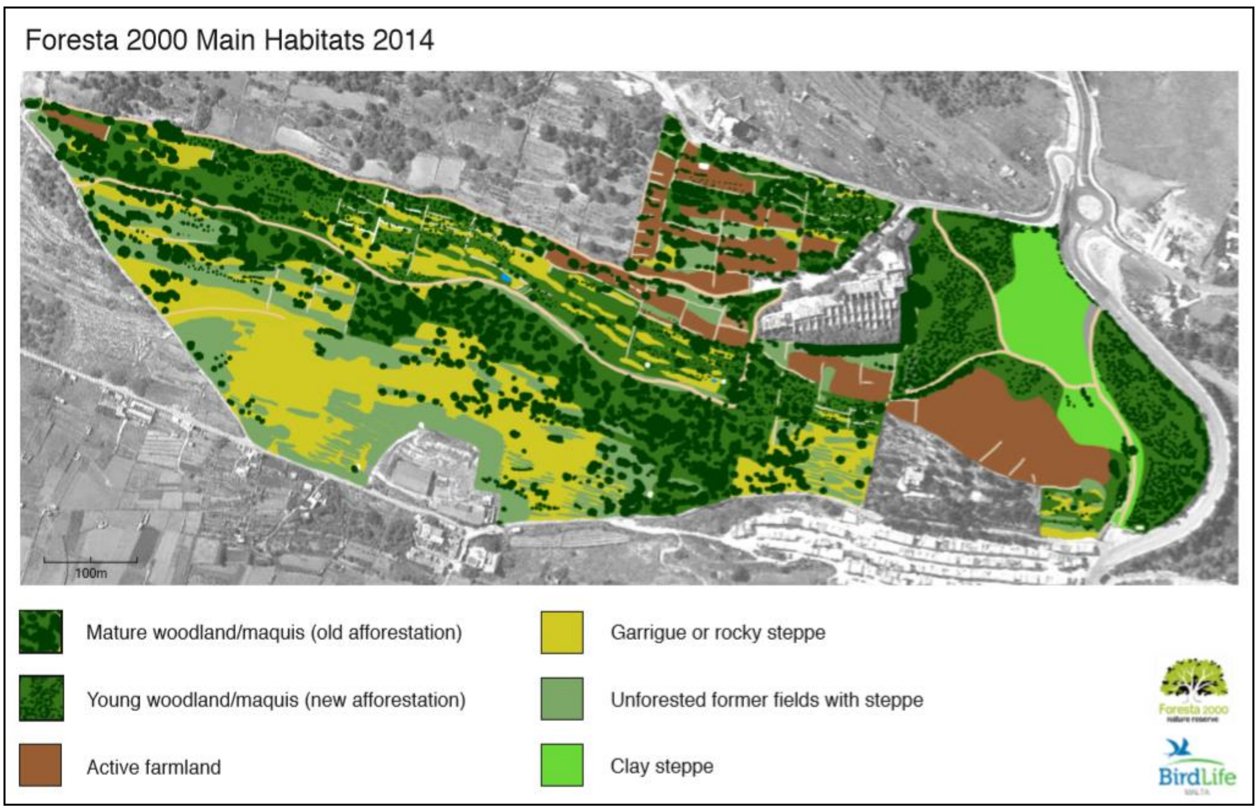

Figure 6-7 Foresta 2000 Main Habitats map

Following the capacity building support visits, the stratification of the forest/woodland areas of Malta were created and considered for the purpose of the NFAP compilation. The same stratification classes will be considered for the compilation of estimations in the Forest Land category, as to be concise with both sets of reports. 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 are 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, Mizieb, 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. These plans were implemented through a collaboration between the former Malta Environment and Planning Authority (MEPA) and Epsilon International SA – Adi Associates Environmental Consultants Ltd Consortium through a service contract, where the project started in October 2012 and ended in March 2014. The management planning exercise involved gathering information, carrying out surveys, defining conservation objectives, and identifying management measures, with intensive stakeholder involvement throughout the entire exercise. A secondary component of the service contract involved an awareness campaign on terrestrial Natura 2000 sites in the Maltese Islands.

With regards to the Mizieb area, no information was utilised for this submission as the documentation has not been received yet, as stated earlier. Efforts will be made to gather the information to be utilised for future submissions.

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[38] 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.

[38] Source: http://geoserver.pa.org.mt/publicgeoserver

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.

Previous assessments of the CO_2 pools for Maltese forests (i.e. previous Forest Land category of the LULUCF sector in the GHG Inventory of Malta) had assumed that all forests considered for Inventory reporting purposes had reached a stage of maturity, where growth is compensated by natural decay. 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 the capacity-building support visit tasks, however, it emerged 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, this required that 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:

1) *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'.
2) *Dominant species:*

    The dominant species are distinguished in order to classify forests in the strata described above, as 'conifer dominated' forests and 'broadleaves 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 6-11 and Table 6-12below indicate the stratifications according to the criteria as proposed above. The description of the relevant habitats for the specified locations mentioned are indicated above. As stated already, no information was provided for the Mizieb area, thus this is not included.

Table 6-11 Stratification of Forest Management

Forest remaining Forest (Forest Management)						
Location	**Habitat**	**Dominant tree species**	**Conifer or Broad-leaved dominant**	**Age (years)**	**Area (hectares)**	**Total Area (hectares)**
Buskett Woodland (Natura 2000 site)	9340 – Oak Forests	*Querces ilex*	Broad-leaved	500+	0.76ha	19.88ha
	9540 – Mediterranean pine forests	*Pinus halepensis*	Conifer	100+	16.7ha	
	9320 – Olive & Carob forests	*Ceratonia siliqua & Olea europaea*	Broad-leaved	100+ and ~50	0.92ha	
	92A0 – Poplar & Willow galleries	*Salix alba, Populus alba & Fraxinus angustifolia*	Broad-leaved	~300-400	1.2ha	
	5230 – Arborescent matorral with Bay laurel	*Laurus nobilis*	Broad-leaved	Unidentified *(area difficult to assess)*	~0.3ha	
Wardija (Natura 2000 site)	9340 – Oak Forests	*Querces ilex*	Broad-leaved	100+	1.11ha	7.51ha
	9540 – Mediterranean pine forests	*Pinus halepensis*	Conifer	50+	5.52ha	
	9320 – Olive & Carob forests	*Ceratonia siliqua & Olea europaea*	Broad-leaved	100+	0.88ha	

Table 6-12 Stratification of Afforestation

Afforestation					
Location	**Habitat**	**Dominant tree species**	**Age (years)**	**Area (hectares)**	**Total Area (hectares)**
Foresta 2000	Conifer Dominated	*Pinus halapensis* *Tetraclinus articulata*	Planted around 2004	~5.42ha	13.5ha
	Broad-leave dominated	*Arbutus unedo* *Quercus ilex* *Quercus coccifera* *Tamarix sp.* *Ceratonia siliqua* *Olea europea*		~8.08ha	
Buskett	Conifer Dominated	*Pinus halapensis*	Planted 2015-2017	~0.42ha	3.85ha

	Broad-leave dominated	*Ceratonia siliqua* *Salix alba, Populus alba & Fraxinus angustifolia* *Querces ilex* *Laurus nobilis*		~3.43ha	

For the 'age dynamic forests' documentation on the planting decade was sourced from documents such as management plans and local plans/reports, 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. For future assessments, efforts will be made to make further improvements on the representation of forest areas, by combining spatial explicit mapping, as discussed in both tasks of the capacity building support. 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 2018. The information on the area of afforested land was retrieved from Ambjent Malta and Birdlife for the Foresta 2000 area. The Afforestation will be considered also in the transition matrix of the GHG Inventory, to account for the land transitions to Forest Land. The reason for this being that information on afforested land was not available in previous assessments, whereas, following the capacity building support visits, ample data was provided on Maltese woodland from the stakeholders/entities involved.

6.4.1.2 Methodological Issues

For this year's submission the Forest Land category will be similar to the previous submission, as a result of the extent of the recommendations and revisions from the two tasks of the capacity building support visits, which have deemed to require more time to be implemented than previously envisaged. As in the previous submission, as was recommended by the LULUCF Expert Review Team in October 2016, the forests in Malta are assumed to be in equilibrium, thus the emissions and removals from the category Forest Land are determined to be equal to zero.

For future submissions the updates in the Forest Land category will feature methodological calculations and latest further information relevant to this category, following the recommendations provided during the capacity building support in-country visits, since latest and new documentation and Activity Data were collected and analysed related to the forestry inventories which was required to submit for the NFAP and establishment of the FRL. In turn this collection of information and parameters will directly contribute to the fulfilment of estimates and calculations in the Forest Land category, noting that the forest-related information falls under the national definition of Forest Land.

Nonetheless, it is pertinent to note that preliminary internal estimations from Forest Land removals based on the related information available from the Maltese woodlands mentioned in sections above, do not result in a significant contribution to the total LULUCF sector, where removals from the LULUCF sector are substantially low due that the woodland areas are very minimal.

6.4.2 Forest Land - Land converted to forest land (4.A.2)

6.4.2.1 Category Description

This will follow the previous submission, thus no land converted to Forest Land occurred.

6.4.2.2 Methodological Issues

This will follow the previous submission, thus not applicable.

6.4.2.3 Uncertainties and time-series Consistency

This will follow the previous submission, thus not applicable.

6.4.2.4 Category-specific QA/QC & verification

This will follow the previous submission, thus not applicable.

6.4.2.5 Category-specific recalculations

Recalculations for the Forest Land category are found to be unnecessary for this year's submission, since this will follow the previous submission, and noting that estimates of emissions and removals were not calculated from this category.

6.4.3 Uncertainties and time-series consistency

This section is not relevant for this year's submission, however, will be updated in future submissions, noting that new data and information will be utilised in the compilation of the Forest Land category.

6.4.4 Category-specific QA/QC and verification

This section is not relevant for this year's submission, however, will be updated in future submissions, noting that new data and information will be utilised in the compilation of the Forest Land category.

6.4.5 Category-specific recalculations

This section is not relevant for this year's submission, however, will be updated in future submissions, noting that new data and information will be utilised in the compilation of the Forest Land category.

6.4.6 Category-specific planned improvements

As already mentioned, this sector will be thoroughly updated in future submissions. Estimations will be calculated from this category in future submission, noting the provision of new information related to Maltese woodlands. The land use matrix will also be updated reflecting accurately the areas covered by the woodlands, and thus used to calculate removals in this sector. Improvements are required in further collection of data related to Maltese woodland and the afforestation areas to address the issue of data collection, considering also the smallness of the woodland areas which can pose difficulties at times to accurately determine the land areas. Malta will strive to make further efforts to continue gathering accurate data especially through spatial mapping, to report more transparently and accurately.

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, with 73.5% of the agricultural holdings having a Utilised Agricultural Area (UAA) of less than 1 hectare each. Medium-sized agricultural holdings made up 24.4% 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):

i. Arable land – accounts for the larger land-based farms which grow fruit and vegetables as well as having forage crops and/or fallow land;

ii. Permanent crops – cover citrus, olives, vines;

iii. 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[39].

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))[40]. 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.

According to the 'Rural Development Plan for Malta 2007-2013' (MEAIM, 2009) and the Farm Structure Survey 2014, the most cultivated crop is vines and therefore, for inventory purposes, the main perennial crops considered are vines/vineyards. Furthermore, limited availability of data and information on crop land areas did not allow for additional splits into other crops to be carried out.

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)[41].

The estimations were calculated only for perennial woody crops, since these are capable to store significant carbon in long-lived biomass. On the other hand, annual crops are harvested each year, thus

39 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.
40 State of the Environment Report 2005, Malta Environment and Planning Authority, 2006
41 Estimation of greenhouse gas emissions from agricultural activities for Malta 's Inventory, Sammut 2015

increase in biomass stocks in a single year is assumed equal to biomass losses from harvest and mortality in the same year – this implies that there is no net accumulation of biomass carbon stocks (IPCC, 2003).

6.5.2 Cropland - Cropland remaining Cropland (4.B.1)

6.5.2.1 Methodological Issues

Activity data on perennial crops coverage as available from the 1991 Agriculture Census (NSO, 1993)[42] has been used for the years 1990 to 1998, whereas for the years 1999 onwards activity data on Perennial crops as published by the National Statistics Office has been used such as the Agriculture and Fisheries survey.

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 woody 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. As abovementioned, for this inventory purposes only data attributed to vineyards are taken into consideration, as this is the most abundant crop in Malta. 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 taken into consideration 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. For annual Cropland and other Grassland the default values were taken into consideration since the carbon stock in biomass is after one year as indicated in **Table 6-13**. On the other hand, for perennial Cropland and maquis Grassland the values from the LIFE Project MediNet were considered, 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 **Table 6-13** below.

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

42 Census of Agriculture 1991, NSO, 1993

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 6-13 Average biomass stock values and Carbon stock values for biomass estimations.

Sub-sector	Parameters		Reference
	Average biomass stock	Carbon stock in biomass	
Annual Cropland		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

Conversion within the category Cropland are described here. Annual Cropland is converted to Perennial Cropland in the whole time-series, however there were no conversions from Perennial to Annual Cropland. 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'. For the conversion from Perennial Cropland to Annual Cropland there were no biomass stocks since no area was reported; while biomass stocks were estimated for the conversions from Annual CL to Perennial CL considering the default values of 4.7 t C ha^{-1} for annual Cropland taken from the updated Table 5.9 in Chapter 5 of the 2019 Refinement to the 2006 IPCC Guidelines, and using the Greek value of 0.50 t C ha^{-1} y^{-1} for perennial Cropland taken from Table 6-13 above.

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. 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. 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 values 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 it was recommended that, 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}. It was recommended that a value like this one could be more representative of the conditions in Malta.

The 20-year transition cumulative areas were utilised in the estimation. **Table 6-14** below indicates the default parameters used to calculate the SOC changes in the conversions.

Table 6-14 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 (tC 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 F_{SOM} 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 conversions, namely annual Cropland to perennial cropland, 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 6-15 represents the estimations in category 4.B.1 Cropland remaining Cropland from 1990-2019 by gas.

Table 6-15 Emissions/removals in Cropland remaining Cropland (kt CO_2 eq.)

Year	CO_2
1990	-0.272
1991	-0.295
1992	-0.279
1993	-0.174
1994	-0.167
1995	-0.140
1996	-0.151
1997	-0.123
1998	-0.147
1999	-0.094
2000	-0.099
2001	-0.070
2002	-0.093
2003	-0.157
2004	-0.214
2005	-0.271
2006	-0.328
2007	-0.385
2008	-0.442
2009	-0.477
2010	-0.508
2011	-0.543
2012	-0.578
2013	-0.613
2014	-0.648
2015	-0.683
2016	-0.718
2017	-0.749
2018	-0.784
2019	-0.819

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; specifically, land converted to annual Cropland coming from other Grassland and maquis, whilst Perennial Cropland is converted from maquis Grassland.

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 6-13**, where the different emission factors were utilised according to and corresponding to each of the conversions.

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 6-14** 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, were the N estimations were performed using the SOC stock change values. As already stated, 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 N2O emissions from N Mineralisation/Immobilisation'. **Table 6-16** represents the estimations in category 4.B.2 Land converted to Cropland from 1990-2019 by gas.

Table 6-16 Emissions/removals in Land Converted to Cropland (kt CO2 eq.)

Year	CO_2	N_2O
1990	-1.165	0.305
1991	-1.165	0.305
1992	-1.145	0.272
1993	-0.763	0.174
1994	-0.763	0.174
1995	-0.589	0.124
1996	-0.589	0.124
1997	-0.589	0.124
1998	-0.589	0.124
1999	-0.502	0.114
2000	-0.502	0.114
2001	-0.307	0.063
2002	-0.117	0.022
2003	-0.171	0.044
2004	-0.227	0.066
2005	-0.284	0.087
2006	-0.341	0.109
2007	-0.372	0.132
2008	-0.401	0.149
2009	-0.429	0.166
2010	-0.457	0.183
2011	-0.485	0.200
2012	-0.513	0.217
2013	-0.541	0.235
2014	-0.569	0.252
2015	-0.598	0.268
2016	-0.626	0.285
2017	-0.654	0.302

2018	-0.682	0.319
2019	-0.710	0.319

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 6-17Error! Reference source not found. below indicates the uncertainly levels for the Emission Factors used:

Table 6-17 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.
Direct N2O emissions from managed soils	N mineralised from mineral soil as a result of	70%	Table 11.1 of 2006 IPCC Volume 4 AFOLU – default	Calculated as an average between the difference of the high and the low

loss of soil carbon	uncertainty range	range estimates of the default factors.

The uncertainties of the C:N ratio and the EF (emission factor) to estimate Direct N2O emissions from managed soils were calculated by estimating the average between the difference of the high and low ranges of the default factors, using the equations: ((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%. These uncertainties represent an approximation since these may vary accordingly.

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.

6.5.5 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

The area data for Cropland used is derived from the NSO. Certain data on areas which are not available 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 all the area for the whole-time series. 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.

6.5.6 CATEGORY-SPECIFIC RECALCULATIONS

Due to the updates in specific factors in the LULUCF sector, as already mentioned, as a result recalculation were performed. Recalculations for the Cropland category are presented below.

Table 6-18 Recalculations in Cropland category

Year	Cropland (Gg CO2 eq.) as reported in the previous inventory report	Cropland (Gg CO2 eq.) as reported in this inventory report	Percentage change in reported emissions (%)	Change in Gg CO2 eq.
1990	3.11	-1.13	-136%	-4.24
1991	3.05	-1.16	-138%	-4.21
1992	2.60	-1.15	-144%	-3.75
1993	1.41	-0.76	-154%	-2.17
1994	1.41	-0.76	-154%	-2.17
1995	0.74	-0.60	-181%	-1.35
1996	0.72	-0.62	-185%	-1.34
1997	0.69	-0.59	-185%	-1.28
1998	0.64	-0.61	-196%	-1.25
1999	0.40	-0.48	-221%	-0.88
2000	0.33	-0.49	-246%	-0.82
2001	-0.44	-0.31	-29%	0.13
2002	-1.01	-0.19	-82%	0.83
2003	-0.74	-0.28	-62%	0.46
2004	-0.47	-0.38	-20%	0.09
2005	-0.20	-0.47	137%	-0.27
2006	0.08	-0.56	-822%	-0.64
2007	0.35	-0.62	-277%	-0.98
2008	0.56	-0.69	-223%	-1.26
2009	0.81	-0.74	-192%	-1.55
2010	1.05	-0.78	-175%	-1.83
2011	1.29	-0.83	-164%	-2.11
2012	1.53	-0.87	-157%	-2.40
2013	1.77	-0.92	-152%	-2.69
2014	2.00	-0.97	-148%	-2.97
2015	2.24	-1.01	-145%	-3.25
2016	2.48	-1.06	-143%	-3.54
2017	2.72	-1.10	-141%	-3.82
2018	2.95	-1.15	-139%	-4.10

6.5.7 Category-specific planned improvements

Estimations will be updated in this category in future submissions. The land use matrix will be updated reflecting accurately the areas covered by cropland, noting the provision of new information related to cropland land use (ex: LPIS use, etc.). The emission factors were updated in this submission, noting latest studies and literature developed for Mediterranean countries through the LIFE MediNet project to better reflect the estimations, and in view that, certain default factors are not adaptable to be used for Malta as a result of possible overestimations in the sector.

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)[43]. 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 rarely 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[44] (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[45]) 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 CLC 1996, 2000, 2006 and 2012 under the sclerophyllous vegetation and sparsely vegetated areas.

6.6.2 GRASSLAND - GRASSLAND REMAINING GRASSLAND (4.C.1)

6.6.2.1 Methodological Issues

Tier 1 approach was used for the calculation for sub-category Grassland remaining Grassland. It is assumed that the increase in biomass stocks in a single year is equal to biomass losses from mortality in that same year. There are no changes in management practices taking place on grasslands, and furthermore, no application of mineral and organic fertiliser, organic residues or biological nitrogen occurs.

Conversion within the category Grassland are described here. Other Grassland is converted to maquis Grassland for a considerable amount of years in the whole time-series; only one year of conversion occurred in the conversion from maquis Grassland to other Grassland. For these conversions, the net

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[43] Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora

[44] Legal Notice 321 of 2011 Environment and Development Planning Act (Cap. 504) - Nitrates Action Programme Regulations, 2011

[45] Legal Notice 12 of 2001 Environment Protection Act (CAP. 348) Trees and Woodland (Protection) Regulations, 2001

biomass stock was calculated using Equations 2.15 of the '2006 IPCC Guidelines for National GHG Inventories'. For both conversions, the biomass stocks were estimated considering the values taken from **Table 6-13** above for maquis Grassland and other Grassland.

For the calculation of the soil organic content changes in land conversions within Grassland, Equation 2.25 of the '2006 IPCC Guidelines for National GHG Inventories' was used. The same method used in Section 6.5.2.1 was used here to calculate the SOC changes. Moreover, similar parameters were also used from **Table 6-14** for the calculations of estimations. The 20-year transition cumulative areas were utilised in the estimation.

Table 6-19 represents the estimations in category 4.C.1 Grassland Remaining Grassland from 1990-2019 by gas.

Table 6-19 Emissions/removals in Grassland remining Grassland (kt CO2 eq.)

Year	CO_2
1990	-9.798
1991	-6.374
1992	-6.671
1993	-6.900
1994	-6.422
1995	-6.722
1996	-6.897
1997	-6.859
1998	-7.159
1999	-7.459
2000	-4.477
2001	-4.478
2002	-4.478
2003	-4.296
2004	-4.102
2005	-3.893
2006	-3.688
2007	-3.471
2008	-3.243
2009	-3.012
2010	-2.993
2011	-2.697
2012	-2.401
2013	-2.101
2014	-1.800
2015	-1.500
2016	-1.200
2017	-0.900
2018	-0.600
2019	-0.300

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 category; specifically, land converted to other Grassland is coming from annual Cropland, whereas land converted to maquis

Grassland is coming from perennial Cropland and Settlements. It is noted that conversions from the category Settlements are assumed to be gardens, thus there is no storage of C stock changes.

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 6-13 above were used for each conversion.

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. Moreover, factors from Table 6-14 were used for the estimations. The conversion from Settlements to maquis Grassland is equivalent to zero for the whole time-series since these are assumed to be gardens, thus there is no C stock changes.

Table 6-20 represents the estimations in category 4.C.2 Land converted to Grassland from 1990-2019 by gas.

Table 6-20 Emissions/removals in land converted to Grassland (kt CO2 eq.)

Year	CO_2
1990	10.982
1991	7.020
1992	7.339
1993	7.661
1994	7.091
1995	7.413
1996	7.605
1997	7.554
1998	7.876
1999	8.198
2000	4.800
2001	4.800
2002	4.800
2003	4.607
2004	4.400
2005	4.174
2006	3.951
2007	3.718
2008	3.470
2009	3.218
2010	3.211
2011	2.892
2012	2.574
2013	2.252
2014	1.929
2015	1.607

2016	1.285
2017	0.963
2018	0.641
2019	0.318

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 6-21 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 6-21 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 N2O emissions	N mineralised from	70%	Table 11.1 of 2006	Calculated as an average

from managed soils	mineral soil as a result of loss of soil carbon	IPCC Volume 4 AFOLU – default uncertainty range	between the difference of the high and the low range estimates of the default factors.

6.6.5 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

The QA/QC issues for this category are the same as in the Cropland category.

6.6.6 CATEGORY-SPECIFIC RECALCULATIONS

Due to the updates in specific factors in the LULUCF sector, as a result recalculation were performed. Recalculations for the Grassland category are presented below.

Table 6-22 Recalculations in Grassland category

Year	Grassland (Gg CO2 eq.) as reported in the previous inventory report	Grassland (Gg CO2 eq.) as reported in this inventory report	Percentage change in reported emissions (%)	Change in Gg CO2 eq.
1990	-4.67	1.18	-125%	5.86
1991	-3.00	0.65	-122%	3.64
1992	-3.14	0.67	-121%	3.80
1993	-3.29	0.76	-123%	4.05
1994	-3.06	0.67	-122%	3.72
1995	-3.20	0.69	-122%	3.89
1996	-3.28	0.71	-122%	3.99
1997	-3.26	0.69	-121%	3.95
1998	-3.40	0.72	-121%	4.11
1999	-3.54	0.74	-121%	4.28
2000	-2.08	0.32	-116%	2.40
2001	-2.08	0.32	-115%	2.40
2002	-2.08	0.32	-115%	2.40
2003	-2.00	0.31	-116%	2.31
2004	-1.91	0.30	-116%	2.20
2005	-1.81	0.28	-116%	2.09
2006	-1.71	0.26	-115%	1.97
2007	-1.61	0.25	-115%	1.86
2008	-1.50	0.23	-115%	1.73
2009	-1.39	0.21	-115%	1.60
2010	-1.40	0.22	-116%	1.61
2011	-1.26	0.20	-116%	1.45
2012	-1.12	0.17	-115%	1.29
2013	-0.98	0.15	-115%	1.13
2014	-0.84	0.13	-115%	0.97
2015	-0.70	0.11	-115%	0.81
2016	-0.56	0.08	-115%	0.64
2017	-0.42	0.06	-115%	0.48
2018	-0.28	0.04	-115%	0.32

6.6.7 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

The emission factors were updated in this submission, noting latest studies and literature developed for Mediterranean countries through the LIFE MediNet project to better reflect the estimations, and in view that, certain default factors are not adaptable to be used for Malta as a result of possible overestimations in the sector.

6.7 WETLANDS (CRF CATEGORY 4D)

6.7.1 WETLANDS - WETLANDS REMAINING WETLANDS (4.D.1)

6.7.1.1 Category Description

In Malta wetlands are mostly saline and therefore contain no or minimal carbon pools. For the purpose of defining Wetlands, the Ramsar Convention[46] was taken into consideration, with two sites, l-Għadira and is-Simar, being designated as such. The Environment Resource Authority (ERA) is the lead nation agency responsible for designation, regulation and management of these protected areas. As from past years ERA issued two management plans on these sites to conserve and improve the area. Both sites do not have any aquaculture, salt production, peat extraction, drainage or rewetting.

The wetland of Ghadira is designated as a Council of Europe Biogenetic Reserve, and a Mediterranean Protection Area. This reserve is a brackish coastal pool (once used for salt production) of varying water level and salinity, bordered by dunes. Several rare plant species, salt-resistant vegetation, and a diverse invertebrate fauna are supported. This reserve is an important area for resting and feeding for numerous species of migratory birds (source: RSIS). Several activities exert pressure on the ecology of the site. The Għadira area is popular with tourists and experiences pressures from recreational activities as well as pressure from development including impacts from noise, trampling, habitat disturbance and habitat loss. Overuse of fertilizers and pesticides from surrounding agricultural practices exerts pressure on the wetland from eutrophication and water pollution (ERA, 2015)[47].

The other wetland Is-Simar, is a nature reserve. This 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). Is-Simar is one of the few remaining habitats of its type in the Maltese Islands. It is a coastal wetland. Such habitats are therefore the only refuge left for a number of endangered or rare species such as the killifish (Aphanius fasciatus) and various species of flora. 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. 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)[48]

The area under the category Wetland covers the two afore-mentioned locations of Għadira and Simar which is equivalent to 0.025 Kha.

[46] Convention on Wetlands of International Importance especially as Waterfowl Habitat, Paris, 1994
[47] Management Plans https://era.org.mt/en/Pages/Natura-2000-Management-Planning.aspx
[48] (https://www.mepa.org.mt/simar).

6.7.1.2 Methodological Issues
No methodologies are provided for Flooded Land Remaining Flooded Land. From the 2006 IPCC Guidelines, it is assumed that CO_2 and N_2O emissions occurring on flooded lands are already covered by methodologies described in other sectors. The estimations for this category gives a value of zero, which was reported as Not Estimated (NE) in the CRF.

6.7.2 Wetlands - Land converted to wetlands (4.D.2)

6.7.2.1 Category Description
No land converted to Wetland occurred.

6.7.2.2 Methodological Issues
Not applicable.

6.7.2.3 Uncertainties and time-series consistency
Further information on the respective trends in the uncertainties for all the categories are presented in the Uncertainty section in the Annex.

6.7.2.4 Category-specific QA/QC and verification
Not applicable.

6.7.2.5 Category-specific recalculations
Not applicable.

6.7.2.6 Category-specific planned improvements
Not applicable

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. 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 of this category was derived from the CLC 1996, 2000, 2006 and 2012.

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 Cropland and Grassland; specifically, converted from annual Cropland, from other Grassland and from maquis 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 6-13 were considered for the conversions to Settlements.

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 **Error! Reference source not found.** were considered for the calculations of estimations. The 20-year t ransition cumulative areas were utilised in the estimation. For conversions to Settlement 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 0.2.

For the N_2O emissions in the conversions to Settlements, the same method as in the previous categories was used here, were the N estimations were performed using the SOC stock change values.

Table 6-23 represents the estimations in category 4.E.2 Land converted to Settlements from 1990-2019 by gas.

Table 6-23 Emissions/removals in land converted to Settlements (kt CO2 eq.)

Year	CO_2	N_2O
1990	6.006	0.697
1991	6.206	0.723
1992	6.407	0.749
1993	6.608	0.774
1994	6.809	0.800
1995	7.010	0.825
1996	7.055	0.831
1997	6.945	0.817
1998	6.758	0.805
1999	6.493	0.791
2000	6.234	0.758
2001	5.861	0.726
2002	5.493	0.695
2003	5.151	0.648
2004	4.827	0.603
2005	4.537	0.562
2006	4.239	0.521
2007	3.889	0.476
2008	3.564	0.435
2009	3.247	0.394
2010	2.508	0.299
2011	2.314	0.274
2012	2.119	0.249
2013	1.925	0.224
2014	1.730	0.199
2015	1.536	0.174
2016	1.342	0.149
2017	1.147	0.123
2018	0.953	0.098
2019	0.758	0.073

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 are thus, 28% 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

The QA/QC issues for this category are the same as in the previous categories.

6.8.5 Category-specific recalculations

Due to the updates in specific factors in the LULUCF sector, as a result recalculation were performed. Recalculations for the Settlements category are presented below.

Table 6-24 Recalculations in Settlements category

Year	Settlements (Gg CO2 eq.) as reported in the previous inventory report	Settlements (Gg CO2 eq.) as reported in this inventory report	Percentage change in reported emissions (%)	Change in Gg CO2 eq.
1990	4.75	6.70	41%	1.95
1991	4.90	6.93	41%	2.03
1992	5.05	7.16	42%	2.11
1993	5.19	7.38	42%	2.19
1994	5.34	7.61	42%	2.27
1995	5.49	7.83	43%	2.34
1996	5.52	7.89	43%	2.36
1997	5.44	7.76	43%	2.32
1998	5.23	7.56	45%	2.33
1999	4.95	7.28	47%	2.33
2000	4.76	6.99	47%	2.23
2001	4.42	6.59	49%	2.17
2002	4.08	6.19	52%	2.11
2003	3.84	5.80	51%	1.96
2004	3.61	5.43	50%	1.82
2005	3.42	5.10	49%	1.68
2006	3.21	4.76	48%	1.55
2007	2.95	4.36	48%	1.41
2008	2.72	4.00	47%	1.28
2009	2.48	3.64	47%	1.16
2010	1.94	2.81	45%	0.87
2011	1.80	2.59	44%	0.79
2012	1.66	2.37	43%	0.71
2013	1.51	2.15	42%	0.63
2014	1.37	1.93	41%	0.56
2015	1.23	1.71	39%	0.48
2016	1.09	1.49	37%	0.40
2017	0.95	1.27	34%	0.32
2018	0.80	1.05	31%	0.25

6.8.6 Category-specific planned improvements

The emission factors were updated in this submission, noting latest studies and literature developed for Mediterranean countries through the LIFE MediNet project to better reflect the estimations, and in view that, certain default factors are not adaptable to be used for Malta as a result of possible overestimations in the sector.

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 it is typically unmanaged. 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 CLC 1996, 2000, 2006 and 2012.

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 maquis 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 6-13 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.

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 6-14 for the calculations of estimations. The 20-year transition cumulative areas were utilised in the estimation. The assumption that Settlements contains 20% of the SOC of the previous use was considered for Settlements converted to Other Land.

For the N_2O emissions in the conversions to Other Land, the same method as in the previous categories was used here, were the N estimations were performed using the SOC stock change values.

Table 6-25**Error! Reference source not found.** represents the estimations in category 4.F.2 Land converted to Settlements from 1990-2019 by gas.

Table 6-25 Emissions/removals in land converted to Other Land (kt CO2 eq.)

Year	CO_2	N_2O
1990	0.667	0.054
1991	0.708	0.058
1992	0.749	0.062
1993	0.767	0.066
1994	0.831	0.070
1995	0.853	0.073
1996	0.861	0.073
1997	0.869	0.074
1998	0.877	0.075
1999	0.885	0.075
2000	0.894	0.076
2001	0.894	0.076
2002	0.894	0.076
2003	0.894	0.076
2004	0.894	0.076
2005	0.894	0.076
2006	0.894	0.076
2007	0.902	0.076
2008	0.910	0.077
2009	0.918	0.078
2010	0.935	0.080
2011	0.935	0.080
2012	0.935	0.080
2013	0.935	0.080
2014	0.935	0.080
2015	0.935	0.080
2016	0.935	0.080
2017	0.935	0.080
2018	0.935	0.080
2019	0.935	0.080

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, 28% 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

The QA/QC issues for this category are the same as in the previous categories.

6.9.5 Category-specific recalculations

Due to the updates in specific factors in the LULUCF sector, as a result recalculation were performed. Recalculations for the Other Land category are presented below.

Table 6-26 Recalculations in Other Land category

Year	Other Land (Gg CO2 eq.) as reported in the previous inventory report	Other Land (Gg CO2 eq.) as reported in this inventory report	Percentage change in reported emissions (%)	Change in Gg CO2 eq.
1990	0.61	0.72	18%	0.11
1991	0.65	0.77	18%	0.12
1992	0.69	0.81	18%	0.12
1993	0.73	0.83	15%	0.11
1994	0.77	0.90	18%	0.14
1995	0.79	0.93	18%	0.14
1996	0.79	0.93	18%	0.14
1997	0.80	0.94	18%	0.14
1998	0.81	0.95	18%	0.14
1999	0.82	0.96	18%	0.14
2000	0.82	0.97	18%	0.15
2001	0.82	0.97	18%	0.15
2002	0.82	0.97	18%	0.15
2003	0.82	0.97	18%	0.15
2004	0.82	0.97	18%	0.15
2005	0.82	0.97	18%	0.15
2006	0.82	0.97	18%	0.15
2007	0.83	0.98	18%	0.15
2008	0.84	0.99	18%	0.15
2009	0.85	1.00	18%	0.15
2010	0.86	1.01	18%	0.15
2011	0.86	1.01	18%	0.15
2012	0.86	1.01	18%	0.15
2013	0.86	1.01	18%	0.15
2014	0.86	1.01	18%	0.15
2015	0.86	1.01	18%	0.15
2016	0.86	1.01	18%	0.15
2017	0.86	1.01	18%	0.15
2018	0.86	1.01	18%	0.15

6.9.6 Category-specific planned improvements

Not applicable

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

7.1 OVERVIEW OF SECTOR

In this Chapter, emissions generated from waste management practices between the period 1990 (base year) and 2019 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 **Table 7-1**). 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 were 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		CH_4		
	5B: Biological Treatment of Solid Waste		CH_4	N_2O	
	5C: Incineration and Open Burning of Waste	CO_2	CH_4	N_2O	
	5D: Wastewater Treatment and Discharge		CH_4	N_2O	
Gases Reported	Direct gases	CO_2	CH_4	N_2O	
	Indirect gases	NO_x	CO	NMVOC	SO_2
Key Categories	Solid Waste Disposal		CH_4		

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[49] (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 recently 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[50]. Organic waste is the material that is biodegradable and comes from either an animal or a plant. This is normally broken down by micro-

[49] Wasteserv. Sant Antnin Waste Treatment Plant.
[50] State of the Environment Report, 2018, Chapter 6: Resources and Waste; Environment & Resources Authority, 2018.

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[51].

Currently, organic waste that is collected is sent to the Sant Antnin Waste Treatment Plant (SAWTP) for processing for landfill capping. Over 25,000 tonnes of organic waste were received at the SAWTP since the nationalisation of the collection (October 2018)[52].

Bring-in-sites

Bring-In sites were introduced in Malta in 2002 where the public can deposit waste in kerbside containers for plastic, paper, glass and metal. During year 2018, according to the latest data available by the National Statistics Office (2020)[53], 4,218 tonnes were collected from bring-in sites.

Another alternative for glass is the once-monthly collection from door-to-door collection by waste collection contractors. When recyclable materials are collected from the bring-in-sites, the material is also taken at the SAWTP to the Material Recovery Facility (MRF) (NSO, 2019).

The total generation of plastic waste in 2016, according to latest data available by NSO, was 8,714 tonnes where 99.5% of the waste treated was recycled while the rest was landfilled[54].

Thermal Treatment Facility

The Thermal Treatment Facility was inaugurated in December 2007. This incinerator treats abattoir waste, clinical waste, refused derived fuel (RDF) and other waste like industrial sludges. 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[55]. Please refer to section 7.4 for further information regarding waste incineration.

Civic Amenity Sites

Civic Amenity Sites are facilities where the public may dispose of various types of bulky household waste, domestic hazardous waste as well as recyclable materials. Six sites can be found distributed across Malta and Gozo. These sites cater for the disposal of furniture, mattresses, carpets and clothing, white goods such as fridges, cookers and microwaves, electronics such as computers, monitors, mobile phones, printers, electronic toys and tools, garden waste, edible oil and lubricant oils, batteries, bulbs and neon tubes, expired medicines and used syringes, solvents, chemicals, paint and other hazardous waste, small quantities of household construction waste such as stone and tiles and tyres. The waste collected at these sites is either exported overseas for

[51] Wasteserv (2018). Organic.
[52] The Malta Independent (2019). Most organic waste ending up in landfills, not suitable for compost.
[53] NSO (2020). Solid Waste Management: 2018. [News Release].
[54] NSO (2018). World Environment Day: 2018. [News Release].
[55] Wasteserv. Thermal Treatment Facility.

treatment, treated locally, re-used for other purposes or recycled[56]. In 2018, according to the latest data available by the National Statistics Office (2020), 30,392 tonnes were collected from civic amenity sites.

A social marketing campaign, funded by the EU project, was recently launched where waste collection vehicles are offering service to the public to dispose of hazardous waste such as cooking oil and light bulbs, apart from disposing waste at the Civic Amenity Sites, as previously mentioned. Other waste which can be disposed in these vehicles are textiles, polystyrene, textiles, plastic, metal, glass, paper and cardboard. Apart from educating the general public, this campaign is also convenient for those with limited access to a Civic Amenity Site since the collection vehicles will visit all localities[57].

Bulky refuse service

Apart from the Civic Amenity Sites, local councils offer free of charge service of bulky refuse collected from the doorstep for large items such as for furniture and appliances[58].

Hazardous waste

Very limited amount of waste is treated locally in incineration since the landfill is not permitted to handle hazardous waste. Moreover, some hazardous waste is exported from Malta for energy recovery include industrial sludges, aqueous washing liquids and mother liquors, waste solvents, paint sludges, waste from gas cleaning and fly ash, waste oils, waste electrical and electronic equipment, lead acid batteries, asbestos, boiler dust, liquid combustible wastes and solid combustible wastes (State of the Environment Report, 2018). The main five types of hazardous waste which are generated locally are: Waste oils; Waste Electrical and Electronic Equipment (WEEE); Lead acid batteries; Waste solvents and Waste from gas cleaning and fly ash[59].

Medicine waste

Medicinal waste is classified as hazardous. For this purpose, since October 2019, expired or unwanted medicines such as loose or packaged tablets and capsules, bottled medicines, inhalers and medicinal cream tubes started to be deposited in specialised medicinal waste bins for safe disposal located in pharmacies around the island. Other biohazardous items such as syringes need to be disposed of in sharp container and taken to Civic Amenity sites[60].

Tyres

Tyres in Malta are currently being exported. Since 2013, 17,567 tonnes of used tyres were exported[61].

Batteries

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[56] Wasteserv. Civic Amenity Sites.
[57] Wasteserv (2019). Roadshow.
[58] Don't waste waste (2016). Bulky Refuse Services.
[59] State of the Environment Report (2018), Review; Environment & Resources Authority, 2018.
[60] Wasteserv (2019). Expired medicine collection – Pharmacies.
[61] Times of Malta (2019). Malta's waste tyres being shipped to India.

Batteries can cause serious environmental damage if disposed of incorrectly. Harmful substances such as lead and heavy metals, will contaminate the soil, underground or surface waters and also have harmful effects on human health.

Small batteries (AA, AAA, Button, C, D, 6V, 9V, mobile phone and mixed batteries) can be disposed into battery bins found at local councils, schools, supermarkets and various stationeries. When the operator collects the batteries, these are then sorted. The sorted batteries are then exported for treatment and recycling[62]. On the other hand, vehicle lead-acid batteries, can be disposed at the Civic Amenity Site or by the bulky refuse service offered by the local council[63].

Waste Electrical and Electronic Equipment (WEEE)

The collection of WEEE waste, two thirds of which was accounted for by large household equipment such as refrigerators and freezers and water heaters, has seen a steady growth over the years. The main destination of such waste is export[64]. WEEE Malta, is the largest Scheme in Malta representing importers of electrical and electronic products. It celebrated its fifth anniversary of its establishment where during these five years, WEEE Malta collected and treated over 5,500 tonnes of electronic waste[65].

In 2018, an increase of 40% of the collection of WEEE waste was observed when compared with previous year. Around 1500 tonnes were collected in 2018 where 2/3 of the collected material was from large household equipment. Among these, 568 tonnes were exported.

Textiles and clothes

Unwanted clothing in good condition can be recycled into metal bins located in different localities around the island. After collection, clothing are carefully sorted where then around 20% is exported to Northern Ireland for re-distribution while the rest is exported to countries for re-use such as Africa for example Togo, Senegal and Tunisia, and India. Other items which can be deposited in the metal bins include shoes, curtains, sheets and carpets. However, unsuitable materials are either used for making rags or as refuse-derived fuel (RDF) in incinerators[66].

Construction and demolition waste

Construction waste is waste generated from the building and construction industry and includes material like bricks, concrete, tiles, debris, ceramics and more[67].

Mineral waste from construction and demolition and from excavation (EWC code 17 00 00) is recycled and recovered locally. The majority of other construction and demolition waste is exported for recovery or disposal with very few of the construction and demolition waste being landfilled locally. Results for the construction and demolition waste landfilled locally are included in the solid waste disposal data as industrial waste.

[62] Don't waste waste (2016). Civic Amenity Site.
[63] Greenpak (2015). Batree.
[64] WEEE Malta (2019). WEEE Malta increases the electrical material and electronics collection by 40%.
[65] WEEE Malta (2020) – Five years of collection and recycling of electronic waste
[66] Times of Malta (2017). A market for recycled clothing.
[67] Wasteserv. Construction waste.

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.

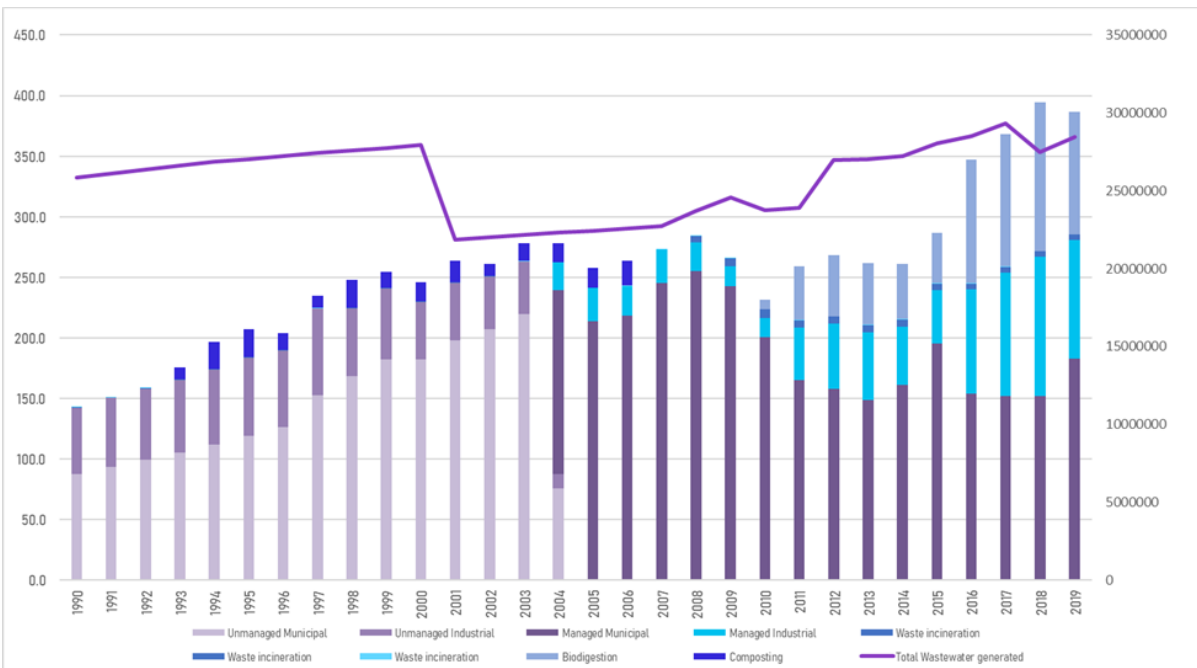

Figure 7-1 Waste disposal trends; amount of MSW generated by year.

Municipal solid waste generation in Malta has seen an increase in trend throughout the years. In fact, as reported by the European Commission (2019)[68], in 2017 (latest available data by the European Commission), municipal waste generation per capita in Malta was the highest amongst the European Union (604 kg/y/inhabitant in Malta compared to 487 kg/y/inhabitant in the EU).

Even though between 2000 and 2017 the average amount of municipal waste per capita declined by 7% in the EU, trends in Malta illustrates an increase (refer to **Figure 7-2**).

[68] European Commission (2019). The Environmental Implementation Review 2019, Country Report Malta.

Figure 7-2 Municipal solid waste generation per capita Source: European Parliament, 2018.

In absolute terms, municipal solid waste per person in Malta (647kg/capita) was ranked as the second highest in 2016 within the EU member states (EU28: 482kg/capita)[69]. Landfilling in Malta remains an important destination of a significant portion of collected waste until alternative disposal solutions are brought into operation. In fact, 2017 landfilling data represents that more than three quarters of the municipal waste is landfilled - an 86% rate, which is more than three times the EU average (24%). On the other hand, the share of recycling and composting was the least amongst EU (6%) (EU average: 46%) (European Commission, 2019).

According to NSO, by the end of 2018, municipal waste generation has increased by 5% over the previous year. Also, during 2018, the total amount of municipal waste treatment increased by 8.5% over 2017. The share of landfilling from the total municipal waste treated stood at 92.9 per cent; up from the 92.2 per cent level recorded a year before[70].

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 2.6 million inbound tourists in 2018 and has seen continuous increases over the years, a 14.3% increase from the previous year[71], should be given due consideration when analysing trends in waste generation in Malta.

[69] European Parliament (2018). Waste management in the EU: infographic with facts and figures.
[70] NSO (2019). Municipal Waste: 2018. [News Release].
[71] NSO (2019). Inbound Tourism: December 2018. [News Release].

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 for reporting year 2018.

	GHG					
	CO_2		CH_4		N_2O	
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.A1 Managed Waste Disposal Sites	NA	NA	T2	M	NO	NO
5.A1.a Anaerobic	NA	NA	T2	M	NO	NO
5.A1.b Semi-aerobic	NA	NA	NA	NA	NO	NO
5.A2 Unmanaged Waste Disposal Sites	NA	NA	M	M	NO	NO
5.A3 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; 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	Environment & Resources Authority (ERA)
- Unmanaged SWDS landfill: amount of CH_4 recovered through the RTO - Managed SWDS: amount of CH_4 recovered and used for energy production - The average % of CO_2 and CH_4 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 were addressed in this inventory (refer to the below table) due to identified issue/s made in previous review report/s (both from ESD and UNFCCC reviews).

The below table refers to recommendations from the TERT during the ESD Review 2019, including revised estimates.

Table 7-5 Recommendations from the TERT including revised estimates (ESD Review 2019).

EMRT - ID	Category, gas, year	Recommendations from the TERT including revised estimates	Status
MT-5A-2019-0001	5.A Solid waste disposal, 2016, CH4	For unmanaged Solid Waste Disposal (5.A), CH_4 and the year 2016, the TERT noted a recalculation of emissions between the 2018 and 2019 submissions. Upon further inspection, the TERT noted that Malta calculated the aeration factor in estimating emissions from an aerated landfill as %CH4/(%CO2+%CH4) instead of 2*%CH4/(%CO2+%CH4), as specified in the Maltese NIR (page 244). In response to a question raised during the review, Malta provided a revised estimate for the year 2017 and stated that it will be included in the next submission. The TERT agreed with the revised estimate provided by Malta. The TERT recommends that Malta include the revised estimate in its next submission.	Addressed. The revised estimate of 2*%CH_4/(%CO_2+%CH_4) has been included in the January 2020 submission.

The below table refers to the status of implementation of issues and/or problems raised in the review reports of Malta during the UNFCCC Review 2019.

Table 7-6 Status of implementation of issues and/or problems raised in the review reports of Malta (FCCC/ARR/2018/MLT).

ID#	Recommendation made in previous review report for the identified issue/s	Number of successive reviews issue not addressed	Status
W.1	Develop QA/QC procedures for the waste sector and report them in the NIR.	4 (2012/2013/2015/2016)	Addressed. QA/QC measures are being reported in the 'Category-specific QA/QC and Verification' section.
W.2	Provide detailed information in the NIR on CH_4 recovery for all years (quantify and method used).	5 (2012/2013/2015/2016/2017)	Addressing. The method used is reported under section 7.2.5.14. Efforts will be made in future submission to quantity of methane recovered will be provided in future submissions.
W.3	Justify, in accordance with the 2006 IPCC Guidelines, estimates of CH_4 recovered, or use	3	Addressed. A description of how CH_4 recovered is quantified/estimated is

	the assumption that no recovery occurs.	(2015/2016/2017)	included in the NIR text 'Parameters' section 7.2.5.14.
W.4	Include the DOC content per type of degradable waste material in the NIR.	4 (2013/2015/2016/2017)	Addressed. The DOC content per type of degradable waste material is included in the NIR 'Parameters' section 7.2.5.1.
W.5	Include information on the k values and half-lives of the waste fractions in the NIR.	4 (2013/2015/2016/2017)	Addressed. Information is included in the NIR 'Parameters' section 7.2.5.1.
W.6	Provide information on the waste composition, DOC content and k value for each waste type in the NIR.	3 (2015/2016/2017)	Addressed. Information is provided in the NIR 'Parameters' section 7.2.5.1.
W.7	Correct the DOC value reported for 2004 in CRF table 5.A.	3 (2015/2016/2017)	Addressed. The DOC value reported in the CRF table for year 2004 has been corrected from 4.84% to 7.07%.
W.8	Explain in the NIR the methodology, assumptions, AD and EFs used to estimate N_2O emissions from pig slurry entering wastewater treatment plants.	3 (2015/2016/2017)	Addressed. An explanation regarding the factor applied to account for the N removal efficiency of wastewater treatment plants in the calculation of N2O emissions from effluent, the activity data of the quantities of N from agricultural sources received at wastewater treatment plants and the default values used in N2O emissions are included in the NIR text 'Methodological Issues' section 7.5.2.
W.9	Investigate and correct the descriptions in the NIR and the method used to estimate CH4 emissions from anaerobic digestion.	1 (2017)	Addressed. A description of the method used to estimate CH4 emissions from anaerobic digestion is provided in section 7.3.2.2.
W.10	Correct the waste disposal data reported in CRF table 5.A, the $F_{NON-CON}$ and $F_{IND-COM}$ values reported in CRF table 5.D and the CH4 and N2O EFs for municipal solid waste, clinical and industrial waste reported in CRF table 5.C.	1 (2017)	Addressed. Unmanaged landfilling in Malta lasted till year 2004 while the shift to managed landfilling started in 2004 and is still operating till present. Municipal solid waste and industrial waste data for incineration has been referred to in the NIR. The 0.26 Gg of Clinical waste refers to year 2008 and not 2017. This is both included in the NIR and CRF. The $F_{NON-CON}$ and $F_{IND-COM}$ values reported in the CRF were corrected to 1.40 and 1.25 in sections 7.5.2.2.
W.11	Ensure all uses of the notation key "IE" are fully explained in CRF table 9.	1 (2017)	Addressing.
W.12	Provide further quantitative information in the NIR regarding the country-specific MCF values applied, such as the time series of adjusted MCF values and the measured landfill gas composition from the Maghtab landfill.	1 (2017)	Addressing. Please refer to section 7.2.5.7 which is based on the findings of a study following the installation of the RTO plant at Magħtab, studies carried out by Scott Wilson (2004, 2010), in line with the findings by Hans Oonk (2012).
W.13	Replace the "IE" notation key for unmanaged waste disposal reported in CRF table 5.A with actual MCF and DOC_f values.	1 (2017)	Addressing.
W.14	Replace "NO" with "IE" if the IPCC default EF is applied and include information in CRF table 9 about the fact that recovery is included in the estimate of net emissions.	1 (2017)	Addressed. The notation key "NO" has been replaced with "IE" as the IPCC default EF of 0.8 has been applied in 5.B.2 Anaerobic digestion at biogas facilities as stated in NIR

			section 7.3.2.2. Recovery is included in the estimate of net emissions. Information has been included in the CRF table 9.
W.15	Include the amount of N from agricultural sources the quantity of N in effluent reported in CRF table 5D.	1 (2017)	Addressed. The amount of N from agricultural sources has been provided in section 7.5.2.
W.16	Include in the NIR further quantitative and qualitative information on the N removal efficiency factor, including the source and justification for the value used and a time series of the values applied.	1 (2017)	Addressing. The NIR section 7.5.2 includes information on the N removal efficiency of wastewater treatment plants of 70% as suggested to the Inventory Agency by EU expert reviewers in 2016.

Additional findings made during the UNFCCC review of the 2019 submission are illustrated in the table below where some of the findings have been already addressed.

Table 7-7 Additional findings made during the individual review of the 2019 annual submission of party (FCCC/ARR/2018/MLT)

ID#	Description of the finding with recommendation or encouragement	Status
W.18	The ERT notes that Malta has not provided a clear and full description of the waste sector waste generation, composition and treatment streams (management data) for all the category and sub-categories using the IPCC 2006 Guidelines. The structure of the NIR does not follow the UNFCCC Annex I inventory reporting guidelines for the NIR. This makes it very difficult to systematically review all the categories and sub-categories of the Waste Sector.	Addressed. Waste management and waste generation trends are reported in sections 7.1 and 7.1.1. The structure of the NIR was also amended as recommended.
W.19	The ERT observed that some Solid Waste Disposal sites in Malta were closed with the waste not removed or relocated to other disposal sites. Malta confirmed that landfills, including Wied Fulija landfill exist and await regrading, reprofiling and capping of the waste mass. According to the FOD model, the solid waste in these landfills continue to emit gases though small in quantities which Malta has not taken into account in its estimation of emissions from SWDS.	As highlighted in the NIR in section 7.2.2 and in Annex 3, data prior year 1997 was scant and only indicative. Therefore, the values for deposited amounts (total municipal solid waste and industrial waste) were back extrapolated using reliable and validated available data in the unmanaged model. Back extrapolation was required for the period between 1950 and 1997. The extrapolation is based on population and GDP data.
W.20	The ERT observes inconsistences in the use of notation keys as some of the Notation keys used in the CRF Tables are not explained in the NIR. For example, on CRF Table 5.D, total organic waste, sludge removed and N in effluent are indicated as IE – included elsewhere, without specifying where these are included as expected to be in in CRF Table 9. It is further observed by the ERT that the unclear use of notation keys such as the case on CRF Table 5.A where Annual waste at the SWDS, MCF and DOCf are indicated as IE instead of providing data on actual amounts of waste and appropriate factors/parameters. In addition, no explanation is given for use of the Notation key IE. This also includes the use of notation key IE for methane recovery in unmanaged SWDS which is not explained in CRF table 9. ERT to follow and review the NIR effectively.	Addressing. The notation key IE (included elsewhere) in the CRF 5.D for sludge refers to sewage sludge which is included in the solid waste disposal category. The notation key is also explained in the CRF Table 9 and NIR section 7.5.2.
W.21	In responding to a question by the ERT on estimation of methane from uncollected wastewater involving some 400 dwellings, the Party indicated that all agglomerations are served with a collection system. Where in the exceptional case, remote hamlets are served with communal and individual cesspits, the local water and wastewater utility collects wastewater from	As described in section 7.5.5.1, the bulk of wastewater generated in Malta is treated aerobically while a small fraction is disposed to sea as untreated.

	these cesspits periodically using a tanker system and subsequently the water is discharges to the sewerage network at designated discharge points and is subsequently received for treatment at the Urban Wastewater Treatment plants. Therefore, the ERT believes that there is no uncollected water in Malta.	
W.22	The ERT observes that while Malta has indicated on page 259 of its NIR that the treatment and discharge system has recently undergone major upgrades with the building of three new sewage treatment plants that came into operation in 2008 and 2011 reflected an increase in the percentage of treated sewage near to 100% treatment of all wastewater generated. However, Malta provided the ERT with a spreadsheet on Waste: (Domestic) Wastewater Treatment and Discharge (GHG emissions contributors of Wastewater: CH4 and N2O) with activity data used for estimating emissions of CH4 and N2O indicating that only 85% of the wastewater generated is treated while 15% is not. The ERT considers this a discrepancy between the Activity data used and the narrative in the NIR.	Addressed. The NIR text section 7.5.1.1 was revised and updated to avoid discrepancy with the activity data.
W.23	The ERT has observed that Malta has reported in its NIR that for the period 1990 to 2000, the sewage generation rate for the year 1992 in m3/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 due to not having data for the two time periods.	Addressed. NIR section 7.5.2.
W.24	In response to a request by the ERT to provide a clear indication of how much and how sludge from wastewater treatment systems in Malta is handled in estimates emissions on from wastewater treatment, Malta indicated that Aerobically and Anaerobically stabilized sludge is currently disposed of to landfills. Malta also provided a spreadsheet with AD for wastewater treatment which shows that no amount of sludge is removed from wastewater treatment. The ERT observes that despite confirming that sludge is disposed in landfills/Solid Waste Disposal Sites, Malta has not clearly reported sludge amounts generated across all waste categories. The ERT also notes that reporting on sludge in Solid Waste on CRF Table 5D is not transparent as the Notation key" NE" is used instead of" IE" for sludge, given that it is accounted for under Solid Waste Disposal Table 5A.	Addressed. The notation key NE (not estimated) in the CRF 5.D for sludge was replaced with IE (included elsewhere) since sewage sludge is included in the solid waste disposal category. The notation key is also explained in the CRF Table 9.
W.25	Though Table 7-16 in the NIR provides Activity data of Swine manure N going to sewers, the ERT observes that Malta has not clearly demonstrated that the swine slurry is the only source of N from agricultural sources that goes into the sewer system.	Addressing.
W.26	In response, to the ERT request that the Party indicates the quantities of plastic waste generated in Malta and if plastic waste is incinerated, recycled or exported, the Party confirmed that they did not have data on the volumes of plastic waste for the 2017 submission.	Addressing. The total generation of plastic waste available for Malta is that for 2016, latest available data. This data is reported in NIR section 7.1.
W.27	The ERT observed that Malta replaced the population data used in the previous submission for the calculation of emissions from wastewater for the period 1990 - 2004. This has implications on time series consistency. Malta has not explained in its NIR how the full time series consistency has been taken into account.	Addressed. As explained during the 2019 review, population data used in the 2018 submission was replaced throughout the whole timeseries. End-of-year population data is provided by the Malta's National Statistics Office as reported in section 7.5.2.
W.28	In response, to the ERT request that the Party indicates the quantities of plastic waste generated in Malta and if plastic waste is incinerated, recycled or exported, the Party confirmed that they did not have data on the volumes of plastic waste for the 2017 submission.	Addressing. The total generation of plastic waste available for Malta is that for 2016, latest available data. This data is reported in NIR section 7.1.
W.29	Malta reports in Table 7-2 (A summary of the methodologies and emission factors used in the waste sector for reporting year) in the NIR (page 235 that the EF for 5.A.1 - Managed Waste Disposal Sites and 5.A.1.a – Anaerobic as Plant Specific. The Party however does not provide an explanation on how the	Addressed. As explained during the 2019 review, the use of the notation key Plant Specific is an erroneous entry. The matter regarding the notation key has been

	Plant Specific Emission Factors were determined.	resolved in this submission to M (Model) since the FOD model is being used to calculate the SWD category.

The below table refers to recommendations from the TERT during the ESD Review 2020, including revised estimates.

Table 7-8 Recommendations from the TERT including revised estimates (ESD Review 2020).

CRF category/issue	Review recommendation	Status
5A Solid Waste Disposal CH_4, 1990-2018	For CH_4emissions from 5A1 Solid Waste Disposal -Managed Waste Disposal Sites and for all years, the TERT noted that the Oxidation Factor value (OX) applied by Malta forManaged Landfills is 0, while in Table 3.2 of Volume 5, Chapter 3 of the 2006 IPCC Guidelines, it is indicated that OX=0.1 should be used when managed landfills are covered with oxidising material and 0 if not. From the introduction of the paragraph on OXit becomes clear that "covered with CH_4-oxidising material" refers to soil or other materials covering the waste. In response to a question raised during the review, Malta agreed with the observation and provided a revised estimate for the years 2005, 2016, 2017 and 2018. The TERT agreed with the revised estimate provided by Malta. The TERT recommends that Malta include the revised estimate in its next submission.	The oxidation factor value has been applied to OX=0.1 for the IPCC Waste model for managed model.
5D Wastewater Treatment and Discharge CH_4, 1990-2018	For CH_4emissions from 5D1 Wastewater Treatment and Discharge -Domestic and for all years, the TERT noted that Malta does not estimate emissions from "Not well managed" WastewaterTreatment Plants (WWTP) which represents 97 % of the organic load. In response to a question raised during the review, Malta agreed with the observation and provided a revised estimate for the years 2005, 2016, 2017 and 2018 and stated that it will be included in the next submission. The TERT agreed with the revised estimate provided byMalta. The TERT recommends that Malta include the revised estimate in its next submission, including modification done on the parameter BOD g/person/day, in order to improve the consistency of the time series.	The observation provided during the review has been applied for the Waste sector. The recalculations and methodology will be provided in the January 2021 submission.

7.1.2.5 *Sector-specific Recalculations*

Some recalculations occurred during data and methodologies revisions carried out throughout the reporting of the waste sector. These recalculations were performed following ESD and UNFCCC reviews.

A summary of the waste sector recalculations is provided in below tables.

Table 7-9Error! Reference source not found. refers to those waste sector categories in which a correction or improvement was carried out either throughout the whole timeseries or in a specified year or years. On the other hand, Table 7-10 represents a summary of recalculations carried out throughout the timeseries by referring to the current (2021 submission) and previous submissions (2020 submission). A percentage change is provided as to illustrate the change between the two submissions.

Table 7-9 Waste sector recalculations carried out in the NIR for reporting year 2019.

Waste Category - Recalculation	Correction or Improvement	Years Affected
Solid Waste Disposal	CH_4 emissions from Managed landfilling (Gg CO_2 eq.)	2005-2018
	Total CH_4 emissions (Gg CO_2 eq.)	2005-2018
Anaerobic Digestion	Net CH4 Emissions (Gg CO_2 eq.)	2012, 2014-2018
Incineration	Emissions from CO_2 from Municipal and Clinical incineration	2013, 2015, 2017, 2018
Wastewater Treatment and Discharge	CH_4 emissions (Gg CO_2 eq.)	2013-2018
	N_2O emissions (Gg CO_2 eq.)	1990-2018
	Total Wastewater emissions (Gg CO_2 eq.)	1990-2018

Table 7-10 A summary of recalculations carried out in the Waste sector throughout the timeseries.

		1990	1995	2000	2005	2010	2015	2018
Current submission: Total waste	Gg CO2 eq.	69.32	104.54	140.22	178.35	141.43	137.17	150.70
Previous submission: Total waste	Gg CO2 eq.	68.79	104.00	139.81	179.09	149.21	147.58	163.86
Percentage change	%	0.01	0.01	0.00	0.00	-0.05	-0.07	-0.08
Solid Waste Disposal	Gg CO2 eq.	41.50	70.41	106.66	145.12	113.39	123.94	138.82
	Gg CO2 eq.	41.50	70.41	106.66	146.19	121.50	136.47	153.56
	%	0.00	0.00	0.00	-0.01	-0.07	-0.09	-0.10
Biological Treatment of Solid Waste	Gg CO2 eq.	0.00	3.92	2.66	2.75	0.15	0.83	2.45
	Gg CO2 eq.	0.00	3.92	2.66	2.75	0.15	0.81	1.10
	%	0.00	0.00	0.00	0.00	0.00	0.02	1.23
Incineration and Open Burning of Waste	Gg CO2 eq.	0.43	0.43	0.40	0.32	0.73	0.72	0.69
	Gg CO2 eq.	0.43	0.43	0.40	0.32	0.73	0.70	0.68
	%	0.00	0.00	0.00	0.00	0.00	0.04	0.01
Wastewater Treatment and Discharge	Gg CO2 eq.	27.39	29.78	30.49	30.16	27.16	11.68	8.74
	Gg CO2 eq.	26.87	29.25	30.09	29.83	26.84	9.59	8.53
	%	0.02	0.02	0.01	0.01	0.01	0.22	0.03

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 7-11 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 Table 7-12).

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 7-12 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 17-12 above and as illustrated in Figure 7-3 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, regular 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)[72].

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)[73].

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.

[72] Wasteserv Press Release (5 June 2015). *Landfills: Past, present and future.*
[73] Adi Associates Environmental Consultants Ltd, 2011. Master Plan for the Maghtab Environmental Complex.

Moreover, **Figure 7-3** 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.

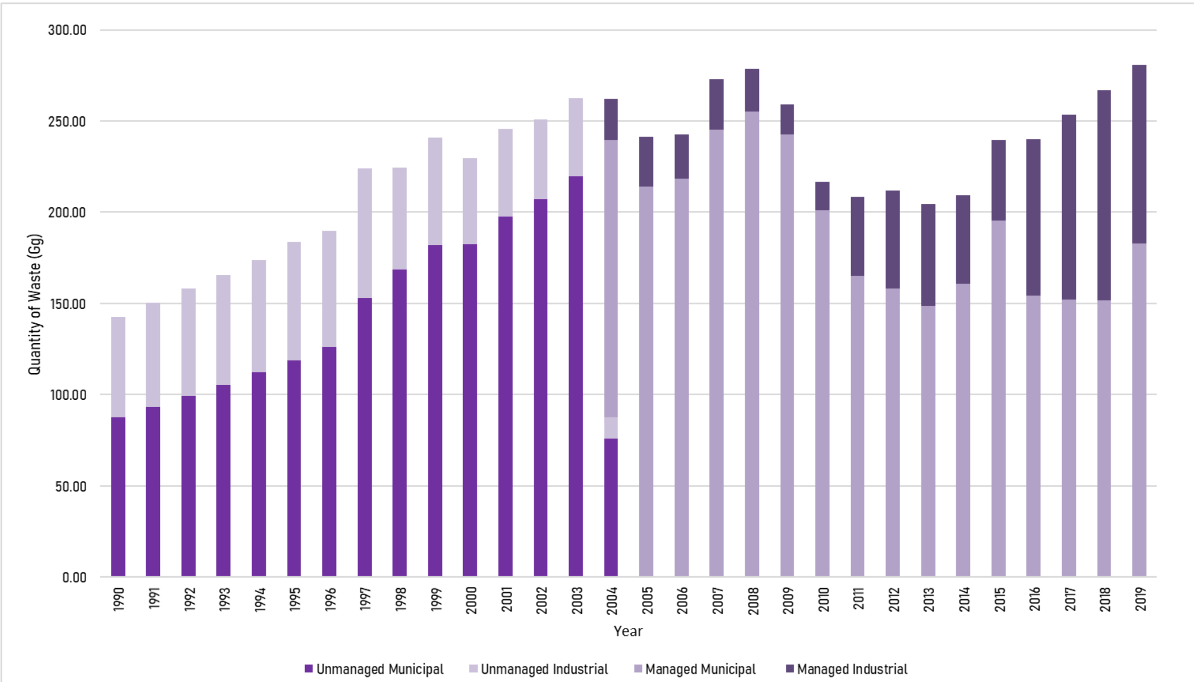

Figure 7-3 Amounts of waste deposited in SWD sites by SWD type.

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 7-13 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)		IPCC 2006 Guidelines default value, Volume 5, Chapter 2, Table 2.4, Page 2.14
Food waste	0.15	
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):		IPCC 2006 Guidelines, Volume 5, Chapter 3, Table 3.3, Page 3.17
Food waste	0.06	
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 used is recommended by the IPCC 2006 Guidelines default value of 0.5.

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)[74] (Scott Wilson, 2010)[75]. Additionally, the findings in the above-mentioned study are in line with the findings in (Oonk, 2012)[76], where the RTO collection efficiency varies between 45-75%. The MCF used in both the unmanaged and managed model is provided in the below table.

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[74] Wilson, S (2004). *Development of Rehabilitation Strategies: Maghtab, Qortin and Wied Fulija Landfills*. Summary report Final. (Derbyshire, UK).

[75] Wilson, S (2010). *Rehabilitation of Maghtab, Qortin and Wied Fulija Landfills in Malta - Aerial Emissions Control Works* CT2586/2004, Final Report. (Derbyshire, UK).

[76] Oonk, H. (2012) Efficiency of landfill gas collection for methane emission reduction. *Greenhouse Gas Measurement and Management, 2(*2-3), 129-145. DOI: 10.1080/20430779.2012.730798

Table 7-14 MCF for unmanaged and managed models

	MSW					Industrial				
	Un-managed, shallow	Un-managed, deep	Managed	Managed, semi-aerobic	Uncate-gorised	Un-managed, shallow	Un-managed, deep	Managed	Managed, semi-aerobic	Uncate-gorised
	MCF	MCF	MCF	MCF	MCF	MCF	MCF	MCF	MCF	MCF
IPCC default	0.4	0.8	1	0.5	0.6	0.4	0.8	1	0.5	0.6
Country-specific value	0.4	0.8	1	0.5	0.6	0.4	0.8	1	0.5	0.6

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 was obtained from ‘‘Household Waste Composition’’ surveys carried out by the National Statistics Office (NSO, 2012). The Survey may be accessed online at https://nso.gov.mt/en/News_Releases/Archived_News_Releases/Documents/2012/News2012_156.pdf[77]

Table 7-15 below 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 unmanaged model for years prior 2002; the period between 1950 and 2002 while the 2011/2012 survey started to be reported in year 2011 till present until an updated data is available from the data provider.

Table 7-15 Municipal solid waste composition survey.

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

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. However, we do not know the estimated percentage that nappies had in the 2011/2012 survey.

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.

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.

[77] National Statistics Office. (2012). *Household Waste Composition Survey*. [News Release]. Retrieved from https://nso.gov.mt/en/News_Releases/Archived_News_Releases/Documents/2012/News2012_156.pdf

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 added with the amount of methane oxidised from the unmanaged model and multiplied with the molecular weight of CO_2 ($\frac{44}{16}$). This results into the Emissions from flaring which are not associated with Energy production (Gg CO_2). Then, the value of oxidation from the FOD managed model is multiplied by the value of the proportion used for energy production and by the molecular weight of CO_2. 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 (*25) and results into the total emissions to be transferred to energy (Gg CH_4).

Therefore, for year 2019 methane recovery was calculated as follows:

i. Emissions from flaring which are not associated with Energy production (Gg CO_2) = ((oxidised value from the FOD managed model * (proportion used for energy production)) + the amount of methane oxidised from the unmanaged model) * (molecular weight of CO_2);
= ((0.20 * (1-0.80)) + 0.02) * (44/16)
=0.17

ii. Total emissions to be transferred to energy (Gg CO_2) = oxidation from the FOD managed model * proportion used for energy production * (molecular weight of CO_2);
= 0.20 * 0.80 * (44/16)
=0.44

iii. Total Emissions to be transferred to Energy (Gg CH4) = Total emissions to be transferred to energy (Gg CO_2) / GWP of CH_4;
=0.44/25
=0.02

7.2.5.15 Unmanaged Landfill MCF rectifications

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 'Braambergen Landfill', Netherlands)[78].

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 project (e.g. Kuhstedt:

78 Duurzaam Storten. (2011). Braambergen Landfill. Retrieved from https://duurzaamstorten.nl/wp-content/uploads/2016/07/Braambergen_project_plan_2011-1.pdf

http://www.ifas-hamburg.com/pdf/aeration03.pdf)[79]. 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

[79] Heyer, K. U., Hupe, K., Koop, A., Ritzkowski, M., & Stegmann, R. (2003). The Low Pressure Aeration of Landfills: Experience, Operation and Costs. (Proceedings Sardinia).

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; $\frac{(2 * \% \, CH4)}{(\% \, CH4 + \% \, CO2)}$

7.2.6 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 Table 7-16 below.

Table 7-16 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.

7.2.7 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.

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 following link with regards to the Daily Penalty Regulation* http://www.justiceservices.gov.mt/DownloadDocument.aspx?app=lom&itemid=11958&l=1
>
> *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 Table 7-2.

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.

7.2.8 CATEGORY-SPECIFIC RECALCULATIONS

The waste composition for years between 2005 and 2018 in the FOD managed model, and the oxidation factor value, were updated as recommended during the ESD 2020 review. Eventually, this revision resulted also in updates in methane emissions from managed landfilling which then affected the total methane emissions in the solid waste disposal category. Therefore, recalculations were required as presented in the tables below.

Table 7-17 Recalculation for category Solid Waste Disposal – CH_4 emissions from managed landfilling (Gg CO_2 eq.).

Year	CH_4 emissions in managed landfilling (Gg CO_2 eq.) as reported in the previous inventory report	CH_4 emissions in managed landfilling (Gg CO_2 eq.) as reported in this inventory report	Percentage change in reported emissions (%)	*Change in Gg CO_2 eq.*
1990	0.00	0.00	NA	0.00
1991	0.00	0.00	NA	0.00
1992	0.00	0.00	NA	0.00
1993	0.00	0.00	NA	0.00
1994	0.00	0.00	NA	0.00
1995	0.00	0.00	NA	0.00
1996	0.00	0.00	NA	0.00
1997	0.00	0.00	NA	0.00
1998	0.00	0.00	NA	0.00
1999	0.00	0.00	NA	0.00
2000	0.00	0.00	NA	0.00
2001	0.00	0.00	NA	0.00
2002	0.00	0.00	NA	0.00
2003	0.00	0.00	NA	0.00
2004	0.00	0.00	NA	0.00
2005	10.98	9.91	-0.10	-1.07
2006	25.49	23.00	-0.10	-2.49
2007	39.36	35.50	-0.10	-3.86
2008	54.42	49.06	-0.10	-5.35
2009	69.06	62.24	-0.10	-6.82
2010	81.81	73.71	-0.10	-8.11
2011	88.50	79.69	-0.10	-8.81
2012	95.69	86.11	-0.10	-9.59
2013	97.52	87.70	-0.10	-9.82
2014	106.92	96.12	-0.10	-10.80
2015	123.44	110.95	-0.10	-12.49
2016	132.91	119.46	-0.10	-13.45
2017	137.21	123.32	-0.10	-13.89
2018	145.69	130.95	-0.10	-14.74
2019	NA	133.87	NA	NA

Table 7-18 Recalculation for category Solid Waste Disposal – Total CH_4 emissions (Gg CO_2 eq.).

Year	Total CH_4 emissions from SWD (Gg CO_2 eq.) as reported in the previous inventory report	Total CH_4 emissions from SWD (Gg CO_2 eq.) as reported in this inventory report	Percentage change in reported emissions (%)	*Change in Gg CO_2 eq.*
1990	41.50	41.50	0.00	0.00
1991	46.99	46.99	0.00	0.00
1992	52.64	52.64	0.00	0.00
1993	58.43	58.43	0.00	0.00
1994	64.33	64.33	0.00	0.00
1995	70.41	70.41	0.00	0.00
1996	76.71	76.71	0.00	0.00

1997	83.04	83.04	0.00	0.00
1998	90.92	90.92	0.00	0.00
1999	98.53	98.53	0.00	0.00
2000	106.66	106.66	0.00	0.00
2001	113.85	113.85	0.00	0.00
2002	121.55	121.55	0.00	0.00
2003	129.20	129.20	0.00	0.00
2004	137.14	137.14	0.00	0.00
2005	146.19	145.12	-0.01	-1.07
2006	154.11	151.62	-0.02	-2.49
2007	161.71	157.85	-0.02	-3.86
2008	83.96	78.60	-0.06	-5.35
2009	103.40	96.59	-0.07	-6.82
2010	121.50	113.39	-0.07	-8.11
2011	122.36	113.55	-0.07	-8.81
2012	123.81	114.23	-0.08	-9.59
2013	114.36	104.54	-0.09	-9.82
2014	129.67	118.87	-0.08	-10.80
2015	136.47	123.94	-0.09	-12.54
2016	145.96	132.51	-0.09	-13.45
2017	145.10	131.21	-0.10	-13.89
2018	153.56	138.82	-0.10	-14.74
2019	NA	141.42	NA	NA

7.2.9 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

A planned improvement, 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, regarding data on the long-term storage of C in waste disposal sites, annual change in long-term C storage, and annual change in C storage in HWP waste, efforts will be made to update current practises such that this information could be included in future reporting. However, the data available on HWP and long-term C storage has not yet been properly investigated and thus details regarding how the improvements will be carried out have not been studied.

As recommended by the UNFCCC review, another planned improvement for future submissions might be that of verifying data from landfill methane recovery.

7.3 BIOLOGICAL TREATMENT OF SOLID WASTE (CRF 5B)

Table 7-19 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 7-4 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 7-4 below illustrates the different quantities of waste composted during the period 1990 to 2018. 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.

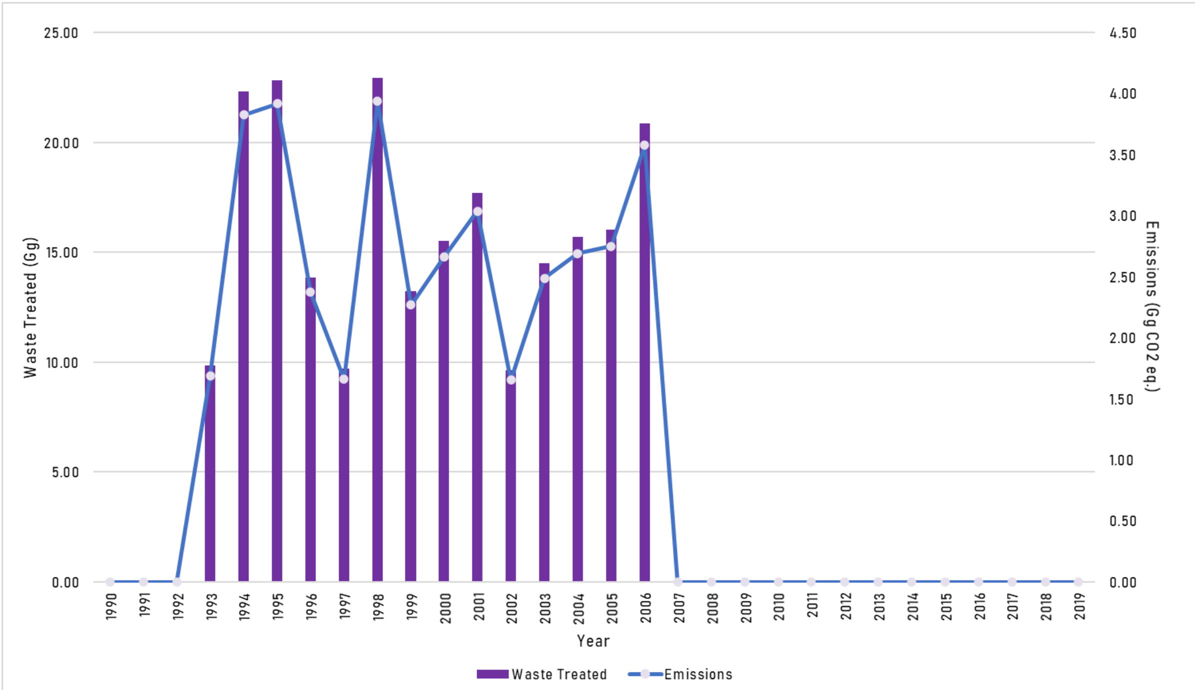

Figure 7-4 Waste treated and emissions from composting.

7.3.1.3 Uncertainty and time series consistency

Not applicable. Compost stopped operating in early 2007.

7.3.1.4 Category-specific QA/QC and verification

Not applicable. Compost stopped operating in early 2007.

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[80].

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 (https://www.ipcc-nggip.iges.or.jp/public/2006gl/corrigenda9.html)[81]. 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 (25) 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).

[80] WasteServ (2020). Mechanical Biological Treatment Plant.
[81] IPCC 2006 Guidelines 9th Corrigenda (2015). Retrieved from https://www.ipcc-nggip.iges.or.jp/public/2006gl/corrigenda9.html

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

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

Due to an update in the activity data as provided by the data provider for years 2012, 2014-2018, a minor recalculation was required for the net methane emissions (Gg CH_4) from anaerobic digestion. The below recalculations are reflected according to the commencement of anaerobic digestion i.e. year 2010.

Table 7-20 Recalculation for category Biological Treatment Anaerobic Digestion – Total CH_4 emissions (Gg CO_2 eq.).

Year	CH_4 emissions from Anaerobic Digestion (Gg CO_2 eq.) as reported in the previous inventory report	CH_4 emissions from Anaerobic Digestion (Gg CO_2 eq.) as reported in this inventory report	Percentage change in reported emissions (%)	*Change in Gg CO_2 eq.*
2010	0.01	0.01	0.00	0.00
2011	0.04	0.04	0.00	0.00
2012	0.04	0.04	-0.04	0.00
2013	0.04	0.04	0.00	0.00
2014	0.04	0.04	0.04	0.00
2015	0.03	0.03	0.02	0.00
2016	0.03	0.08	1.51	0.05
2017	0.03	0.09	1.69	0.05
2018	0.04	0.10	1.23	0.05
2019	NA	0.08	NA	NA

7.3.2.6 Category specific planned improvements

One of the planned improvements was regarding the data of the total annual amount treated by biological treatment facilities (Gg wet weight). However, the data has been provided by the data provider.

7.4 INCINERATION AND OPEN BURNING OF WASTE (CRF 5C)

Table 7-21 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 Indirect gases	 CO_2, CH_4, N_2O 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 Open Burning of Waste	 1990 – till present Not Occurring (NO)

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[82]. This incinerator allowed for the decommissioning of old non-compliant local incinerators.

Figure 7-5 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.

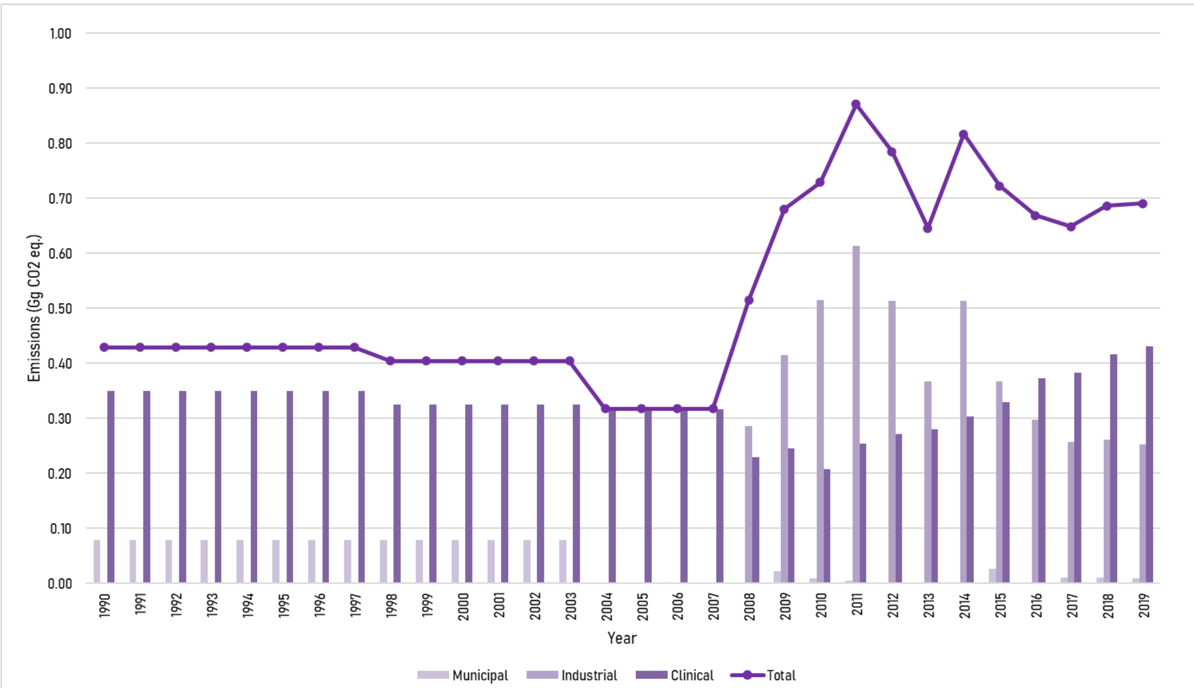

Figure 7-5 Direct GHG emissions from category Incineration.

The below Figure 7-6 includes the indirect emissions from the combustion of municipal, clinical and industrial waste.

[82] Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste.

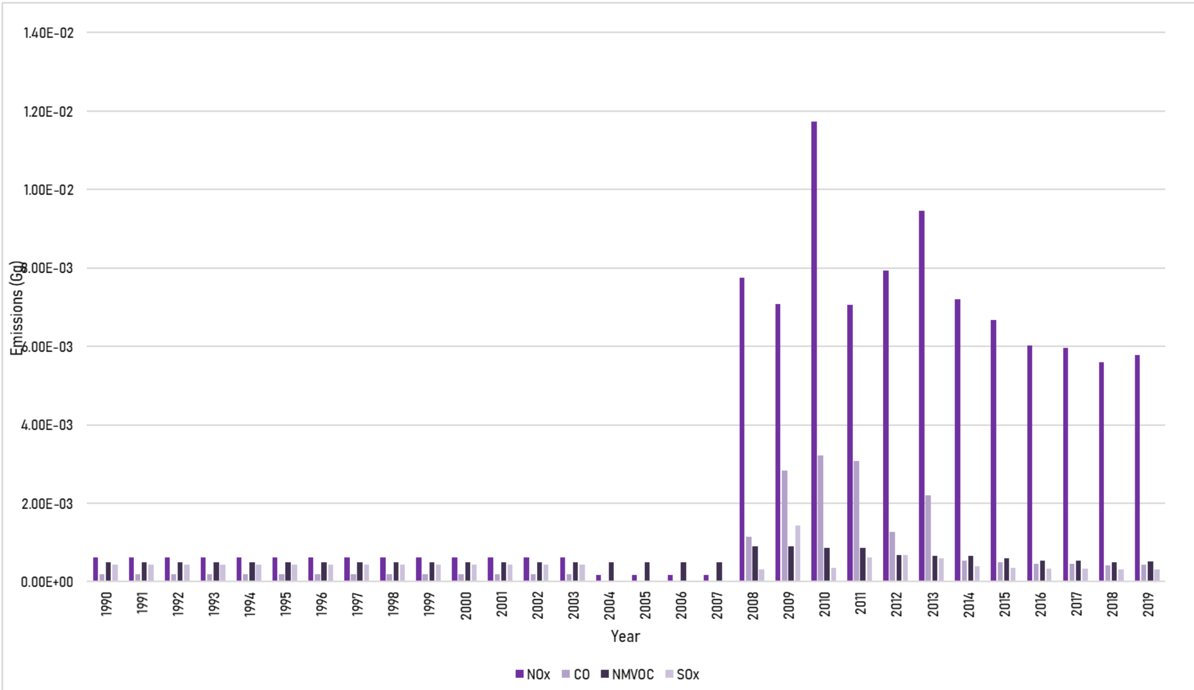

Figure 7-6 Indirect GHG emissions from category Incineration.

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.

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[83], 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.

[83] State of the Environment Report for Malta 1998

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[84].

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 plant will manage around 40% of the overall waste generated in the Maltese Islands, equivalent to 114,000 tonnes and recover a substantial amount of energy of about 69000 MWh per year. The WtE plant will use a robust technology known as Moving Grate Incineration and the waste fed in the plant will be non-recyclable waste.

An online technical report on the setting up of a Waste-to-Energy facility in Malta can be found at

https://environment.gov.mt/en/Waste%20Management/Documents/W2EReportOnline.pdf[85]

The ECOHIVE project is divided as the following:

Energy

The waste-to-energy facility is meant to process waste that cannot be easily recycled. This facility will be treating 40% of non-recyclable waste generated in Malta diverting it away from landfill disposal with a capacity of 192,000 tonnes annually.

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

[84] ECOHIVE, 2020 https://www.ecohive.com.mt/en/home

[85] Ministry for the Environment, Sustainable Development and Climate Change, Technical Report on the setting up of a Waste to Energy Facility in Malta (2018).

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).

Table 7-22 below illustrates the quantified uncertainty for this category.

Table 7-22 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

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

Due to a minor error in the reported activity data, an update in years 2013, 2015, 2017 and 2018 for the CO_2 emissions from Municipal and Clinical Incineration was required. This recalculation hence affected the total emissions for the Incineration category. Both tables are presented below.

Table 7-7-23 Recalculation for category Incineration – Total CO_2 emissions (Gg CO_2 eq.).

Year	CO_2 emissions from Incineration (Gg CO_2 eq.) as reported in the previous inventory report	CO_2 emissions from Incineration (Gg CO_2 eq.) as reported in this inventory report	Percentage change in reported emissions (%)	*Change in Gg CO_2 eq.*
1990	0.37	0.37	0.00	0.00
1991	0.37	0.37	0.00	0.00
1992	0.37	0.37	0.00	0.00
1993	0.37	0.37	0.00	0.00
1994	0.37	0.37	0.00	0.00
1995	0.37	0.37	0.00	0.00
1996	0.37	0.37	0.00	0.00
1997	0.37	0.37	0.00	0.00
1998	0.35	0.35	0.00	0.00
1999	0.35	0.35	0.00	0.00
2000	0.35	0.35	0.00	0.00
2001	0.35	0.35	0.00	0.00
2002	0.35	0.35	0.00	0.00
2003	0.35	0.35	0.00	0.00
2004	0.32	0.32	0.00	0.00
2005	0.32	0.32	0.00	0.00
2006	0.32	0.32	0.00	0.00
2007	0.32	0.32	0.00	0.00
2008	0.35	0.35	0.00	0.00
2009	0.47	0.47	0.00	0.00
2010	0.52	0.52	0.00	0.00
2011	0.69	0.69	0.00	0.00
2012	0.62	0.62	0.00	0.00
2013	0.36	0.46	0.29	0.10
2014	0.64	0.64	0.00	0.00
2015	0.54	0.56	0.05	0.02
2016	0.52	0.52	0.00	0.00
2017	0.50	0.51	0.02	0.01
2018	0.54	0.55	0.02	0.01
2019	NA	0.55	NA	NA

Table 7-24 Recalculation for category Incineration – Total emissions (Gg CO_2 eq.).

Year	Total emissions from Incineration (Gg CO2 eq.) as reported in the previous inventory report	Total emissions from Incineration (Gg CO2 eq.) as reported in this inventory report	Percentage change in reported emissions (%)	*Change in Gg CO2 eq.*
1990	0.43	0.43	0.00	0.00
1991	0.43	0.43	0.00	0.00
1992	0.43	0.43	0.00	0.00
1993	0.43	0.43	0.00	0.00
1994	0.43	0.43	0.00	0.00
1995	0.43	0.43	0.00	0.00
1996	0.43	0.43	0.00	0.00
1997	0.43	0.43	0.00	0.00
1998	0.40	0.40	0.00	0.00
1999	0.40	0.40	0.00	0.00
2000	0.40	0.40	0.00	0.00
2001	0.40	0.40	0.00	0.00
2002	0.40	0.40	0.00	0.00
2003	0.40	0.40	0.00	0.00
2004	0.32	0.32	0.00	0.00
2005	0.32	0.32	0.00	0.00
2006	0.32	0.32	0.00	0.00
2007	0.32	0.32	0.00	0.00
2008	0.51	0.51	0.00	0.00
2009	0.68	0.68	0.00	0.00
2010	0.73	0.73	0.00	0.00
2011	0.87	0.87	0.00	0.00
2012	0.78	0.78	0.00	0.00
2013	0.54	0.65	0.19	0.10
2014	0.82	0.82	0.00	0.00
2015	0.70	0.72	0.04	0.03
2016	0.67	0.67	0.00	0.00
2017	0.64	0.65	0.02	0.01
2018	0.68	0.69	0.01	0.01
2019	NA	0.69	NA	NA

7.4.7 CATEGORY SPECIFIC PLANNED IMPROVEMENTS

Another future improvement is to create a Waste-to-Energy model with experts by ensuring that appropriate data and methodologies are applied.

7.4.8 OPEN BURNING OF WASTE (CRF 5C2)

Open burning of Waste does not occur in Malta. In fact, it is reported in the CRF category 5.C.2 by using the notation key NO, referring to Not Occurring.

7.5 WASTEWATER TREATMENT AND DISCHARGE (CRF 5D)

Table 7-7-25 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 recently 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 - to under 20% of wastewater is untreated and an increase of treated wastewater – with over 80% 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; about 400 dwellings where wastewater is stored in buffer tanks which is frequently emptied; every one or two weeks.

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;

(i) investing in additional treatment capacity (Sant'Antnin Treatment Plant upgrade currently underway) and
(ii) 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, all wastewater generated in year 2012 was treated, thus zero volume of discharged raw wastewater. Therefore, the notation key for year 2012 for the methane emissions has been updated from Not Estimated (NE) to Not Occurring (NO) to reflect in the CRF for March submission (5.D.1 row L12).

As illustrated in Figure 7-7 below, as per the previous explanation, 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.

However, for the reporting year, year 2019, the trends in the volumes of wastewater treated and untreated, between years 2018 and 2019, have been confirmed again with the operator of the national wastewater management system (Water Service Corporation, WSC). The total wastewater treated has decreased while the total wastewater untreated has increased, both in 2019, hence, the increase is reflected in emissions from the wastewater category. According to the discussions we had with WSC, the primary cause for the change in operations that led to the observed trend is the issue of farmyard waste disposal in the national sewer network. It is our understanding that WSC has a programme of measures to rectify the situation subject to the issue being resolved.

The mentioned increase is reflected in the below figure for both methane and nitrous oxide emissions.

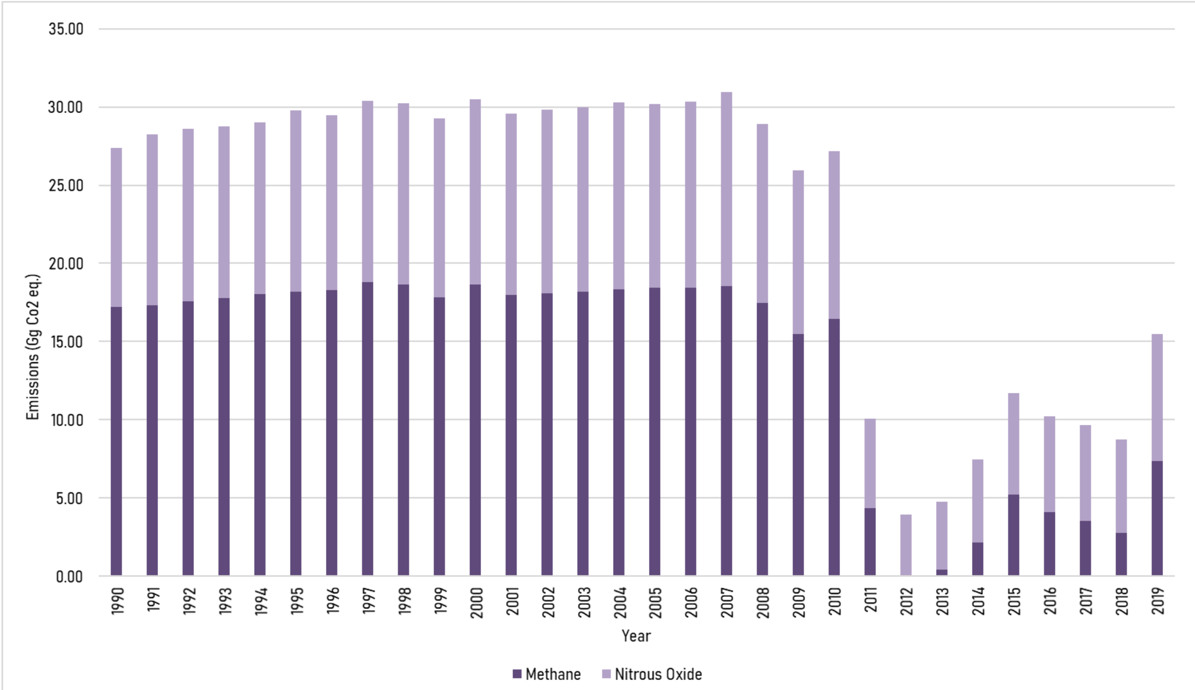

Figure 7-7 GHG emissions for category Wastewater Treatment.

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.

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.

During the ESD 2020 Review (MT-5D-2020-0003), the TERT noted that emissions from “Not well managed” wastewater treatment plants, which represent 97% of the organic load entering, were not being estimated. Hence, the methodology used is an MCF of 0,3 which is applied to organic load treated in not well managed wastewater treatment plants (97% of total load). An MCF of 0 is applied to organic load treated in well managed wastewater treatment plants (3 % of total load). The averaged (97 % x 0,3 + 3 % x 0 = 0,29) is applied to organic load treated in wastewater treatment plants. This was extracted from the European Commission urban Wastewater web site[86] and calculated as follows:

Table 7-26 UWWTD Treatment Plants

Name	Load entering (p.e.)	Physical Capacity (p.e.)	IPCC category
Ta' Barkat Urban Wastewater Treatment Plant	591.967	500	Not well managed
Cumnija Urban Wastewater Treatment Plant	120.916	60	Not well managed
Ras il-Hobz Urban Wastewater Treatment Plant	52.313	46	Not well managed
Sant Antnin Urban Wastewater Treatment Plant	23.843	120	Well managed

Not well managed:	765.196	(Ta' Barkat + Cumnija + Ras il-Hobz Urban Wastewater Treatment Plants)
Well managed:	23.843	(Sant Antnin Urban Wastewater Treatment Plant)
Fraction of not well managed Wastewater Treatment Plant:	97.0%	(765.196/789.039*100)
MCF of well managed Wastewater Treatment Plant:	0	2006 IPCC GL, Volume 5, Chapter 6, Table 6.3
MCF of not well managed Wastewater Treatment Plant:	0.3	2006 IPCC GL, Volume 5, Chapter 6, Table 6.3
Average MCF of Wastewater Treatment Plant:	0.29	((0.3*97.0%+(1-97.0%)*0)

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:

[86] UWWTD Treatment Plants – Compliance Map UWWTD Treatment Plants- Compliance map | European Commission urban wastewater website: Malta

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 (Table 7) should be included in the NIR. 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 Animal Manure Nitrogen Applied to Soils.

Table 7-7-27 Activity data of Swine manure N going to sewers N (kt).

	Year									
	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019
Swine manure N going to sewers, N (kt)	0.94	0.96	0.74	0.65	0.65	0.44	0.41	0.34	0.36	0.36

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 2005 https://nso.gov.mt/en/publicatons/Publications_by_Unit/Documents/C5_Population%20and%20Migration%20Statistics/Demographic_Review_2014.pdf *and*

- NSO's News Release entitled, 'World Population Day: 2020' for inventory years between 2006 and 2019 https://nso.gov.mt/en/News_Releases/Documents/2020/07/News2020_114.pdf

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 Emissions

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'[87] where the name of the country, elements, items aggregated, and years are selected.

An annual figure for the years between 1990 and 2018 is provided from the 'Food Balance Sheets'. However, the data used between years 1990 and 2013 is currently not available on the FAOSTAT website. Therefore, 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 2014 and 2018 only (latest update from FAOSTAT: February 8th, 2021; date accessed by the Inventory Agency: 3rd March 2021).

For the remaining year, year 2019, an extrapolation is being used (refer to Table 7). Therefore, the formula ''=TREND'' five-year moving average, was applied until an updated data is available from FAOSTAT.

Table 7-7-28 Protein Consumption (g/capita/day).

	Year									
	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019
Per Capita Protein Consumption (g/capita/day)	93.34	103.87	109.34	110.15	107.32	112.26	113.62	116.13	116.4	118.34*

*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.

$$N_{EFFLUENT} = \left(\left((P * Protein * F_{NPR} * F_{NON-CON} * F_{IND-COM}) - N_{Sludge} - N_{WWT}\right) + N_{Agri}\right)$$

$$N_2O\ Emissions_{Effluent} = N_{EFFLUENT} * EF_{EFFLUENT} * {}^{44}/_{28} * (1 - Efficiency_{plant})$$

$$N2O\ Emissions_{\ Total} = N2OEmissions_{Plant} + N2O\ Emissions_{Effluent}$$

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.

[87] Food and Agriculture Organization of the United Nations. (2017). *Food Balance Sheets*. Retrieved from http://www.fao.org/faostat/en/#data/FBS

7.5.3 *UNCERTAINTY AND TIME SERIES CONSISTENCY*

Uncertainty in both methane and nitrous oxide emissions are summarised in Table 7. It is clear that the biggest uncertainty is at EF level especially for N_2O emissions.

Table 7-7-29 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*

2021 Review

During the ESD 2021 Review (Step 1), the TERT noted an increase in both methane and nitrous oxide emissions from the wastewater category. The cause for this increase is explained in section 7.5.1 due to a decrease in the total wastewater treated and an increase in the total wastewater untreated.

2020 Review

As explained in the methodological section, during the ESD 2020 Review (MT-5D-2020-0003), the TERT noted that emissions from “Not well managed” wastewater treatment plants, which represent 97% of the organic load entering, were not being estimated. Hence, the methodology used is an MCF of 0,3 which is applied to organic load treated in not well managed wastewater treatment plants (97% of total load). An MCF of 0 is applied to organic load treated in well managed wastewater treatment plants (3 % of total load). The averaged (97 % x 0,3 + 3 % x 0 = 0,29) is applied to organic load treated in wastewater treatment plants.

Moreover, 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*

Due to the updates mentioned already in the methodological section, recalculations in the CH_4 and N_2O emissions were required, which also affected the total emissions from the Wastewater category, as illustrated in the below tables.

Table 7-30 Recalculation for category Wastewater Treatment – Total CH_4 emissions (Gg CO_2 eq.).

Year	CH4 emissions from Wastewater (Gg CO2 eq.) as reported in the previous inventory report	CH4 emissions from Wastewater (Gg CO2 eq.) as reported in this inventory report	Percentage change in reported emissions (%)	*Change in Gg CO2 eq.*
1990	17.20	17.20	0.00	0.00
1991	17.30	17.30	0.00	0.00
1992	17.57	17.57	0.00	0.00
1993	17.78	17.78	0.00	0.00
1994	18.04	18.04	0.00	0.00
1995	18.19	18.19	0.00	0.00
1996	18.28	18.28	0.00	0.00
1997	18.82	18.82	0.00	0.00
1998	18.62	18.62	0.00	0.00
1999	17.83	17.83	0.00	0.00
2000	18.65	18.65	0.00	0.00
2001	17.97	17.97	0.00	0.00
2002	18.09	18.09	0.00	0.00
2003	18.21	18.21	0.00	0.00
2004	18.33	18.33	0.00	0.00
2005	18.44	18.44	0.00	0.00
2006	18.47	18.47	0.00	0.00
2007	18.57	18.57	0.00	0.00
2008	17.46	17.46	0.00	0.00
2009	15.50	15.50	0.00	0.00
2010	16.44	16.44	0.00	0.00
2011	4.37	4.37	0.00	0.00
2012	0.00	0.00	0.00	0.00
2013	0.20	0.43	1.18	0.23
2014	1.58	2.18	0.38	0.60
2015	3.17	5.20	0.64	2.03
2016	3.30	4.09	0.24	0.80
2017	2.74	3.56	030	0.82
2018	2.44	2.80	0.15	0.36
2019	NA	7.38	NA	NA

Table 7-7-31 Recalculation for category Wastewater Treatment – Total N_2O 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	9.67	10.20	0.05	0.53
1991	10.40	10.92	0.05	0.53
1992	10.50	11.05	0.05	0.56

1993	10.42	10.99	0.05	0.57
1994	10.41	10.99	0.06	0.58
1995	11.06	11.60	0.05	0.54
1996	10.80	11.16	0.03	0.36
1997	11.18	11.55	0.03	0.37
1998	11.25	11.62	0.03	0.37
1999	11.07	11.42	0.03	0.35
2000	11.44	11.85	0.04	0.41
2001	11.15	11.59	0.04	0.44
2002	11.32	11.72	0.04	0.40
2003	11.44	11.78	0.03	0.35
2004	11.56	11.93	0.03	0.37
2005	11.39	11.72	0.03	0.33
2006	11.53	11.89	0.03	0.36
2007	11.99	12.39	0.03	0.40
2008	11.15	11.45	0.03	0.30
2009	10.15	10.43	0.03	0.28
2010	10.40	10.73	0.03	0.33
2011	5.56	5.69	0.02	0.13
2012	3.88	3.97	0.02	0.08
2013	4.16	4.32	0.04	0.16
2014	5.19	5.32	0.02	0.12
2015	6.43	6.47	0.01	0.04
2016	6.21	6.14	-0.01	-0.08
2017	5.87	6.10	0.04	0.24
2018	6.09	5.99	-0.02	-0.10
2019	NA	8.18	NA	NA

Table 7-7-32 Recalculation for category Wastewater Treatment – Total Wastewater emissions (Gg CO_2 eq.)

Year	Total emissions from Wastewater (Gg CO2 eq.) as reported in the previous inventory report	Total emissions from Wastewater (Gg CO2 eq.) as reported in this inventory report	Percentage change in reported emissions (%)	*Change in Gg CO2 eq.*
1990	26.87	27.39	0.02	0.53
1991	27.70	28.23	0.02	0.53
1992	28.06	28.62	0.02	0.56
1993	28.20	28.77	0.02	0.57
1994	28.44	29.02	0.02	0.58
1995	29.25	29.78	0.02	0.54
1996	29.08	29.44	0.01	0.36
1997	30.00	30.37	0.01	0.37
1998	29.88	30.24	0.01	0.37
1999	28.90	29.25	0.01	0.35
2000	30.09	30.49	0.01	0.41
2001	29.12	29.56	0.02	0.44
2002	29.40	29.80	0.01	0.40
2003	29.64	29.99	0.01	0.35
2004	29.90	30.26	0.01	0.37
2005	29.83	30.16	0.01	0.33
2006	30.00	30.36	0.01	0.36
2007	30.56	30.96	0.01	0.40
2008	28.61	28.91	0.01	0.30

2009	25.65	25.93	0.01	0.28
2010	26.84	27.16	0.01	0.33
2011	9.93	10.06	0.01	0.13
2012	3.88	3.97	0.02	0.08
2013	4.36	4.75	0.09	0.39
2014	6.77	7.50	0.11	0.72
2015	9.59	11.67	0.22	2.08
2016	9.51	10.23	0.08	0.72
2017	8.60	9.66	0.12	1.06
2018	8.53	8.79	0.03	0.26
2019	NA	15.56	NA	NA

7.5.6 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 7-8** below summarises the emissions of biogenic CO_2 from 1990.

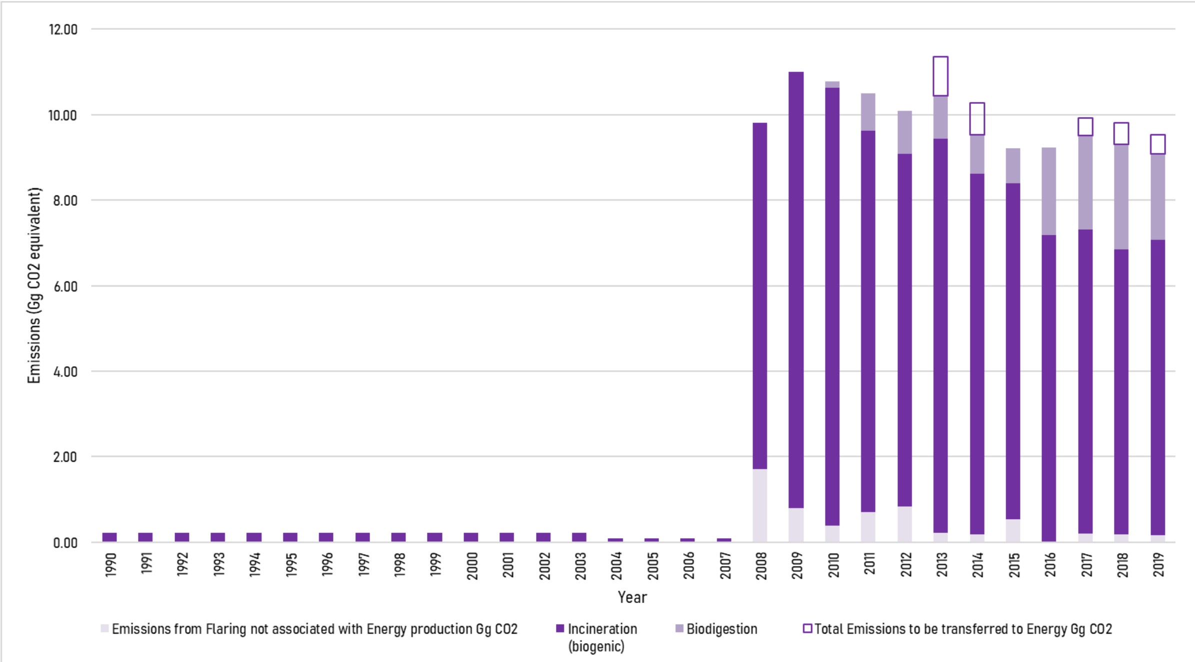

Figure 7-8 CO_2 emissions of biogenic origin from a number of waste processes.

It should be pointed out that the variations in the data for the years 2013, 2014 and 2015 from the chart above to the same chart in the 2017 inventory submission of Malta is due to an error in the worksheet used to generate the figures.

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

No recalculations were required.

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 CO_2 & N_2O EMISSIONS

Information on indirect N2O emissions may be found in Chapter 5, relating to source sector Agriculture.

Chapter 10 RECALCULATIONS & IMPROVEMENTS

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.

Table 10-1 below shows the percentage change in 1990 and 2018 for the total national GHG emissions with and without LULUCF, for both previous and latest submissions. As illustrated in the table, a change of 1.12% occurred for year 1990, while a percentage change of -6.77% occurred in year 2018 including LULUCF emissions.

Table 10-1 Total national GHG emissions recalculations for years 1990 and 2018.

	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	2574.17	2602.98	2570.37	2595.50	1.12	0.98
2018	2190.45	2042.13	2186.11	2041.17	-6.77	-6.63

Chapter 11 KP-LULUCF Reporting

11.1 GENERAL INFORMATION

This chapter refers to information related to KP-LULUCF reporting. This reporting was introduced for the 2nd Commitment period (2013-2020) for Malta.

As indicated in the Forest Land section of this NIR, the KP-LULUCF chapter will be also updated in future submissions following the updates to be completed in the LULUCF and KP-LULUCF sectors, thus to be consistent with each other and also reflect and be consistent with what is reported in the National Forestry Accounting Plan. The updates will be made following the recommendations of task 1 and 2 of the capacity building support visits, which as a result contributed to updates in the both the Forest Land category and KP-LULUCF sector.

Noting that the extent of the recommendations and revisions from the two tasks of the capacity building support visits have deemed to require more time to be implemented than previously envisaged, the updates in the area land use matrix and calculation of estimations in Forest Land will not be indicated in this submission. Nonetheless, an explanation of the areas that will be considered for the woodlands criteria, as used for the Forest Land category, for the future updates will be explained in this section, reflecting the information present in the national forestry accounting plan and for consistency with the two reporting systems. More details and further discussion of the status and the planning of these updates are mentioned in the LULUCF Chapter of this NIR, based on the conclusions from the Capacity Building Plan tasks discussions.

11.1.1 Definition of forest and any other criteria

For reporting purposes under the Kyoto Protocol Malta has identified the minimum values for the three relevant parameters. Thus, 'Forest' is defined as '*an area with minimum area of land of 1 hectare, tree crown cover more than 30% and trees minimum height more than 5 meters.'*. The same definition of forest land is used for the UNFCCC inventory, in order to maintain coherence between the two inventories. Similarly, the same criteria and areas of Maltese woodlands are considered for the purposes of reporting under the KP-LULUCF reporting.

The definitions of Planted Forest and Natural forest further distinguish between the two types of forest. The definition of Planted Forest as set by the FAO is thus: *'Forest predominantly composed of trees established through planting and/or deliberate seeding.'* Additionally, Natural forests are all forests that do not conform to the definition of 'Planted Forests'.[88] Further detailed explanation of the Maltese woodland reserve are provided below.

The forest/woodland areas which are considered are the same areas used for the Forest Land category, which are in line with the definition, namely the 'Buskett', 'Mizieb' and 'Wardija' areas. Moreover, for the afforestation criteria the area pertaining to the 'Foresta 2000' reserve and 'Buskett' are taken into consideration, since afforestation occurred within these two locations. Below accounts for the detailed description of the woodland areas.

[88] As required by the Kyoto Protocol Supplement for reporting under the Kyoto Protocol (step 1.2, p. 1.8)

Il-Buskett

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 and is located within Ir-Rabat, Ħad-Dingli and Is-Siġġiewi locality boundaries. The area includes both a Special Area of Conservation (SAC) and a Special Protection Area (SPA). L-Inħawi tal-Buskett SAC is one of the largest SACs in the Maltese Islands. It consists of three valley systems, Wied l-Isqof, Wied il-Luq and Wied il-Girgenti, each of which has a permanent watercourse running through it, 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. Buskett is also a popular site with both Maltese and foreigners, recording a high footfall, particularly in winter. Buskett, and the area around it, is also important as a concentration point for birds of prey, many of which are of international importance. This has allowed the area to receive designation both as a Special Area of Conservation (SAC) and a Special Protection Area (SPA).

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. Certain parts of the woodland are under direct management of the ELC consortium through a Private-Public Partnership agreement with the Government of Malta while the former Directorate for Parks, Afforestation and Countryside Restoration (PARKS) (now called 'Ambjent Malta' agency) within the Ministry for Sustainable Development, the Environment and Climate Change is responsible for the woodland.

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 11-1 and Figure 11-2 below present the boundary map and habitats map of the Buskett area.

Figure 11-1 L-inhawi tal-Buskett u tal-Girgenti (SAC & SPA) Site boundary

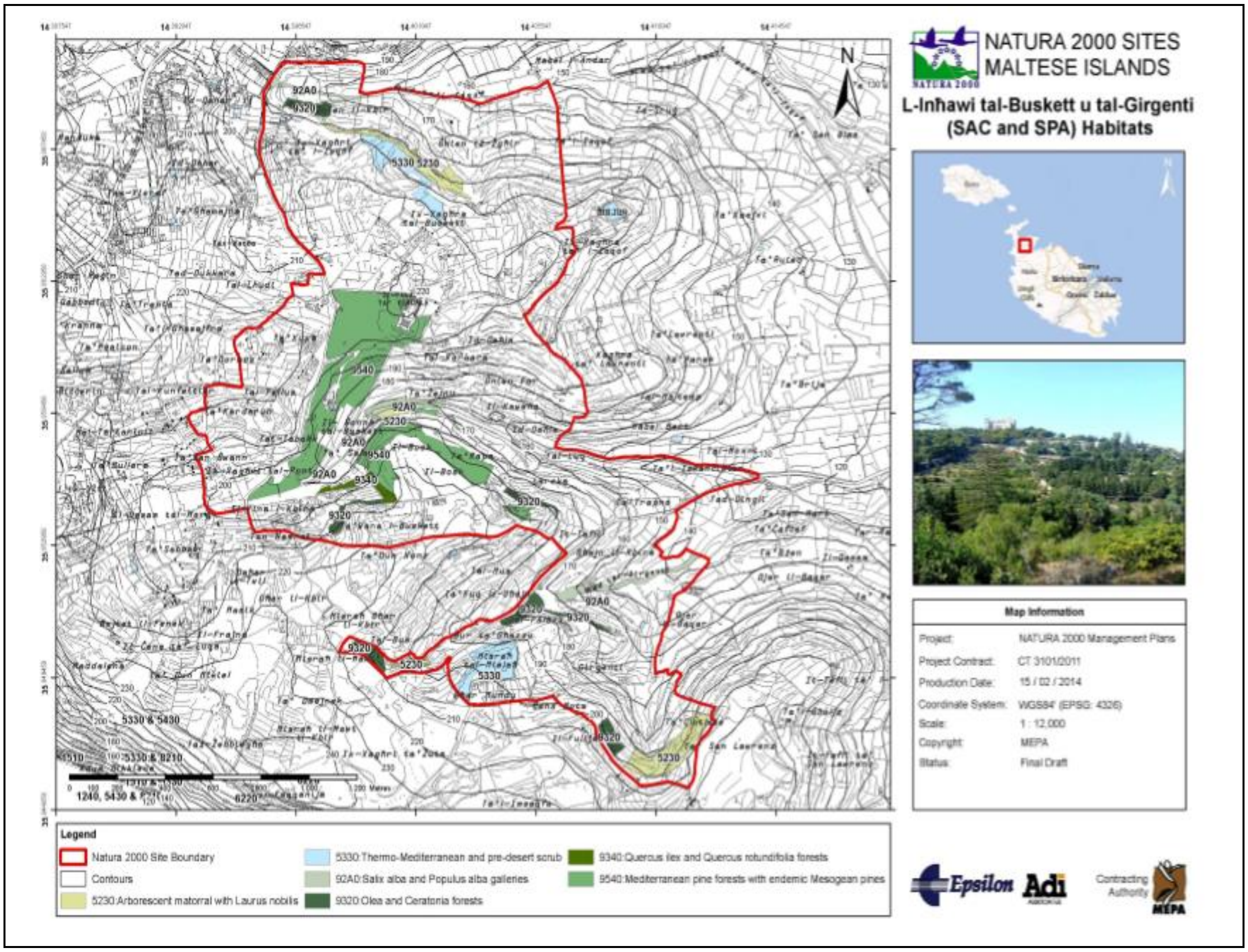

Figure 11-2 **L-inhawi tal-Buskett u tal-Girgenti (SAC & SPA) Habitats**

Il-Wardija

Il-Ballut tal-Wardija Special Area of Conservation (SAC) is found in the north-east coast of Malta. The site is found in an area between Wardija and St. Paul's Bay. To the north of the site there is St. Paul's Bay and there are views of Xemxija Bay whilst to the west there are views of the Pwales Valley. The Wardija settlement is found to the east of the SAC. To the south west there is the San Martin Valley. Il-Ballut tal-Wardija SAC 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 11-3 and **Figure 11-4** present the boundary map and habitats map of the Wardija area SAC.

Figure 11-3 Il-Ballut tal-Wardija (SAC) Site boundary

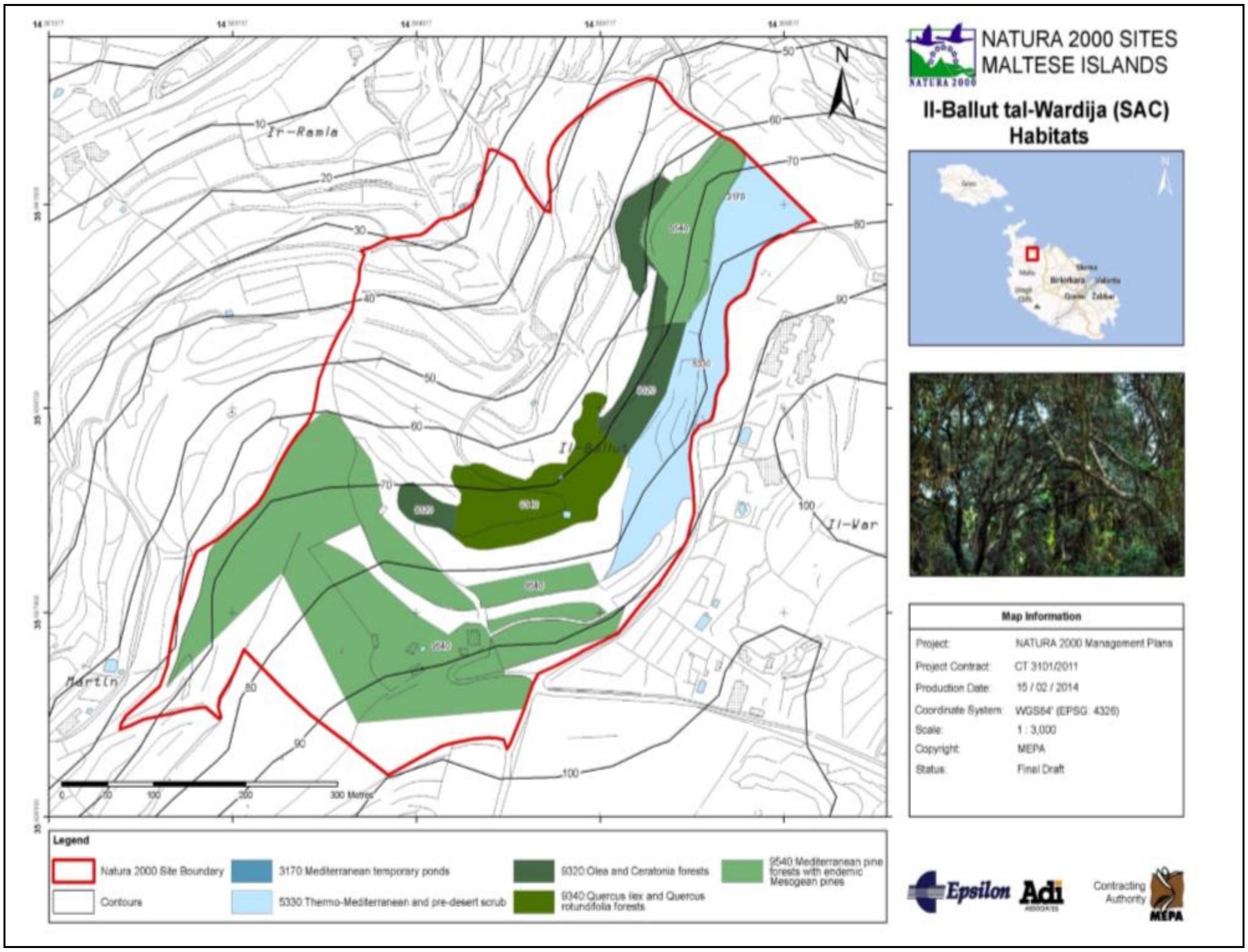

Figure 11-4Il-Ballut tal-Wardija (SAC) Habitats

Il-Mizieb

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.

Information on the Mizieb site was still not provided to the LULUCF inventory compilers from FKNK's side, for the preparation and submission of the GHG Inventory as well as the NFAP, thus this forest reserve will be considered and updated in the LULUCF sector reporting accordingly for future submissions, based on the information that may eventually be received.

Foresta 2000

The northern flank of the SAC, at is-Sdieri, below the ridge is under the joint management of a Non-Governmental Organisation, entitled Birdlife Malta and the Government, being the focus of an afforestation project: Foresta 2000. 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 that would become an attraction for both Maltese and foreigners wanting to explore and enjoy nature. The Foresta 2000 initiative is being run by BirdLife Malta, in collaboration with Din l-Art Helwa and the former PARKS which was the afforestation department of the Ministry for Sustainable Development, Environment and Climate Change (now 'Ambjent Malta' Agency), and involves the environmental improvement of a site of approximately 104 ha located on the west slope of Marfa Ridge, 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, as was confirmed by the Ambjent Malta agency during task 1 of the capacity building support visits, which up until now amounts to a total of 44 hectares of afforested land.

The project has drawn on the participation of several individuals, schools and corporations, and on the work of volunteers. It has also 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).

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 in **Figure 11-5** below.

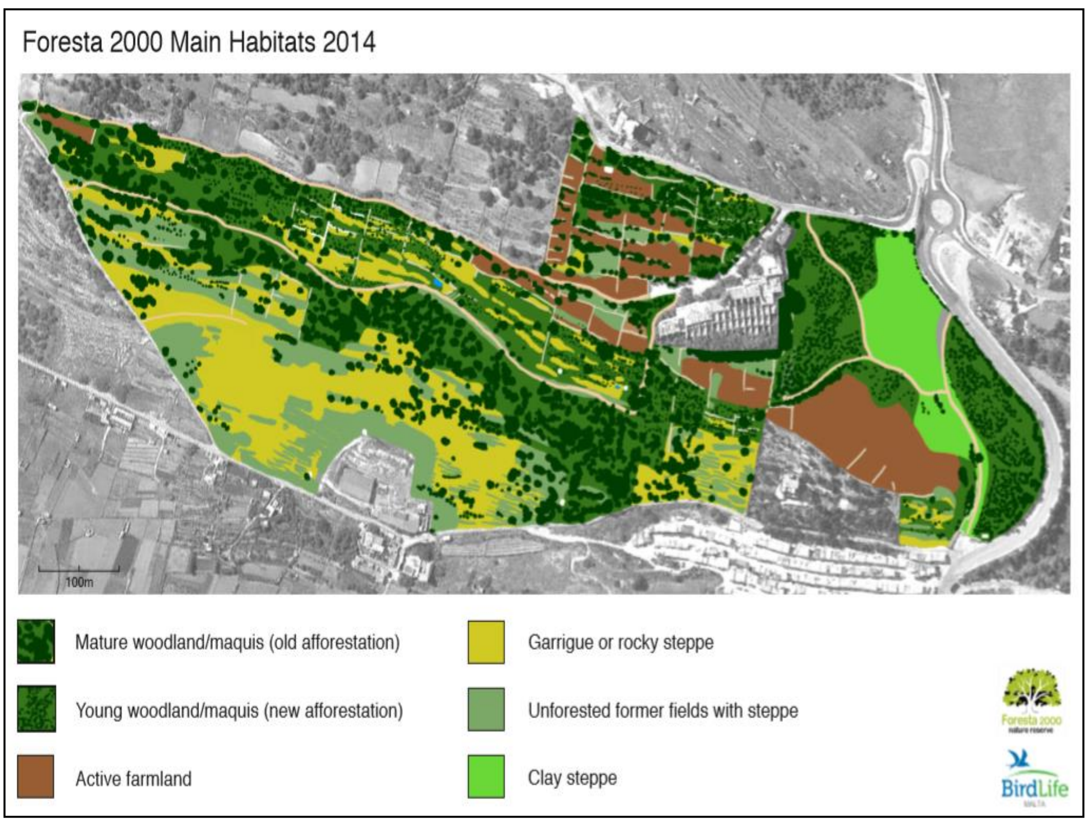

Figure 11-5 Foresta 2000 Main Habitats map

As already explained in the Forest Land section of the LULUCF chapter, in Malta there is no relevant harvest commercialized for material use, and wood for material use is currently imported from other countries. Woodland is protected under Maltese legislation, namely Legal Notice 12 of 2001[89] 'Trees and Woodland (Protection) Regulations'. The evergreen woodland is dominated by evergreen tree species such as oak (*Quercus ilex*) and Aleppo pine (*Pinus halepensis*); however very few old oak trees still exist.

Malta has co-financed a project in order to meet the obligations emanating from the Habitats and Birds Directives. The overall aim of the project, entitled "Natura 2000 Management Planning for Malta and Gozo" was to establish management plans and legal provisions for the management of all terrestrial Natura 2000 sites in the Maltese Islands and to increase awareness of Natura 2000 amongst the general public and stakeholders. The project was formally launched by the then MEPA in January 2013. It was implemented through collaboration between MEPA and Epsilon International SA – Adi Associates Environmental Consultants Ltd Consortium through a service contract.

The consideration of site management emanates from a legal requirement to prepare conservation measures for protected sites under the Environment Protection Act, as transposed from the European Union Habitats Directive. The management planning exercise involved gathering information, carrying out surveys, defining conservation objectives, and identifying management measures, with intensive stakeholder involvement throughout the entire exercise. A secondary component of the service contract involved an awareness campaign on terrestrial Natura 2000 sites in the Maltese Islands amongst the public at large and amongst specific target groups, such as farmers and land managers.

A Management Plan was compiled for most of the sites forming part of the terrestrial Natura 2000 Network, while a Conservation Order was considered to be a more appropriate tool for the smaller sites. These tools became effective after the publication of relevant government notices of 14 December 2016.

11.1.2 ELECTED ACTIVITIES UNDER ARTICLE 3, PARAGRAPH 4 OF THE KYOTO PROTOCOL

Malta confirms 'Forest Management' as the only activity elected under Article 3, paragraph 4 of the Kyoto Protocol for inclusion in the accounting for the 2nd Commitment Period of the Kyoto Protocol (period 2013-2020).

11.1.3 DESCRIPTION OF HOW THE DEFINITIONS OF EACH ACTIVITY UNDER ARTICLE 3, PARAGRAPH 3 OF THE KYOTO PROTOCOL AND EACH MANDATORY AND ELECTED ACTIVITY UNDER ARTICLE 3, PARAGRAPH 4 OF THE KYOTO PROTOCOL HAVE BEEN IMPLEMENTED AND APPLIED CONSISTENTLY OVER TIME

Definitions for the KP-LULUCF reporting chapter are consistent with those used in the UNFCCC inventory. Units of land subject to Article 3, paragraph 3 Afforestation and Reforestation are reported jointly, and are defined as units of land that did not comply with the forest definition on 1st January 1990 but do so some time thereafter. Afforestation/Reforestation category is equivalent to category 4.A.2 (Land converted to Forest land). Forest Management activity under Article 3, paragraph 4 is equivalent to category 4.A.1.2 (Forest land remaining Forest land/managed). Units of land subject to Article 3, paragraph 3 Deforestation are defined as units of land that did comply with the forest definition on or after 1st January 1990 but ceased to comply later on. Deforestation does not occur in Malta, thus will not be taken into consideration for the reporting purposes. Further details indicating deforestation as not

[89] Legal Notice 12 of 2001 Environment Protection Act (CAP. 348) Trees and Woodland (Protection) Regulations, 2001

occurring is presented in the Forest Land chapter. It is to note that other treed lands that may meet the forest definition have been excluded from the reporting because those lands are predominantly urban use.

11.1.4 Description of precedence conditions and/or hierarchy among Article 3, paragraph 4 activities, and how they have been consistently applied in determining how land was classified

As described in the '2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol', Article 3.3 activities and Forest Management (FM) are mandatory and take precedence over elected 3.4 activities. The overall hierarchy among mandatory and elected activities is established as follows:

- Deforestation (D) activities take precedence in the reporting hierarchy over Afforestation (AR) activities. Therefore, land that was reported under D, on which subsequent regrowth of forests occurs continues to be reported under Article 3.3 (D) and it is good practice to report it as a subcategory to indicate that this previously deforested land can be acting as a carbon sink.
- AR and D activities take precedence in the reporting hierarchy over FM activities.
- AR, D and FM activities take precedence in the reporting hierarchy over any other elected Article 3.4 activity.
- Parties establish the reporting hierarchy among elected activities of Cropland Management (CM), Grassland Management (GM) and Revegetation (RV).
- Since Wetland Drainage (WDR) is limited to lands that are not accounted for under any other activity, lands not already reported under any of the above activities in a given year, on which drainage and rewetting of organic soils take place are reported under WDR, if elected by the Party.

Since Forest Management activity is only elected under Article 3, paragraph 4, the same hierarchy is followed for the Forest Land category, meaning that the same area and similar woodlands classifications are considered, thus, to be consistently applied throughout the whole reporting system.

11.2 LAND-RELATED INFORMATION

11.2.1 Spatial assessment used for determining the area of the units of land under Article 3, paragraph 3 of the Kyoto Protocol

The assessment made is the same one that is mentioned in the LULUCF sector chapter (refer to Chapter 6), where datasets are mainly acquired from the Corine Land Cover 2012.

No emissions and removals were calculated from this sector since the management rules which apply to the two forests occur in Malta are not subject to change the profile of the forested lands. In view of this, no activity from Afforestation is occurring in these areas. With regards to the activity of Deforestation as mentioned in the Forest Land chapter, no logging or deforestation takes place in Malta.

Noting that the extent of the recommendations and revisions from the two tasks of the capacity building support visits have deemed to require more time to be implemented than previously envisaged, the updates with regards to the activity of afforestation will not be indicated in this submission. The future updates will reflect the description of the woodlands considered for the category of Forest Land.

11.2.2 METHODOLOGY USED TO DEVELOP THE LAND TRANSITION MATRIX

The data sources on land areas used are the same for both the UNFCCC inventory and the Kyoto Protocol reporting. Data on the land use areas are obtained from the Corine Land Cover and the National Statistics Office of Malta as mentioned earlier in the LULUCF Chapter.

As abovementioned the updates relating to the re-development of the land transition matrix will be implemented in future submissions.

11.2.3 MAPS AND/OR DATABASE TO IDENTIFY THE GEOGRAPHICAL LOCATIONS, AND THE SYSTEM OF IDENTIFICATION CODES FOR THE GEOGRAPHICAL LOCATIONS

Figure 11-6 below represents the graphical illustration of the map of Malta by Corine Land Cover (CLC), derived from the former MEPA for the year 2012 utilised for the various land uses.

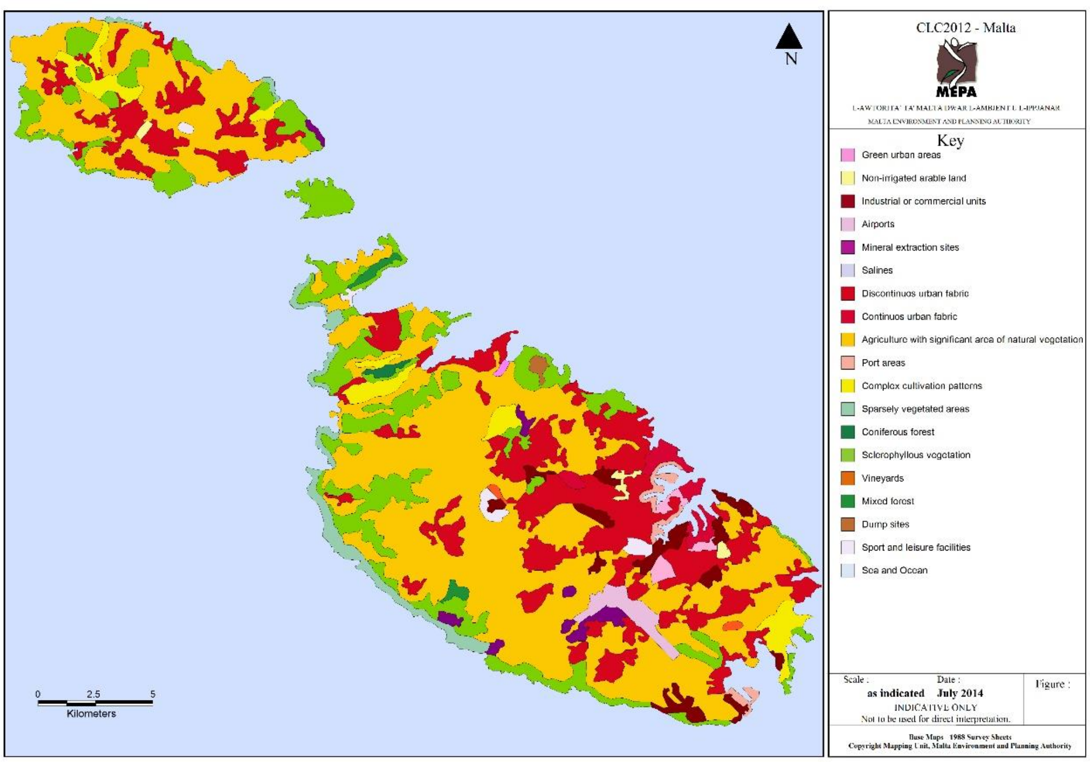

Figure 11-6 Illustration of MALTA by the Corine Land Cover of 2012

Source: Corine Land Cover, MEPA 2014

The total units of land subject to activities under Article 3 paragraph 3 is identical to the units of land used in the Forest Land category, which in total measures at 0.072 kilo hectares. The same unit of land is also subject to forest management provisions.

11.3 ACTIVITY-SPECIFIC INFORMATION

No emissions and removals estimations occurred from the activities under Article 3, paragraph 3 and Article 3, paragraph 4.

(These will be updated in future submissions to reflect the estimations to be done in these activities).

11.4 ARTICLE 3, PARAGRAPH 3 OF THE KYOTO PROTOCOL

11.4.1 Information relating to Afforestation and Deforestation

No activity is occurring in Afforestation and Deforestation.

(These will be updated in future submissions to reflect the estimations to be done in these activities).

11.4.2 Information on harvested wood products under Article 3, paragraph 3

Malta does not produce any harvested wood products; therefore, this category does not occur in Malta.

11.5 ARTICLE 3, PARAGRAPH 4 OF THE KYOTO PROTOCOL

11.5.1 Information relating to Forest Management

For the activity Forest Management under Article 3, paragraph 4, this year's submission follows the previous one, were reported removals and emissions were not calculated from this category. This, considers the woodland reserves of Malta to be in equilibrium, as previously assumed, thus the estimates of emissions and removals from this category is considered to be zero. Information in this section will however be changed and updated in future submissions in view of the new information received, and the updates to be performed in the Forest Land sector.

11.5.2 The forest reference level (FRL)

The European Union report 'Submission of information on forest management reference level by the European Union as requested by Decision 2/CMP6: The Cancun Agreements: Land use, Land Use Change and Forestry' published in 2011 defined (paragraph 4) the FRL value for Malta at -0.049 Mt CO2 equivalent/year, indicating that this was derived through extrapolation of historic data on greenhouse removals related to forest management.

The FRL will be updated in future submissions to reflect the FRL value established in the National Forestry Accounting Plan for the 1st Commitment Period until 2025.

11.5.3 TECHNICAL CORRECTION OF FMRL

A description of how the present FRL was established is provided here. Since the national greenhouse gas inventory submission of 2011, Malta has changed the methodology for estimating emissions and removals for the sector LULUCF. During those previous submissions the category 'Forestland remaining forestland' was taken to include coniferous forest, mixed forest and shrubland (maquis).

Malta has now a national definition which states that a forest is defined as an area of minimum 1 hectare with a tree crown cover of more than 30% and minimum tree height of 5 meters. This has resulted in shrubland no longer being considered as part of the category 'Forestland', now being classified as part of the category 'Grassland'.

In view of this, Malta did a correction of the FMRL currently inscribed under the Kyoto Protocol. This methodological change led to the sink value of -49Gg CO2 equivalent as reported when using the previous methodology being reduced to a net removal for the category 'Forestland remaining forestland' of 0 Gg CO2 equivalent. This means that for Malta, if a FMRL value of -49 Gg CO2 equivalent had to continue being applied, it would always start with a deficit of -49 Gg CO2 equivalent when accounting for national emissions under the Kyoto Protocol. Under such a situation Malta would have to surrender an additional amount of Assigned Amount Units equivalent to the deficit. The inconsistency created by the change in methodology used in the determination of the FMRL therefore was addressed through a technical correction.

During the UNFCCC in-country review of the GHG emissions and removals Inventory for Malta of October 2016, the Forest Reference Level was reviewed based on changes in the forest land category of the LULUCF. Thus, through the help of the LULUCF Expert Review Team, the FMRL was recalculated and set to zero. The reasoning behind this, is that forests in Malta were considered at maturity and where therefore C stock losses are offset by C stock gains, thus, the long-term C stock balance in Maltese forests are assumed to be in equilibrium. The table below indicates the method used to calculate the technical correction for Malta. The technical correction to the original FMRL was set at 49 Gg CO2 equivalent.

Table 11-1 Technical Correction for the Forest Management Reference Level

	Emissions and removals
FMRL (Forest Management Reference Level inscribed in the appendix to Decision 2/CMP.7)	-49 [Gg yr^{-1}]
$FMRL_{corr}$ **(recalculated FMRL)**	0 [Gg yr^{-1}]
Difference in per cent = 100 * [($FMRL_{corr}$ – FMRL)/FMRL] %	100%
Technical correction = $FMRL_{corr}$ – FMRL (where 'technical correction' refers to the net value of emissions and removals to be added, at the time of accounting, to the original FMRL so as to reflect the impact of methodological inconsistencies)	49 [Gg yr^{-1}]

As stated in the previous section, the FRL will be updated in future submissions to reflect the FRL value established in the National Forestry Accounting Plan for the 1st Commitment Period from 2021- 2025.

11.5.4 Information related to natural disturbances

Malta will not be applying the provisions related to Natural Disturbances.

11.5.5 Information on harvested wood products under Article 3, paragraph 4

Malta does not produce any harvested wood products; therefore, this category does not occur in Malta.

11.6 OTHER INFORMATION

No key categories were identified within this category.

11.7 INFORMATION RELATING TO ARTICLE 6 OF THE KYOTO PROTOCOL

Article 6 of the Kyoto Protocol states that, for the purpose of meeting its commitments under Article 3, any Party included in Annex I may transfer to, or acquire from, any other such Party emission reduction units resulting from projects aimed at reducing anthropogenic emissions by sources or enhancing anthropogenic removals by sinks of greenhouse gases in any sector of the economy.

Information related to Article 6 of the KP is not applicable for Malta.

Chapter 12 INFORMATION OF ACCOUNTING OF KYOTO UNITS

12.1 STANDARD ELECTRONIC FORMAT REPORT

The Standard Electronic Format report containing the information required pursuant to paragraph 11 of the annex to Decision 15/CMP.1 will be submitted separately, in the upcoming submission.

12.2 CALCULATION OF THE COMMITMENT PERIOD RESERVE

Malta's assigned amount1 is 9,299,769 tonnes CO2 equivalent.

Paragraphs 6 to 10 of the Annex to Decision 11/CMP.1 and paragraph 18 of Decision 1/CMP.8 require Parties included in Annex B to the Kyoto Protocol to maintain, in their respective national registries, a commitment period reserve (CPR) which should decrease to a level below either:

i. 90% of the Party's assigned amount calculated pursuant to Article 3, paragraphs 7bis and 8bis of the Kyoto Protocol,

   = 9 299 769 * 0.90 = 8 369 792;

ii. or eight times its most recently reviewed inventory[90]

   = 2 175 372 * 8 = 17 402 976;

whichever is the lowest. The commitment period reserve for Malta is thus established at 8,369,792 tCO_2eq.

[90] The value used here represents total greenhouse gas emissions as reported in 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 (2020) of Malta’s national GHG inventory.

Chapter 14 INFORMATION ON CHANGES IN NATIONAL REGISTRY

The following changes to the national registry of Malta have occurred in 2020. The 2020 Standard Independent Assessment Report (SIAR) confirms that previous recommendations have been implemented and included in the annual report.

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 change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	There has been a new EUCR release (version 11.5) after version 8.2.2 (the production version at the time of the last Chapter 14 submission). Due to the new release, some changes were applied to the database. The updated database 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 version 11.5 compared with version 8.2.2 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.

Reporting Item	Description
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	The use of soft tokens for authentication and signature was introduced for the registry end users.
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, PARAGRAPH 14 OF THE KYOTO PROTOCOL

As a small country, Malta's policy action would not be expected to have major adverse impacts on third countries, including developing countries. Notwithstanding, Malta takes a proactive approach through actions that offset, to the highest extent possible, any adverse impacts that may occur.

Malta is a fully committed participant in the global action on climate mitigation. The Kyoto Protocol, in its very nature, aims at addressing in tangible terms the anthropogenic causes of observed climate change, through emission reduction or limitation efforts that contribute towards alleviating the harmful consequences of climate change for, among others, developing countries. Malta is an Annex I Party to the UNFCCC and thus has taken on emission limitation obligations under the Protocol as part of the joint fulfilment of the European Union's overall commitments. Though not a Party inscribed into Annex II of the Convention, still, Malta provides financial support to developing countries through both bilateral and multilateral channels.

One may also reflect on the fact that Malta's contribution towards international climate action started at the very beginning of the international political process that eventually led to the adoption of the UNFCCC, the Kyoto Protocol and the more recent Paris Agreement. In 1988, Malta had introduced an item on the agenda of the General Assembly of the United Nations entitled '*Conservation of Climate as part of the Common Heritage of Mankind*', eventually leading to the adoption of Resolution 43/53 on the '*Protection of Global Climate for Present and Future Generations of Mankind*'. The resolution requested that action be taken that would eventually lead to recommendations on elements for inclusion in a future international convention on climate; the Framework Convention on Climate Change was eventually adopted in 1992.

Malta's climate policy and legislative framework reflects, to a large extent, and builds on, policy and legislation enacted within the European Union. Any legislation proposed at EU level is subject to public consultation and a formal process of impact assessment that also looks at economic and social impacts of the proposed legislation. EU climate policy provides for emission mitigation action across all economic activities. All classes of Kyoto Protocol greenhouse gases are addressed.

Apart from the overarching policy framework at EU level ensuring the proper assessment of impacts of policy decisions, there are also important examples of sector-specific legislation that incorporate requirements that directly or indirectly may safeguard against adverse impacts to third countries. One such example is that for biofuels to count towards mandatory national renewable energy targets under EU law, they must comply with sustainability criteria that include that biofuels cannot be grown in areas converted from land with previously high carbon stock such as wetlands or forests and cannot be produced from raw materials obtained from land with high biodiversity such as primary forests or highly biodiverse grasslands. These conditions are, among other, aimed at protecting these important ecosystems, including in developing countries.

Further to its participation in international and EU efforts that already strive to be in line with the principle in Article 3, paragraph 4, of the Kyoto Protocol, Malta also undertakes direct action with developing third countries in areas of capacity building and transfer of technology and knowledge. Such action includes financial support for the implementation of alternative technologies, adaptation and capacity building and education, the latter including the provision of post-graduate scholarships in climate action at a major Maltese tertiary education institution.

The UNFCCC, in Article 4, requests that developed country Parties listed in Annex II to the Convention provide financial resources to meet the costs incurred by developing country Parties in complying with their commitments under the UNFCCC, to assist developing country Parties that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation, and to promote, facilitate and finance the transfer of and access to environmentally sound technologies and expertise to other Parties, especially supporting the development of endogenous capacity and technologies of developing country Parties.

Malta is not inscribed in Annex II to the Convention. Notwithstanding, it still provides support to developing countries in the sphere of mitigation and adaptation actions and capacity building. Since 2013, Malta has provided financial support for climate action totalling €726,694, through both bilateral and multilateral funding channels (Table 15-1). Multilateral funding contributions primarily relate to the Green Climate Fund (GCF), a fund set up by the UNFCCC in 2010 and dedicated towards helping developing countries reduce their greenhouse gas emissions and enhance their ability to respond to climate change.

Table 15-1 Financial support provided by Malta for years 2013 to 2019.

(source: annual reporting by Malta pursuant to Article 16 of Regulation (EU) No 525/2013)

	Bilateral/regional funding channels	Multilateral funding channels
	Euros	
2013	29,637	N/A
2014	30,725	50,000
2015	105,953	54,410
2016	96,704	100,000
2017	69,265	90,000
2018	N/A	100,000
2019	N/A	100,000

Chapter 16 OTHER INFORMATION

There is no other information to report under this chapter.

REFERENCES

Agriculture and Fisheries 2014, National Statistics Office (NSO), 2016

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

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

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.

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.

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.

Cassar, L. F., & E., C. (2014). *An Outline Strategy for implementation of a National Restoration and Afforestation Project in the Maltese Islands*. Malta.

Census of Agriculture 1991, NSO, 1993

Convention on Wetlands of International Importance especially as Waterfowl Habitat, Paris, 1994

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.

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

EUROSTAT, (2018). Presentation of annual energy statistics in Eurobase: Changes in datasets in node [nrg_quanta]. European Commission.

FAO (2014) *State of Mediterranean Forests 2013*. FAO and Plan Bleu.

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

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

Hunt, C.O. (1997). Quaternary deposits in the Maltese Islands: a microcosm of environmental change in Mediterranean lands. GeoJournal 41 (2), 101-109.

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.

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.

NSO. (2012). Household Waste Composition Survey: 2012. Malta: National Statistics Office.

NSO Malta. (2012). Cencus 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.

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.

Ramsar Sites Information Service, Annotated List of Wetlands of International Importance

Rural Development Programme for Malta: 2007 – 2013, Funds and Programmes Division within the Ministry for European Affairs and the Implementation of the Electoral Manifesto (MEAIM), 2009

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

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. Brussels: European Commission.

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.

Vassa. (2006). data.

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.

A-1.1. Approach 1

Table 17-1 Key Category Level assessment (Base Year [1990] With LULUCF)

CRF code	Category	Classification	Gas	Level (%)	Cumulative (%)
1A1	Public electricity and heat production	Liquid Fuels	CO_2	40.27	40.27
1A1	Public electricity and heat production	Solid Fuels	CO_2	27.23	67.50
1A3b	Road Transportation	Liquid Fuels	CO_2	11.50	79.00
1A4a	Commercial/Institutional	Liquid Fuels	CO_2	6.32	85.32
1A4b	Residential	Liquid Fuels	CO_2	3.65	88.97
1A2	Manufacturing industries and construction	Liquid Fuels	CO_2	2.02	90.99
5A2	Unmanaged Waste Disposal Sites		CH_4	1.59	92.59
3A	Enteric Fermentation		CH4	1.47	94.06
1A3d	Domestic Navigation	Liquid Fuels	CO_2	0.95	95.01

Table 17-2 Key Category Level assessment (Base Year [1990] Without LULUCF)

CRF code	Category	Classification	Gas	Level (%)	Cumulative (%)
1A1	Public electricity and heat production	Liquid Fuels	CO_2	40.42	40.42
1A1	Public electricity and heat production	Solid Fuels	CO_2	27.34	67.75
1A3b	Road Transportation	Liquid Fuels	CO_2	11.54	79.30
1A4a	Commercial/Institutional	Liquid Fuels	CO_2	6.34	85.64
1A4b	Residential	Liquid Fuels	CO_2	3.67	89.31
1A2	Manufacturing industries and construction	Liquid Fuels	CO_2	2.03	91.34
5A2	Unmanaged Waste Disposal Sites		CH_4	1.60	92.93
3A	Enteric Fermentation	Cattle	CH_4	1.48	94.41
1A3d	Domestic Navigation	Liquid Fuels	CO_2	0.96	95.36

Table 17-3 Key Category Level assessment (Latest Year [2019] With LULUCF)

CRF code	Category	Classification	Gas	Level (%)	Cumulative (%)
1A3b	Road Transportation	Liquid Fuels	CO2	32.83	32.83
1A1	Public electricity and heat production	Gaseous Fuels	CO2	32.53	65.36
2F1	Product Uses as Substitutes for Ozone Depleting Substances - Refrigeration and Air Conditioning		HFC	11.37	76.73
5A1	Managed Waste Disposal Sites (Anaerobic)		CH4	6.15	82.88
1A4a	Commercial/Institutional	Liquid Fuels	CO2	3.39	86.27
1A2	Manufacturing industries and construction	Liquid Fuels	CO2	2.10	88.37
1A4b	Residential	Liquid Fuels	CO2	1.91	90.28
1A1	Public electricity and heat production	Liquid Fuels	CO2	1.42	91.71
3A	Enteric Fermentation	Cattle	CH4	1.28	92.98
1A3d	Domestic Navigation	Liquid Fuels	CO2	1.20	94.19
1A4c	Agriculture/Forestry/Fishing	Liquid Fuels	CO2	0.90	95.09
5D1	Wastewater treatment and Discharge Domestic wastewater		N2O	0.38	95.47
5A2	Unmanaged Waste Disposal Sites		CH4	0.35	95.81

Table 17-4 Key Category Level assessment (Latest Year [2019] Without LULUCF)

CRF code	Category	Classification	Gas	Level (%)	Cumulative (%)
1A3b	Road Transportation	Liquid Fuels	CO2	32.88	32.88
1A1	Public electricity and heat production	Gaseous Fuels	CO2	32.57	65.45
2F1	Product Uses as Substitutes for Ozone Depleting Substances - Refrigeration and Air Conditioning		HFC	11.39	76.84
5A1	Managed Waste Disposal Sites (Anaerobic)		CH4	6.16	83.00
1A4a	Commercial/Institutional	Liquid Fuels	CO2	3.40	86.39
1A2	Manufacturing industries and construction	Liquid Fuels	CO2	2.10	88.49
1A4b	Residential	Liquid Fuels	CO2	1.92	90.41
1A1	Public electricity and heat production	Liquid Fuels	CO2	1.43	91.84
3A	Enteric Fermentation	Cattle	CH4	1.28	93.12
1A3d	Domestic Navigation	Liquid Fuels	CO2	1.21	94.32
1A4c	Agriculture/Forestry/fishing	Liquid Fuels	CO2	0.90	95.23
5D1	Wastewater Treatment and Discharge		N2O	0.38	95.60
5A2	Unmanaged Waste Disposal Sites		CH4	0.35	95.95

Table 17-5 Key Category Trend assessment (latest year [2019] with LULUCF)

CRF code	Category	Classification	Gas	Trend (%)	Contribution to trend (%)	Cumulative Total (%)
1A1	Public electricity and heat production	Liquid Fuels	CO2	32.46	40.24	40.24
1A1	Public electricity and heat production	Solid Fuels	CO2	22.76	28.21	68.45
1A3b	Road Transportation	Liquid Fuels	CO2	17.82	22.10	90.55
1A4a	Commercial/Institutional	Liquid Fuels	CO2	2.45	3.03	93.58
1A4b	Residential	Liquid Fuels	CO2	1.45	1.80	95.38

Table 17-6 Key Category Trend assessment (latest year [2019] without LULUCF)

CRF code	Category	Classification	Gas	Trend (%)	Contribution to trend (%)	Cumulative Total (%)
1A1	Public electricity and heat production	Liquid Fuels	CO_2	32.66	40.39	40.39
1A1	Public electricity and heat production	Solid Fuels	CO_2	22.90	28.32	68.71
1A3b	Road Transportation	Liquid Fuels	CO_2	17.87	22.10	90.81
1A4a	Commercial/Institutional	Liquid Fuels	CO_2	2.47	3.05	93.86
1A4b	Residential	Liquid Fuels	CO_2	1.47	1.81	95.67

A-1.2. Approach 2

Table 17-7 Key Category Level assessment (Latest Year [2019] with LULUCF

CRF code	Category	Classification	Gas	Level (%)	Cumulative (%)
2F1	Product Uses as Substitutes for Ozone Depleting Substances - Refrigeration and Air Conditioning		HFC	11.37	29.70
1A3b	Road Transportation	Liquid Fuels	CO2	32.83	48.88
5A1	Managed Waste Disposal Sites (Anaerobic)		CH4	6.15	62.50
1A1	Public electricity and heat production	Gaseous Fuels	CO2	32.53	71.00
1A4a	Commercial/Institutional	Liquid Fuels	CO2	3.39	74.64
5D1	Wastewater Treatment and Discharge - Domestic wastewater		N2O	0.38	78.05
1A2	Manufacturing industries and construction	Liquid Fuels	CO2	2.10	
5A2	Unmanaged Waste Disposal Sites		CH4	0.35	
1A4b	Residential	Liquid Fuels	CO2	1.91	
3A	Enteric Fermentation	Cattle	CH4	1.28	
3D1	Direct N2O Emissions from Managed soils	Organic N/Manure	N2O	0.34	
2F2	Product Uses as Substitutes for Ozone Depleting Substances - Foam Blowing Agents		HFC	0.23	
3D1	Direct N2O Emissions from Managed soils	Inorganic N Fertilizers/ Synthetic	N2O	0.13	
1A4c	Agriculture/Forestry/Fishing	Liquid Fuels	CO2	0.90	

2F3	Product Uses as Substitutes for Ozone Depleting Substances - Fire Protection		HFC	0.15	
1A3d	Domestic Navigation	Liquid Fuels	CO2	1.20	
2D1	Non-Energy Products from Fuels and Solvent Use - Lubricant use		CO2	0.15	
5D1	Wastewater Treatment and Discharge - Domestic wastewater		CH4	0.34	
3B	Manure Management	Cattle	N2O	0.22	
3D1	Direct N2O Emissions from Managed soils	Organic N/ Crop Residue	N2O	0.18	
3D2	Indirect N2O Emissions from Managed soils	N Leaching/ Runoff	N2O	0.14	
3B2	Indirect N2O Emissions from Manure Management	Rabbits	N2O	0.07	
3D2	Indirect N2O Emissions from Managed soils	Atmospheric Deposition	N2O	0.08	
1A1	Public electricity and heat production	Liquid Fuels	CO2	1.42	

Table 17-8 Key Category Trend assessment (Latest Year [2019] with LULUCF

CRF code	Category	Classification	Gas	Trend (%)	Cumulative Total (%)
1A3b	Road Transportation	Liquid Fuels	CO2	18.52	28.74
1A1	Public electricity and heat production	Liquid Fuels	CO2	33.06	51.68
5A2	Unmanaged Waste Disposal Sites		CH4	1.07	69.62
1A4a	Commercial/Institutional	Liquid Fuels	CO2	4.36	82.04
1A4b	Residential	Liquid Fuels	CO2	1.48	86.27
1A4c	Agriculture/Forestry/Fishing	Liquid Fuels	CO2	0.62	88.05
4E	Settlements	Total	CO2t, N2Ot	0.19	89.36
5D1	Wastewater Treatment and Discharge - Domestic wastewater	Liquid Fuels	CH4	0.29	90.65
3D1	Direct N2O Emissions from Managed soils	Inorganic N Fertilizers/ Synthetic	N2O	0.04	91.70
3A	Enteric Fermentation	Swine	CH4	0.07	92.46
3B2	Indirect N2O Emissions from Manure Management	Rabbits	N2O	0.04	93.17
3A	Enteric Fermentation	Cattle	CH4	0.16	93.85
3B	Manure Management	Cattle	N2O	0.05	94.24
2G3b	Other Product Manufacture and Use - N2O from Product Uses		N2O	0.03	94.62
1A3d	Domestic Navigation	Liquid Fuels	CO2	0.21	94.98
4C	Grassland	Total	CO2t, N2Ot	0.04	95.32
5D1	Wastewater Treatment and Discharge - Domestic wastewater		N2O	0.01	95.67

2. ASSESSMENT OF UNCERTAINTY (ANNEX VII OF IMPLEMENTING REGULATION (EU) 749/2014)

A detailed assessment of uncertainty is presented in a separate excel template in accordance with Annex VIII of Implementing Regulation (EU) 749/2014.

The overall uncertainty in the total inventory was of 4.78%, whereas the trend uncertainty was that of 4.40%.

With regards to the uncertainty by sector, this is aimed to be included in the next submission.

3. DETAILED METHODOLOGICAL DESCRIPTIONS FOR INDIVIDUAL SOURCE OR SINK CATEGORIES

A- 3.1 TRANSPORT: ROAD TRANSPORT (CRF 1.A.3.B)

The following is a list of input parameters used for COPERT 5 in respect of the estimation of emission using this modelling tool.

Table 17-7 Parameters used for the COPERT5 model for the estimation of emissions.

INPUT PARAMETER	UNIT	INPUT PARAMETER	UNIT
MIN_TEMPERATURE	[°C]	URBAN_PEAK_ROAD_SLOPE	[%]
MAX_TEMPERATURE	[°C]	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]

A- 3.2 TRANSPORT: NATIONAL WATER-BORNE NAVIGATION (CRF 1A3D)

Table 17-8 Classification between National Navigation and International Navigation of Marine-Going Vessels.

NOTE: In order 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.

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

A- 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[91].

Table 17-9 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)[92] was applied; this study was selected as the values of all parameters required in the equation were available at the national

[91] Additional fields were included in the Intrastat declaration following a request made by the Agency.

[92] 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.

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;

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.

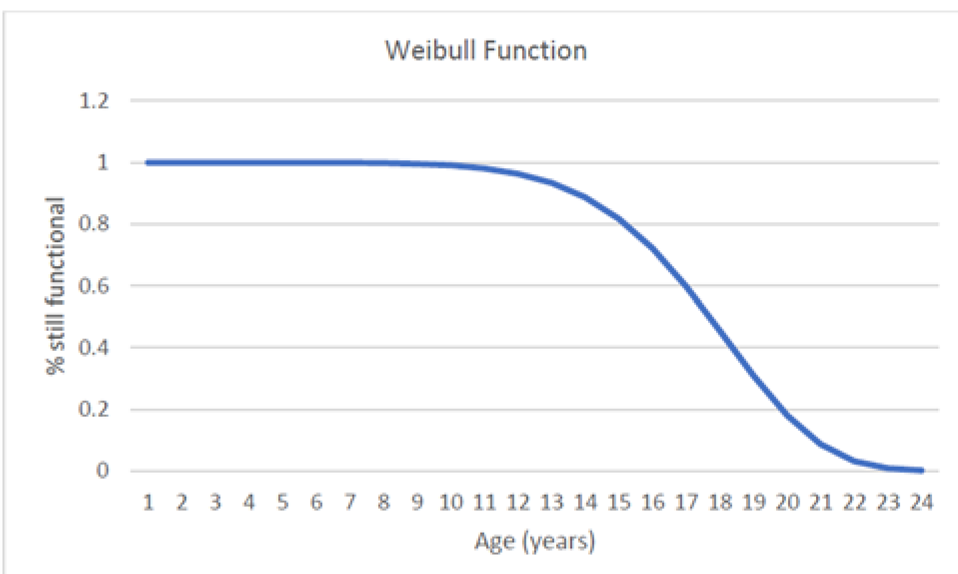

Figure 17-1 Weibull function.

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 17-10 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.

A- 3.4 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 Figure 17-2.

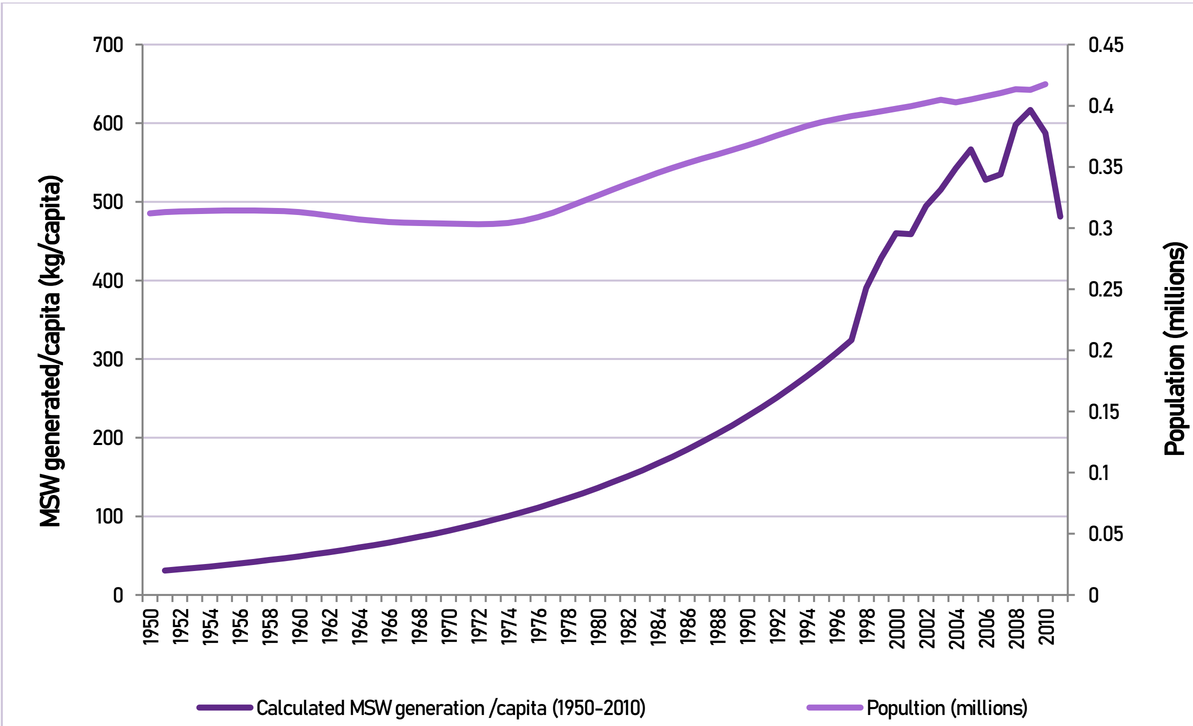

Figure 17-2 Trend of municipal solid waste generation/capita

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).

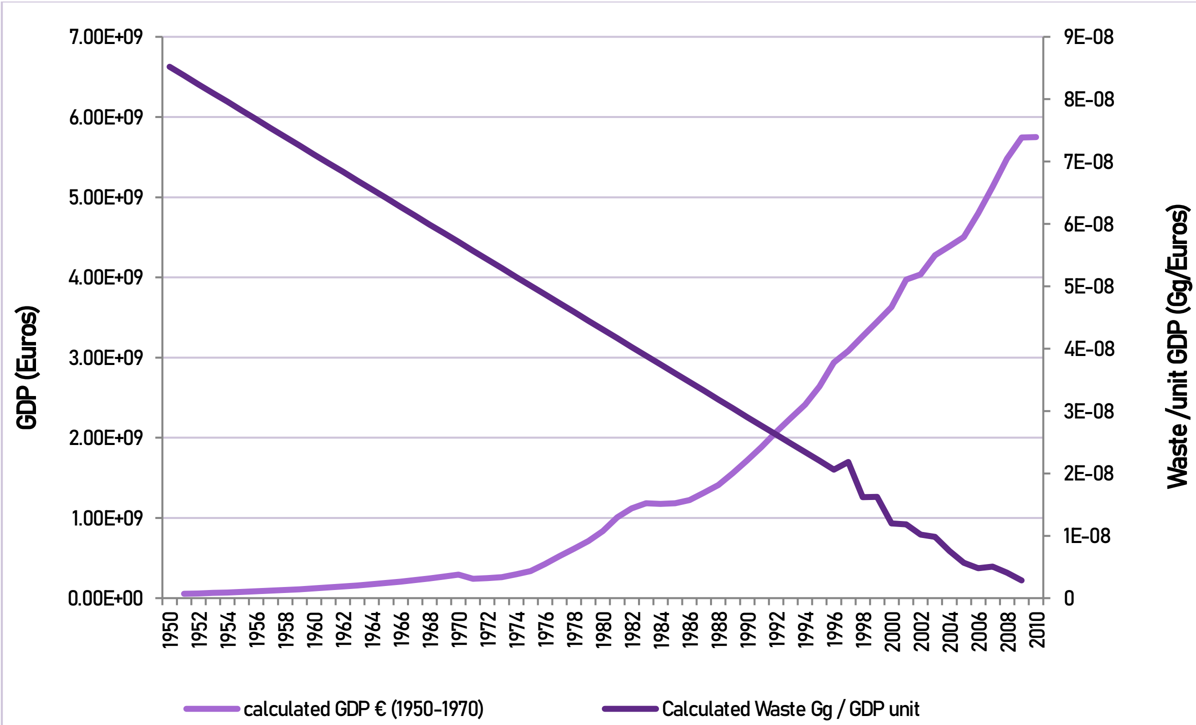

Figure 17-3 Trend of industrial waste/unit GDP for 1950-2010 compared to GDP

Following the combination of the two above mentioned calculations Figure 17-4 depicts the final activity amounts used in the FOD model.

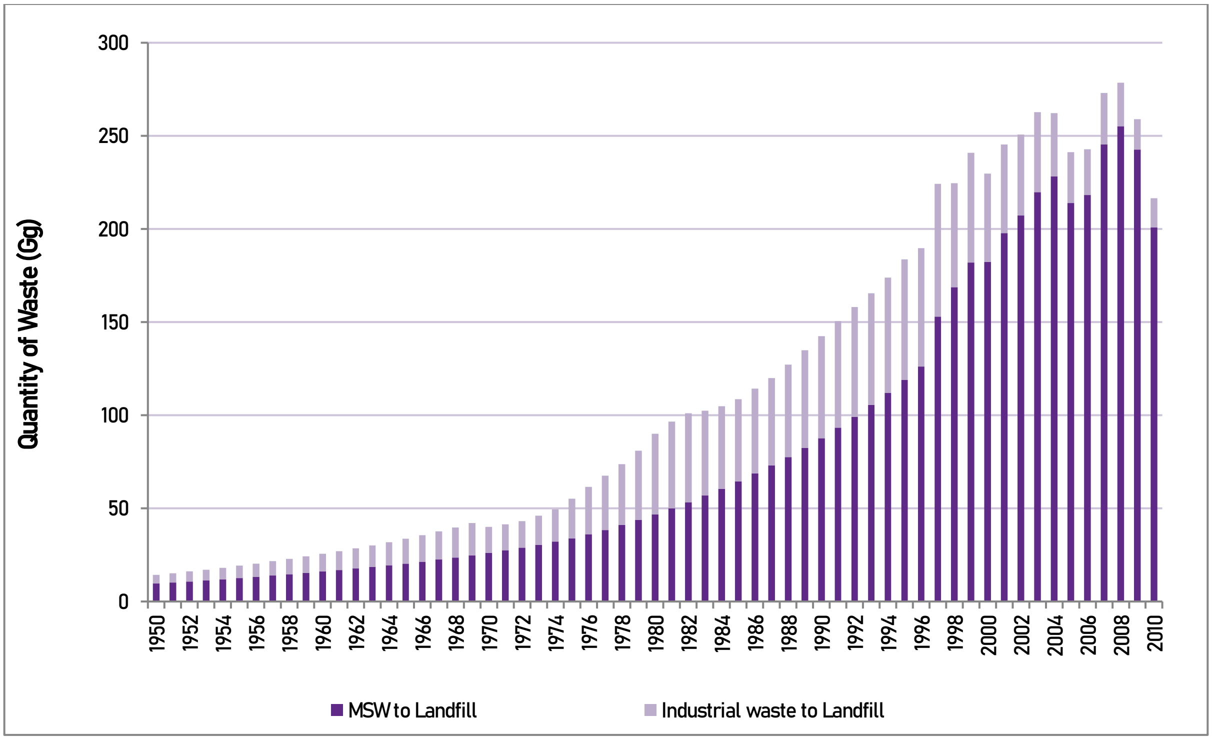

Figure 17-4 Waste deposited in landfills for 1950-2010

Incineration emission factors

- Municipal Waste

Table 17-11 Example calculation for CO_2 emissions of municipal waste from incineration

Year	A: Total Amount of municipal 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 CO_2/ Gg waste) (B*C*D*E*F)	H: Emissions of CO_2 (Gg) (A*G)
1990	0.25	0.40	0.38	0.15	1.00	3.67	0.08	0.02

The following emission factors have been used to calculate CH_4 emissions: (6500g CH_4/tonne waste for 1990 to 2003; 0.2g CH_4/tonne waste for 2008) and N_2O emissions (221g N_2O/tonne waste for 1990 to 2003; 8g N_2O/tonne waste for 2008), as available in the IPCC 2006 guidelines.

The following emission factors have been used to calculate NO_x emissions (1.8 kg NO_x/Mg waste), CO emissions (0.7 kg CO/Mg waste), NMVOC emissions (0.02 kg NMVOC/Mg waste) and SO_2 emissions (1.7 kg SO_2/Mg waste, as available in EMEP/EEA. 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 CH_4 emissions), this assuming the plant operated to the limit for the whole number of hours of operation as reported in the E-PRTR report. Table 17-12 illustrates the emission factors used.

Table 17-12 Emission factors for indirect GHGs in incineration

Year	NO_x	CO	NMVOC	SO_2
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	0.50	0.14	0.10
2012	1.40	0.22	0.12	0.12
2013	1.53	0.36	0.11	0.10
2014	1.24	0.09	0.11	0.07

- Clinical Waste

Table 17-13 Example of calculation for CO_2 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 CO_2/ Gg waste) (C*D*E*F)	H: Emissions of CO_2 (Gg) (A*G)
1990	1.99	NA	0.60	0.40	1	3.67	0.88	1.75

The following emission factors have been used to calculate CH_4 emissions (60kg CH_4/Gg waste for 1990 to 2007; 0.2kg CH_4/Gg waste for 2008) and N_2O emissions (100g N_2O/tonne waste), as available in the IPCC 2006 guidelines.

The following emission factors have been used to calculate NO_x emissions (2.3kg NO_x/Mg waste for 1990 to 2007), CO emissions (0.19 kg CO/Mg waste for 1990 to 2007), NMVOC emissions (0.7kg NMVOC/Mg waste for 1990 to 2007) and SO_2 emissions (0.54kg SO_2/Mg waste for 1990 to 2007), as available in EMEP/EEA. Following 2007 emissions factors listed in Table 17-12 were used.

- Industrial Waste

Table 17-14 Example of calculation for CO_2 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 CO_2 emissions (Gg CO_2 / Gg Waste) (B*C*D*E*F)	H: Emissions (Gg CO_2) (A*G)
1990	0.07	0.90	0.46	0.01	1.00	3.67	0.02	0.00

The following emission factors have been used to calculate CH_4 emissions (60kg CH_4/Gg waste for 1990 to 2007; 0.2kg CH_4/Gg waste for 2008) and N_2O emissions (10g N_2O/tonne waste for 1990 to 2007; 100g N2O/tonne waste for 2008), as available in the IPCC 2006 guidelines.

The following emission factors have been used to calculate NO_x emissions (2.5kg NO_x/Mg waste for 1990 to 2007), CO emissions (0.13 kg CO/Mg waste for 1990 to 2007), NMVOC emissions (7.4kg NMVOC/Mg waste from 1990 - 2007) and SO_2 emissions (0.07kg SO_2/ Mg waste for 1990 to 2007), as available in EMEP/EEA. Following 2007, emission factors listed in Table 17-12 were used.

ANNEX 4. NATIONAL ENERGY BALANCE

Table 17-15 Malta's Oil Balance Report for year 2019

Oil Statistics of Malta including Natural Gas-2019 (October 2020)														
Metric Tonnes		Liquified Petroleum Gas	Petrol	Jet A1	Aviation Gasoline	Kerosene	Diesel	Biodiesel	Gasoil	Fuel Oil (including Light Cycle oil)	Propane	Crude Oil	HVO	Natural Gas
Imports	+	10,173	73,552	174,184	51	177	150,203	2,024	391,435	1,963,302	14,892	-	9,103	307,516
Imports - Tickets held in Malta	+	-	-	-	-	-	7,900	-	162,030	132,895	-	-	-	-
Exports	-	-	-	-	-	3	1,512	172	2,426	46,103	-	-	741	-
Exports - Tickets held in Malta	-	-	-	-	-	-	4,060	-	127,546	200,230	-	-	-	-
International Marine Bunkering	-	-	-	-	-	-	4,426	-	373,420	1,961,826	-	-	-	-
Indigenous Production	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Inter-Product Transfers:		(8,874)	(21)	329	5	(337)	(7,460)	2,024	(1,308)	(2,079)	8,874	-	8,846	-
Reductions	+	127	2,292	329	5	-	17,245	2,024	2,086	1,263	9,001	-	8,846	-
Additions		9,001	2,313	-	-	337	24,705	-	3,394	3,342	127	-	-	-
Intra-Installation Movements:		-	-	-	-	-	-	-	-	0	-	-	-	-
Reductions	+	-	-	503,078	5	-	90,299	-	27,194	148,804	-	-	8,403	-
Additions		-	-	503,078	5	-	90,299	-	27,194	148,804	-	-	8,403	-
Third-Party Product Transfers:		-	(2,748)	-	-	(53)	(11,329)	-	(1,408)	824	-	-	-	-
Sales	+	-	2,136	-	-	51	31,695	-	6,107	824	-	-	-	-
Purchases		-	4,884	-	-	105	43,023	-	7,515	-	-	-	-	-
Stock Change:		21	(6,660)	13,079	(4)	(30)	2,053	(172)	25,512	(99,650)	(1,445)	-	(470)	10,753
Total Closing Stock as at 31st December	+	193	4,507	28,539	4	83	22,358	-	82,831	46,214	1,543	-	1,379	49,846
Total Opening Stock as at 1st January		172	11,168	15,460	9	113	20,305	172	57,319	145,864	2,988	-	1,849	39,093
Returns to Petrochemical Industry	-	-	-	-	-	-	409	-	5,419	2,247	-	-	-	
Product Gains/(Losses)	+	175	88	258	(1)	39	129	-	8,803	19,377	25	-	14	(0.29)
Gross Inland Consumption (Calculated)	=	19,202	83,071	161,034	49	634	164,561	(0)	30,661	6,072	7,488	-	(0)	-
Biodiesel (Blended):														-
Gross Inland Consumption (Adjusted)		19,202	83,070	161,034	49	634	153,691	2,024	30,661	6,073	7,489	-	8,846	-
Statistical Difference - (GIC (O) - GIC)		0	(0)	0	0	(0)	(0)	-	(0)	(0)	0	-	0	-
		0%	0%	0%	0%	0%	0%		0%	0%	0%			0%
Gross Inland Consumption (Observed) - GIC (O)	=	19,202	83,070	161,034	49	634	164,560	-	30,661	6,073	7,489	-	-	296,470.00

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 2017 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 6.4 kt CO2e, with the sectoral estimate being the greater in terms of emissions.